Abstract Book

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Great Together: Separate Challenges and Collective Solutions
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In each abstract, the presenting author’s name is underlined. The author index cross-references the corresponding abstract numbers.
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Specific goals of the society are:

• Promote research, education and training in the environmental sciences
• Promote the systematic application of all relevant scientific disciplines to the evaluation of chemical hazards
• Participate in the scientific interpretation of issues concerned with hazard assessment and risk analysis
• Support the development of ecologically acceptable practices and principles
• Provide a forum (meetings and publications) for communication among professionals in government, business, academia and other segments of society involved in the use, protection and management of our environment

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• Conduct meetings with study and workshop sessions, platform and poster presentations, and achievement and merit awards
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• Provide funds for education and training through the SETAC Scholarship/Fellowship Program
• Organize and sponsor chapters and branches to provide a forum for the presentation of scientific data and for the interchange and study of information about local and regional concerns
• Provide advice and counsel to technical and nontechnical persons through a number of standing and ad hoc committees

SETAC membership currently comprises about 5,400 individuals from government, academia, business and nongovernmental organizations with backgrounds in chemistry, toxicology, biology, ecology, atmospheric sciences, health sciences, earth sciences, environmental engineering, hazard and risk assessment, and life cycle assessment.

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Environmental Quality Through Science®
Concentrations and Impacts of UV Filters in Aquatic Environments

1 Investigating the environmental fate and transport of sunscreen components: Understanding the exposure route

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Recently, sunscreens containing oxybenzone have been subject to heightened controversy due to their reported potential toxic effects on coral. This has even led to bans on oxybenzone-containing sunscreens in places such as Hawaii and Key West. However, while much of the research on oxybenzone is focused on its toxicological effects, far less research has been done on its behavior in aquatic systems. One very important property of these chemicals in order to understand their behavior is their solubility in natural environments and ability to partition from a sunscreen formulation into the water column. Generally, organic UV filters used in sunscreen formulations have log Kow’s between 4 and 7. In this study, in order to better understand the solubility and partition of sunscreen components into the water column, partition experiments were performed using silicon passive-diffusion releasers (SPDRS) to create a homogenous truly-dissolved exposure solution of the UV filter compounds. These partition experiments were conducted using a commercially-available sunscreen formulation containing five active ingredients (oxybenzone, avobenzone, octocrylene, homosalate, and octisalate). Samples were taken over a period of a week and analyzed by liquid chromatography-triple quadrupole mass spectrometry to determine the equilibrium time, equilibrium concentration achieved, and the constancy of the equilibrium concentration and the saturation times. The diffusion through the SPDR was modeled mathematically though a first order exponential curve, which showed a plateau after 40 hours for most compounds tested. The study was carried out in DI water and artificial seawater to determine the effects of the ionic strength of the solution. Concentrations of oxybenzone in DI water were found to plateau around 5.5 mg/L, which is smaller than the total amount of oxybenzone present in the formulations and also lower than the predicted solubility. Results indicate that SPDRs could be used to create exposure solutions for toxicological assessments.

2 Occurrence and fate of UV organic filters in natural and chlorinated seawater

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Swimming and bathing activities are part of points of entry of UV organic filters into the environment via washing off from the bathers’ skin. Although hydrophobic in nature and even when present in the formulation of sunscreens claimed to be “water-resistant,” these UV organic filters are released and can be found on beachfront and in swimming pools. Concerns about the bioaccumulation and persistence of organic UV filters in the environment have been raised because of an increasing number of experimental studies indicated that several UV filters might have endocrine disruptive effects. Moreover, some studies have shown that chlorination of UV organic filters may increase the mutagenicity of water. The determination of the fate of UV filters and the identification of their transformation products when exposed to chemical oxidants (as chlorine in swimming pools) or to natural light (as in untreated bathing waters) is necessary for risk assessment. The first objective of this study was to determine the occurrence of five organic UV compounds: di oxybenzone, oxybenzone, avobenzone, octyl methoxycinnamate and octocrylene) in bathing waters of Marseille, France (3 beaches and 2 chlorinated outdoor seawater pools) and to examine temporal patterns of their concentrations during three days in hot season (July). This field survey was then completed by laboratory experiments to study the photodegradability of these five compounds upon exposure to artificial solar radiations and their reactivity towards chlorine in reconstituted seawater. Analysis of seawater samples - after Liquid-Liquid Extraction- by Liquid Chromatography coupled to a quadrupole/time-of-flight mass spectrometry (LLE-LC-Q/ToF-MS) revealed the presence of four of the five compounds sought, at levels reaching up to 2400 ng.L-1 and 780 ng.L-1 in beach waters and up to 11,000 ng.L-1 and 180 ng.L-1 in swimming pool waters, for octocrylene and oxybenzone respectively. Among these compounds only octocrylene showed an accumulation trend during the day, while oxybenzone, avobenzone and octyl methoxycinnamate concentrations fluctuated on a frequency basis. Lab experiments confirmed these observations: octocrylene is UV and chlorine stable while all the other compounds react to form by-products. These latter ones have been identified (by GC-ECD) and their presence confirmed (by GC-MS) allowing to propose their transformation pathway to bromoform and bromal hydrate.

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3 Occurrence and distribution of UV-filters in water, sediment, and oysters from Chesapeake Bay rivers fed by urban and agricultural areas

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The environmental occurrence of ultraviolet-filters (UV-filters), which are active ingredients in sunscreen and other personal care products, has raised ecotoxicological concerns about endocrine disruption and growth inhibition in photosynthetic organisms. Our previous work indicated that oxybenzone, which was recently banned in Hawaii and Key West, Florida, was frequently detected in water, sediment, and oysters from the Chesapeake Bay at concentrations as high as 114 ng/L, 11 ng/g, and 118 ng/g, respectively. Nevertheless, the concentrations and distribution of UV-filters are unknown in urban- and agriculturally-impacted rivers that feed the Chesapeake Bay. The main objective of this work was to measure 11 UV-filters in water, sediment, and oysters collected from 5-11 sites in the Chester, Choptank, Patuxent, and Potomac rivers to understand potential sources and the influence of adjacent land use characteristics. The Chester and Choptank rivers are located in predominantly agricultural areas along the Eastern shore of the Chesapeake Bay, whereas the Patuxent and Potomac rivers are in urban areas on the Western side of the Bay. UV-filters were extracted from water, sediment, and oysters collected at each site and measured by liquid chromatography with tandem mass spectrometry. A large suite of human- and animal-use antibiotics and sucralose (e.g., a conservative wastewater indicator) were also measured in water samples to contextualize potential sources of UV-filters in the four river systems. Cinoxate, homosalate, octinoxate, octisalate, octocrylene, and oxybenzone were detected at over 90% of the sampling sites, highlighting their ubiquitous presence in the Chesapeake Bay. Oxybenzone was detected at median concentrations of 24, 27, 27, and 23 ng/L in the Chester, Choptank, Patuxent, and Potomac rivers, respectively, suggesting that land use had a negligible impact on oxybenzone levels in the aquatic environment. However, octisalate was detected at concentrations as high as 133 ng/L downstream of wastewater treatment plants and as low as 28 ng/L at more isolated sites. Interestingly, the concentration of several UV-filters increased near marinas and other human development, potentially indicating input from septic systems. Ultimately, these data highlight the widespread occurrence, distribution, and partitioning of a full suite of approved UV-filters in the aquatic environment.
4 The chronic effect of oxybenzone and temperature on the growth, physiology and microbiome of two reef building corals

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Emerging evidence suggests that benzophenone-3 (oxybenzone), a UV-filter applied in sunscreens, is harmful to reef-building corals. Water pollution with sun care products might in addition act synergistically with global warming, affecting coral bleaching threshold levels. In this study, we tested the effect of oxybenzone on the temperature sensitivity of the reef-building corals Stylotphora pistillata and Acropora tenuis. Coral microcolonies were cultured in flow-through aquaria, with or without oxybenzone exposure, at a field-relevant concentration of ~0.1 μg L^{-1} at 26 °C for several weeks. Subsequently, half the corals experienced a heat wave culminating at 33 °C (N=5 replicate tanks for each treatment combination). Survival, effective and maximum PSII yield, growth rate, zooxanthellae density and microbiome composition were recorded. Observations showed species dependent sensitivity to oxybenzone and temperature. Furthermore, oxybenzone exposure accelerated mortality of A. tenuis during the heatwave. Both oxybenzone and the heat wave reduced effective PSII yield of both species, although maximum yield was affected for S. pistillata only. During the heatwave, growth rate and zooxanthellae density of S. pistillata were reduced irrespective of oxybenzone. Finally, the microbiome of S. pistillata responded to a combination of both stressors applied, with a significant reduction in the abundance of four species, and an increase of one other. Our results add to the understanding of the potential impact of oxybenzone to corals at field relevant levels. The ecological significance should however be placed in context and will be addressed in the presentation.

5 Investigation of the toxicological impacts of mineral sunscreen formulations on reef-building corals in a warming ocean

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In recent years chemical UV filters in sunscreens have received considerable attention regarding their potential toxicity towards tropical corals, leading to selected UV-filters ban in Hawaii and Palau. Although mineral UV filters, especially titanium dioxide nanoparticles (nTiO₂), are popular cosmetic ingredients, their impact on corals has been scarcely studied. Moreover, the other core components of sunscreen comprising the sunscreen oil phase, emulsifier and emollient ingredients, have not been given due consideration. Significant quantities of the mineral and oil phase ingredients composing sunscreens are discharged into high-touristic coral reef’s waters, which interact among themselves and the environment resulting in a potential threat to tropical corals. Additionally, ocean warming is widely recognized as the major threat to coral survival and will persist even under the most optimistic scenarios, but the combined effects of sunscreen exposure and elevated temperatures are currently unknown. Here we present an integrated view of the effects of custom-made sunscreen lotions, formulated with different nTiO₂ types and emulsifier ingredients, on the sea anemone Exaiptasia pallida, a coral model organism, adult reef-building corals and their early-life stages, under present and projected future ocean warming conditions. Sea anemones photosynthetic activity and heat shock proteins (HSP70, HSP90) gene expression were investigated, along with coral respiration, photosynthetic efficiency, symbiont density, chlorophyll a concentration and larvae survival at multiple timepoints. Formulations lacking nTiO₂ and simultaneous heat stress caused in E. pallida a concentration-dependent inhibition of photosynthetic efficiency, comparable to sunscreen having the same composition but with nTiO₂ as UV-filters. Moreover, the stress induced by mineral sunscreen ingredients in adult corals, sea anemones and coral larvae was worsened by elevated temperatures. Results from the studies presented here suggest that sunscreen exposure may exacerbate the bleaching response of corals at elevated temperature, potentially leading to higher instances of bleaching at tourist coral reef locations. Our results also indicate that sunscreen toxicity is not due to UV-filters alone, and highlight the importance of taking into account the emollient and emulsifier ingredients in addition to UV filters when developing environmentally friendly sunscreens.

6 Investigating the Toxicity of the UV filter Benzophenone-3 (BP-3 or oxybenzone) on the coral Galaxea fascicularis

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The active ingredients in sunscreens, UV filters, have gained increasing notoriety due to concern that these compounds may have negative impacts on sensitive coral species. Legislative activity in Hawaii and Key West, among others, has led to bans on the sale of sunscreens containing the specific active ingredient benzophenone-3 (BP-3 or oxybenzone) after a single published study demonstrated the potential for coral mortality, deformity, and bleaching when larvae were exposed to BP-3 at parts per billion to parts per million concentrations. However, a recent study using two species of adult coral fragments and larvae found little impact at parts per billion concentrations of BP-3. Given and the small amount of variable data on the toxicity of BP-3 to coral, additional toxicological assessments are necessary to determine the true risk of this UV filter. Therefore, we conducted a number of acute (i.e. 96-hour) and chronic (i.e. 21+ days) toxicity tests using nubbins from a common shallow-water hard coral species, Galaxea fascicularis. These experiments were coupled with chemical analysis to determine the actual aqueous concentrations at several time points during the exposure. Multiple endpoints pertinent to risk assessments (i.e. mortality and growth) were examined along with other biological endpoints such as bleaching and algal cell loss. With the results from these experiments, toxicological measures such as NOECs, LC50s, and EC50s were calculated in order to compare the results of this test to previous assessments of BP-3 toxicity. A risk assessment of BP-3 on Galaxea fascicularis was conducted using these results coupled with global analytical values of BP-3 in seawater from a variety of coral reef locations.

7 Adverse Effects of Organic Ultraviolet-filters on Daphnia magna Development and Their Role as Potential Invertebrate Endocrine Disruptors

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Ultraviolet-filters (UV-Fs) are emerging contaminants of concern found ubiquitously in the aquatic environment. Many organic UV-Fs are endocrine disrupting compounds (EDCs) in vertebrates. However, few studies have assessed their effects on invertebrates. The process of molting, or the shedding of the exoskeleton, may be a target of these compounds. Molting is necessary for growth and development and is regulated by an arthropod specific endocrine system, the ecdysteroid pathway. Alterations of this process by EDCs can result in improper development, reduced growth, or death. These outcomes have potentially significant implications for organismal and population health. In this study, we investigate the effects of organic UV-Fs in a crustacean. Daphnia magna are chronically exposed to three organic UV-Fs commonly found in aquatic environments, 4-methylbenzylidene camphor (4MBC), octylmethoxycinnamate (OMC), and benzophenone-3 (BP3), and assessed for alterations in normal reproduction, molting, and development. We demonstrate that OMC and BP3, but not 4MBC, cause carapace deformities in the offspring of exposed parents. To assess whether these developmental abnormalities are potentially related to chemically induced alterations in ecdysteroid signaling, we further investigate the effects of acute exposure to 4MBC, OMC, and BP3 on the expression of several ecdysteroid-regulated genes (EcR, HR3, and FTZ-F1) in D. magna. This is the first study to assess the effects of UV-Fs on ecdysteroid regulated processes and ecdysteroid signaling.
in a crustacean. Results from these experiments indicate that some environmentally relevant concentrations of UV-Fs can affect crustacean development.

8 Assessing the Environmental Risk of UV Filters and Other Anthropological Contaminants to Coral in the United States
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UV filters are active ingredients in sunscreen products that are designed to protect people against the harmful effects of solar radiation. In recent years, UV filters have been detected in coastal marine waters, which has led to concerns that these materials may be contributing to coral reef degradation. At a time when coral reefs are in overall decline, it is important to assess the risk that UV filters pose to coral reefs and use this information within a holistic assessment of all anthropogenic chemical contaminants to prioritize research and guide environmental management and policy decisions. Sources of UV filters in the environment are wash-off of sunscreen ingredients from bathers’ skin and wastewater treatment plant effluent. Generally speaking, UV filters have been detected in the marine environment at parts per trillion concentrations. Meanwhile, a limited number of ecotoxicological investigations have looked at the effects of UV filters on various coral species. Most studies have investigated acute effects, such as mortality and bleaching, while a single study looked at chronic effects. The following talk will summarize the state of science with regard to exposure of the marine environment to UV filters and other contaminants and the hazard these materials pose to coral species. Moreover, key data-gaps will be outlined and future research needs will be identified. Exposure and hazard data can then be used to assess the environmental risk of UV filters and other chemical contaminants to coral. However, regulatory guidance for assessing the risk posed by UV filters to coral is limited and there is an urgent need for coral-specific methods to be developed. This talk will provide an overview of environmental risk assessment methods and propose an approach that is specific to coral. It is also important to assess environmental risk using relevant and reliable exposure and hazard data. This presentation will also provide an outline of the reliability and relevance of existing data following published guidance also used by regulatory authorities in the US, Canada and the EU. The utility of coral risk assessment methods outlined previously will then be demonstrated using several case study contaminants for which extensive data are available. Additionally, given the extensive data gaps that exist for UV filters and other contaminants to which coral reefs may be exposed, future research needs will be identified and an overview of how these data should be used for a coral environmental risk assessment will be discussed.

Addressing Existing Challenges in Immuno-ecotoxico[logy]: From Tool Development to Risk Assessment - Part 1

9 Immunomodulatory effects of aceterminophen on C-reactive protein and interleukin-6 functions in juvenile catfish (Clarias gariepinus)
N.O. Erhunmuwa, I. Tongo, L.I. Ezemoney, University of Benin / Dept of Animal and Environmental Biology

It is well known that acetaminophen overdose can lead to oxidative stress and induce hepatic and renal damage. The chronic phase response in three life stages of Africa catfish triggered by immunomodulatory process against the action of acetaminophen was investigated using pro-inflammatory marker C-Reactive Protein (CRP) and Interleukin-6 (IL-6). The serum and tissue levels of CRP and IL-6 were measured by Enzyme-Linked Immunosorbent Assay (ELISA). The levels of C-reactive protein (CRP) and IL-6 were significantly increased by acetaminophen treatment (p < 0.05) as a response to inflammation. Following the induction of liver injury with acetaminophen (APAP), elevated levels of IL-6 was observed in different life stages of catfish, suggesting a possible hepatoprotective role played by this cytokine family.

10 Inflammation of gill epithelia in fish causes disruption of tight junctions leading to increased permeation of polar organic chemicals
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In fish, the gill epithelial layer controls paracellular permeation of chemicals through epithelial tight junctions. Previous research has indicated that the integrity of epithelial tight junctions can be adversely impacted by gill inflammation. A loss of junction integrity could lead to greater uptake of harmful contaminants, effectively increasing their toxicity. In this study we investigated if inflammation could induce disruption of tight junctions in fish gill epithelia, and if this in turn increases passive transport of chemicals across the epithelia. Inflammation was experimentally induced in a permanent rainbow trout gill cell line (RTgill-W1) through exposure to non-cytotoxic concentrations of lipopolysaccharide (LPS). Transepithelial electrical resistance (TEER) was used to indicate epithelial tight junction integrity. Cells were also co-exposed to LPS and oil sands process-affected water (OSPW) to determine if the hypothesized reduction in tight junction integrity would result in greater transport of OSPW across the gill cell epithelial layer in vitro. Quantitative real-time PCR (qPCR) was carried out to characterize changes in transcript abundance of genes responsible for tight junction proteins (e.g. claudins). Cells exposed to LPS showed significant reduction in TEER after 24 h of exposure. qPCR data showed that the abundance of transcripts of genes coding for tight junction proteins (i.e. Claudin 28b and 10e) were significantly decreased in cells exposed to 20, 50, and 100 mg/L LPS. Furthermore, chemical analyses revealed a significant increase in transport of constituents of OSPW across the gill cell epithelial layer at all concentrations of LPS. These in vitro findings were confirmed by an in vivo exposure experiment with fingerling rainbow trout that showed a comparable increase in OSPW content in fish exposed to both LPS and OSPW for 48 h, compared to fish exposed to OSPW alone. RNA-sequencing was conducted on RTgill-W1 cells exposed to LPS and analyses are currently ongoing to characterize any effects inflammation might have at the transcriptome level related to tight junction integrity. Overall, these results indicate that fish living in environments high in pathogens could be at risk of greater uptake of contaminants of environmental concern (i.e. chemicals in OSPW) than previously thought. This in turn highlights the need to further assess the risks that exposure to pathogens may pose from a toxicological perspective.

11 Isolation and characterization of OSPW fractions and assessment of their toxicity using mammalian cells
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Oil sands process water (OSPW) is a brackish mixture of suspended and dissolved solids (sand/clay), inorganics (metals), and organic compounds (e.g. naphthenic acids (NAs)) that has been reported to cause both acute and sub-chronic toxicity to a variety of organisms, including aquatic invertebrates, fish, and mammals. To date, the principal toxic components of OSPW have not been fully identified mainly due to the complexity of these waters. Research examining OSPW toxicity has focused on the NA containing organic fraction (OSPW-OF), indicating it as the primary toxic component. However, our recent work has shown that substances within the inorganic fraction (OSPW-IF) also significantly affect the...
health and functions of exposed cells. Therefore, the specific objectives of the present study were to develop a multistep extraction procedure for the separation and isolation of OSPW fractions (i.e. OSPW-OF and OSPW-IF) and to then compare their effects on the viability, metabolism, and antimicrobial activities on a population of cells called macrophages. Macrophages are an innate immune cell-type found in all animals that are essential for the detection and killing of microbial pathogens through a cellular engulfment process called phagocytosis as well as the production of potent antimicrobial substances such as nitric oxide (NO). Macrophages are also decedents of the earliest free-living aquatic amoeba that have since evolved into specialized sentinel invertebrates and vertebrates. High numbers of macrophages are found in tissues exposed to the external environment, which increases their chances of interacting with incoming pathogens. Consequently, these cells populate tissues commonly exposed to environmental substances making them useful for determining the effects of potentially harmful contaminants that interact with the skin and gills of fishes as well as the mucosal tissues of terrestrial animals. Overall, our data shows that the dynamic mixture of OSPW-IF and OSPW-OF contains potent immunomodulatory components that profoundly influence the viability, homeostasis, and immune functions of mouse macrophages. We also show for the first time that OSPW constituents drive macrophage polarization into different functional phenotypes, representing a potentially new bioindicator for tracking contaminants of potential concern within these contaminated waters.

12 Use of immune function assays in wild fish: Multi-year study of smallmouth bass immunity at US Geological Survey integrator sites


Unexplained epizootic mortality of adult and young-of-year smallmouth bass has been occurring for over a decade in the Potomac (adults) and Susquehanna (young-of-year) Rivers, Chesapeake Bay watershed, USA. We believe complex interactions between water quality, contaminants, pathogens and parasites, and other environmental stressors are impacting smallmouth bass immunity making it difficult to pinpoint any specific cause(s) for disease or death. This study field tested methods for assessing immune function in wild fish by comparing results across four U.S. Geological Survey (USGS) integrator sites - sites where chemical data was also collected - in the affected areas. Smallmouth bass were collected from three sites potentially influenced by various chemical contaminants and from one reference site. Sampling took place during spring and fall over three years (2016-2018). Fish were euthanized, weighed and measured, and any visible abnormalities were recorded. Anterior kidney was aseptically removed and homogenized for leukocyte isolation. Following removal of the anterior kidney, a necropsy was performed and tissues were preserved for histopathological analyses and gene expression analyses. Leukocyte isolations were performed using anterior kidney homogenates and leukocytes were tested for: bactericidal activity against Aeromonas veronii bv. sobria and Yersinia ruckeri; respiratory burst activity in phagocytes; and mitogenesis activity of lymphocytes when stimulated with and without the mitogens concanavalin A, phytohemagglutinin P and lipopolysaccharide. The respiratory burst assay detects general reactive oxygen species (ROS) in live cells using imaging flow cytometry. The mitogenesis assay detects DNA synthesis, nuclear morphology, Ig+ cells and cell cycle analysis with imaging flow cytometry; however, in the data being presented, only DNA synthesis and nuclear morphology were labeled. Nuclear morphology staining was replaced with Ig+ cell staining for data collected after 2018 to increase sensitivity and cell cycle analysis was added. Our analyses from 2016 to 2018 revealed significant seasonal and site differences in all three immune function tests. In the future, our analyses will be put into perspective using chemical, total estrogenicity, land use and other environmental data to evaluate potential risks to smallmouth bass populations in the affected areas.

13 Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish

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Current assessment practices for immunotoxicity involves a tiered approach for hazard identification and mechanistic studies, including observational studies, evaluation of immune function, and measurement of susceptibility to infectious and neoplastic disease. These studies generally use costly, low-throughput mammalian models. Zebrafish, however, offer an excellent alternative due to their rapid development, ease of maintenance, and homology to mammalian immune system function and development. Larval zebrafish also provide a convenient model to study the innate immune system with no interference from the adaptive immune system. In this study, we utilized a respiratory burst assay (RBA) to measure reactive oxygen species (ROS) production after xenobiotic exposure. ROS are produced in macrophages and neutrophils in response to pathogens in order to eliminate them from the host. Embryos were exposed to subteratogenic doses of chemicals from 6 hours post fertilization (hpf) to 96 hpf with daily media changes, and at 96 hpf the ability to produce ROS was measured. Through the RBA, we identified five compounds that suppressed global ROS production: 17β estradiol, benzo[a]pyrene, lead acetate, methoxychlor, and phenanthrene; these compounds have also previously been identified as immunosuppressive in mammalian innate immunity assays. In order to evaluate whether the suppression of ROS by these compounds was due to a decreased number of neutrophils or macrophages, we combined flow cytometry with transgenic zebrafish larvae to count the numbers of these cell types after chemical exposure. With this assay, we found benzo[a]pyrene altered macrophage number, but not neutrophil number. Taken together, this work demonstrates the utility of zebrafish larvae as a tool for identifying compounds that impact innate immune function at subteratogenic levels and identifies two mechanistic routes by which xenobiotic exposure may alter immune function.

14 Health indices of African sharptooth catfish (Clarias gariepinus) inhabiting some polluted streams in Ibadan, Nigeria

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Since biomarkers are effective monitoring tools that have successfully been used in environmental monitoring and assessment, the health status of fish naturally inhabiting selected polluted streams were examined using biomarker responses. A total number of 55 African catfish obtained from FOL-Hope farms (reference site), Eleyele, Dandaru and Oluyole streams (polluted streams). Condition indices showed differences in condition factor being significantly higher in fish from the reference sites compared to those from the polluted sites. Histopathological changes were observed in the gills, liver and the kidneys of fish from polluted sites. Intraalumella hyperplasia of the gills, marked disseminated congestion involving the vessels and sinuoids, as well as steatosis in the liver. Desquamation of tubules with atresia and multifocal patches with severe distortion of the tubular architecture and outright loss of tubular structure were seen in the kidneys of fish from polluted streams. No significant lesion was observed in the muscle of all the fish examined from all sites. Significant differences in values were seen for WBC, lymphocytes and heterophils when compared to the reference site. Increased erythrocyte osmotic fragility was observed in fish from Dandaru (p < 0.001) compared to the other sites. Serum biochemistry results showed Alanine Amino Transferase (ALT) was significantly higher in the two (2) most polluted sites (Dandaru and Oluyole) (p < 0.01) compared to others two sites (Eleyele and Hope).
There was no significant difference in Aspartate Amino Transferase (AST) and Alkaline Phosphatase (ALP) across the groups (p< 0.05). Increased incidence of micronuclei formation (MN) was observed in fish from polluted sites when compared to the control. Values showed MN formation 20.42±2.07 (Oluyole), 14.17±0.50 (Eleyele), 8.33±0.77 (Dandaru) and 1.30±0.50 for the reference site at P< 0.05. Water physicochemical properties revealed that Cd, Mn and Fe were significantly higher at the polluted streams compared to reference sites. Although water chemical analysis only identified heavy metals as contaminants in the polluted stream, the application of a suite of biomarkers in C. gariepinus demonstrated that pollutants of possible public health concern were present in all polluted streams.

15 Optimization of the infection test method using common carp with Aeromonas salmonicida for the assessment of immunotoxicity

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In order to evaluate the immunotoxicity of environmental contaminants, the chemical effects on susceptibility to pathogen have been tested using fish and their pathogens. Since, in this type of experiment, mortality or the immune system responses are observed in experimentally infected host fish under the exposure to a test chemical, a highly reproducible and validated method for experimental infection is required. Our group developed a test method using common carp (Cyprinus carpio) as the host and Aeromonas salmonicida as the pathogen, and confirmed the reproducibility of the tests. In addition, we observed the increased susceptibility to A. salmonicida in carp exposed to an immunosuppressive agent, dexamethasone. For further optimization of the method, in the present study, we investigated the suitable size of fish for the infection test, and improved the method to detect A. salmonicida from the infected fish. Fish of varied size (n = 60, body weight [BW]: 3.68 ± 1.56 g, 1.16-7.59 g) were separated into three groups (sum of BW: 72.5 to 74.0 g), and each group of fish was kept in a 31 L glass aquarium. Two groups were exposed to 1 mg/L of dexamethasone (Dex) for whole experimental period, and another group was unexposed. Three days after the exposure started, each group of fish was bath infected to A. salmonicida (6.85 x 10^5 cfu/mL). Occurrence of typical symptom of A. salmonicida infection, ulcers on body surface, fin base and jaw, was observed until 14 days post infection. When the infection test was terminated, the existence of A. salmonicida was confirmed by culturing bacteria on HI agar added CBB. The incidence rates of the symptom were 15%, 30% (Dex exposed groups), and 10% (unexposed). Body weight of the diseased fish was 4.30 ± 0.69 g, which was slightly larger than that of all the fish used in this study. Combining the data of our previous and present studies, small fish (BW < 2.0 g) was less susceptible to A. salmonicida infection. Therefore, it is preferred not to use small sized carp for the infection test. Additionally, blue colonies were found on the plates seeded with bacteria from bleeding ulcers. Since it is known that A. salmonicida forms blue colonies on CBB containing agar, the observed ulcers were certainly caused by A. salmonicida. Because it cannot be denied that blue colonies are formed by other bacterial species, it is preferred to be double-checked A. salmonicida infection by a PCR method.

16 Transcriptome analysis of Florida manatees exposed to multiple stressors

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Florida Manatees (Trichechus manatus) is a threatened species exposed to multiple stressors in the environment. They drink fresh water and they rely on freshwater refuges during winter, when they can be exposed to runoff containing industrial and agricultural contaminants. Toxic substances such as flame retardants (per- and polyfluoroalkyl substances, PFAS) have been detected in their plasma with a higher concentration in manatees from the Atlantic Coast (Brevard County) than in the population considered healthy in Crystal River (Gulf Coast). We have selected 32 manatees from these two populations with widely varying PFAS concentrations for further investigation of their transcriptomes. Manatees from Crystal River range with less than 5 ng PFAS/g plasma (wet weight) while those from Brevard have more than 20 ng PFAS/g (wet weight). In preliminary analysis of a subset of manatees (n=10), we have found that glyphosate, a commonly used herbicide formulated as roundup, is more prevalent in manatees from Brevard County. The mean concentrations we measured were 0.17 (±0.08) ng/mL for Brevard manatees, and 0.1 (±0.11) ng/mL for Crystal River manatees. These substances can produce lymphocyte extravasation and inflammation. Glyphosate exposure in animal models caused immune dysfunction associated with others pathologies. Both chemicals promote the expression of inflammatory cytokines in lymphocytes and immune suppression. Our working hypothesis is that exposure of manatees to multiple stressors hinders their immune systems. To test the hypothesis, we will perform total RNA extraction and RNA sequencing by Illumina on white blood cells collected from 32 manatees from Crystal River and Brevard County. Plasma glyphosate concentrations will be determined for all manatees by LC-MS/MS. Using pathway analysis, we will analyze the transcriptome data to determine the most affected molecular functions. We suspect that multiple contaminant stressors contribute to manatee disease in South Florida.

17 Thyroid function and PCBs in flesh-footed shearwaters on Lord Howe Island, Australia

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The population of flesh-footed shearwaters inhabiting Lord Howe Island, a supposedly pristine island off the coast of Australia; has been in decline for more than two decades. Large quantities of plastics have been found in the digestive system of dead shearwaters. However it has also been suggested that endocrine disruption as a consequence of exposure to environmental pollutants has played a role in the decline of their individual and population health. Flesh footed shearwaters are apex feeders at the top of the trophic chain and hence vulnerable to bioaccumulated and biomagnified organic pollutants. The aims of this study were to quantify body burden levels of mercury and polychlorinated biphenyl (PCB) and evaluate their effects on thyroid function in both fledgling and adult flesh-footed shearwaters. PCBs were most abundant within adult blood cells, indicating that bird age may be an important factor in influencing circulating PCB concentrations. The link between age and mercury body burden was less clear. Negative relationships were
observed between mercury/PCB body burden and circulating thyroid hormone concentrations in both age categories. The results of this study provide some evidence of disrupted thyroid function within flesh-footed shearwaters as a consequence of mercury and PCB exposure. However, available sample sizes were a limiting factor in statistical analysis, as a result of field sampling difficulties on the remote terrain. Utilisation of larger sample sizes in future, better resourced studies, should be considered. This is the first study in Australia to quantify circulating thyroid hormone concentrations and address the accumulation of mercury and PCBs in relation to their effects on endocrine health in seabirds.

18 Standard methods and performance criteria needed for laboratory assessment of periphyton communities

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Periphytic algal community characteristics are often used to assess the condition of aquatic ecosystems exposed to stressors. Methods for sampling and laboratory analysis have been developed by jurisdictions around the world, but leave sufficient flexibility for differences to occur among practitioners even within jurisdictions. In this study, seven periphyton samples were homogenized and divided for distribution to four commercial laboratories (2 in Canada, 2 in USA) for algal identification and enumeration. For each sample, taxon lists were combined among laboratories to approximate total sample richness at different levels of taxonomy. Although all laboratories identified all organisms they encountered in subsamples that were analyzed, on average, each laboratory identified about 37% of all species reported among the laboratories for each sample (total richness ranging from 30 to 68 species per sample). At least 42% of species identified in a sample by an individual laboratory were not reported by any other laboratory for the same sample. Major taxonomic groups represented were cyanophytes, chlorophytes, chrysophytes, rhodophytes, and diatoms. All laboratories reported at least one of these groups as absent in 2 or more of the 7 samples even though at least one other laboratory reported the group as present. This indicated large differences among laboratories even at a coarse level of taxonomy. Evaluation of laboratory methods revealed myriad differences that may have contributed to inter-laboratory variability in sample results, such as: 1) sample homogenization methods; 2) enumeration and identification of live vs. combined live and dead organisms; 3) selection of counting units (i.e. cells vs. natural counting units including filaments and colonies); 4) counting mechanics (i.e. counting along a transect or selection of random fields, as well a number of fields); and 5) percent of sample evaluated. Furthermore, quality assurance and quality control (QA-QC) measures are not routinely reported. Better standardization of identification and enumeration methods, and QA-QC performance requirements, are needed if monitoring results are used to make resource management decisions. Taxonomy standardization and proficiency testing frameworks have been implemented for phytoplankton (Proficiency Testing Australia) and freshwater macroinvertebrates (Society for Freshwater Science) but not for periphyton.

19 Coastal stormwater pond pollutants and the potential for development of antibiotic resistance

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The Southeastern coastal plain is the most rapidly urbanizing region in the United States. Associated landscape changes which increase imperiousness lead to alterations in the hydrological cycle, increasing runoff of nonpoint source (NPS) pollution. Meanwhile, the U.S. has seen a shift from individually-owned livestock farms to large-scale Confined Animal Feeding Operations. Urban and agricultural NPS runoff is discharged into stormwater ponds and lagoons, which sequester chemical contaminants, nutrients, and microbes to reduce loading into coastal ecosystems. Previous studies in retention ponds indicate elevated levels of trace metals, in addition to the presence of clinically-relevant antimicrobial products and high levels of bacterial contamination. Other investigations have shown significant association between trace metals contamination in surface waters and sediments with increased rates of antibiotic resistance (ABR). As a result, these ponds may pose a public health risk from drug-resistant microbes. As climate change conditions increase the frequency and severity of rainfall and flood events, sequestered contaminants may be flushed into neighboring estuaries. Affected microbes may then pass on resistance genes to bacteria encountered in their new environment, where people come in contact with harmful microbes via contact recreation or seafood products. Interactions of aquatic pathogens Vibrio vulnificus and Enterococcus faecium with trace metals commonly found in coastal ponds and estuaries (As, Cu, Zn) and clinically-relevant antimicrobials (triclosan, ciprofloxacin, and oxytetracycline [OTC]) will be discussed in terms of how they may enhance antibiotic resistance and upregulation of resistance genes. Single- and dual-exposure data for V. vulnificus and E. faecium grown in the presence of antimicrobials and/or trace metals will be presented. Preliminary data indicate that environmentally-relevant concentrations of antimicrobials inhibit growth in V. vulnificus and E. faecium. In the case of OTC, 38% inhibition of E. faecium growth occurred at 0.34 µg/L. For comparison, levels of OTC as high as 68 µg/L have been measured in agricultural lagoons containing 2.43*105 CFU/100 mL fecal enterococci. Sublethal stressors provide an excellent opportunity for microbes to express antimicrobial resistance. In addition to exposure results, ABR profiles of the two test organisms under a variety of exposure conditions will also be discussed.

20 The effects of sedimentation on the survival of winter flounder eggs incubated in the laboratory


Dredging and other natural events can result in the resuspension of sediments in the water column where they eventually settle and can bury sessile or immobile life stages of aquatic organisms. In this study, the sensitivity of winter flounder (Pseudopleuronectes americanus) eggs to sedimentation was conducted under laboratory conditions. Egg burial experiments using sediment collected from three Connecticut waterways were performed using 48 h old flounder eggs obtained from broodstock collected from the Gulf of Maine. Overall, burial depths of 0.3, 0.6, and 1.2 mm resulted in 86.6, 81.1 and 73.9% average survival, while 3 mm resulted in 10% survival of hatched eggs on average across the three sediments. Results of the experiment corroborated closely with prior research on winter flounder egg burial hatch success and demonstrated that egg hatching success was similar between the three sediments evaluated. The results suggest that a flounder egg (~ 0.75 mm diameter) may be 80% buried (0.6 mm) without substantially affecting hatch success. Before sedimentation risk can be appropriately assessed and managed, field measurements of the incremental contribution to sediment layers attributable to dredging operations and natural events, as well as other environmental factors such as timing of burial (with respect to egg development) and local hydrodynamic conditions need to be considered.

21 Biomonitoring and biomarker evaluations of abattoir discharges into the Ogun River from Kara Market, Nigeria using Clarias gariepinus

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The discharge of untreated effluents into aquatic ecosystems poses potential adverse effects to aquatic organisms. In this study, the physicochemical characteristics of abattoir effluent from Kara cow market, Ogun state, Nigeria, surface water and sediments from the Ogun River were evaluated. Fish species and macrobenthic fauna diversity in the river were also examined. Acute toxicity, biochemical and histological studies were investigated in Clarias gariepinus exposed to sub-lethal concentrations of the effluent over a period of 28 days. Effluent physico-chemical parameters such as ammonia, conductivity, total dissolved solids and total suspended solids were higher than set limits. Total polycyclic aromatic
hydrocarbons (PAHs) in the effluent and sediment were 6.73 mg/L and 8.07 mg/kg respectively. Tetracycline (an antibiotic administered to the cows at the market) levels in the effluent and surface water were 0.23 µg/mL and 0.85 µg/mL respectively. Fish species diversity was lower at the test site compared to the reference site. Chironomus spp. and Tubifex tubifex dominated the benthic assemblage at the test site. There were significant changes (p< 0.05) in the biochemical indices but no histological alterations in exposed C. gariepinus after 28 days. The results demonstrate that the effluent poses potential risks to the aquatic organisms and ecosystem services provided by the river. We recommend that environmental regulatory agencies and stakeholders should establish effluent and solid wastes management systems at the market to prevent environmental and public health epidemics within the framework of the United Nations Sustainable Development Goals 6 (clean water and sanitation) and 14 (life below water).

22 Assessment of hazards caused by industrial effluent on environmental indicators

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Due to increasing industrialization and urbanization, water bodies are being disturbed in many ways through dyes, agrochemicals, paper-pulp, cosmetics, refining etc. In the present study, industrial effluents of three season were collected from GIDC Sachin i.e. the study area located in Surat city within Gujarat state of India. Samples were evaluated for toxicity towards environmental indicators. There are numerous dye and agrochemical industries at the study area, Sachin. Results imparted that all the samples exhibit toxic effect on algae, daphnids and fish. The maximum biomass reduction, decreased growth rate and lower yield were recorded at the highest concentration of effluent from all the season. In summer, the minimum EC50 value recorded for biomass, growth rate and yield were 9.04, 20.37 and 8.67%, respectively. Daphnids showed maximum lethargy and immobility of 60% at 5.0% concentration of effluent from summer and with the minimum EC50 value for immobility as 5.07%. The effluent collected in summer season had minimum LC50 value of 8.59% and showed acute toxicity on fish, Danio rerio at 12.5% concentration. The collected samples were subjected to GC-MS analysis which confirmed the presence of various aromatic, aliphatic, heterocyclic, cyclic, aromatic cyclic and aliphatic cyclic compounds. Consequently might be possible reason for effluent toxicity on environmental indicators. Findings postulate that effluent from summer season impart more hazard to primary producer along-with primary & secondary consumer. Thus, may alter the entire aquatic ecological system and thereby form basis for the effluent toxicity and seasonal variation effects. Lack of eco-toxicological data about these contaminants represents a major concern due to the uncertainty in possible effects they could cause on the aquatic environment and human health.

23 Environmental DNA assessing impacts of anthropogenic pollutants in rivers

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Rivers are among the most threatened freshwater ecosystems and anthropogenic activities are affecting both river structures and water quality. Assessing the organisms living within rivers can provide a comprehensive measure of the river’s ecological status, however, it is limited by the traditional morphotaxonomy-based biomonitoring. Environmental DNA (eDNA) as a novel tool can identify almost all biomes in one sequencing run, it provides a historic opportunity to rapidly assess the impacts of pollutants through direct observation the ecological consequences (e.g., changes in community structure and biodiversity) in rivers. Here, we used aqueous eDNA to profile all biomes (from bacteria to fish) in rivers from the Yangtze River Delta (YRD) area, and to unravel the impacts of pollutants at community and ecosystem levels. In recent decades, large amounts of anthropogenic pollutants discharged into the YRD, which rises major health concerns to humans and aquatic wildlife. Hence, this study is: 1) to assess the potential ecological risks of anthropogenic pollutants (e.g., ammonia, metal(loid)s and organic pollutants) based on the traditional hazard quotients (HQs) approach; 2) to unravel the impacts of pollutants through analyzing the changes in community structure, biodiversity and indicative OTUs from eDNA data. Results showed ammonia, metal(loid)s and organic pollutants had high ecological risk for fish, crustacea and algae based on HQs even at low concentration level (0.7) with the HQs for fish, crustacea and algae. Overall, our study further enhances the understanding on how pollutants affect aquatic ecosystems, and provide a comprehensive view on the impacts of pollutants at community and ecosystem level.

Building Bridges Between Lab-and Field-Derived Data: Methods for the Assessment of Complex Environmental Issues

24 Mobilization of estrogenic compounds from sediment during a simulated flood-like event

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Various anthropogenic micropollutants accumulate in high quantities in river sediments including endocrine disrupting chemicals (EDCs). Sediments might turn into a source for those substances, e.g. during flood events. So far, little is known about the extent flood events might result in adverse effects for aquatic wildlife such as fish caused by such remobilized substances. The main objective of the project Floodhydrotox was to estimate the effects of EDCs, and more specifically estrogenic compounds, remobilized from sediments during flood events on fish, i.e. rainbow trout (Oncorhynchus mykiss). In this study 25 rainbow trout were exposed for 7 days in an annular flume to Luppe-sediment which is known to contain high amounts of nonylphenol (NP) as well as estrone (E1). The annular flume allows for the simulation of a flood-like event by remobilizing the sediment through a stepwise application of defined force onto the sediment (i.e., bed shear stress). Natural sediment from the river Rhine in the area of Koblenz (Ehrenbreitstein) was used as control. Water samples were collected during every stage and were used for chemical analysis to receive time-dependent resolved data about the behavior of the main EDCs (i.e., NP and E1) and passive samplers (ChemCatcher) were used to assess their bioavailability. Vitellogenin (VTG) was measured in mucus as an initial biomarker and plasma concentrations of the target EDCs were measured via LC-MS/MS. Furthermore, gene expression of selected target genes (e.g. cyp19a and cyp11b) in gonads were investigated to reveal the physiological reactions caused by these compounds. Overall, a high remobilization potential of EDCs from the Luppe-sediment was observed compared to the Ehrenbreitstein-control including a 100-fold and a 4-fold increase of aqueous bioavailable NP and E1, respectively (3300 ng/L vs. 34 ng/L NP; 6.5 ng/L vs. 1.5 ng/L E1 ) and a 5-fold higher plasma NP-concentration was observed (33 ng/L vs. 7 ng/L NP; E1< LOD). Nonetheless, only 0.17% of the sediment-bound NP in the Luppe-sediment became bioavailable again compared to 11.95% in the Ehrenbreitstein-sediment. No increase in VTG in mucus and no differences in gene expression were observed. This project is among the first to investigate the impact of sediment-borne EDCs on fish, which is of great importance in context of the increasing frequency of flood events expected with climate change scenarios and the observed decline of many fish populations globally.
25 Why are my gonads small? An EEM investigation of cause for reproductive effects in caged bivalves

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A pulp and paper mill in eastern Canada is part of the federal Environment Effects Monitoring (EEM) program under the Fisheries Act. Reproductive effects in fish manifested as reduced gonad size in caged blue mussels have been identified in multiple EEM cycles and, accordingly, an investigation of cause study was initiated. A review of potential causative agents for fish reproductive effects exposed to pulp and paper effluent did not list specific chemicals, rather groups of chemicals, such as phytosterols and ligands, that have been associated with toxicity. It has also been found that biological oxygen demand (BOD) can generally be used as a surrogate measure for reproductive effects in mill effluent. In an attempt to isolate the component(s) of the process water system that may be contributing to the observed reproductive effects, chemical and toxicological testing was completed on the process streams associated with: 1) the thermal mechanical pulping (TMP) process; 2) the boiler blowdown; and, 3) the white water from the paper machines/save all. In addition to these three locations, the final influent to and the final effluent from the treatment plant were also tested. Samples from each of the five locations were collected multiple times in summer and winter. Sublethal toxicity testing on the Green Sea Urchin (fertilization) was performed concurrent with chemical analysis. No one process stream was determined to be the primary contributor to reproductive effects, but the effluent treatment plant was found to significantly reduce toxicity. The results of this study indicated that process streams from the white water, boiler blowdown, and TMP had similar toxicity and had greater toxicity than the final influent or effluent. The white water and TMP had higher concentrations of organics and BOD than the influent and effluent. The boiler blowdown had higher concentrations of metals than the influent or effluent. Phytosterols in the final effluent were the only compounds measured that may potentially contribute to reproductive effects seen in the receiving environment. Concentrations of the various parameters investigated in the final effluent were similar to those measured in effluents from other mills. The investigation is ongoing.

26 Spatiotemporal endocrine disruption activity in an effluent-impacted river under low instream flow: Integrating field and laboratory assessments

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Effluent-impacted streams represent a threat to aquatic organisms due to their potential to cause adverse biological effects, such as endocrine disruption, especially during low instream flows. To evaluate the estrogrenicity of wastewater effluent to fish, field- and laboratory-based experiments were integrated using a weight of evidence (WoE) approach. During summer and fall seasons, juvenile rainbow trout (Oncorhyncus mykiss) were individually placed in cages and exposed for 1, 3 and 7 days, at three different locations downstream and one location upstream of a wastewater treatment plant (WWTP) in East Canyon Creek, Utah, a river influenced by seasonal snowmelt. In the summer, the wastewater effluent accounted for ~50% of the total stream discharge, and concentrations of plasma vitellogenin (VTG) were high in fish from the upstream and furthest downstream sites, whereas estradiol (E2) to 11-ketotestosterone (11KT) ratios were high across all sites, primarily on day 7. In the fall, the effluent accounted for ~25% of the stream discharge, and increases of VTG as well as high E2/11KT ratios were observed in fish from the downstream sites near the WWTP on day 7. However, both VTG and E2/11KT levels in the fall were significantly lower than in the summer. Experimentation with primary hepatocytes exposed to water extracts from the same locations used the field study also presented evidence for the expression of VTG, though on-going experimentation aims to integrate these results with field observations in search for suitable in vitro methods that facilitate the evaluation of the endocrine disruption potential of effluent-impacted streams.

27 Anxious copepods in the Anthropocene: Combined predation risk and copper exposure on isotopic trophic shifts

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Stable isotope analysis (SIA) is commonly used in ecotoxicology to assess food web structure based on δ13C and δ15N values and general assumptions of isotopic trophic shifts (i.e., trophic enrichment factors: δ13C 0.5-1‰; δ15N 3.4‰). Knowledge of food web structure is commonly used to calculate contaminant biomagnification potential, yet these calculations are highly sensitive to estimates of organisms’ trophic position. Little is known of whether and how combinations of natural and anthropogenic stressors affect isotopic trophic shifts. Predation risk is an important factor structuring marine ecosystems and may also interact with contaminant toxicity. In a previous study using single-individual exposure, predation risk doubled the toxicity of copper (Cu), causing delayed development to maturity in the coastal copepod Tigriopus brevicornis. Stable isotope analysis (SIA) showed that copepod foraging had no effect on Cu concentration. However, this contrasts previous findings for both stressors and might indicate a higher sensitivity to predation risk exposure alone and in combination with an environmental contaminant. Copepod nauplii (<48h old) were exposed throughout ontogeny (17 days) in groups of 150 individuals per replicate. We changed exposure solution and food (Rhodomonas salina, 300 µg C L-1) every second day. After exposure we checked survival and life stages, and then prepared living individuals for SIA by freeze drying. Surprisingly, predation risk negatively affected survival and development to maturity, whereas no effects of Cu were found. This contrasts previous findings for both stressors and might indicate a higher sensitivity to predation risk exposure when in groups. According to expectations from previous studies, Cu exposure caused δ15N enrichment, but there was no effect on δ13C. Predation risk caused δ15N depletion, which was also observed in the combined treatment. Previous studies on starvation generally report δ15N enrichment. Our results suggest that food limitation is not a likely explanation for the predation risk effect, and support previous suggestions that contaminant exposure can affect isotopic trophic shifts.

28 Linking endpoints from mesocosms and other field studies to environmental protection goals

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In the 1980’s, EPA affirmed the potential of microcosms (both terrestrial and aquatic) as tools to evaluate the transport and effects of toxic substances, stating that “with appropriate attention to the design of specific questions, answers to which are relevant to interpreting ecological transport and effects of contaminants, microcosms can be useful tools.” Considerable resource and intellectual investments were subsequently made in field studies, particularly micro/mesocosm studies, for pesticide registration in the United States. However, field studies lost favor during the 1990’s due to challenges of interpretation and risk paradigm incorporation. Regulators historically have had difficulty interpreting and incorporating results from these studies into risk management decisions because of misalignment between field endpoints (e.g., species diversity, productivity, community structure, population dynamics) and the individual-based measurement endpoints of standard test methods.
(survival, growth, and reproduction). Because most regulatory criteria are based on standard test endpoints, alternate approaches are needed to make use of field study endpoints. This presentation will review measurement endpoints from commonly used field study designs (mesocosms, avian field studies, and pollinator studies) and explore their relationship to specific environmental protection goals.

29 Context-dependent responses of aquatic insects to metals and metal mixtures: A meta-analysis summarizing 24 years of stream mesocosm experiments

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Modernizing water quality criteria to better predict how contaminants affect natural aquatic communities requires that we utilize data obtained across multiple lines of evidence, including laboratory, mesocosm and field studies. Mesocosm experiments can provide mechanistic insights into the discrepancies between results of laboratory toxicity tests and responses observed in the field. We report results of 29 mesocosm experiments conducted from 1994 to 2017 at the Colorado State University Stream Research Laboratory (Fort Collins, CO, USA). The primary goal of the study was to quantify variation among metal combinations and source communities. Communities were collected from 6 streams (8 locations) and were exposed to a range of metal concentrations and different combinations of Cd, Cu, Fe and Zn. Responses of all dominant taxa were compared to Zn alone, the least toxic metal across all combinations. Treatments that included Cu or Fe, either alone or in combination with other metals, were especially toxic to aquatic insects. In addition to the effects of metal combination, results showed that effects of metals were strongly context-dependent and varied significantly among the eight sites where communities were collected. For some taxa, variation in the effects of metals among source communities was greater than variation among metal combinations. In particular, effects on communities collected from smaller streams were significantly greater than those from larger streams. Although water quality criteria are routinely adjusted to reflect differences in physicochemical characteristics that determine metal bioavailability, there have never been attempts to account for context-dependent responses of aquatic communities to metals. Our analyses also showed that several morphological (body size, shape, gills, degree of sclerotization) and life history (votinism) traits were significantly correlated with sensitivity to metals. Across all taxa and experiments, aquatic insects broadly classified as small (maximum body length < 8 mm) were significantly more sensitive to metals than medium or large individuals. These findings demonstrate the advantages of integrating experimental evidence with species traits to develop a better mechanistic understanding of community responses to contaminants.

30 Development of integrated risk assessment framework and methodology for assessing environmental safety of chemicals discharged down the drain in China

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The new Chinese regulatory chemical management scheme calls for increased development of risk-based assessment framework and tools that can address regional and national needs. Important considerations include identifying chemicals with high potential for adverse impact to humans and the environment early in the assessment, while also recognizing regional differences in the levels of economic and infrastructure development as well as environmental conditions. An integrated, tiered environmental risk assessment framework and methodology was developed for assessing the environmental safety of chemicals discharged down the drain in China. The tiers incorporate China’s specific exposure conditions as well as consideration of Chinese native species for effects assessment. The framework starts with a Low Tier utilizing the existing Chinese regulatory qualitative method, whereas Mid-Tier is quantitative using deterministic and probabilistic approaches that account for per capita residential water usage, wastewater treatment capability, as well as wastewater/in-stream dilution factors. A High Tier spatially explicit aquatic exposure model was recently created which leveraged historic work on the iSTREEM(R) model (American Cleaning Institute). A high-resolution river flow dataset was established based on the Curve Number method (Natural Resources Conservation Service, U.S. Department of Agriculture) and further validated by monitoring data. Case studies will be presented for consumer product ingredients which indicate Lower Tiers are conservative with greater environmental realism associated with High Tier methodology. A key aspect for the integrated framework is environmental effects assessment based on Chinese native species, as chemical registrations in China routinely involve local fish testing. The Chinese Rare Minnow (Gobioicypris rarus) and Chinese Medaka (Oryzias sinensis) are examples of leading local species. This research developed an understanding of the ecology, physiology, and other biological information allowed for the extrapolation between these two species and other OECD standard test species (e.g., zebrafish). We investigated comparative fish acute toxicity using 3,4-Dichloroaniline and NaCl with studies planned on additional chemicals and species. Chinese native species data will be utilized not only for direct hazard assessment but also for the development of statistical extrapolation methods, such as interspecies correlation estimation (ICE) models. ICE models use available toxicity data of surrogate species to predict untested species to expand the domains of ecotoxicological information for China’s integrated environmental risk assessments.

31 How is our risk assessment doing? What large scale environmental monitoring can and cannot tell us

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The ultimate goal of Ecological Risk Assessment is to ensure that the social and economic thriving is not at the expense of unreasonable harm to the environment. Current regulatory Risk Assessment frameworks relies mostly on a combination of modeling and laboratory tools that represent simplified worst case scenarios in which realism is given up in favor of conservatism. This approach has the advantage of simplicity, but the disadvantage of reduced realism. Interestingly, although the ultimate goal of the process is to ensure protection of the environment and its ecosystems, biological monitoring of natural systems typically had a low profile role on (1) understanding baseline conditions, current variability, and trajectories of the entities we are trying to protect. (2) Putting into context the relative contribution of potential factors/stressors affecting current state of these entities. (3) Evaluating the efficacy of current Ecological Risk Assessment process to inform potential improvements, and (4) to holistically prioritize policy, management, and interventions to maximize overall improvement of the environment. A lot of work is required to improve any of these aspects, starting with understanding strengths and weaknesses of currently available environmental datasets. In this presentation, we explore a large environmental dataset compiled by the Iowa Department of Natural Resources (DNR) for the last 20 years. The dataset is unique in terms of the spatial (near a thousand sampled locations across the state of Iowa), and temporal (near 20 years) coverage, as well as the number of environmental factors monitored (ecological indicators, habitat condition, in situ water physicochemical characteristics, and chemical pollution). We believe this dataset is an unprecedented opportunity to take a closer look to Iowa freshwater
ecological communities, and explore large-scale trends in terms of temporal evolution of these communities, and main natural and anthropogenic factors likely driving their ecological quality. During the presentation, the strengths and weaknesses of the dataset, modeling approaches, and findings will be emphasized.

**Nanotechnology - Fate, Transport and Effects**

32 Developing an in vitro model from Daphnia magna to evaluate the molecular interactions of nanomaterials

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Nanotechnology is playing an important role in many existing and emerging technologies; while nanomaterials have the potential to improve society, relatively little is known about how they will interact with organisms, and thus how their unintentional release from consumer or industrial products could impact environments such as aquatic ecosystems. By studying the complexity of how nanomaterials interact with different organisms on a cellular and molecular level, it will provide a better understanding of the initiating mechanisms that lead to adverse outcomes, as well as their potential environmental impacts. This presentation will discuss how an in vitro cell culture model of the aquatic invertebrate, *D. magna*, can be used to study these molecular interactions that are related to nanomaterial exposures in aquatic ecosystems. More specifically, this in vitro system consists of epithelial cells from the gut of *D. magna*. This is the key target tissue that comes directly in contact with contaminants found in the environment, and indirectly through the consumption of food. The main goal of this research is developing this in vitro method as a model for classic invertebrate toxicology. Since the acute and chronic toxicity of some nanomaterials, as well as their biological impacts, have been tested in vivo, the successive goal of this research is to link the molecular events observed in vitro to the longer term, whole organism, impacts. Some methods for studying nanomaterial toxicity in vitro include using standard cell viability assays, as well as looking at other endpoints such as oxidative stress. Additionally, global gene expression analyses are used to identify pathways of interest in response to nanomaterial exposures. With the initial data and observations collected from mixed metal oxide nanomaterial exposures, this in vitro model shows promise that these cellular/molecular assay endpoints can match that of long-term organism assays.

33 Determining the toxicity of silver nanoparticles on a model intestinal cell: Bioaccumulation and impact on essential trace elements homeostasis

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Silver nanoparticles (AgNPs) belong to the most commercialized nanomaterials. Each year, more than 60 tons of AgNPs are released into aquatic environments, raising concerns about their impact on the environment. Although several studies were conducted to investigate the toxicity of AgNPs, its impact on the homeostasis of essential trace metals such as Cu, Fe and Zn within the cells remains poorly understood. To determine the toxicity, accumulation and chemical modifications of AgNPs occurring at the luminal/intestinal epithelium interface, a model of the fish intestine, the trout derived RTgutGC cell line was used. Toxicity threshold were determined by a multiple endpoint viability assay which measures simultaneously metabolic activity, cell membrane and lysosome membrane integrity. Making use of the cytotoxicity data, non-toxic and toxic concentrations of AgNO₃ and AgNPs were applied to the cells for 1, 24, 72 and 142 hours (H). Silver and essential trace elements concentrations were then analyzed by ICP-MS. In a parallel set of samples, metal speciation was analyzed by X-ray absorption spectroscopy (XAS) and cellular metals distribution was mapped by X-ray fluorescence microscopy (XFM). Our results showed that for similar concentrations of intracellular Ag, AgNO₃ was more toxic than AgNPs. Indeed, when exposed to 5 mM of AgNO₃ or AgNPs for 24H, the cells accumulated similar Ag amounts (114 and 101 ng of Ag/mg of protein, respectively), yet a 50% versus 4% reduction in viability were induced, respectively. This difference of toxicity is due to different intracellular Ag speciation. Indeed, XAS analyzes showed that after 24H exposure to 1mM AgNO₃, 100±5% of the Ag complexed with cysteine while Ag-NPs mainly remained as Ag-NPs in the cells (72±5%). The ionic form of Ag has a higher bioreactivity than the nanoparticulate form. XAS analyzes also showed that Zn intracellular speciation was found to remain identical to the control when the cells were exposed to 1 mM AgNO₃ or 5 mM Ag-NPs. Accordingly, XRF and ICP-MS analyzes showed similar intracellular distribution and levels of Zn, but also Cu and Fe in the exposed cells, compared to control. Altogether, our data show that similar intracellular concentration of Ag induce different toxicity whether cells are exposed to AgNO₃ or Ag-NPs, due to different intracellular speciation of Ag, yet no impact on the homeostasis of essential trace elements was detected at the tested concentrations.

34 Leveraging electrochemistry to uncover the role of nitrogen in the biological reactivity of nitrogen-doped graphene

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Research on the biological implications of metal and non-metal engineered nanomaterials (ENMs) has put into perspective with the relative magnitude of the inherent hazard of different ENMs, environmental considerations that influence ENM behavior and toxicity, and the ability to manipulate properties to influence interactions at the bio-interface. The unique physicochemical properties of graphene have enabled remarkably rapid progress in their electrochemical (e.g., energy storage and conversion, sensors) and biological (e.g., antimicrobials, biosensors, drug delivery) applications. Chemical doping of graphene with nitrogen is used to modulate electronic properties of graphene (e.g., doping-induced charge redistribution) and to tune chemical reactivity, which has advanced energy and sensing applications. However, to date, very little is known about the influence of the nitrogen (N) heteroatom on the biological activity of graphene. Given the growing evidence from our previous research that supports the importance of reactive sites, electron exchange, and electron transport, this work aims to elucidate the bioelectrochemical properties of N-doped graphene. We prepared a suite of systematically modified N-doped graphene materials using the hydrothermal method. The degree of N-doping and types of N in doped graphene is tailored by using two different nitrogen precursors (urea and uric acid) and thermal annealing under different temperatures. The electrochemical activity for oxygen reduction and oxygen evolution reactions confirms the different electron transfer properties between the N-types. The bioactivity of the prepared materials is evaluated as the inactivation of a bacterial model organism, *Escherichia coli*, and the propensity to oxidize the intracellular antioxidant, glutathione. Given the importance of oxygen and electron transfer in mechanisms of biological activities, the results from electrochemical experiments further our goal of connecting the electronic behavior and the mechanism underlying differential biological activities of 2D carbon nanomaterials. Additionally, this work explores the potential to tailor functional performance (electrochemical reactions) and hazard outcomes (the biological implications) through advancement towards global rational material design guidelines.
35 Nanoparticle uptake and elimination kinetics in mosquitofish, clams and two snail species in wetland mesocosms

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Engineered nanoparticles (NPs) may pose a risk to human and ecosystem health. While there is a growing body of research on the toxicity of NPs, risk assessment of NPs still requires a better understanding of bioavailability of NPs at environmentally relevant exposure concentrations and in complex ecosystems. For improved modeling of uptake and bioaccumulation, there is especially a need for kinetics experiments. Here, we present results from a study in replicated outdoor wetland mesocosms exploring the bioavailability of NPs in eastern mosquitofish (Gambusia holbrooki), Asian clam (Corbicula fluminea), and two freshwater pond snails (Physella acuta and Lymnaea sp.). Over a 9-month study, these aquatic taxa were exposed to weekly doses of either: large (19 mg per week, primary particle size 185.3 nm) cerium dioxide (CeO2) NPs, small CeO2 NPs (19 mg, 3.8 nm), gold (Au) NPs (19 mg, 11.8 nm), copper hydroxide NPs from Kocide 3000 (35 mg, 118.3 nm), or controls with no NPs. The Au NP, Kocide and control groups were also tested with or without weekly nutrient additions (88 mg KNO3, 35 mg KH2PO4 per week) as a covariate. We sampled quarterly for long-term NP uptake over the 9-month experiment (i.e. at 3, 6 and 9 months). During those times, we also conducted 1-week caged exposures in the mesocosms with naive animals to quantify short-term uptake kinetics. Subsequently for all exposure groups, animals underwent a deputation period of up to 7 days in clean water to quantify NP elimination kinetics. All data were determined by quantifying body burdens in animals using ICP-MS. Our results indicate that Physella snails consistently took up the most NPs, followed by Lymnaea snails, clams, and fish. The accumulation of copper in all taxa was 1-3 orders of magnitude higher than Au or Ce, despite a similar NP dose mass, with Physella at the highest relative ratio and Gambusia the lowest. In snails, the small CeO2 and Au NPs accumulated equally, both at significantly higher levels than large CeO2 NPs, while in fish the small and large CeO2 NPs and Au NPs all accumulated equally. Clams exposed for 3 months took up relatively more of the large CeO2 NPs than the small CeO2 NPs, but it was the opposite for clams exposed 1 week. The animals fully depurated both CeO2 NPs within 12 h, but were only able to depurate about 68% of the Au NPs even after 7 days. Finally, nutrient additions did not significantly influence long-term NP accumulation or retention.

36 Multi-level responses of yellow perch (Perca flavescens) to a whole-ecosystem silver nanosilver addition at the IISD-Experimental Lakes Area

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Silver nanosilver (nAg) is an antibacterial agent with widespread commercial and industrial applications. As a result, nAg has high potential for entering freshwater environments at point sources. As part of a collaborative study involving a whole-lake nAg addition at environmentally-relevant (low ug/L) concentrations, we evaluated biological responses in Yellow Perch (Perca flavescens) through baseline, two-year nAg addition and lake recovery periods. Perch were monitored for responses at the cellular (biomarker), individual (growth, consumption and metabolism) and population level (abundance and gross consumption). At the cellular level, biomarkers of oxidative stress in perch livers revealed down-regulation of catalase (cat) and glutathione peroxidase (gpx) in fish collected during the first year nAg addition, and elevated ratios of reduced to oxidized glutathione (GSH:GSSG) in perch collected during the second years of nAg addition. At the individual level, perch bioenergetic models revealed significant changes in consumption and total metabolism, which declined during nAg addition and remained depressed. At the population level, perch densities declined along with gross prey consumption after nAg was added to the lake. This whole-ecosystem multi-scale response study of Yellow Perch exposed to a long-term addition of nAg revealed negative impacts across cellular, individual and population levels.

37 Toxicogenomic responses of Caenorhabditis elegans to pristine and transformed zinc oxide nanoparticles

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Manufactured nanoparticles (MNPs) undergo transformation immediately after they enter wastewater treatment streams and during their partitioning to sewage sludge, which is applied to agricultural soils in form of biosolids in many parts of the world. We examined toxicogenomic responses of the model nematode Caenorhabditis elegans to pristine and transformed ZnO-MNPs (phosphatized pZnO- and sulfidized sZnO-MNPs). To account for the toxicity due to dissolved Zn, a ZnSO4 treatment was included. Transformation of ZnO-MNPs reduced their toxicity by nearly ten-fold, while there was almost no difference in the toxicity of pristine ZnO-MNPs and ZnSO4. This combined with the fact that far more dissolved Zn was released from ZnO- compared to pZnO- or sZnO-MNPs, suggests that dissolution of pristine ZnO-MNPs is one of the main drivers of their toxicity. Transcriptomic responses at the EC30 for reproduction resulted in a total of 1161 differentially expressed genes. Fifty percent of the genes differentially expressed in the ZnSO4 treatment, including the three metal responsive genes (mtl-1, mtl-2 and numr-1), were shared among all treatments, suggesting that responses to all forms of Zn could be partially attributed to dissolved Zn. However, the toxicity and transcriptomic responses in all MNPs treatments cannot be fully explained by dissolved Zn. Two of the biological pathways identified, one essential for protein biosynthesis (Aminoacyl-tRNA biosynthesis) and another associated with detoxification (ABC transporters), were shared among pristine and one or both transformed ZnO-MNPs, but not ZnSO4. When comparing pristine and transformed ZnO-MNPs, 66% and 40% of genes were shared between ZnO-MNPs and sZnO-MNPs or pZnO-MNPs, respectively. This suggests greater similarity in transcriptomic responses between ZnO-MNPs and sZnO-MNPs, while toxicity mechanisms are more distinct for pZnO-MNPs, where 13 unique biological pathways were identified. Based on these pathways, the toxicity of pZnO-MNPs is likely to be associated with their adverse effect on digestion and metabolism.

38 Intelligent re-design of silver nanowires to reduce cellular and organismal toxicity in aquatic ecosystems

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Silver nanowires are more favorable than indium tin oxide for transparent electronic applications, and silver nanowire production rates are expected to increase as flexible electronics become more mainstream. Although spherical silver nanoparticles have been extensively studied over the past decade, it is likely that the transport and toxicity of silver nanowires will be different from their spherical counterparts due to the high aspect ratio of silver nanowires. The goal of this work is to determine the environmental fate and toxicity of silver nanowires with various dimensions in Daphnia magna and rainbow trout cells.
39 Differential toxicity elicited from a series of hybrid lipid-coated silver nanoparticles with varying degrees of surface stabilization

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Silver nanoparticles (AgNPs) are one of the most widely used and advertised nanomaterials due to their well-documented antimicrobial properties. They are used in a variety of consumer and commercial products as well as in industrial applications such as wastewater treatment. While the antimicrobial properties of the AgNPs are likely controlled by their physiochemical properties such as size, shape and surface chemistry, these properties are often hard to study as they are confounded by AgNPs propensity to undergo Ag⁺ ion dissolution. Due to their wide and varying uses, there is a need to understand the biological interactions of AgNPs with diverse physiochemical characteristics while controlling for the release of Ag ions. Here a suite of 10 hybrid lipid-coated spherical and triangular plate shaped AgNPs were created with increasing complexity of their surface-coating. Dissolution studies showed that increased complexity of the hydrophobic thiol surface-coating protected the AgNP from surface oxidation and ionic release. Embryonic zebrafish were then exposed the suite of AgNPs at exposure concentrations ranging from 0.03125 mg Ag/L to 4 mg Ag/L confirmed by ICP-MS for each of the synthesized AgNPs. Decreased rates of morbidity and mortality were observed in the AgNPs with the longest chain thiol surface coatings. At the concentrations tested, no significant toxicity was observed for the longest chain surface composition in either the spherical and triangular plate geometries. In contrast, AgNPs smaller chain thiol surface coatings allowed for Ag⁺ leaching or increased surface oxidation which resulted in higher mortality rates across both geometries. The higher surface area spherical AgNPs showed increased toxicity over the triangular plate AgNPs with the same surface coating. The ability to control the Ag⁺ ion dissolution of the AgNPs allowed us to gain a better understanding of the size and shape effects that drive the toxicity of AgNPs.

Stockholm Convention on POPs: Progress in Monitoring, Research and Risk Assessment of Legacy and Emerging Chemicals - Part 1

40 Monitoring and effectiveness evaluation under the Stockholm Convention: Origins and future prospects

A. Daniel, Government of Canada

This presentation will kick off the panel on the Stockholm Convention by outlining the evolution of the Stockholm Convention from the initial scientific research conducted in the 1980s, to the push for action in a regional context in the 1990s at both the political and legal levels. Developments in scientific understanding of the fate and transport of persistent organic pollutants (POPs) and their impacts on the Arctic environment and indigenous peoples continued to evolve during this time. In particular, scientists came to understand how POPs travel globally, why the Arctic is particularly vulnerable to long-range transport from around the world, and the resultant human health and environmental impacts. By the mid-1990s, there was keen interest in taking regulatory action at the global level, with multi-stakeholder meetings helping to shape a common understanding that a global treaty was required. The presentation will then focus on key aspects of the negotiation of the Stockholm Convention, in particular Article 16 on effectiveness evaluation, which provides the legal basis for the ongoing monitoring and assessment work taking place under the Global Monitoring Plan (GMP) under the Convention. It also provides the basis for periodic reviews of the effectiveness of the Convention in meeting its objective of protecting human health and the environment from POPs, using monitoring data to assess progress against agreed indicators. The GMP and the EE process together form a continuous loop to achieve incremental improvements to the global environment over time. By highlighting the importance of these two elements, this presentation will set the stage for other panel members who will focus on the monitoring aspects by highlighting measurement techniques, monitoring and research studies on legacy and emerging POPs, and recent advances in their international risk assessment and risk management under the Convention, as well as strategies for future work.

41 Atmospheric monitoring of persistent organic pollutants (POPs) and emerging contaminants in Canada in support of the Stockholm Convention

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Two major air monitoring programs conduct measurements of persistent organic pollutants (POPs) and emerging contaminants in the Canadian Arctic and the Great Lakes regions since the 1990s. At the Canadian High Arctic station of Alert, Ellesmere Island (82°30’ N, 62°20’ W), POPs measurements in air started in 1992 under the Northern Contaminants Program (NCP). Canada’s Chemicals Management Plan (CMP) also conducts Monitoring and Surveillance in the Great Lakes Basin (GLB) which collaborates with the U.S. Integrated Atmospheric Deposition Network (IADN) to assess atmospheric deposition of Chemicals of Mutual Concern to the Great Lakes. There were two Canadian GLB master stations, located at Point Petre (PPT) on Lake Ontario (43°50’ N, 77°09’ W) and Burnt Island (BNT) on Lake Huron (45°49’ N, 82°57’ W). Since air is a core medium for monitoring under the Stockholm Convention (SC), long-term time trends of POPs derived from these two programs contribute to SC’s Global Monitoring Plan (GMP) Reports and are part of the Effectiveness Evaluation (EE) process of the Convention. In addition, these two programs screen for emerging chemicals of concern, results of such screening efforts contribute to the risk assessment of candidate POPs. This presentation will provide an update on atmospheric levels and trends of POPs and emerging contaminants monitored in these two ecologically sensitive regions in Canada which contribute to the third phase of the GMP.

42 10 years of monitoring persistent organic pollutants under the Global Atmospheric Passive Sampling (GAPS) network (2005-2014)

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The Global Atmospheric Passive Sampling (GAPS) network supports the global monitoring plan (GMP) under the Stockholm Convention on
Persistent Organic Pollutants (POPs) by providing information on POP concentrations in air on a global scale. The GAPS network was started in 2005 with 55 sites characterised by use and location as urban, rural, agricultural, background and polar sites. Background sites make up the majority of sites to fill in information gaps in remote areas. Over time new sites were added and sites were discontinued and the network has been maintained at approximately 60 sites. The GAPS network utilizes passive air samplers (PAS) with polyurethane foam (PUF) disks, which are a simple and cost effective tool for monitoring concentrations of semi-volatile pollutants in remote areas. PAS are deployed by volunteers on a global scale for consecutive 3-months periods since 2005. The data from the GAPS network for concentrations of legacy POPs in air currently provides information for more than 110 global sites. Global concentrations reflect differences in region, remoteness of sites and local use of POPs. Measurements spanning 10 sampling years are available for 20 of these sites. Concentrations for legacy POPs in air between 2005-2014 show different trends for organochlorine pesticides and polychlorinated biphenyls (PCBs). PCB concentrations in air are decreasing at most sites though at a differing rates. OCP concentrations are steady and declining less rapidly over time at the majority of sites, especially lindane and the chlordanees. Endosulfan and its metabolites are decreasing at most sites, reflecting the regulation of this chemical and its relatively lower environmental persistence compared to other POPs. DDT shows different trends depending on sampling region with some examples of recent use.

43 Legacy POPs, new POPs, PAHs and compounds of emerging concern in the atmosphere of Bogota (Colombia) using XAD-based passive samplers

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The present study assessed the levels of legacy Persistent Organic Pollutants (POPs), new POPs, Polycyclic Aromatic Hydrocarbons (PAHs) and some compounds of emerging concern in the atmosphere of Bogotá, Colombia using XAD2-based passive atmospheric samplers (XAD-PAS). Samplers were deployed at 8 urban sites for 12 months between 2014-2016, as part of LAPAN (Latin American Passive Atmospheric Sampling) Network. XAD2 samples were analyzed by gas chromatography/mass spectrometry at RECETOX (Masaryk University - Czech Republic). Resins were analyzed for 10 PBDEs (polybrominated diphenyl ethers), 17 nBFRs (novel brominated flame retardants), 38 CUPs (currently-use pesticides), 30 OCPs (organochlorine pesticides), 7 PCBs (polychlorinated biphenyls) and 15 priority PAHs. Results for nBFRs and CUPs were reported as sequestered amount of the compound per PAS and exposure time, while PBDEs, OCPs, PCBs and PAHs were reported in volumetric concentration considering the specific sampling rates. XPBDEs showed an average concentration of 2.3 ± 1.3 pg m⁻³ and a predominance of BDE47, 99 and 100, the main components of commercial penta-BDE mixture. XnBFRs, with an average level of 2.9 ± 2.5 pg PAS-1 day⁻¹, were dominated by PB2 (pentabromotoluene) and α-TBEC (dibromomethylcyclohexane) at all sites. XOCUPs presented an average level of 50.2 ± 70.6 pg PAS-1 day⁻¹. Among the 38 investigated CUPs, only 12 were above detection limit (predominance of tebuconazole and chlorpyrifos), indicating a limited influence of surrounding agricultural areas over this urban region. XOCUP and XPCBs showed average concentrations of 151 ± 27 pg m⁻³ and 27.2 ± 20.4 pg m⁻³, while PeC and HCB were the predominant legacy pesticides, and PCB28 the main congener found, respectively, at all sites. Higher vapor pressure PAHs ( phenanthrene, fluorene and fluoranthene) had the highest concentrations at all sites, with an average concentration of 3676 ± 1813 pg m⁻³ for XPAHs. Slightly higher levels of contaminants were found in areas under heavier traffic and/or more densely populated, such as Pardo

Rubio (PBDEs and CUPs) and La Candelaria neighbourhoods (nBFRs and OCPs) and Municipality of Zipaquirá, northern Bogota (PAHs). In spite of that, most contamination levels are comparable to other studies done in large cities using different PAS.

44 GAPS megacities: First results for flame retardants and metals in urban air across the globe

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GAPS Megacities is a new, multi-national pilot study under the umbrella of the Global Atmospheric Passive Sampling (GAPS) network. The aim of the project is to investigate levels and spatial patterns of organic pollutants and metals and to explore assay-based health indicators in the most highly populous cities in the world. Urban areas are the primary emission points for a range of persistent organic pollutants (POPs) such as flame retardants (FRs), with contributions from multiple source sectors. Given the fact that the majority of the world’s population reside in urban settings, air pollution in these environments is one of the predominant factors impacting human health. The high levels of POPs add to the chemical burden in urban air and resulting toxic effects. This work advances domestic and international initiatives for chemicals management by linking air pollution and health. Polyurethane foam passive air samplers (PUF-PAS) were deployed in 20 major cities with populations ranging from 3 to 22 million. Pre-cleaned PUF disks and double-dome housings were sent to collaborators for deployment. Samplers were deployed for two 3-month periods in 2018 to capture gas- and particle-phase chemicals. Upon retrieval, samples were shipped back and stored below -10 °C. Details for sample extraction and processing are provided in Rauert et al. (2018). Samples from first period of deployment were analysed for organophosphates esters (OPEs), polybrominated diphenyl ethers (PBDEs), novel flame retardants (NFRs) and hexabromocyclododecane (HBCDD) compounds. All urban sites were dominated by OPEs with concentration of £100OPEs ranging between 900-17000 pg/m³ and highest levels measured at New York (USA) and London (UK) sites. The total levels of other FRs were 2 orders of magnitude lower than OPEs. Across all sites, NFRs were higher or equivalent to PBDEs. Upcoming analysis includes measuring levels of total metals in urban air and will generate new information on use/emission patterns and how these differ among sites/regions and in relation to urban source characteristics.

45 Silicones (siloxanes) as environmental sources of polychlorinated biphenyls (PCBs)

L.A. Rodenburg, Rutgers University / Environmental Sciences

Polychlorinated biphenyls (PCBs) are persistent organic pollutants (POPs) addressed as one of the ‘dirty dozen’ original POPs under the Stockholm Convention. PCBs consist of 209 separate congeners and in many countries, including the US, are regulated as the sum of all 209 congeners. The main sources of PCBs in most developed countries are the original PCB
formulations intentionally manufactured in many countries. Recently it has become clear that there are other, inadvertent, sources of PCBs. Organic and inorganic pigments have been identified as important sources of inadvertent PCBs. We here introduce a new source of inadvertent PCBs: silicones, also known as siloxanes. Recent measurements of all 209 PCBs in samples from various locations in the US. display evidence of two types of silicone-related PCB sources: PCBs 44+47+65, 45+51, and 68 arising from polymers cured using bis(2,4-dichlorobenzoyl) perox- ide, and PCBs 1, 2, 3, 4, 8, 15 and others arising from silicone products derived from phenylsiloxanes. Products that use phenylsiloxane-based silicon include adhesives, caulks, sealants, and additives for paint, among many other uses. Due to their ubiquitous use, silicone-based products appear to be an important source of PCBs to laboratory blanks, and can appear as contaminants in water samples collected using silicone rubber tubing. In some locations where silicones were manufactured, PCBs from these sources can be important in environmental samples.

**46 Direct injection analysis of legacy and emerging PFAS in soil and sediment**

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Perfluoroalkyl substances (PFAS) are common, man-made, persistent environmental contaminants that are used in the production of many consumer products such as non-stick coatings, surfactants, and for stain and water resistance coatings. PFAS are also a major component of fire fighting foams used for suppression of fuel fires. Global widespread use of these compounds over many decades has led to their release into the environment. Current advisory guidelines around the globe mainly use of these compounds over many decades has led to their release into the environment. Current advisory guidelines around the globe mainly use parts per trillion (ppt) detection of a variety of legacy and emerging PFAS. Due to the amphiphilic properties of PFAS they are found not only in water, but also soils and sediments. In this work we evaluated a simple extraction method coupled with large volume injection onto a high sensitivity mass spectrometer for the analysis of a wide range of legacy and emerging PFAS in soils and sediments. A basic sample preparation approach was used which consisted of diluting a 2 g sample of soil or sediment in 10 mL of 1:1 water:methanol, shaking for 1 hour, and syringe filtration. Acid was added to each sample before injection. A 30 µL injection was performed on a high sensitivity LC-MS/MS system. 31 native PFAS and 20 isotope labelled PFAS standards were evaluated, including GenX and other emerging PFAS compounds of interest. A variety of soil and sediment types from an EPA study were evaluated including silt, sand, lean clay, and fat clay. The simple extraction method was successful in extracting all PFAS compounds in the prescribed range of 70 – 130% from all sample types. Limit of detection for all compounds was in the low ng/kg (parts per trillion) range making this method suitable for the trace level detection requirements. Multiple quality control samples were monitored throughout the analysis including solvent blanks, method blanks, sample blanks, laboratory controls, and continuing calibration checks. All QC samples passed typical requirements for best practices in analytical data quality. A variety of PFAS were positively detected in the blank soil samples indicating the prevalence of PFAS in all types of environmental samples. The simple extraction method coupled with a large volume injection proved to provide a robust and sensitive workflow for PFAS analysis in soil and sediment samples. The basic extraction method allows for a reduction in sample preparation time, therefore allowing higher throughput of samples without sacrificing method performance. The authors would like to acknowledge the United States Environmental Protection Agency (USEPA) for providing samples for the analysis.

**47 A baseline atmospheric passive sampling network of legacy and emerging organic contaminants in Sri Lanka**

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Sri Lanka is part of the United Nations’ Asia-Pacific Global Monitoring Plan (APGMP) region, and is a signatory of the Stockholm Convention on persistent organic pollutants (POPs), however, there is currently no atmospheric monitoring of POPs in this island nation. Here we present the results of a 15 month atmospheric monitoring effort across three representative sites in Sri Lanka that include a dry zone agricultural region (n=5), an urban site (n=5) and a remote mountain site (n=3). Legacy and emerging target pollutants include polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), polychlorinated diphenyl ether (PBDEs) flame retardants, organophosphate ester (POEs) flame retardants, poly cyclic aromatic compounds (PACs), including parent and alky-lated polycyclic aromatic hydrocarbons (PAHs) and dibenzothio-phenes (DBTs). The results show both seasonal and spatial variations in POPs that vary seasonally. The urban site was the most impacted and concentrations were relatively high throughout the sampling period indicative of regional sources for all compound classes except PCBs where lower congeners inferred a remote source. The dry zone had relatively low concentrations but similar seasonality to the urban site. The remote site had one very high period in January to March 2016 where back trajectories showed air masses originated over Southeast Asia and swept over the capital city, whereas concentrations were much lower between April to September when winds originated from the Southern Ocean. These results provide the first baseline POPs data for Sri Lanka and fill in a significant gap in the APGMP region.

**Challenges in Characterizing Exposures to Organic Chemicals: Multiple Sources, Multiple Pathways and Multiple Scales**

**48 Global ecological fate and assessment of home and personal care products**

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The increasing use of household and personal care (HPC) products in developing countries requires new tools to assess the potential ecological impacts of HPCs, accounting for local hydrological and use characteristics. To address these needs, the EcoHOPE project developed a multi-scale multimedia fate and transport model, Pangea, able to estimate freshwater Predicted Environmental Concentrations (PECs) in Asia. This presentation aims a) to present the extension of Pangea implementing the global HYDROBASINS hydrological data set and perform global PEC estimations for the entire world and b) to estimate the spatial variations of five case study Household Product Chemicals (HPCs) within and between all main water basins of the world, i.e Linear Alkylbenzene Sulphonate (LAS), triclosan, D5, octocrylene and octyl methoxycinnamate. First we created a default world grid enabling global coverage with higher resolution in regions of high emissions and populations while ensuring accurate coverage of main rivers in the world. The resulting global version of Pangea/EcoHOPE comprises a total of 496,000 virtual compartments, including more than 70,000 freshwater compartments worldwide. We present cumulative distribution frequency curves of estimated LAS PECs for 390 GCRD water basins, separated by continent. Variation is noticeable across the continents with the lowest modelled concentration of LAS in North America, Western Europe and Australia due to the high connection to Waste Water Treatment Plants (WWTP). The highest modelled
concentrations, are observed in India, China, and Indonesia - associated with high population densities combined with only partial connection to WWTP. When comparing estimated PECs of the 5 case study chemicals, LAS has the highest relative predicted concentrations in Asia due to the higher emissions. All 5 substances have similar median concentrations for North America, due to both high connectivity to waste water treatment plants (WWTP) and high removal of LAS. The development of a multi-scale multimedia model at global level in collaboration with Unilever is a major milestone in the field of PECs modeling of HPCs. While covering the entire globe, the multiscale capabilities of Pangea offer a high resolution in areas of high concentrations or high emission while covering all main rivers of the world.

49 Effect of cannabis legalization to drug consumption in two cities in Canada
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Wastewater based epidemiology (WBE) is a prospective and valuable tool for the estimation of drug use. When researchers compared WBE with other drug use estimation tools such as questionnaires, they found that WBE is a more accurate estimation tool than surveys since it does not rely on honest responses. They also suggested WBE can be instrumental to provide substantial and reliable data to a body of government for identification of policy and legislation changes. In this study, our objectives were (1) to identify the short-term effects of cannabis legalization on consumption rates of not only cannabis but of other drugs as well, (2) to identify drug consumption rates and patterns in two different cities in Canada with a different population structure during a time period of 50 days. For this purpose, we monitored cocaine metabolites (benzoylcgonine, and coca- ethylene), heroine metabolites (morphine and 6-acetylmorphine), codeine, MDMA, methamphetamine, amphetamine, LSD and its metabolite (2-oxo-3-hydroxy-LSD), Fentanyl and its metabolite (norfentanyl), alcohol metabolite (ethyl sulfate), and cannabis metabolite 11-nor-9-carboxy-Δ9-THC (THC-COOH) in three wastewater collection systems serving more than 2,000,000 people in total. It is the first time that a powerful tool such as WBE has been used to identify the effects of this major policy change on drug consumption. Results contribute to not only the effects of legislature change but also the identification of consumption rates, consumption trends, and consumption pattern differences over 50-day period in three different residential areas. This long-term uninterrupted data enabled us to use advanced statistical tools to interpret consumption patterns during the sampling period. Here, we show that the legalization of cannabis had only a minor effect on total drug consumption in two cities in Canada. We also determined temporal and spatial changes of drug consumption patterns for alcohol, amphetamine, cannabis, cocaine, MDMA, and methamphetamine with a 50-day monitoring period. This monitoring revealed one of the highest cannabis, cocaine and alcohol consumption rates in the literature (100 g/day/1000 inhabitants, 8.9 g/day/1000 inhabitants, and 100 L/day/1000 inhabitants, respectively) and higher methamphetamine consumption rates (as high as 2.5 g/day/1000 inhabitants) in a relatively small city with a 10 times lower population.

50 High-resolution global mean-annual surface runoff and river flow datasets for use in risk assessments
The availability of detailed surface runoff and river flow data across large geographic areas is crucial for modeling in ecological risk assessments; a few countries (e.g., U.S.) offer such data at a high-resolution and most countries do not. Lack of detailed spatial data and challenges with intense processing have been the limiting factors in developing high-resolution river flows over large spatial scales. iSTREEM(R), a broad-scale spatial model in the U.S. incorporates a detailed hydrology network with river flows from the NHDPlus to estimate exposure across large areas from the use of down-the-drain chemicals. It combines WWTP emissions into corresponding flow at receiving rivers to estimate dilution factors and down-the-drain chemical concentrations, and route them through the river network. A similar approach to integrate chemical emissions with a global hydrologic river network and associated flows can be employed to estimate local dilution factors and chemical concentrations across river network over countries where environmental concerns are a high priority. To address this specific need, the well-established Curve Number (CN) method was applied to develop a detailed surface runoff dataset. Publicly available, scientifically accepted and high-resolution global datasets for hydrologic soil groups, land cover, and precipitation were spatially processed by applying the CN equations to generate a contiguous global mean-annual surface runoff grid at a very high-resolution of 50m x 50m. Surface runoff was converted to river flow by spatially combining with a detailed global hydrology of rivers and catchment boundaries from HydroSHEDS and HydroBASINS to estimate mean-annual flows across the global river network. Evaluation of the estimated river flow was conducted against publicly available gage measurements in China and river flows in the Ohio River basin, U.S.; both showed high correlation (r2 = 0.70 for China and 0.97 for Ohio River). Applying the detailed global mean-annual river flows with broad-scale environmental exposure models like iSTREEM(R) provides a robust approach to assess ecological risk of chemicals used in home and personal care products, cosmetics, pharmaceuticals, etc. over large river basins, across a country, or at a continental scale.

51 Using mechanistic, integrative environmental modeling to address the multi-dimensional human chemical exposure
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Integrated environmental modeling has been advocated as a novel paradigm to tackle a wide spectrum of environmental issues (e.g., climate change and air pollution) in a holistic and comprehensive manner. In this presentation, we demonstrate how integrated environmental modeling aids in addressing the multi-dimensional nature of human chemical exposure (multiple sources, pathways, and scales). We introduce an integrated human exposure model named “PROTEX” (“PROduction-To-Exposure”), which allows modeling the journey of chemicals from production to dose in the human body by coupling a technosphere module, a nested indoor-urban-rural environmental fate module, a food-web bioaccumulation module, and a human exposure-toxicokinetic module. The PROTEX model integrates state-of-art knowledge for processes and transport of chemicals in the technosphere (i.e., human socioeconomic system), physical environment, and biosphere (i.e., food webs and humans). Such a mechanistic, integrative modeling approach sheds light on the time-variant exposure of multiple cohorts of the general population to chemicals via multiple exposure routes (e.g., near- vs. far-field exposure routes) resulting from emissions from multiple lifecycle stages (e.g., industrial processes, indoor uses, and waste handling). The performance of PROTEX is evaluated through comparisons between modeled and measured concentrations in various environmental media and the human body. As case studies, we demonstrate how the PROTEX model characterizes the aggregate exposure of Swedes to PCBs, and Canadians to PBDEs. Our modeling explains the reason that the relative importance between near- and far-field exposure routes varies between sampling times, congeners, and sampled age groups, and how such variations are linked to the properties of chemicals and associated products, environmental settings, and human behaviors and exposure factors. PROTEX provides mechanistic insights into human exposures that cannot be achieved by traditional approaches considering separate components of the complex production-to-exposure continuum. The model offers a scientifically defensible and unique tool for chemical management decision-making.
52 Target and non-target screening of chemicals in the indoor environment for human exposure assessment
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People are spending more and more time indoors in well-insulated buildings, and are more heavily engaged with multiple electronic devices already at a young age. The indoor environment is known to be contaminated by compounds belonging to various classes, that are emitted from construction materials, interior decorations, kitchen utensils, food packaging, electronic equipment, carpets, textiles, flooring, furniture, etc. The indoor environment is rather complex as there are several sources of substances and some of the substances can even have multiple functions. Within the SHINE project (funded by CEFIC-LRI), aiming at target and non-target screening of chemicals in the indoor environment for human exposure assessment, firstly, novel BFRs, HBCDDs, OPFRs, PFASs, CPs, plasticizers and pesticides were analyzed in dust and air samples from homes, offices and daycare centers in several European countries. In addition to this targeted analysis aimed at quantifying the levels of known contaminants, a database was compiled to support the suspect screening of these samples using high resolution mass spectrometry to identify chemicals of emerging concern. Information from the CPCat, KEMI, BUMA, NORMAN and ECHA databases was combined with reports from the literature on the occurrence of chemicals in consumer products, dust and air [1]. Suspect screening of a selection of dust and air samples is ongoing, while the concentrations of > 100 different compounds belonging to a wide variety of chemical classes form a rich data set for evaluation of e.g. trends and differences in use of certain compounds between countries, but also for human exposure modeling. The model of choice is the RAIDAR-ICE model (Risk Assessment, IDentification And Ranking - Indoor & Consumer Exposure), a model for risk-based screening and prioritization of human exposure to chemicals from near-field sources [21]. Lucattini, L., Poma, G., Covaci, A., De Boer, J., Lamoree, M., Leonards, P. 2018. A review of semi-volatile organic compounds (SVOCs) in the indoor environment: occurrence in consumer products, indoor air and dust. Chemosphere, 201, 466-482.2. Li, L., Westgate, J.N., Hughes, L., Zhang, X., Givehehi, B., Roose, L., Armitage, J.M., Wania, F., Egeghy, P., Arnot, J.A. 2018. A model for risk-based screening and prioritization of human exposure to chemicals from near-field sources. Environmental Science & Technology, 52, 14235-14244.

53 Combining river model with a toxicokinetic model to simulate the whole-body burden of micropollutants in sensitive freshwater invertebrates
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The aquatic environment is repeatedly exposed to micropollutants (e.g., pharmaceuticals, personal care products, and pesticides) primarily released from wastewater treatment plants (WWTPs). The use of modeling techniques in micropollutant monitoring is increasingly recommended not only for predictive assessments but also to supplement costly chemical and bioanalytical studies. Furthermore, it has been strongly advocated that information on the fate and transport of micropollutants in the receiving environment can be subsequently linked to the contaminant dynamics within the organism and/or at its target site of action. In this study, we coupled a simple river model with a toxicokinetic (TK) model to determine the impact of highly dynamic environmental concentrations in the movement of micropollutants in freshwater invertebrates (Gammarus spp.). After evaluating several surface water quality modeling approaches, we employed the dilution model to estimate the concentrations of 22 micropollutants downstream of 9 WWTPs in Swiss midlands. Monte Carlo simulation was further applied within the dilution model to account for the scarce data in effluent concentrations. The outputs from the river model were then employed as inputs into the TK model that simulates the time course of micropollutants in invertebrates. Both river and internal concentration simulations mostly agree with the measured data, suggesting the suitability of the assumptions and simplifications employed within the models. Furthermore, since data on the uptake (ku) and depuration (kd) rate constants required to run the TK model are limited, we evaluated the model under steady-state conditions. It was observed that the bioaccumulation factors (BAFs, ku/kd) may be employed to predict the fluctuating internal concentrations in invertebrates. These results additionally suggest that when the uptake occurs faster relative to the exposure dynamics, the use of scaling factors (dilution factors and BAFs) within the river and TK models are sufficient when predicting the internal concentrations. However, caution must be exercised when following this modelling platform as the study is only restricted to small streams that are well-mixed a few meters below the WWTP discharge pipes. In the future, the time-varying field simulation of external (river) and internal concentrations may be combined with higher-level effects modelling to finally link exposure and effect.

54 Understanding Spatial and Temporal Patterns of Contaminants in the Maumee River to Assess Biological Hazards

Assessing the potential for adverse biological effects of complex contaminant mixtures in aquatic environments is an ongoing challenge. The interplay of environmental complexity, seasonal variation, and human activities leads to dynamic mixtures varying through space and time. To evaluate potential hazards influenced by system complexity, an understanding of how chemical mixtures vary across anthropogenic gradients interannually and seasonally is necessary. To better characterize the spatial and temporal variability of contaminants in an agricultural to urban watershed, we collected data from 8 locations in the Maumee River watershed (OH) during 2012 and across two seasons in 2016. Sites were selected to capture a range of human activity gradients including wastewater treatment, urban drainage, and agricultural sources. Analysis of organic contaminants targeted pharmaceuticals and wastewater indicators to evaluate interannual patterns among sites between 2012 and 2016. In 2016, a detailed assessment of pesticides was conducted to observe seasonal variability. Chemicals varied greatly across sampling sites, ranging from 27 to 64 chemicals detected in 2012. Sites downstream and nearby WWTPs generally had the highest chemical detections for pharmaceuticals and wastewater indicators. In 2016, pesticide concentrations increased significantly in June with pronounced changes in more
agricultural, upstream locations. Highest concentrations were detected for atrazine and metolachlor in 2016. Hierarchical cluster analysis revealed distinct site separations associated with diverse chemical mixtures across the landscape for both years indicating such approaches may be effective to predict chemical occurrence for future prioritization. To put chemical concentrations into a biological context, exposure-activity ratios (EARs) for detected chemicals were assessed using the ToxCast database. EAR analysis identified multiple sites, biological pathways, and chemicals that warrant future prioritization for assessment in the complex system. This abstract does not necessarily reflect USEPA policy.

55 Determination of pesticide exposure in aqueous systems through measurement of water, suspended sediment, and zooplankton

The Cache Slough/Liberty Island complex and the Yolo Bypass are areas of critical habitat for several San Francisco Bay-Delta (California) fish species including the threatened Delta Smelt, and multiple restoration projects are planned in these areas. In addition, recent research suggests that the Yolo Bypass can serve as an important source of phytoplankton and zooplankton, benefitting fish downstream. However, these areas are impacted by agricultural and urban runoff containing mixtures of current-use pesticides which may have direct, harmful effects on fish as well as on plankton production and quality. Samples were collected from sites within the Yolo Bypass as well as one comparison site on the Sacramento River during 2017-2018. Samples were collected during baseflow and managed pulse flow conditions and were analyzed for over 150 current-use pesticides and pesticide degradates in water, suspended sediment, and zooplankton. In water and suspended sediment 49 pesticides were detected including 14 fungicides, 16 herbicides, 18 insecticides, and 1 synergist. All water and suspended sediment samples contained a mixture of pesticides that ranged from 3 to 27 compounds. For the zooplankton samples, 22 pesticides were detected (3 fungicides, 8 herbicides, and 11 insecticides); these included nine pesticides that were not detected in water or suspended sediment samples (the pyrethroid insecticides cyfluthrin, cyhalothrin, cypermethrin, esfenvalerate and permethrin; p,p’-DDT, p,p’-DDD, p,p’-DDE, and pendimethalin). Knowledge of the composition and timing of occurrence of these pesticide mixtures is critical to understanding and mitigating any potential detrimental environmental effects. Determining which pesticides are detected in various environmental compartments, including zooplankton, can aid in better determining exposure and potential effects of pesticides to sensitive species.

Environmental Occurrence, Bioaccumulation, Fate and Transport of Poly- and Perfluoroalkyl Substances (PFAS)

56 PFAS in the urban terrestrial ecosystem; the case study Oslo city
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As a part of modern way of life, a large number of chemicals is emitted into the urban environment exposing the coexisting wildlife to a complex mixture of harmfull chemicals with only very little understanding to their concentrations, composition and impact. Both conventional and emerging PFAS are an important part of these urban emissions to the terrestrial environment in Norway. A food chain encompassing soil, earthworms, fieldfare and sparrowhawk, as well as predators as towiny owls, foxes and badgers were investigated together with the insects represented by bumblebees and a opportunistic feeder, the brown rat in a comprehensive investigation of the terrestrial ecosystem in the city of Oslo, within 2014 to 2018. More than 50 PFAS were measured. Distinct interspecies differences were found. PFOS is the overall dominating compound. PFDoA, PFTriA and PFTeA contribute more higher up in the food-chains (fieldfare, sparrowhawk and towiny owl), but also in rodents. Emerging PFAS were also detected. In general, we found a broad variety of the investigated pollutants in all matrices, with even being able to point out so far unknown pointsources of pollution within the city. Elevated PFAS concentrations in soil and earthworms were for example found in locations used for skiing activities, airport as well as industrial activities. When comparing with remote samples, the urban impact on PFAS exposure could also be shown for a number of species, pointing to complex sources within large cities. The estimation of bioaccumulation and trophic magnification showed TMF > 1 for PFOS and the longchained PFCAs in the foodchain earthworm - fieldfare - sparrowhawk while no magnification could be found for PFHxS and PFCAs shorter than PFOA.

57 Fluorine Mass Balance in Marine Mammals from the Northern Hemisphere - A combination of targeted, total (organofluorine, and non-targeted analysis
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Per- and polyfluoroalkyl substances (PFASs) are ubiquitously spread in the environment and have been detected in abiotic and biotic media, including blood of humans and wildlife globally. While most research has focused on studying the occurrence and behavior of < 30 PFASs, recent studies have shown that these substances may only represent a small fraction of the extractable organofluorine (EOF) in the environment. Here, a fluorine mass balance analysis was applied to livers from eleven different marine mammal species from five different locations. Out of 36 target PFASs, 20 were quantifiable, of which perfluorooctane sulfonic acid (PFOS) was the dominant substance. The second most predominant substance was 7:3 fluorotelomer carboxylic acid (7:3 FTC), which is reported here for the first time in polar bears (~1000 ng/g, ww) and cetaceans (~6-190 ng/g, ww). The 7:3 FTC was also observed in seals, but in higher concentrations than reported previously (~6-190 ng/g, ww). EOF measurements were carried out using a combustion ion chromatography (CIC) and seven samples showed a significant gap between target PFAS concentrations and EOF concentrations, where the unidentified fraction ranged from 30-75% of the EOF. Suspect screening utilizing liquid chromatography - high resolution mass spectrometry (LC-HRMS) revealed an additional 20 PFASs (from 5 classes) which were not included in the targeted analysis, bringing the total number of PFASs detected to 44. Overall, these results demonstrate that focusing on the standard suite of perfluoroalkyl acids underestimates PFAS exposure in marine mammals. Since few toxicological data are available for the novel PFASs detected in the present work, these substances pose unknown risks to marine mammals as well as humans who consume them for food.

58 Per- and polyfluoroalkyl substances (PFAS) concentrations in human placental tissues and associations with birth outcomes
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Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental contaminants that have been found in human serum, breast milk, and umbilical cord blood. Placental transfer of PFAS to developing fetuses has been observed and is of concern due to the known toxicity of these compounds. Previous studies have found associations between maternal
59 Investigation of Perfluoroalkyl and Polyfluoroalkyl substances (PFAS) in foods in the United States

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Perfluoroalkyl and polyfluoroalkyl substances (PFAS), in particular perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), have been widely studied due to their persistence, distribution, toxicity, and bioaccumulation in humans and the environment. Humans can be exposed to these compounds from environmental contamination (landfills, wastewater treatment plants, the use of aqueous film forming foams (AFFF)), household exposure (upholstery, carpeting, dust) and the diet. Recently several contamination events in the United States caused concern of possible contamination of food commodities produced using contaminated water and soil. A QuEChERS LC-MS/MS method has been developed for PFAS in a number of commodities including fruits, vegetables, milk, cheese, grains, meats and other foods. This method was further used to analyze 91 composite food samples collected in the Mid-Atlantic region as part of the FDA’s Total Diet Study program. This method was also used to analyze produce samples collected in a region near a PFAS production plant in the eastern US and to analyze samples (milk, water, silage, cheese) collected from a dairy farm in New Mexico with contaminated ground water due to its close proximity to an Air Force Base where AFFF was used. The results of this data will be used by the FDA to estimate human dietary exposure. This method will also be used by the FDA to monitor food samples including certain Total Diet Study samples.

60 Mapping the Extent of PFAS Contamination in North Carolina’s Drinking Water Sources: The NC PFAST Monitoring Network

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Per- and Polychlorinated alkyl substances (PFASs) have been found to contaminate drinking water sources in several locations throughout the state of North Carolina (NC). The sources of this contamination are in some cases well-understood, e.g. fluorochemical manufacturing discharge to rivers, firefighting activities at military installations, and application of biosolids to agricultural fields leading to runoff runoff into reservoirs. Data from the US Environmental Protection Agency’s third Unregulated Contaminant Monitoring Rule (UCMR3), suggests at least 13% of NC public water systems have detected at least one PFAS species in their drinking water. While UCMR3 only targeted 6 PFAS compounds (from two legacy PFAS classes), these results suggest there are additional unknown sources of PFAS contamination to drinking waters within the state. We have initiated a broad-ranging monitoring study to assess occurrence and map sources of PFAS in drinking water sources across NC in order to assess this uncertainty. This work, mandated by state legislative action, involves sampling and analysis of all municipal drinking water sources in NC for PFASs using suspect screening, non-targeted analysis, and quantitative measurements. We are collecting raw water from 191 municipal surface water systems and 149 municipal ground water systems, with two rounds of sampling at each site to be finished by the end of 2019. Quantitative measurements are conducted using a novel sensitive and high throughput, direct-injection LC-MS/MS method for measuring 48 PFAS compounds at low ppt concentrations. This method includes PFCAs ranging from C4 through C16, PFSA, zwitterions, and 16 new generation ether-acid/sulfonate compounds including GenX. The wide range of PFAS classes targeted will inform about possible PFAS sources and their impacts on drinking water sources. Non-targeted analysis and suspect screening utilizes high resolution, Orbitrap tandem mass spectrometry combined with cheminformatic and computational mass spectrometry methods for annotation of chemical structures. Results of our analyses to date indicate sporadic groundwater and surface water contamination with legacy PFAS (including PFCAs and PFSA)s at levels exceeding the 70 ng/L USEPA health advisory level as well as persistent elevated levels of new-generation PFAS such as GenX in surface water downstream of a major fluorochemical manufacturing facility.
PFAS concentration in serum. Ongoing analysis of this population will focus on investigating the role of individual and combined PFAS on the reproductive fitness of striped bass. Similar to the fish, American alligators sampled from the Cape Fear River had a high concentration of PFOS in serum. Continuing studies will examine PFAS in the muscle tissue of recreationally harvested species within the Cape Fear River (Flathead catfish, Largemouth bass, American shad) to advise the local community consumption guidelines.

62 The application of multi-matrix methods for understanding occurrence of emerging PFAS in water, soil, sediment and fish in North America

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Monitoring of PFAS across multiple ecosystem compartments is a critical tool in assessing fate, transport, effects and exposure. Two decades worth of PFAS monitoring, especially in biota, have focused on a short list of carboxylates and sulfonates such as PFOA and PFOS. Given the phaseout of PFAS monitoring, especially in biota, have focused on a short list of tool in assessing fate, transport, effects and exposure. Two decades worth of PFAS monitoring, especially in biota, have focused on a short list of precursors/intermediates including FOSA, MeFOSA and EtFOSA, MeFOSAA and EtFOSAA, and MeFOSE and EtFOSE. All methods used best-practice approaches including isotope dilution, weak anion exchange (WAX) and carbon cleanup and shared common instrumental methods to facilitate comparison across ecosystem compartments. Results from validation show that with a few exceptions for neutral sulfonamides/ethanol in tissue, recoveries were between 70-130% for analytes and 50-150% for isotope-dilution surrogate standards. Water, soil, sediment and fish from five sites in Canada and the US were analyzed for this expanded PFAS list. Results showing overall occurrence of emerging PFAS such as HFPO-DA and 6:2 FTS, and relative abundance compared to PFAAs such as PFOA and PFOA are in progress and will be presented.

63 Multimedia, Non-Targeted Examination of Emerging PFAS Sources

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Per- and polyfluoro alkyl substances (PFAS) are an environmentally persistent and high interest class of chemical pollutants with a rapidly expanding roster. As manufacturing processes evolve, the number of PFAS in use in commerce has exploded to thousands of analytes, and new and emerging analytical techniques are necessary to identify and monitor the most environmentally relevant chemical pollutants. High resolution mass spectrometry (HRMS) has been a workhorse technique supporting non-targeted approaches to sample analysis, compound discovery, and chemical characterization across a range of media and unique circumstances. The application of the EPA’s PFAS lists to HRMS screening has allowed rapid examination of unknown samples for the ever-expanding list of known PFAS chemicals. New chemical species continue to be uncovered and described using a combination of computational tools - formula and fragmentation prediction, homologous series screening (e.g., CF2, CF2O, etc.), and geographic/temporal feature correlation. Tentative assignment from the preponderance of chemical evidence (i.e., HRMS isotope/fragment information and spectral predictions) offers a methodology for PFAS analysis while the availability of authenticated, commercially available standards lags the diversity of known species. PFAS screening and discovery approaches have been applied to numerous industrial production/use sites for fluoropolymers throughout the United States and reveal a varied landscape of emerging PFAS chemicals. Environmentally relevant emerging PFAS are structurally diverse, corresponding to their specialized applications by different users/producers. This diversity leads to variable occurrence across media - air, soil, water, and biota - that reveals the underlying chemical nature of the species and informs assessment of their transport mechanisms and human health risk.

Environmental DNA (eDNA) Approaches to Enhance Biodiversity Monitoring and Risk Assessments - Part 1

65 The potency of environmental nucleic acid detection: advancing the sensitivity of the biodiversity toolkit

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The biosphere is at tipping point. Faced with the onslaught of anthropogenic climate change, global biotic exchange and widespread habitat loss or modification, the need for highly efficacious and cost-effective biomonitoring tools are needed more than ever. Whilst conventional tools (e.g., nets, electrofishing) represent long established means to gather essential biodiversity data (e.g., age-class structure, parasite loads, etc.), they may not be neutral with respect to unintended side effects (e.g., bycatch mortality, habitat disturbance). Furthermore, they may not meet the requisite standards of extreme sensitivity that are necessary to detect extremely low populations of endangered or invasive species. Highly sensitive tools are increasingly needed to map the distributions of organisms that are otherwise difficult to detect, and thereby increase the confidence of population and ecosystem models. Environmental DNA detection can detect the shed DNA of a target organism or community from simple environmental samples (e.g., water, soil), minimizing the sampling footprint and vastly increasing the sensitivity of surveys. In the past decade, increasing numbers of comparative studies provide evidence in support of increased sensitivity. We provide further evidence in affirming increased sensitivity and review in detail the adaptability of environmental DNA detection to aquatic and terrestrial fields. We also brief on methodological directions environmental molecular genetic detection will take in the future, including how the method may be expanded to include molecular traces of organism functionality (e.g., gene transcripts, or RNA, detection).

66 Development of a novel, non-invasive method of measuring fish stress using water samples

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Measurements of waterborne environmental DNA are currently being employed to monitor populations of both invasive and endangered fish species throughout the world. However, few studies have examined environmental RNA within the water as a marker of the health status of a local community, an important predictive endpoint. These studies are currently restricted to microbial communities; due to the instability and low abundance of fish mRNA in the water column. However, microRNA (miRNA) can last up to five days, potentially allowing for the measurement within water. miRNA are also conserved, targeted, post-transcriptional regulators of mRNA, and are therefore useful markers of phenotypic responses. Changes in miRNA levels in tissues and circulation have previously been measured in fish in response to acute and chronic stress. Additionally, our group has measured miRNA in water samples; however, changes to specific miRNA in response to stress have never been identified in water. This study examines all miRNA present in rainbow trout blood plasma, mucus, and water samples before and after an acute handling stressor in order to identify environmental markers of stress and elucidate a potential path of secretion into the environment. Rainbow trout (Oncorhynchus mykiss) were held above the water for three minutes, which induced an
acute stress response. Control samples were collected prior to the stressor and stressed samples were collected one-hour post stressor. From these samples, total miRNA was sequenced using Illumina NextSeq technology with an average of 15 million reads per sample. Differentially expressed miRNA were identified and validated in all three sample types. In the water, three miRNA (miR-128, miR-26, and miR-30) were significantly upregulated and one miRNA (miR-451) was significantly downregulated, which can be used as non-invasive biomarkers. In order to understand phenotypic changes that are associated with the altered miRNA in all samples, enriched gene pathways (KEGG) that are affected by altered miRNA were identified using in silico analysis. Changes in these specific miRNA, linked to altered phenotypes in organisms, indicate the overall health status of fish, and due to the conserved nature of miRNA, other aquatic organisms, without the need to sample species. Overall, this study identifies novel, predictive, non-invasive biomarkers for use in environmental monitoring.

67 Quantifying Ecosystem Responses to Stress: An Environmental DNA (eDNA) Approach

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To better understand ecosystem responses to anthropogenic stress, new biomonitoring methods are needed that assess biodiversity in a quick and cost-efficient manner. The emerging field of environmental DNA (eDNA) potentially offers such an approach, as it may provide rapid, low-cost identification of species present in an area. To test the effectiveness of this new technology, eDNA was collected from ponds along an acid-mine drainage (AMD) gradient within The Wilds Conservation Center (Cumberland, OH). Here there are several AMD-gradient watersheds, with each system often consisting of one AMD-affected headwater pond that filters downstream to several smaller ponds where pH returns to background levels. We previously observed fish recolonization downstream from AMD sources and plan to use eDNA samples to quantify biodiversity in fish, amphibian, and invertebrate communities along a specific AMD gradient. The gradient here consists of 5 primary ponds separated by abandoned beaver dams each with highly different AMD characteristics. The goal of this proof-of-principle study is to estimate biodiversity and community structure at each pond using eDNA. Water quality parameters (pH, metals, conductivity) were also assessed along the gradient for comparison to derived community structures. The main source of metal contamination in our gradient is manganese (~6-10mg/L) with aluminum (~1-4mg/L) and iron (~0.5-3 mg/L) contributing as well. pH values range from 3.5-7.5 across the 5 ponds that were sampled. Our working hypothesis is AMD reduces biodiversity and simplifies community structure at ponds closest to the AMD source and that these ecosystem changes can be detected via eDNA. These simplified community structures can then lead to reductions in ecosystem functions such as carbon cycling. Results from this study will provide a wealth of species information to be used in future remediation efforts by The Wilds. Knowing which levels of AMD correspond to desired community structures can help create AMD benchmark levels.

68 Identifying structural responses of bacterial, fungal and eukaryote communities to trace-metals using multi-marker metabarcoding

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The pollution of soils by multiple metals released from mining and smelting activities is one of the most pervasive and intractable pollution issues faced today. To understand the effects of metal pollution on ecosystem services, we need to better understand how metals impact on the often unseen soil biodiversity that contributes to key soil processes, such as the bacteria fungi and micro-eukaryotes. The Avonmouth smelter located in the UK was, during its operational life (1928-2003), the largest primary Cd/Pb/Zn smelter in Europe and also one of the largest point pollution sources on the continent. Sampling of 92 soils from sites in the area around the smelter revealed prevailing metal concentrations resulting from aerial deposition from this source ranging from grossly polluted e.g. Cd, Pb, Zn of 300 mg/kg, 1000 mg/kg and 30,000 mg/kg respectively to near background at >12 km distance. These measured concentrations were used to calculate multi-substance potentially affected fractions (msPAF) for all soils to indicate the potential metal stress experienced by the soil community. The structure of the bacterial, fungal and eukaryotic communities inhabiting the sampled site soils were also characterised using 16S rDNA, ITS, and 18S rDNA marker gene metabarcoding. This complex multi-dimensional data-sets were then interrogated to identify the main drivers of soil community change with the aim of identifying metal stress to community structure relationships and identifying characteristic indicators of the metal pollution load. Rank order tests were used to correlate entropies with variables to identify the primary driver-diversity relationship. Trace metal concentration and soil pH were identified as the driving variable of community structure, however, relationships against overall diversity metrics were relatively weak. Cluster analysis was used to identify the minimum number of community types (i.e. sets of related species) present in the region. The distribution of these clusters could be clearly related to soil pH and also the total concentration of metals and bioavailable concentrations in the site soils. Finally, AI algorithms were used to build models that predict the minimal set of indicator species needed to correctly categorize soils according to their prevailing levels of both soil metal stress and pH.

69 The utility of ultra-deep sequencing in environmental metabarcoding studies

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Environmental metabarcoding is an increasingly popular means of obtaining rapid, inexpensive, and comprehensive biodiversity information. While most comparative studies of eDNA-based and morphology-based analyses of the same sampling sites shows that eDNA is capable of identifying more taxa overall, it is often the case that morphological analysis still finds organisms that were missed by eDNA-based analysis. With the increasing capacity of modern DNA sequencing instruments, we wondered if ultra-deep sequencing could help close this gap by allowing even extremely low eDNA copy numbers to be measured. We applied a standard metabarcoding approach to marine water samples with one exception: instead of employing a typical sequencing depth (~100,000 reads per sample) we obtained millions of reads per sample to see if this additional sequencing effort would allow more taxa to be recovered. Our results demonstrate that ultra-deep sequencing does indeed uncover new biodiversity that shallower sequencing depths would miss. Moreover, we believe these organisms represent low-abundance taxa (e.g., rare or endangered species) that are of particularly great interest to many studies. Finally, modern high-capacity sequencing instruments allow such ultra-deep sequencing to take place for little or no increase in cost per sample when compared with conventional-depth sequencing on previous-generation instruments.
70 Environmental DNA (eDNA) Solutions for Species Detections in Tidal Energy Environmental Effects Monitoring
M. Skinner, Stantec Consulting, Ltd.; M. Murdoch, Stantec Consulting, Inc.; T. Loeza-Quintana, S. Crookes, University of Guelph / Department of Integrative Biology; R. Hanner, Precision Biomonitoring, Inc. / Integrative Biology

Environmental effects monitoring in marine ecosystems are challenging, particularly in dynamic settings like the Bay of Fundy. Environmental deoxyribonucleic acid (eDNA) provides a useful tool for determining species presence in such challenging places to access and sample. Moreover, recent studies showing a link between eDNA concentration and fish density/biomass reveal the great promise for eDNA tools to improve biodiversity assessments in the marine environments. Our project objectives were to: a) develop and refine species-specific TaqMan quantitative polymerase chain reaction (qPCR) assay for eDNA detection of striped bass (Morone saxatilis); b) assess the accuracy and precision of a handheld point-of-need (PoN) tool which can analyze eDNA in situ to confirm species identification in real-time versus conventional laboratory-based eDNA techniques; c) derive estimates of eDNA signal persistence in saline water; and, d) assess whether relationships exist between striped bass densities and eDNA concentration. These objectives were achieved through a series of manipulative laboratory-based mesocosm experiments conducted at Dalhousie University’s Aquatron facility. Using species-specific primers-probe, the first of these experiments determined that striped bass eDNA was reliably detected using either of the laboratory-based or PoN platforms, with some variation observed in the estimates of eDNA concentrations derived from each. Next, a time series experiment established that eDNA in water samples collected within a 24-hour period of exposure to striped bass was reliably and consistently detectable with either platform. Our final experiment found that the linear relationship between eDNA concentrations and manipulated striped bass stocking densities was significant and positive based on results from each of the laboratory-based or PoN platforms. Our results validate and advance eDNA approaches towards environmental monitoring efforts and demonstrate the potential for eDNA tools to quantify and identify the spatial and temporal distribution of species-at-risk in an open ocean environment.

71 Solving eDNA challenges with field-friendly extraction and detection methods
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The use of environmental DNA (eDNA) has greatly improved monitoring of water quality, as well as endangered and invasive species in aquatic environments. Superior monitoring increases early detection/prevention of emergent issues, leading many government agencies to adopt eDNA detection methods. However, numerous challenges must be overcome prior to widespread implementation. These include extended periods of time from sample collection to results, variability of sample type and extraction method, and carryover of inhibitors into PCR reactions. Biomeme has developed novel extraction/detection methods to overcome these limitations, including field ready DNA purification kits and portable rechargeable qPCR devices, that can be used with a wide array of sample types in under an hour, on site, without the need for a dedicated lab. The inclusion of an enhanced master mix capable of overcoming common inhibitors found in eDNA extracts has further improved the workflow. This presentation will discuss two recent studies: Early detection of low-density populations of the invasive New Zealand mudsnail (Potamopyrgus antipodarum) in Michigan, USA. Field validation studies were conducted to determine if field eDNA analysis can be used to map mudsnail eDNA distribution and quantify temporal fluctuations. Levels of Flavobacterium psychrophilum (the causative agent of Bacterial Coldwater Disease in salmonids) were examined over a 23-day period after juvenile trout were exposed to the pathogen. eDNA was extracted and analyzed from the fish tank water by two different methods: 1) the Biomeme qPCR platform and, 2) traditional benchtop qPCR workflow. The two methods identified similar fluctuations in F. psychrophilum over the course of the trial and strongly correlated with bacterial counts. This correlation suggests that rapid, field-based qPCR can be incorporated into daily water quality monitoring protocols to detect and monitor microbes in aquaculture systems. Current laboratory methods of eDNA detection can take weeks to produce results; this may prevent timely management action, in addition to requiring dedicated lab space, equipment, and highly trained personnel. The Biomeme eDNA platform represents a major step forward in eDNA analysis by providing rapid eDNA detection results and simplifying the overall process of the eDNA extraction and detection.

Challenges and Strategies for Linking Adverse Effects to Endocrine Modes of Action

72 Distinguishing between endocrine disruption and non-specific effects on endocrine systems
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The endocrine system is responsible for growth, development, maintaining homeostasis and for the control of many physiological processes. Due to the integral nature of its signaling pathways, it can be difficult to distinguish endocrine-mediated adverse effects from transient fluctuations, adaptive/compensatory responses, or adverse effects on the endocrine system that are caused by mechanisms outside the endocrine system. This is particularly true in toxicological studies that require generation of effects through the use of Maximum Tolerated Doses (or Concentrations). Endocrine-mediated adverse effects are those that occur as a consequence of the interaction of a chemical with a specific molecular component of the endocrine system, for example, a hormone receptor. Non-endocrine-mediated adverse effects on the endocrine system are those that occur by other mechanisms. For example, systemic toxicity, which perturbs homeostasis and affects the general well-being of an organism, can affect endocrine signaling. Some organs/tissues can be affected by both endocrine and non-endocrine signals, which must be distinguished. This presentation will examine in vitro and in vivo endocrine endpoints that can be altered by non-endocrine processes. We recommend an evaluation of these issues in the assessment of effects for the determination of endocrine disrupting properties of chemicals. This underscores the importance of using a formal and systematic weight of evidence (WoE) process to evaluate potential endocrine activity.

73 An Update on Public Tools for Prediction of Endocrine Hazard and Risk
K. Paul Friedman, J.F. Wambaugh, R. Judson, A.J. Williams, US Environmental Protection Agency / National Center for Computational Toxicology

Prediction of potential chemical-induced endocrine hazard and/or risk is relevant for chemical safety assessment internationally, and there are a number of publicly available tools for this purpose. A workflow for understanding chemical endocrinicity should begin with assessment of available in silico and in vitro data and predictions, integrated consideration of these information, followed by the use of high-throughput toxicokinetic data and models to transform in vitro concentrations to doses that can be compared to the units of exposure for an endocrine bioactivity:exposure ratio (BER). A BER may be a useful metric for prioritization of substances for further evaluation. This presentation provides a brief overview and update on the status of available tools for such a hazard and risk screening workflow. An initial source of endocrine activity information can be defined using results from quantitative structure activity models including the Collaborative Estrogen Receptor Activity Prediction Project (CERAPP) and the Collaborative Modeling
Project for Androgen Receptor Activity (COMPARA); these models provide information for tens of thousands of chemical structures, well beyond the scope of high-throughput screening (HTS) in vitro. HTS data from the ToxCast program have been used to inform models of estrogen and androgen receptor activity and steroidogenesis disruption, and additional HTS assay data are available for thyroid-related bioactivity. HTS bioactivity data and models should be considered in concert with other available information on cytotoxicity, often referred to as the cytotoxicity “burst” threshold that typically aligns with an increase in the number of non-specific assay responses in vitro. For transformation of bioactive in vitro concentrations to external doses for comparison to exposure doses, an R software package that operationalizes high-throughput toxicokinetic modeling using toxicokinetic data from in vivo, in vitro, and/or in silico experiments, HTTK, is available with iterative refinement. Finally, a new meta-model for aggregate population median exposure, ExpoCast, is now available. Much of this information is already viewable in the CompTox Chemicals Systematic Empirical Evaluation of Models (SEEM3), is now available. This abstract does not necessarily reflect

### 74 Predicting Endocrine Disruption with Estrogen Receptor Machine Learning Models

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Endocrine disruption is a major focus of toxicology research today, driven by government initiatives/responses for the evaluation of environmental risks to the population. The estrogen receptor is a major target of interest, but the downstream effects of activation are difficult to anticipate without expensive, time-consuming in vitro and in vivo testing. The Environmental Protection Agency (EPA) ToxCast program periodically releases high-throughput screening assay data across a wide variety of targets and biological processes. This data has been used by the EPA to construct mathematical models from early and intermediate molecular initiating event assays to predict and rank the likelihood of estrogen receptor activation. However, mathematical models require the in vitro data and lack the power of prospective prediction from molecular structure alone. Bayesian machine learning models (BMLMs) have shown applicability in using drug discovery and toxicology data. The current study describes several groups of BMLMs using either in vitro ToxCast estrogen receptor bioactivity data, the output data of EPA mathematical models, or data which incorporates cytotoxicity considerations. Performance of the BMLMs was evaluated by internal five-fold cross-validation statistics and cross-referencing output predictions with three sets of external in vitro and in vivo reference chemicals. These predictions were generated across all models and evaluated to produce an overall active/inactive classification of the potential for downstream effects of estrogen receptor agonism. These classifications were compared to the results reported by the previous mathematical model studies, notably those published by the EPA; BMLM predictions were equivalent to or exceeded benchmark results. The best performing datasets were selected for further comparison of alternative machine learning algorithms (e.g. support vector machines, deep neural networks). This study was limited to machine learning methods and yet demonstrated that prospective prediction is attainable from a suite of estrogen receptor activation models; this represents a starting point for incorporation of advanced models into the evaluation of endocrine disruption and activity potential on the basis of molecular structure alone. This methodology can be extended to other aspects of endocrine disruption such as the androgen pathway and steroidogenesis.

### 75 Effects-directed analysis of endocrine-active sediment samples from the Chesapeake Bay Watershed


The Chesapeake Bay Watershed contains agricultural, industrial, and commercial activities. These activities release complex chemical mixtures that may cause the high prevalence of intersex and immunosuppression observed in resident smallmouth bass (Micropterus dolomieu). To better understand the link between chemical mixtures in the watershed and smallmouth bass health, we utilized effects-directed analysis (EDA). Our EDA process combined in vitro tests for endocrine activity with analytical chemistry methods (ultra performance liquid chromatography-quadrupole time-of-flight-mass spectrometry [UPLC-QTOF-MS]) to characterize endocrine active compounds (EACs) from various locations in the Chesapeake Bay Watershed. Sediment and large-volume (30-50 L) water samples were collected in two different seasons in consecutive years from several sites in the Chesapeake Bay Watershed. Extracts of these samples were tested in two estrogen-responsive chemically-activated luciferase expression (CALUX) cell bioassays (the human VM7Luc4E2 and VM7LucERβc9 cell lines), two aryl-hydrocarbon-responsive CALUX cell bioassays (the human HG2L7.5c1 cell line and rat H4L7.5c2 cell line), and a glucocorticoid/androgen-responsive CALUX-type cell bioassay (the human MDA-kb2 cell line) to screen for EACs in the samples. Both anti-estrogenic and aryl-hydrocarbon activity were observed in sediment samples from one site, and potent estrogenic activity was observed in sediment from a second site (we observed low potency or no activity in sediment from the remaining sites and water at all sites). To facilitate identification of specific chemicals, sediment extracts from Sites 1 and 2 were fractionated and the fractions tested for activity in the CALUX cell lines. One broad peak of anti-estrogenic and aryl hydrocarbon activity was visualized in the “biogram” (the bioassay assessment) of the fractions from Site 1 sediment, and four distinct peaks of estrogenic activity were observed in the biogram of fractionated sediment extracts from Site 2. These bio-active fractions of Site 1 and 2 sediment extracts were evaluated using UPLC-QTOF-MS to further characterize EACs that may be associated with intersex and immunosuppression prevalence in Chesapeake Bay smallmouth bass.

### 76 Affinity Explains Estrogen Receptor Potency Impacts and Toxicity Prediction in Chemical Mixtures

**L. Burgoon, US Army Engineer Research and Development Center / Environmental Laboratory**

Humans, plants, and animals are a bag of chemical mixtures. These include endogenous as well as exogenous chemicals. Given that there are trillions of molecules of endogenous chemicals that have varying affinity for the estrogen receptor (and this is true for other receptors as well), a key question in biochemical pharmacology is how can the estrogen receptor still operate properly even when constantly being bombarded by all of these endogenous chemicals. Expand this same question to now include exogenous chemicals, and suddenly this becomes a biochemical mixtures toxicology question. In this presentation I will introduce the Chemical Affinity, Potency and Efficacy (CAPE) Theory of Mixtures, which demonstrates how multiple chemicals operating at the same receptor will actually function at environmentally relevant concentrations. Specifically, I will demonstrate how the endogenous estradiol actually functions in the presence of lots of competing chemicals, including the exogenous chemical, bisphenol A (BPA). This work will also demonstrate why BPA does not exert estrogenic activity in humans or animal models in vivo, and at what blood and exogenous levels BPA would need to reach in order to exert an estrogenic effect in humans. This presentation will also demonstrate what happens when there are thousands or millions of competing chemicals at very low doses with varying levels of affinity for the estrogen receptor, and how they may or may not disrupt estrogen signaling. This work builds further support for the idea of the
human-relevant potency threshold. The US Army Chief of Engineers has approved this paper for release. The views presented in this article do not necessarily reflect current or future opinion or policy of the U.S. Army Corps of Engineers.

77 Screening for Chemical Inhibition of the Iodide Recycling Enzyme, a Novel Molecular Target for Thyroid Axis Disruption


Environmental contaminants can disrupt thyroid function through a variety of molecular mechanisms, however some putative molecular targets have little known of their toxicological relevance, including susceptibility to chemical perturbation and resulting adverse organismal effects. The iodide recycling enzyme, iodotyrosine deiodinase (IYD), is one conserved putative molecular target that plays an essential role in maintaining adequate levels of free iodide in the thyroid gland for hormone synthesis. Thyroid disruption has recently been demonstrated in a model amphibian (Xenopus laevis) following in vivo IYD inhibition. These effects, along with previously documented effects in mammals, support the biological importance of IYD for proper thyroid function. Here we present development and application of screening assays to assess susceptibility of IYD to chemical perturbation and cross-species concordance between two IYD orthologues. With recombinant human IYD (hIYD) enzyme and Xenopus laevis liver microsomal fractions (xIYD), 96-well plate in vitro assays were developed to screen chemicals for inhibition of mammalian and amphibian IYD enzyme activity. The ToxCast phase 1, v2, phase 2, and e1k chemical libraries were screened using the hIYD assay. Of the over 1,800 unique chemicals tested, less than 200 (~11%) inhibited hIYD activity by 20% or greater at a single, high concentration (target of 200 µM). Further testing of 155 chemicals in concentration-response was conducted to determine IC50s and rank-order potency; this set of chemicals included 83 that produced inhibition of 50% or greater, 22 that produced low to moderate inhibition (20-50%), and 50 non-inhibitors. These same 155 chemicals were tested in concentration-response using the xIYD assay. There was strong cross-species agreement between inhibition of hIYD and xIYD (similar maximum inhibition and potency across most chemicals), with a few notable exceptions. These results greatly expand the number of compounds tested for inhibition of IYD and suggest that, in general, response of IYD activity to potential chemical inhibitors is conserved across these vertebrate species. Combining in vitro screening results, such as presented here, with targeted in vivo testing lends an iterative approach for characterizing the causal linkages between chemical inhibition of a specific molecular target and thyroid-related adverse outcomes. This abstract does not necessarily reflect USEPA policy.

78 Human-Relevant Potency Threshold for ER alpha Agonism

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The ability of chemicals to produce physiological effects depends on pharmacokinetics and potency via the modes of action (MoAs) underlying the effects. Besides pharmacokinetics, a chemical’s ability to produce a physiological effect via a particular MoA depends on its affinity for the functional components (receptors, enzymes, transporters, etc.) that comprise the MoA and the ability to alter their functional state (activity). We tested the hypothesis that a minimum level of mechanistic potency is required for chemicals to produce physiological effects by a particular MoA in humans by comparing their potencies for the ERα-agonist MoA to data from clinical trials of estrogenic effects. Systematic literature searches identified potency data for transcriptional activation of human ERα (ERTA) and for rodent uterotrophic activity (RUA) for chemicals with consistently observable, possible, and no physiological estrogenic effects. Mean relative potencies (17β-estradiol reference) in the ERTA ranged from 3.5E-02 to 1.00 for endogenous estrogens (11 data points), 2.6E-02 to 2.0E+00 for pharmaceutical estrogens (19), 3.3E-05 to 7.0E-02 for botanical estrogens (109), and 2.5E-06 to 7.1E-06 for synthetic and endogenous androgens (5). ERTA potencies were corroborated by RUA data which showed similar rank orders at 0.5 to 1E-01 the ERTA potency. Physiological estrogenic effects in clinical trials are clear for endogenous hormones and pharmaceuticals, absent for androgens, and were equivocally observed for botanical estrogens with relative ERα-agonist potencies in the range of 1.0E-03, but not lower. Based on this approach and analysis, we conservatively propose a human-relevant potency threshold (HRPT) for ERα agonism of 1E-04 relative to the potency of the endogenous estrogenic hormone 17β-estradiol or the pharmaceutical estrogen, 17α-ethinylestradiol. This approach provides a practical means for addressing hazard identification based on MoAs, for defining common assessment groups for mixtures risk assessment, and for determining candidate chemicals for AOPs. Preliminary analysis suggests future work could extend the approach to ecological species by de-novo evaluations or possibly by species-extrapolation of potency data for conserved homologous molecular targets.

79 Mechanistic Potency is an Important Tool in Hazard Identification

E.M. Mihalch, ER2; C. Borgert, Applied Pharmacology & Toxicology, Inc.

Regulatory initiatives for identifying and managing chemical endocrine disruptors (EDs) are being developed and implemented in several jurisdictions in response to concerns that exogenous chemicals may interfere with the endocrine systems of humans and environmental organisms. According to the World Health Organization’s International Programme on Chemical Safety, an ED must (1) alter the function of the endocrine system; and (2) as a consequence of that alteration, cause an adverse health effect in humans or wildlife. This definition requires a causal link between the endocrine mode of action (MoA) and the adverse effect. However, with the publication of the ECHA/EFSA guidance for the identification of EDs, this requirement for a causal association appears to have shifted to one that is “biologically plausible.” This is a very different criterion, especially when the guiding regulatory approach is one of hazard and not risk. Pathway models are being established that provide plausible links between molecular initiating events, key events and ultimately adverse effects. However, when several potential pathways or MoA converge on the same adverse effect in an intact organism it becomes challenging to identify the biologically plausible causal link between the MoA and the environmental or health effect of concern. To minimize the risk of misidentification of an endocrine MoA, an objective and transparent weight of evidence (WoE) procedure based on biological plausibility, essentiality, and empirical evidence is recommended. In order to determine whether it is biologically plausible that a chemical produces an adverse effect via an endocrine MoA, i.e., that it might fit the definition of an ED, the mechanistic potency must be evaluated to measure the strength of a chemical’s activity via a specific endocrine MoA. We present a case study that applies a recently published potency threshold methodology to two chemicals identified on various lists of Endocrine Disrupters, a cyclic siloxane and bisphenol A. Mechanistic potency was evaluated along with other relevant information in a WoE framework to determine the potential for the chemical to meet the definition of an ED.
Natural and Ambient Soil Background Studies and Their Utility in Risk Assessment

80 Establishing Soil Background for Use in Risk Assessment Using USGS’s Data
B. Brooks, Minnesota Pollution Control Agency / Environmental Analysis and Outcomes

The amount of metal present in soil due to natural background is important to consider when conducting risk assessments. Health-based soil values, derived using toxicity data along with exposure and metal specific parameters, are used to estimate risks to people and ecological species. For some metals, health-based soil values are below natural background levels. In these cases, most regulatory agencies will replace the metal specific health-based soil value with a soil background value when conducting risk assessments. The preferred method of establishing a soil background value is to conduct a soil study in the area being assessed, but this is not always possible as these studies are often costly and require significant effort. As an alternative method, we consulted with the United States Geological Survey (USGS) regarding their 2007 to 2010 Soil Survey of the Conterminous United States, to establish soil background values for some inorganics. USGS and EPA use different soil preparation and analytical methods; EPA’s method is typically used to evaluate soil in risk assessment. For some chemicals, there may be significant differences in the results from these two methods. We compared the results of USGS and EPA’s methods by reanalyzing a subset of USGS’s soil samples collected in the state of Minnesota using EPA’s methods. Results between the two methods varied from no significant difference in the analysis of arsenic to a significant difference in the analysis of aluminum and barium. We used this information and EPA’s ProUCL statistical software to establish soil background threshold values (BTV) applicable to the state of Minnesota.

81 The Development of Regional Background Concentrations with the Consideration of Naturally Elevated Areas
S. Fernandes, H. Phillips, C. Lucas, N. Thackeray, CanNorth

Establishing background soil concentrations is an important part of risk assessment, and provides context to the data and results. A robust estimate of background concentrations will help strengthen the risk assessment and can be used to inform risk management decisions. Guidance from the Canadian contaminated site program (FCSAP 2015) indicates that background soil should be representative of the true range of concentrations associated with the geographic area of the site. In addition, the CCME (2006) guidance document “A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines” provides a definition of a background concentration as a representative ambient level for a contaminant in soil or water. They note that “ambient concentrations may reflect natural geological variations in relatively undeveloped areas or the influence of generalized industrial or urban activity in a region.” Thus, background concentrations can represent natural conditions based on geological formations or ambient conditions representing the sum of natural background concentrations and large-scale regional anthropogenic contamination (CCME 2016). In some areas in Canada there are natural geologic formations, such as volcanic rock areas which contain ore deposits of gold, silver, copper, zinc and lead making it a prime location for mining activities. These may not be representative of the surrounding areas that do not have these geological conditions and thus have lower concentrations. This presentation discusses an approach for development of background concentrations within an area of natural geological conditions as well as more regional conditions and how various considerations of background can be used in risk assessment. The discussion will use arsenic as an example and will touch on different statistics to describe background as well as the handling of method detection limits.

82 Contrasting Methods for Relative Human Health Risks Based on Background Soil Contribution
C. Peterson, T.M. Biksey, EHS Support / Risk Assessment

To evaluate potential cancer risks and non-cancer hazards in soils from anthropogenic sources and inform risk managers on the need for remediation, a human health risk assessment was conducted using the results of soil sampling conducted at a site to estimate potential excess lifetime cancer risks (ELCR) and hazard quotient/hazard indices (HQ/HI). Chemical concentrations occurring naturally in the soil exceeded human health risk-based screening levels. As a result of these elevated naturally occurring levels, cancer risks and non-cancer hazards calculated for the site also exceeded target cancer risks and target non-cancer hazards. To provide context around the contribution of naturally occurring risk in soils to the cumulative ELCR and HI, a background risk characterization was conducted. To quantify background concentrations, site-specific soil samples were collected from an area not affected by the anthropogenic activities of the site. These samples were submitted for comparable chemical analysis as soil samples analyzed during site investigation activities. Using the site-specific background soil results, two methods to evaluate the contribution of background risks relative to site risks were conducted to inform the risk managers on sources of anthropogenic risk drivers. Method 1 calculated the ELCR and HI from background data for all receptors across all exposure pathways; Method 2 calculated the ELCR and HI from background data specifically for risk drivers identified during the risk characterization of site data. For Method 1, an exposure point concentration (EPC) was determined for each chemical and input into intake equations. The ELCR and HQ were then calculated for each chemical and summed across each pathway to identify a cumulative ELCR/HI for each receptor to provide the contribution to risks from background soils. In Method 2, the EPC for each risk driver was calculated as well as the individual ELCR/HQ for the chemical and the percent contribution of the ELCR/HQ of background to the overall ELCR/HQ for the chemical. Both methods provided insight into the contribution of background concentrations to cumulative risk and hazards and focus remediation efforts. The differences in costs and time spent conducting the two methods was summarized.

83 Role of Arsenic Background Soil Concentrations in Risk Assessment: Hanford Site Case Study
D.A. Delistraty, E.A. Rochette, Washington State Department of Ecology

Several studies have evaluated background soil metal concentrations in Washington state, including the U.S. Dept. of Energy (USDOE) Hanford Site. Arsenic (As) is notable, since it is often a risk driver. The purpose of this study was to evaluate the relationship between As background soil concentrations and soil cleanup levels in order to frame As background risk. Arsenic background soil concentrations were compiled from relevant studies (both statewide and at Hanford) and compared against As soil cleanup levels (for human and ecological receptors, obtained from EPA and state sources). Risk-based As soil cleanup levels for human health (e.g., 0.0015-0.77 mg/kg, 1E-6 cancer risk) are typically 1-3 orders of magnitude below background (7.0 mg/kg statewide, 6.5 mg/kg at Hanford, 90th percentile) and sometimes below the practical quantitation limit (0.1-1 mg/kg). Consequently, risk-based As soil cleanup levels for human health often default to background. In contrast, ecological screening levels for As (e.g., 7-132 mg/kg) are similar to or exceed soil background concentration. Soil waste sites at Hanford may contain As from both naturally occurring and anthropogenic sources (e.g., former orchard lands). USDOE has previously presented risk with and without As to highlight its contribution to total site risk at Hanford and to more clearly show risk from other contaminants, respectively. Subsequently, a 2013 policy decision by the Washington State Dept. of Ecology allows soil background concentration of As at Hanford to be set at 20 mg/kg (~3-fold increase over measured background). This policy effectively establishes a soil cleanup level for As at 20 mg/kg at Hanford to reduce remedial cost and to promote consistency with area-wide cleanups associated
with anthropogenic sources in Washington (e.g., smelter plumes, orchard lands). A soil concentration of 20 mg/kg for As may correspond to human cancer risk levels, ranging from 3E-5 (soil direct contact) to 1E-2 (soil to protect groundwater ingestion), using exposure scenarios employed in EPA's Regional Screening Levels (RSLs) for soil. These observations clearly demonstrate that As is a risk driver at background levels. To illustrate components of risk at Hanford, and for consistency with EPA guidance that encourages retaining hazardous substances with concentrations that exceed risk-based screening levels, risk assessments should present results with and without As.

84 Characterizing Urban Background: A Collaborative Study in the Southeastern United States

T. Frederick, G. Adams, B. Alfano, S. Chan, USEPA / Region 4; F. Barnett, R. Ford, B. Schumacher, USEPA / Office of Research and Development

Soils in urban settings are likely to contain elevated levels of certain metals and/or polynuclear aromatic hydrocarbons (PAHs), due to human activity, non-point source industrial operations, and infrastructure materials. Because these increased contaminant concentrations are due to anthropogenic urban activity and not site-related point source releases, they can be considered to represent urban background soil concentrations. Whether certain soil contaminant concentrations are site-related or are part of natural or anthropogenic background is a question that frequently arises during environmental site investigations in urban settings. Robust data on urban background concentrations on a large scale is lacking, which can complicate decision making. To address these issues, EPA Region 4 (Atlanta) partnered with EPA's Office of Research and Development and all eight Region 4 States to conduct an urban background study. Project goals include the creation of a Region-wide urban background database that can be used to inform decision making across the Region and the creation of standardized procedures that can be used in other cities and Regions where the collection of robust and defensible background data is a priority. The project team has collaboratively collected data from eight cities in the Southeastern United States. This presentation will address the project methods and findings to date.

85 Background Concentrations of Polychlorinated Biphenyls, Polychlorinated Dibenzo-p-dioxins, and Polychlorinated Dibenzofurans at Superfund Sites

M.K. Lambert, US Environmental Protection Agency / Office of Superfund Remediation and Technology Innovation; K. Palaia, P. Sinski, K. Lamb, ICF

A robust background data set may be important for a variety of risk assessment and management purposes. Where risk-based Preliminary Remediation Goals (PRGs) are below background, it may be used to set the Cleanup Level (CUL). Often, this is true of PRGs for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (D/Fs), and polychlorinated biphenyls (PCBs). To understand how background levels are likely to affect Superfund remedy decisions, the Office of Superfund Remediation and Technology Innovation reviewed sites with D/Fs or PCBs in either soils or sediments for background datasets. The goal was to compile background concentrations near Superfund sites (including urban, rural, industrial, and residential areas) to understand the common challenges with developing and using background data. The study also sought to compare background values observed at Superfund sites to other published background studies for D/Fs and PCBs. The Superfund Program database was queried for site Records of Decision that were signed after 2002 and had D/Fs or PCBs as contaminants of concern in either soils or sediments. The administrative records of these sites were searched for information on background concentrations. The reported background concentrations and important meta-data, such as the number of samples collected and analytical methods, were collated, summarized, and compared to the final CULs for the site. There has been a steady increase over time in the number of background studies being conducted, although background sampling is more common at PCB sites than D/F sites. Ranges of background PCB and D/F concentrations in soil and sediment span several orders of magnitude. Reported background concentrations for PCBs and D/Fs in sediment span a similar, but lower, range than that of the final CULs. Reported background concentrations for PCBs and D/Fs in soil span a smaller range than that of final CULs. While background concentrations in the past tended to be lower than the CULs, recent changes in toxicity values, the consideration of additional exposure pathways, and incorporation of higher fish consumption values have lowered more recent CULs. Most sites surveyed used background concentrations in the development of the conceptual site model and as part of a risk assessment. Recently, several sites also formally incorporated background concentrations into the PRG and CUL selection process and a few sites have set the CUL to background.

86 Per- and Polyfluoroalkyl Substances (PFAS) Regulatory Values for Soil in the Context of Background Concentrations

C. Faith, K. Hathaway, Barr Engineering Co.

PFAS regulatory values for soil are being set below one part per billion (ppb) in several jurisdictions. At the same time, recent regional and global background studies have detected PFAS in soils at background levels exceeding one ppb. The methods used and considerations given to set the PFAS regulatory values for soil vary greatly between agencies including recent regulatory directives from certain agencies to evaluate the potential for PFAS to leach from soils using Synthetic Precipitation Leaching Procedure (SPLP). The presentation will compare and contrast established or proposed PFAS regulatory values for soils, how these values have been developed, causes for variability in these values and how these values relate to background levels. A compilation of hypothetical groundwater protection values, based on the methods used by various regulatory agencies, will be also be presented. The information presented will illustrate the relevance of background PFAS levels in the investigation and risk assessment at PFAS-impacted sites.

87 Establishing Soil Background Concentrations of Polynuclear Aromatic Hydrocarbons from Wildfire Sources

K. Patel-Coleman, AECOM

There are various sources of polycyclic aromatic hydrocarbons (PAHs) in the environment, both natural and anthropogenic. Anthropogenic sources of PAHs are often associated with environmental pollutant cleanup programs to protect human and environmental health. These sources typically come from crude oil related releases or industrial processes involving organic matter combustion, such as petroleum refining, coal gasification, chemical production, or incineration. Human exposures to PAHs may result in carcinogenic, mutagenic and immunosuppressive effects. Ecotoxic effects include tumors and adverse reproductive, developmental and immunological outcomes. However, because there are also natural sources of PAHs, such as wildfires, petroleum or coal seeps, and volcanic activity, it becomes imperative that cleanup programs for potential PAH releases consider the contribution of PAH concentrations from these natural sources as background levels. Various published studies report soil background PAH concentrations from both natural and anthropogenic sources. For certain geographies, such as the western United States, wildfires are commonplace and sometimes encroach upon urban areas, representing a potentially significant source of natural soil background PAHs for cleanup sites located in the vicinity of the wildfires. This presentation will review available literature on natural soil PAH concentrations with a particular emphasis on wildfire sources. In addition, wildfire air quality data as indicators of potential background soil PAH concentrations through aerial deposition will be considered.
Monday Platform Abstracts

Breaking Down Barriers in Science Communication: Methods, Language and Tools - Let’s Get Everyone Engaged

88 Science outreach through your local SETAC NA Chapter: Laurentian SETAC engages with its membership and the local community

E.A. Gilroy, Environment and Climate Change Canada / Aquatic Contaminants Research Division; O. Bireceanu, Wilfrid Laurier University / Biology; Y. Gopalapillai, Environment and Climate Change Canada / Department of Earth & Atmospheric Sciences; N.C. Feisthauer, Agriculture and Agri-Food Canada (AAFC) / Science and Technology Branch; R. Frank, Environment and Climate Change Canada / Water Science and Technology Directorate; L. Chibwe, Environment and Climate Change Canada / University of Guelph / School of Environmental Sciences; S. Roberts, Environment and Climate Change Canada / Aquatic Contaminants Research Division; R.K. Giles, University of Toronto / Department of Ecology and Evolutionary Biology

In 2016, in light of increasing awareness of the importance of equity, diversity and inclusion (EDI) in science, the Laurentian Chapter of SETAC (L-SETAC - the Ontario, Canada Chapter of SETAC) created the Diversity in Science Committee (DISC). The DISC’s mandate is: implementing EDI practices within all of our Chapter activities; highlighting the achievements of women and members of other underrepresented groups; raising awareness of disparity in science (e.g., disparity in representation and opportunities); and creating mentorship opportunities for up-and-coming scientists. The establishment of the International Day of Girls and Women in Science, first celebrated in 2017, has been an unparalleled opportunity to communicate science to a diverse audience, while addressing questions and issues related to of diversity and equity. L-SETAC has been celebrating this event since 2017, by engaging its members and the community in discussions and activities relevant to science and EDI. Such events included photo-research exhibits by Dr. Eden Hennessey (2017) that uniquely communicated issues of sexism and gender discrimination in science, a tripartite panel (2018) discussion entitled We are Here: Constructive Actions Towards Achieving Equity in Science,” and a “Science on the Road” event (2019) to engage local high-school students in science. The 2019 event was themed “The Many Faces of Environmental Science,” where government, consulting and academic groups shared their love for science with high-school students, highlighted the diversity of career paths that are available in the field, and provided discussion points on how everyone has a voice in working towards equity. In this presentation, we will describe the various activities that the L-SETAC Chapter has done to promote EDI while also engaging with its community and member in science outreach and communication. We will discuss how we approached our different partners to promote and organize our events and will touch on future directions. Although regional chapters are small by comparison to the parent organization, SETAC North America, we strongly believe that each chapter has a powerful voice that can make a difference in their respective communities.

89 Science Education and Public Outreach- lessons from the IISD Experimental Lakes Area

S. Warrack, IISD-Experimental Lakes Area / Department of Environment and Geography; P. Gerrard, IISA-ELA

The International Institute for Sustainable Development Experimental Lakes Area (IISD-ELA) is an exceptional natural laboratory comprised of 58 small lakes and their watersheds in a sparsely populated region of Northwestern Ontario, Canada set aside for scientific research. Through whole ecosystem research on these small freshwater systems, scientists can examine how all aspects of the ecosystem respond. This unique research approach has influenced billion-dollar decisions of governments and industries and has generated more cost-effective environmental policies, regulations and management of large lakes and freshwater systems around the world. This presentation will use IISD-ELA’s 50 years of experience to examine the connections between science education, and public outreach. We will explore our current strategies for both our science programming, and public outreach as well as lessons learned through our successes and failures. Through our educational programming efforts we hope to build legitimacy in our freshwater science.

90 AquaSONG: An Interactive Field Trip Program to Inspire Future Scientists

G. Bruun, Wilfrid Laurier University / Center for Cold Regions and Water Science

Scientific research and discovery underlay many of the primary needs and daily activities within a community; from food and agriculture, to transportation, to communication and leisure. Despite this reliance on scientific endeavors, an understanding of basic science and an appreciation for the role science plays within society is often limited, ignored, or considered elitist. To foster a change in this trend, young people need to be inspired and excited about science revived. Hands-on experience with science in a local setting is one method for achieving this goal; however, current school budgets often leave little room for innovative activities. Too connect with the local community, share scientific knowledge, and inspire high school students, Wilfrid Laurier University initiated the Aquatic Science Outreach Network for the Grand (AquaSONG). AquaSONG is a full day field trip that engages and inspires high school students in the field of water science through field sampling and laboratory analyses. In addition, students may apply their own creativity to the challenge of water treatment. As a participant in AquaSONG, each student collects samples from a waterbody near a wastewater treatment plant or builds filters to replicate wastewater treatment processes. Under the direction of experienced Laurier staff, they assess these samples using sophisticated laboratory equipment and use microscopy to investigate the aquatic environment. AquaSONG began in 2016 and has grown dramatically. With continued Laurier funding and additional NSERC support, this project aims to reach approximately 500 students each year. This presentation will provide details on how AquaSONG began, how funding is obtained, the daily structure of the program, and advertising and media strategies. Challenges and successes will be included in the discussion.

91 Mama Aki Camp: Challenges, Successes, and Lessons in Indigenous Science Outreach

J. Duke, Wilfrid Laurier University / Indigenous Initiatives and Services; A. Strauss, S.M. Ramsay, F.C. Guinel, Wilfrid Laurier University / Biology

Indigenous youth are under-represented in the Science, Technology, Engineering and Mathematics (STEM) fields. In 2018, Wilfrid Laurier University launched the week-long Mama Aki / Mother Earth Camp to help address this issue. The goals of the camp are to engage Indigenous youth in the sciences and link science with Indigenous knowledge. The 2018 pilot camp targeted students in grade 7, with the initial challenge being recruitment for the camp itself. To increase attendance, it was essential to gain both the trust of the parents and that of the community. To resolve this challenge we included the involvement of respected community members, provided information sessions for parents and children, and conducted in-class visits. The trust of the parents was important as many of the children were experiencing the freedom of on-campus residence for the first time. Once the participants arrived in Waterloo, the challenge shifted to keeping activities entertaining and engaging while considering and expanding on the grade 7 Science curriculum. We presented relevant topics including biodiversity, ecosystem health, sustainability, diet, and waste management in fun and relatable ways. Throughout the week, elders and knowledge keepers helped link and incorporate traditional Indigenous knowledge. The campers loved the opportunity to explore the microscopic world they had learned about in school. At the end of the week, the campers left wanting more. The overall feedback was positive, expressed as a desire to return with friends for the 2019 camp. As a result, Mami Aki expanded and improved. We have two separate camps scheduled for the summer 2019: the revised grade 7 camp and a second advanced camp for grade 8 students. The advanced camp
aims to build on concepts in the grade 8 Science curriculum, includes more experiments, and revisits topics and locations from 2018 in new ways. The new camp experiments include documenting the development of Artemia salina, live observations of various protists and plant cells, and an introduction to paleoecology. We see this program as a successful model to share with other institutions looking to build offerings in support of under-served communities.

92 Going from scientist to science writer
B. Borowiec, McMaster University / Biology
The difficulties of accessing and digesting peer-reviewed research papers lead most members of the general public to rely on popular science articles, often written by non-specialist journalists, to stay informed about contemporary scientific research. By participating in popular science writing, scientists can reach new audiences, become more aware of public interests, and even correct the narrative around their work. Moreover, scientists can leverage their specialized knowledge and skills to increase the accuracy, quality, and diversity of writing about science. Unfortunately, getting into popular science writing as a scientist is difficult due to lack of formal training opportunities, different styles of writing, and strong cultural differences between the academic and popular press. I will use my experiences as a scientist, freelance popular science writer, and assistant editor at a popular science media outlet to discuss how scientists can get started with science writing, avoid some common pitfalls and barriers especially relevant to scientist-science writers, and how the inclusion of more scientist-science writers could improve the popular science landscape.

93 Do Scientific Publications in Environmental Toxicology and Chemistry (And Other Journals) Make A Difference?
G.A. Burton, University of Michigan / School for Environment and Sustainability; J. Lynch, SETAC
The high-quality science published in Environmental Toxicology & Chemistry (and elsewhere) supports SETAC’s motto of “Environmental Quality through Science.” But, does our science improve environmental quality? It appears the answer is yes: As we have learned about the ecological fate and risks of some chemicals their uses have been restricted; approaches to site assessments have been improved and guided restoration and remediations; and regulatory guidance and criteria have been improved. Nevertheless, we are failing in many ways to improve ecological risk assessments (covering different regions, agencies, and client-types) and discuss how to write and communicate more effectively for specific audiences. This presentation will also cover an example of on-the-job communication training for scientists and risk assessors.

95 The Duke Furniture Foam Testing Project: A Case Study in Citizen Science, Research Translation, and Science Communication
The National Institute of Environmental Health Sciences promotes environmental health science communication by requiring each of the funded Superfund Research Program Centers to have a Research Translation Core (RTC). Along with analytical chemistry support, the RTC at the Duke University Superfund Research program administers the Duke Furniture Foam Testing Project (http://foam.pratt.duke.edu). This free service screens samples of polyurethane foam submitted by the public for the presence of nine common flame retardants. Chemical flame retardants have been detected in household items such as couches, mattresses, car seats, and some baby products. Scientific evidence suggests that exposure to these chemicals occurs in the home and may elicit adverse health effects. Because manufacturers are not required to disclose the specific flame retardant used in a product, public access to and awareness of such information is limited without laboratory testing. The RTC interprets and disseminates the results for each submitted foam sample, and answers questions from individuals about their test results. In addition, the RTC has developed research-based educational materials for participants. The RTC recently evaluated the effectiveness of these materials in a survey of all past participants from the last 4 years. Survey questions assessed knowledge of potential exposure and health risks, flame retardant regulations, and behavior change. The response rate of the pilot survey was 45% (n=100). The full survey (n=1,000) will be distributed in June of 2019. In the pilot survey, more than 70% of participants had flame retardants detected in their samples. Almost 90% of survey respondents reported sharing the results with family or friends, suggesting the importance of this type of education. In order to invite the public, the Foam Testing Project aims to serve as an ideal platform to monitor trends in commercial flame retardant use, and helps direct future scientific research. This case study demonstrates the public’s interest in engaging with science, guides development of other RTC initiatives, and furthers RTC goals of increasing environmental health literacy and cultivating skilled science communicators.
applications is a hallmark of our society and is manifested throughout SETAC workshops, publications, and topical initiatives. It is inherently connected with bringing a multi-sector view to problem solving.

**97 The evolution of ecological risk assessment**

**A. Fairbrother**, Exponent / EcoSciences

Ecological risk (ecorisk) assessment is the art and science of predicting the probability of an adverse outcome to the environment as the result of a specified human activity, generally related to release of chemicals to the environment. This practice, initiated primarily as an assessment art, began in the late 1960s in response to the publication of Silent Spring by Rachel Carson when the US Department of Agriculture began considering the potential for adverse effects from birds from the use of pesticides. This was a simplistic analysis that compared known levels of toxicity to estimated environmental concentrations, i.e., what has become known as a hazard quotient. When the USEPA took over pesticide registration in 1972 and began similar assessments for industrial chemicals in 1976, they continued the same approach, developing standardized toxicity test protocols for a long list of species/endpoints and upgrading the sophistication of exposure models. The Framework for Ecological Risk Assessment, published by USEPA in 1992, was a major step forward as it emphasized the importance of the Problem Formulation step and explicit descriptions of assessment endpoints. The science of ecorisk has advanced to include uncertainty and reporting of results as probabilities (the true definition of risk) instead of deterministic hazard quotients. Expressing risks in ecological terms such as changes in population growth rates or community biodiversity metrics also has proven scientifically feasible. Similarly, techniques have evolved for assessing risks on ecologically relevant scales, such as watershed assessments that include nonpoint pollution sources. It is unfortunate that the science of ecorisk, developed by SETAC scientists through research, publications, and multisectoral SETAC workshops, has evolved at a much faster rate than regulatory applications. The art of the possible is truly exciting; scientists now need to partner with educators and communication specialists to bring the best available tools and strategies to managing the risks of chemicals that are integral to our modern lifestyle and provide useful and meaningful information to the decision makers charged with protection of our overall societal interest.

**98 Landscape scale ecological risk assessment and the development and use of the Bayesian network relative risk model**

**W.G. Landis**, Western Washington University / Institute of Environmental Toxicology

In 1997 it had become apparent that the original formulation of ecological risk assessment was not applicable for our project on the fjord of Port Valdez, AK. In this case study there were multiple stressors operating on multiple endpoints over a diverse marine and freshwater landscape. Janice Wiegers proposed the alternative approach of using ranks and filters to describe the interactions in the sources-stressors-habitats-effects-impacts pathway. Methods were developed to incorporate uncertainty and the risk assessment for the fjord of Port Valdez in 1998 demonstrated the applicability of the approach. In the early 2000s the relative risk model (RRM) incorporated Monte Carlo to better describe uncertainty. By 2010 the RRM had been applied to sites in Tasmania, Brazil, Australia, China, the United States, and Chile. The development of the Bayesian network derivative of the RRM (BN-RRM), published in 2012 by Ayres and Landis, broadened the applicability of the approach to better describe uncertainty, sensitivity, and incorporate data from a number of sources. Since the development of the BN-RRM the method has been applied to invasive species, forestry management, a CRCA contaminated site, large scale risk assessments in Australia, emergent parasitic disease in the American Southwest and to develop quantitative AOPs and QSARs, synthetic biology and water flows. The latest development is the incorporation of the BN-RRM into adaptive management for the South River and the Upper San Francisco Estuary.

**99 Quantification of Risks, the Evolution of the Risk Characterization in Ecotoxicology**

**K.R. Solomon**, University of Guelph / School of Environmental Sciences

One can only pity the ancient Romans who threw dice with no concept of the risk (probability) of winning. In the thousands of years since the teachings of the ancient Romans and Greeks, we have advance in many ways but not so much in the understanding or risk and the probability of harm. Risk assessment was focused on humans and was empirical from the time of Hippocrates to 1600s when the word probability was first used to describe risk. In 1854, James Snow tested a hypothesis on the risk and origins of cholera in London and in 1965, Sir Austin Bradford Hill published his eponymous guidelines for causality. Since then human-health risk assessment (HHRA) flourished in the area of human epidemiology. It was only in the 1980 that probability theory was used to determine environmental quality criteria (EQCs) in the work of Stephan and several others, including members of SETAC. At about the time the concepts of risk of harm in the environment were being picked up in the Netherlands and this transatlantic connection resulted in further evolution of the ecorisk concept. Refinements were added over the years and probabilistic environmental risk assessments (PERA) started to appear in journals, including ET&C. The use of species sensitivity distributions has become widespread for setting EQCs, the joint probability distribution (JPC) has become to display tool in risk assessment but full probabilistic risk assessment still eludes or is avoided by regulators. PERA is now ahead of HHRA in the sense that variation in response of ecological receptors is explicitly considered. Cycling back to the some of the guidelines of Bradford Hill, concepts such as weight of evidence and adverse outcome pathways are increasingly being used to better understand responses and their propagation to apical endpoints.

**100 The best of all worlds: Integrating decision analysis and causal modeling with ecological risk assessments**

**J.E. Carriger Jr., US Environmental Protection Agency / National Risk Management Research Laboratory**

For the past several decades, the ecological risk assessment (ERA) process has been an instrumental tool for government agencies to protect and evaluate risks to environmental resources. Predicting the future of ERA is difficult because of the many methodological improvements currently under development. One direction that has the potential to be especially useful for managing risks is the integration of ERA with decision analysis frameworks and tools. The primary goal of an ERA process is to provide information for decision making; consequently, better correspondence between risk assessment and decision making has been a topic of ongoing research and discussion. For example, integrating risk with decision making was a focus of a National Academy of Sciences charge by the United States Environmental Protection Agency in 2009. This was echoed in a 2011 journal special issue article and rejoinder discussions on moving towards a “solution-focused risk assessment” that integrates the decisions under consideration with the design and output of the risk assessment. Decision analysis frameworks and analytic structures can be especially useful for solution-focused ERAs by augmenting the problem formulation stage, the characterization of risks, and the identification of the value of ERA information for risk management decisions. Decision analytic tools that would be useful for an integrative approach for decision modeling in ERAs are graphical modeling approaches as exemplified by Bayesian networks and influence diagrams. Recent advances in causal modeling and inferences with graphical modeling approaches have opened a pathway towards better integration of decision making, risk management, and risk assessment. Graphical models, such as results chains and Bayesian decision networks, are powerful tools for capturing and evaluating the information needed for managing risks. Moreover, incorporating ERAs into the steps of a formal decision analysis approach, one that examines the consequences and quality of candidate decisions, will help ensure that the technical data and analyses are focused on what is needed for examining trade-offs and making more informed decisions.
Behind each ERA is a decision problem. Better correspondence between
decision analysis and ERA will lead to improved risk assessments and
information for managing environmental stressors.

101 SETAC’s role in establishing the science foundation behind life
cycle assessment
J.A. Fava, Anthesis

In 1990, the Society of Environmental Toxicology and Chemistry
(SETAC) sponsored an international Pellston workshop (in Smugglers
Notch, Vermont, USA) where the term ‘Life cycle assessment’ was
coinined. SETAC (NA and Europe) and its global members played key on-
going and global roles in the continued advancement of the understanding
and use of the LCA framework, methodology, and data through effort
through a) SETAC’s own LCA advisory groups, b) establishment and
development of the International Organization for Standardization (ISO)
- life cycle assessment standards, TC-207 - SC5 on Life cycle assessment,
and c) co-founded the UNEP/SETAC Life cycle Initiative. As SETAC
grew and expanded on its own and with its supporters and partners, it
continues to advance the understanding and use of LCA while ensuring
that science is kept at the forefront of LCA development. The presenta-
tion will outline the key roles that SETAC has played in establishing the
scientific foundation for LCA.

102 Life Cycle Assessment: Development and Evolution of Methods
for Addressing Heath and Environmental Life-Cycle Impacts
O. Jolliet, University of Michigan; T.E. McKone, University of California
/School of Public Health; P. Fantke, Technical University of Denmark
/Quantitative Sustainability Assessment Division; B.W. Vigon, Breveja
Environmental Consulting, LLC

Life Cycle Assessment (LCA) aims to compare environmental impacts of
products and services on a functional basis. With life-cycle invento-
ries established, LCA must provide in its Life Cycle Impact Assessment
(LCIA) phase impact factors per kg of chemical emission/extracted
resources, expressed in term of impacts on human health, ecosystem
quality, or resources depletion. In this presentation, we track the development
and evolution of LCIA methods over three decades and focus on the role
of SETAC in collaboration with the United Nations Environment Program
in forming the Life-Cycle Initiative to establish, interpret, and dissemi-
nate a globally harmonized LCIA approach. The Initiative has hosted a
series of complementary efforts for LCIA consensus building, striving for
recommendations and guidance on LCIA methods and factors. SETAC
conferences and Pellston Workshops have provided important venues
for the Initiative process. Three rounds of SETAC working groups have
resulted in category-specific recommendations for developing LCIA
impact indicators, taking advantage of broader consensus efforts, such as
the World Health Organization, USEPA, and EU health risk assessment
efforts. A combination of academic, government, and industry experts
have participated in these efforts. As an informative example we will
review the development and dissemination of the USEtox global scien-
tific consensus model, which provides LCIA characterization factors for
human toxicity and ecotoxicity, and which is now used worldwide. It is the
default tool in both the European Union and North America. We conclude
by considering future needs and opportunities for LCIA with a focus on
the continuing role of SETAC.

103 Panel Discussion on Past Successes and Future Needs in Risk
and Life Cycle Assessment
B.W. Vigon, Breveja Environmental Consulting, LLC; E.J. Dorward-King,
Newmont Mining Corporation / Sustainability and External Relations
A spotlight session at the 40th Annual Meeting of the Society of
Environmental Toxicology and Chemistry (SETAC) represents an opportu-
nity to reflect on our progress, consider the current state of the science,
and look to the future. There will be two panel discussions during this
session: this one from the morning session and one from the afternoon
session reflecting talks in environmental fate and modeling, aquatic
toxicology, and terrestrial and wildlife toxicology. The six representative
speakers and several invited guests will participate in the panel discus-
sion to allow questions and interaction with the SETAC audience. The
speakers will address development of the science and application of risk
assessment and life cycle assessment, particularly highlighting SETAC
contributions over the past four decades, will evaluate and address the
current state of play and will give perspectives on future scientific needs
that could be encouraged through SETAC. This is an excellent opportu-
nity for coordinated discussions from the audience with key leaders in the
field that represent long-standing contributions to the science and applica-
tion development RA and LCA. We believe this session and the discussion
panel will be of historical significance since some of the participants in
this panel will represent expertise in RA and LCA and involvement in
SETAC in these areas for decades. We welcome SETAC members and
guests to join us for this anticipated and very interesting panel discussion
where they will have the opportunity to ask questions and interact with
significant leaders in our fields of science.

Mollusca Toxicology: An Ecological Important and
Imperiled Phyla but Often Left Out

104 Assessing the efficacy of EarthTec QZ for controlling Bithynia
tentaculata populations in the Upper Mississippi River
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The invasive freshwater snail species, Bithynia tentaculata, has become a
growing concern to the Great Lakes and Mississippi River Regions since
its introduction from Europe in the late 1800s. Bithynia tentaculata is a
carrier of multiple parasites that have caused the death of over 200,000
waterfowl since 2002. Because of this, and due to the fact that the species
may be outcompeting native species, there has been great interest in iden-
tifying strategies that mitigate the spread of this snail and its associated
parasites. For this project, we conducted two separate laboratory studies
that assessed the effectiveness of a novel copper-based molluscsicide,
EarthTec QZ, on our target species, B. tentaculata. In the first study we
compared the effects of two concentrations of EarthTec QZ on the adult
life stage of B. tentaculata and a coexisting native snail species, Physa
gyrina. Upon completion of this study, we observed that B. tentaculata
adults were better able to persist at higher concentrations of Cu^{2+} (the
active ingredient of EarthTec QZ) than their native counterparts. We also
found that female B. tentaculata experienced higher mortality than males
after exposure to the compound, which may generate consequences for
local populations of this species. In the second study, we conducted LC50
experiments on the adult life stage of the two snail species in which we
identified the EarthTec QZ concentrations required to eradicate 50% of
a population of exposed adult B. tentaculata and 50% of a population of
exposed adult Physa gyrina. Together, our results demonstrate that
EarthTec QZ holds potential for B. tentaculata control, but further work
needs to be conducted in order to minimize the negative effects of this
compound on non-target, native species.

105 Ecotoxicological Consequences of the Invasive Apple Snail
Pomacea maculata in Louisiana wetlands
S. Banerjee, P.L. Klerks, University of Louisiana, Lafayette / Department of Biology

The apple snail Pomacea maculata is an invasive species that has recently
been introduced and is now present in several marsh areas in the southern
United States. The introduction and range expansion of this species are
bound to have a variety of ecotoxicological consequences, including
possible changes in the biogeochemical cycling of metals. Such changes
can result from diverse activities of the snail including feeding by pedal
surface collecting from the water column, benthic grazing and sedi-
ment resuspension, and herbivory. In addition, fecal matter deposition on
the sediment surface can enhance metal flux from water column to the

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sediment. The apple snail invasion may also have a favorable aspect by providing us with a species that may be well suited for biomonitoring of environmental contaminants. Our ongoing research will provide insights into both aspects of the snail’s introduction, using two approaches. A field approach investigates the presence of correlations between snail tissue burdens and environmental concentrations of metals, by quantifying copper levels in sediment, water, vegetation and snails at sites that differ in physicochemical parameters and biological characteristics. The other approach uses laboratory mesocosms set up with sediment, water and aquatic vegetation collected from one of our field sites. This approach will determine whether the presence of apple snails affects the distribution of copper in these mesocosms. Copper levels will be determined in snail tissues, plants, sediment and water at the end of a 1-month period, and the environmental distribution compared between mesocosms with and without apple snails. The research is ongoing; results will be presented at the meeting. The study connects two environmental issues - biological invasions and metal pollution, both of which can have significant impacts in freshwater ecosystems. It is critical to understand whether invasive species affect contaminant dynamics in their environment and whether they can be used as contaminant biomonitor.

106 eDNA metabarcoding supporting community assessment of environmental stressor in a field-based sediment microcosm study

Y. Jianghua, Nanjing University / School of Environment

Conventional ecological risk assessment on toxic stressors in sediment is limited to a small and select fraction of benthic communities. Ecogenomic approaches provide unprecedented capacity to monitor the changes of biodiversity and community composition in the field, but how to utilize it to assess ecological impact by contaminants remains largely unexplored. Here, an environmental DNA (eDNA) metabarcoding approach was used to assess the effect of copper on changes in biodiversity and community composition across the Tree of Life (including bacteria, protist, algae, fungi and metazoa) in a field-based microcosm. Many micro-organisms across a broad range of taxa groups changed their relative abundance in response to increased copper concentrations in sediments. Changes in community structure of microbiota appeared to be more sensitive to copper than survival of laboratory-bred organisms and indigenous macroinvertebrates. Copper caused a significant shift in prokaryotic community composition via substitution of dominant species. Network heterogeneity and Shannon diversity of the bacterial community decreased in the copper contaminated sediment with less effort than manually processing samples. Our study highlighted the value of community profiling by eDNA based approach in prospective and retrospective risk assessment of environmental stressors.

107 Antioxidant defense, metabolism and morphological changes in Octopus maya during embryo development: Does mommy history matter?

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Octopus maya is an endemic species from the Yucatan Peninsula, Mexico, which presents holobenthic embryonic development. Characterizing the biology and biochemistry of embryonic forms provides information on how organs develop and activates the physiological mechanisms that will prevail for the rest of their lives. The importance of aerobic respiration lies in the efficiency and production of energy, translated into ATP which is traditionally measured as oxygen consumption (MO2). During respiration, reactive oxygen species (ROS) are produced, which react with biological macromolecules, producing structural cellular damage. Its effects are counteracted by the antioxidant defense system (ANTIOX). The objective of this work was to establish a solid baseline of the ANTIOX, morphological changes and MO2 throughout the embryonic development of O. maya using embryos from mothers captured at different seasons. Three females were captured at Sisal, Yucatan, Mexico during dry and rainy season and were kept at similar conditions until spawning. Embryos were maintained for development in 40 L tanks at 24°C, 36 UPS and 5 mg/L OD for approximately 50 days. Every 5 days, 15 embryos were sampled from each female. It was observed that there is a very close relationship between organogenosis and the metabolism of embryos: at the end of stage XV enzymatic activity, the consumption of vitellus, and the MO2 showed an evident increase, just when the activity of the systemic heart started. Results of morphological changes indicated that there were statistical differences between developmental stages, but no significant differences were detected between embryos from mothers captured at different seasons. Oxygen and vitellus consumption indicated significant differences at stages closer to hatching with respect to early stages. In addition, there was a higher consumption in oxygen and vitellus in embryos from mothers captured during the dry season. With respect to antioxidant defense, activities of CAT, SOD and GST indicated that there were differences between developmental stages, increasing with the growth of the embryo, but no significant differences were detected between seasons. On the contrary, oxidative damage, measured as lipid hydroperoxides and oxidized proteins presented higher values at early development stages, especially in embryos from mothers captured during the dry season.

108 Alterations in the Gonads of Blue Mussels Mytilus edulis Exposed to Paracetamol

W. Koogow, University of Brighton; C. Ciocan, University of Brighton / School of Pharmacy and Biomolecular Sciences

Paracetamol or acetaminophen is the most widely used pharmaceutical in the world and recent studies have reported its progressively increasing concentrations in aquatic compartments. Meanwhile, scientific evidence suggests that pharmaceuticals can exert some important toxic effects to non-target aquatic species, due to their chemical and biological properties. The present study aims to assess the biological responses induced by paracetamol, at environmentally relevant levels, in the blue mussel Mytilus edulis, namely focusing on reproductive parameters. After 24 days laboratory exposure, seven potential target genes were selected to investigate toxicological effects in mussel gonads, and potential disturbances of the reproductive cycle. Results show the modulation of some important reproduction-related genes: estrogen receptor 2 (ER2), vitelline envelope zona pellucida domain 9 (V9), and vitellogenin (VTG). The variation in mRNA expression of four other genes involved in apoptosis (CASP8, HSP70, BCL2 and FAS) was also investigated. Histopathological alterations caused by paracetamol, together with its potential to act as a non-traditional endocrine disruptor are discussed.

109 But first, let me take a shelf-fie: Standardizing embryo development for novel ecotoxicological endpoints in freshwater snails using macrophotography

R.K. Osborne, R.S. Prosser, University of Guelph / School of Environmental Sciences

Despite being the most diverse class of the Molluscan phylum, very little is known about Gastropods (snails and slugs), especially those that live in freshwater. Embryonic development in freshwater gastropods has yet to be characterized thoroughly and as a result, developmental milestones are not common as ecotoxicological endpoints. Throughout embryonic development, numerous complex changes occur on timescales ranging from seconds to days and improvements in technology allow us to accurately measure these changes on increasingly finer scales. As these developmental changes reveal important underlying evolutionary and ecological processes, it is especially important now to improve our understanding of them in light of the unprecedented local
and global change that many populations are experiencing. Using novel macrophotography and image processing techniques, we identified and measured embryonic growth patterns and the timing of developmental milestones in the freshwater snail Planorbella pilsbryi. Variations in abiotic factors (temperature and light) were tested to assess the natural variability of embryonic development within and between egg masses, as well as the influence of culturing conditions on development. There was very little variability within and between egg masses cultured under the same conditions, which allowed us to develop a standardized growth and development curve for this species. Our previous multi-generational work has shown that embryonic milestones may reveal the influence of past parental contaminant exposure, provide insight into the complex biological responses to environmental stress, and predict the health of juveniles later in life. To explore these concepts further, testing of the influence of contaminants on embryonic development and their use in multi-generation studies is ongoing.

110 Exploring the effects of bisphenols in the freshwater snail Planorbella pilsbryi using traditional apical endpoints and metabolomic approaches

E.A. Gilroy, K.B. Robichaud, M. Villega, Environment and Climate Change Canada / Aquatic Contaminants Research Division; R. Brua, Environment and Climate Change Canada / Watershed Hydrology and Ecology Research Division

Bisphenol A is a precursor to plastic polymers used in consumer products, including some food containers and/or packaging, adhesives and paper coatings. Increasing concerns about its endocrine activity and leaching from plastics have led to its ban from the production of baby bottles. However, BPA remains in use in other applications; alternate products are being developed and/or are in use, many of which are similar in structure and could pose comparable health hazards. These concerns are being addressed by the Chemicals Management Plan, a government initiative aiming to reduce the risks posed by chemicals to Canadians and their environment. Endocrine disrupting chemicals (EDCs) interfere with hormone systems and can change the normal functioning of a variety of processes, including, sexual development, reproduction, and growth. These compounds are often not overtly toxic, but cause effects at low concentrations after prolonged exposure. Hence, these chemicals with endocrine disrupting potential are of concern at concentrations detected in the environment. Freshwater snails have been identified as sensitive biota to BPA, however, there is a lack of information on the effects of alternative bisphenols (e.g., BPF and BPS). Until recently, the bulk of toxicology studies have overlooked freshwater mussels, even though early stages of some species have been reported as particularly sensitive to contamination (e.g., metals, road salts). Recent efforts to develop internationally standardized toxicity testing procedures have been fruitful, with the development of guidelines for life-cycle toxicity testing with freshwater snail species for the assessment of endocrine disruption. In the present study, we assessed the acute and chronic toxicity of BPA in the freshwater snail Planorbella pilsbryi in a 96 h assay examining survival and egg production, and a 28 d assay modelled on the OECD 2016 Lymnea stagnalis Reproduction Test, extended to evaluate effects on juvenile stages. The metabolomic response of snails after a 96 h exposure to BPA will also be assessed by nuclear magnetic resonance spectrometry using a non-targeted approach, to gain a better understanding of potential mechanisms of action. This study will evaluate the acute and chronic toxicity of BPA in different life stages of freshwater snails, as well as its endocrine effects, if any. Further research underway will also assess the toxicity of alternative bisphenols BPF and BPS.

111 Refining Standard Methods for Conducting Chronic Toxicity Tests with Juvenile Freshwater Mussels

N. Wang, J.L. Kunz, J.A. Steevens, US Geological Survey / Columbia Environmental Research Center; E. Hammer, USEPA; C. Barnhart, Missouri State University / Biology

The ASTM International standard for chronic toxicity tests with freshwater mussels was published in 2005 and needs refinement to optimize survival and growth of juvenile mussels in standard (4-week) and longer-term (12-week) exposures. We conducted multiple studies with juvenile fatmucket (Lampsilis siliqua), a commonly tested mussel, to refine test conditions and use refined methods to evaluate the influence of test duration (4 to 12 weeks) and starting age of organisms (1-week to 2-month-old juveniles) on mussel sensitivity to chemicals. Results of a feeding study indicated that (1) an addition of silica sand substrate limited the accumulation of debris and biofilm on mussel shells; (2) replacement of sand and test chambers every 2 weeks reduced debris and biofilm on test chamber surface; (3) raising water temperature from 20°C recommended in ASTM standard to 23°C increased growth of juvenile fatmucket; and (4) increased feeding rate and frequency of algal mixture from traditional twice daily (i.e., manual feeding 2 mL of algal mixture in the morning and afternoon) to 6 times daily (automatic feeding 2 mL once every 4 h) increased more stable food in water column and substantially improved growth. Several 12-week toxicity tests were successfully completed with 95 to 100% control survival under refined test conditions. Younger (1-week-old) juveniles were more sensitive to NaCl than older (2-month-old) juveniles. Chronic effect concentrations of NaCl and Ni to fatmucket did not substantially change from 4- to 12-week exposures whereas effect concentrations of Zn observed in 4-week exposure decreased more than 2-fold at the end of 12-week exposure, indicating that chronic toxicity remained the same or increased (depending on chemicals tested) with extended periods from 4 to 12 weeks. An additional 4- to 12-week test with juvenile fatmucket in KCl exposures is ongoing, along with a partial life cycle KCl test starting with gravid female fatmucket. The effects on the juvenile growth in the 4- and 12-week exposure will be compared to the effects based on reproduction endpoints (e.g., glochidia viability and metamorphosis success) from the partial life cycle study.

Environmental Considerations for the Risk Assessment of Polymers, Rubber and Macropolymers: State of the Science

112 Overview of aquatic risk assessment polymers - evidence from cationic polymers

H. Sanderson, A. Brun, Aarhus University / Environmental Science; S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; J. Brill, J.M. Rawlings, Procter & Gamble Company / Environmental Stewardship and Sustainability; M. Lam, Procter & Gamble / Global Product Stewardship; K.A. Connors, Procter & Gamble Company / Environmental Stewardship and Sustainability

Polymers including macropolymers and rubbers are large macromolecules consisting of repeating monomer units. Polymers are an exceptionally diverse group of compounds with varying properties and uses. They can both be synthetic, such as plastics and rubbers (e.g. polystyrene; PET; PE; etc.) or natural, (e.g. DNA; starch; polyamides; polysaccharides). - hence, while all plastics are polymers - not all polymers are plastic. They have a wide and growing global use and represent a multi-billion US$ global market value with uses in the millions of tons per year. According to REACH legislation, polymers are defined as molecules that have at least three covalently bonded monomer units. These repeating monomers must represent the majority of the molecule’s weight. Polymers are currently exempt in REACH and generally not reviewed in some regulatory programs - this exemption is due to the assumption that there would be little toxicological concern due to their significant molecular weight and low water solubility. The big question now is how to assess and model these
113 Towards a Robust Quantitative Analytical Method for Aquatic Effects Testing of Cationic Polymers

M. Lam, Procter & Gamble / Global Product Stewardship; Y. Sun, K. Wehmeier, M.J. Karb, Procter & Gamble Company / Trace Analytical Core; J.M. Rawlings, Procter & Gamble Company / Environmental Stewardship and Sustainability; J. Brill, K.A. Connors, Procter & Gamble Company / Environmental Stewardship and Sustainability; S.E. Belanger, Procter & Gamble Company / Global Product Stewardship

There is growing regulatory attention and increased use of water-soluble polymers in consumer cleaning products which requires robust environmental risk assessment methods. Analytical characterization is key step to provide an accurate measure of test chemical concentration in exposure solutions. With advances in mass spectrometric instrumentation, robust approaches are possible with many simple organic chemistries. However, historically polymers were a challenge due to their complexity of varying repeating subunits, and non-specific methodology such as total organic carbon was often applied for exposure solution analysis. The scope of analytical methods used in the past several decades have been to characterize polymers for molecular weight and structure, number of repeat subunits, with the aim to evaluate performance, measure rheological properties, and thermal mechanical properties (for solid polymers used in packaging). Several regulatory agencies have already identified cationic polymers as higher priority for registration due to their expected higher ecotoxicity potential, and this has led to the selection of several variants of polyquaternium-10 as candidate cationic polymers to case study the development of a high throughput, high sensitivity Flow Injection-High Resolution QTOF mass spectrometry method for exposure solution analysis in the testing of algae, aquatic invertebrate and fish embryo as part of the CEFIC “Improved Aquatic Testing and Assessment of Cationic Polymers (iTAP)” research program. To the best of our knowledge, this work represents the first known mass spectral attempt to quantitate high Mw cationic polymer exposures in aquatic ecotoxicity tests. Attempts have been made by others using wet chemistry methods or selective membrane methods for polyquaternium-10, but these were limited and generally not used in support of environmental effects testing. This presentation will cover polymer characterization methods to measure physical-chemical properties expected to be relevant for environmental risk assessment, and the strategy for detection and quantitation in exposure solutions and field studies. Insights into method reproducibility, specificity and sensitivity with mass spectrometric based methods are covered, and an evaluation of other analytical approaches like Capillary GPC-Mass Spectrometry for cationic polymers will be presented.

114 Progress in understanding the ecotoxicology of cationic polymers - evidence with Polyquat 10s

J. Brill, J.M. Rawlings, Procter & Gamble Company / Environmental Stewardship and Sustainability; A. Brun, Aarhus University / Environmental Science; Y. Sun, Procter & Gamble Company / Trace Analytical Core; M. Lam, S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; K.A. Connors, Procter & Gamble Company / Environmental Stewardship and Sustainability; H. Sanderson, Aarhus University / Environmental Science

Research has been undertaken to support the development of methods to improve the accuracy and precision of the aquatic environmental risk assessment of cationic polymers. The project aims to lay the foundation for regulatory acceptance based on improved methods for regulatory assessment and compliance testing of polymers and address significant gaps in the knowledge base. Cationic polymers are used in a wide range of personal care and fabric care products and present challenges to traditional hazard assessment. Cationic polymers combine two contrasting elements - a positive charge and a long hydrophobic chain - and the resulting dichotomy typically provides unusual behaviors in water, particularly in interfacial regions. One of the challenges is that the polymers are typically large and not expected to pass biological membranes, making toxicity testing problematic as they still exert demonstrable effects. Another is that they are expected to interact with the outer membranes of aquatic organisms and thereby affect their functionalities. This behavior makes it hard to describe the dose-response relationship as responses likely confound external physical effects and internal uptake. We are assessing a group of related but “understudied” model cationic polymers widely used in industry - polyquaterniums 6, 7, 10, and 16. The proposed polyquaterniums vary in molecular weight, %N, #C-N bonds, and charge density that we assessed for a correlation with effects. Initial investigations have focused on the polyquaternium 10 group. Due to widespread usage and lack of biodegradability the potential for environmental exposure is high. We conducted algal inhibition, acute invertebrate and fish embryo toxicity studies to understand potency within the class and assess toxicity mitigation factors such as humic acid. In parallel, analytical methods were developed and used to measure freely dissolved concentrations of cationic polymer. Experimental data to date suggests unique toxicity patterns to cationic polymers with issues concerning bioavailability, mitigation and physical impairment versus conventional organic compounds. This presentation will emphasize learnings on polymer/humic acid interactions and their effect on cationic polymer toxicity. We summarize by identifying informational needs for future environmental risk assessments of cationic polymers.

115 Application of standard tests to non-standard compounds - the aquatic toxicity of cationic polymers

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Risk assessment of chemicals used in the environment rely to a large degree on data gained through standard toxicity test guidelines. The guidelines are designed to ensure comparability between chemicals and laboratories. But what if we want to test a chemical that is not comparable to our “usual suspects”? Polymers are widely used globally, but they differ from well-investigated compounds like pesticides or pharmaceuticals on a number of parameters, e.g. their size and structure or the way they interact with a non-target organism. Not a lot is known on polymers’ effect on aquatic organisms. This is mainly due to the assumption that polymers because of their large size will not be able to cross the cell membrane and therefore not be toxic. This assumption has made them exempt from the REACH-framework, leading to low requirements for acquiring data on polymers. Though, it is known that cationic polymers (CP) bind to
negatively charged surfaces, including the surface of an organism or some aquatic organic substances. Early polymer work showed that CPs may not cause direct toxicity but actually can indirectly harm or impair aquatic organisms. The limited data on CPs combined with the known effect CPs can have, underlines the need for further exploring of the effects on aquatic organisms. Scientific knowledge should add to a better understanding of environmental effects of polymers and to lay the scientific foundation for a possible inclusion in regulatory frameworks. The unusual mode of“toxicity” and how we describe, test and model environmental interactions of CPs is a challenge that needs to be met. The known effect-predictors like hydrophobicity may not describe physical-chemical impacts on toxicity caused by a CP. Instead, other properties as charge-density, average molecular weight or viscosity may be more appropriate effect-predictors. This research is the early foundation of a science-based approach of testing CPs. As a starting point different tradenames of the cationic polymers Polyquaternium-6, -7, -10 and -16 have been tested by applying standard toxicity guidelines, namely ISO 11348-3, OECD 201, OECD 202, OECD 211 and OECD 236. We will present these findings to give an overview of the aquatic toxicity and cast light upon which properties could be drives for toxicity. In addition, we will present what challenges arise when applying standard test guidelines to non-standard compounds, and possible solutions on how to overcome them.

116 A proposed approach for assessing cationic polymers bioavailability in the environment

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PolyHexaMethylene Biguanide, hydrochloride (PHMB) is a cationic polymer used as a biocide in a wide range of end-use products. One of its properties is to combine very quickly and very strongly to most of solids leading to formation of non-extractible residues. This property is an advantage for its biocide effect however this makes environmental studies difficult to carry out and to interpret results for conducting an Environmental Risk Assessment (ERA). No consensus is (yet) available to well define how Non-Extractible Residues (NER) should be addressed in an ERA. Ideally, it should be tested in a standard system but soils, sediments and waters sources are so diverse around the world. We tried to address this question by using HPLC to study the overall behaviour of PHMB towards easily available stationary phases (5um), selected for their similarity to components of environmental soils : bare silica to assess its behaviour with polar suspended solids or sediments with low electronic charge, cation exchange bonded silica to assess its behaviour on soluble or suspended matter carrying a strong anionic function (such as humic, fulvic and similar acids) and C18-grafted silica to evaluate its behaviour on apolar un-charged soluble or suspended organic matter (or other plant debris). To increase the environmental relevance of study, empty HPLC columns were filled-in with natural sand grades. PHMB behaviour was evaluated with a 2-step protocol: - A percolation step to measure its combination ratio towards environmental substrates. - A washing step with severe conditions to assess PHMB combination strength with various carriers by measuring its maximum extractable portion. In all cases, 100% PHMB was retained on the tested stationary phases during the percolation step. After the washing step, the recovery rates were 55%, <14% and 71% for the 3 tested columns respectively. PHMB towards natural sands showed the same behaviour, but with no recovery during the washing step. This was probably due to the presence of organic matter in these natural matrices (not measured) as inorganic and high size organic compounds create cavities able to strongly entrap organic substances. This approach, easily reproducible inter-lab, is proposed to assess limited bioavailability after binding (mainly cationic polymers), and taken into consideration in ERA.

117 Quantitative determination of microplastics in environmental water samples using Pyrolysis-Gas Chromatography - Mass Spectrometry

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In the recent past, microplastics have been recognized as emerging pollutants and their measurements in environmental waters have emerged as challenging to the analytical scientist. The pyrolysis - gas chromatography/ mass spectrometry (Pyr-GC/MS) has been used for simultaneous determination of the microplastics and polymer additives. The technique is based on the combustion of the sample and subsequent detection of the thermal degradation products of the polymers. The identification of thermal degradation products then serves as markers specific for each polymer. Sadly, results obtained through Pyr-GC/MS analysis have been the limited determination of the mass concentration of plastic and have not been used to provided information on the number of particles in the aquatic sample. In this work, we report a new approach of using Pyr-GC/MS method to provide particle counts of common consumer microplastics (polypropylene, polycarbonate, polystyrene terephthalate, polyvinyl chloride, polystyrene, poly (methyl methacrylate), polystyrene and polyamide 6) in environmental water samples. To obtain external calibration curves, the stock solution of certified reference microplastics suspension were diluted with an appropriate solvent. Quantification of individual microplastics was based on a five-point matrix-matched using integration results of mass chromatograms for preselected indicator compounds. The concentration ranges to which the method can be applied were determined and reported. Further, the Pyr-GC/MS-based method was successfully applied to the microplastic standard mixtures and typical environmental water samples.

118 Short-Term Effects of Plastic Consumption on Anemones

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Ubiquitous plastic pollution raises pertinent questions of the impacts of plastic pollution on organisms. Plastic consumption by organisms is documented though impacts of the complex mixtures that are plastic leachates are poorly understood. This study aims to quantify metals in anemones, Aiptasia pallida, after individuals consumed one pellet per day of level II high-density polyethylene (HDPEII) and level III high-density polyethylene (HDPEIII) for 12 days. The pellets were fresh preproduction pellets from the National Institute of Standards and Technology (NIST). Anemones consumed all NIST pellets as if they were food. On average, pellets were retained for 5.5 to 6 hours. In a separate experiment, pellets egested by the first anemones were fed to other anemones until they were no longer consumed. For some plastics, the flavor appears to decline over time. HDPE III pellets were retained for shorter periods of time and not eaten after 4 egestions. Inductively coupled plasma mass spectrometry results show that depending on the plastic type, consumption alters the amount of metals in anemones. Some plastics delivered metals to anemones, others removed them. Anemones consume plastic, plastic loses flavor, and plastic changes metal concentrations in anemones. Our results have environmental health and food safety implications.
119 Towards the Development and Application of an Environmental Risk Assessment Framework for Microplastic

T. Gouin, TG Environmental Research / Safety and Environmental Assurance Centre

Plastic waste emissions to the environment and subsequent degradation into microplastic particles (MPs) represents a global concern given their potential to interact with biota. Current understanding of the potential impacts from MPs on aquatic and terrestrial population stability and ecosystem structure and function, however, is insufficient to fully assess these environmental risks. To address these issues, we held a multi-stakeholder discussion to identify and prioritize key knowledge gaps in assessing potential risks. This discussion took place during a one-day, International Council of Chemical Associations (ICCA) sponsored symposium, which involved 39 scientists from 8 countries with representatives from academia, industry, and government. We asked participants to consider the following: Discuss the scientific merits and limitations of i) applying a proposed conceptual environmental risk assessment (ERA) framework for MPs and 2) identify and prioritize major research needs in applying ERA tools for MPs. Multi-stakeholder consensus was obtained with respect to the interpretation of the current state-of-the-science related to effects and exposure to MPs, whereby it was suggested that environmental MPs are unlikely to represent a high risk. It should be noted, however, that participants also agreed that the quality and quantity of data requires substantial improvement before conclusions regarding the potential risks and impacts of MPs can be fully assessed. This presentation will summarize conclusions on research needs and outline a framework for an environmental risk assessment on MPs.

121 Response to Edwardsiella piscicida infection in estrogen exposed juvenile largemouth bass (Micropterus salmoides)


Disease outbreaks, skin lesions, fish kill events, and reproductive abnormalities have been observed in wild populations of Centrarchids in the Chesapeake Bay watershed (CBW). Occurrence of estrogenic endocrine disrupting compounds (EEDCs) such as synthetic and natural hormones from wastewater treatment plants and livestock operations as well as pesticides and phytoestrogens from agricultural lands have been implicated as potential causes of these adverse effects. Fish health is currently monitored in the CBW; however, direct associations between altered disease susceptibility and EEDC exposure have not been confirmed. Host-pathogen interactions and outcomes following EEDC exposure depend on a number of factors including the host fish life stage and physiological condition, environmental conditions (e.g. water temperature), and specific attributes of the disease organism. This study was designed as an initial investigation to evaluate the effects of estrogen exposure on disease susceptibility in a fish species relevant to the CBW using a laboratory disease challenge model. We examined the effects of exposure to a potent synthetic estrogen (17alpha-ethinylestradiol, EE2) on disease susceptibility in juvenile (6 months old) largemouth bass (Micropterus salmoides) infected with Edwardsiella piscicida. Fish were exposed to EE2 treatments for 4 weeks, then moved to EE2-free water and infected with E. piscicida through intraperitoneal injection within 48 h post-treatment. The average measured EE2 concentrations in each treatment were: < 0.4 ng/L EE2 (control); 0.9 ng/L EE2; and 9.1 ng/L EE2. Endpoints included: survival, histopathology, hepatosomatic index (HSI), alternative complement pathway analysis, and transcriptomic changes in liver and spleen tissue. Increased survival was observed with increasing EE2 concentration, resulting in significantly greater survival in the 9.1 ng/L EE2 treatment compared to control. HSI was significantly greater in the high EE2 treatment compared to control, both immediately after EE2 treatment and following the disease challenge. The observed effects may result from stimulation of immune pathways in response to the estrogen exposure. These pathways are being further examined through RNAseq. Our results demonstrate that exposure to a model EEDC can induce changes in disease susceptibility in this economically important fish species.

Addressing Existing Challenges in Immuno-ecotoxiconology: From Tool Development to Risk Assessment - Part 2

120 The fish immune system under the impact of stressor combinations: are estrogenic endocrine disruptors enhancing or attenuating the susceptibility towards pathogens?

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Freshwater fish are threatened by the cumulative impact of multiple stressors. Exposure to environmental contaminants can alter immune responses, potentially putting fish at risk of disease and death. Here, we investigate if exposure of rainbow trout, Oncorhynchus mykiss, to environmentally relevant concentrations of ethinylestradiol (EE2) modulates the response of the fish to infection with the myxozoan parasite, Tetracapsuloides bryosalmonae, which causes proliferative kidney disease (PKD). The experiment was designed as a long-term, chronic study. Three key findings were generated by the experiment: (i) the EE2 exposure had an immunomodulating effect in rainbow trout and this effect occurred in the same concentration range as the EE2 effect on the reproductive system. (ii) the EE2 exposure altered immune parameters of rainbow trout. RNAseq analysis revealed a greater number of differentially expressed genes (DEGs) across major physiological and immunological processes in the PKD x EE2 group. These DEGs were observed neither in the PKD-only group nor in the EE2-only group. (iii) the infected EE2-exposed fishes showed a decreased parasite load and reduced pathological alterations in comparison to the PKD-only condition, suggesting an attenuating effect of the EE2 treatment. This finding is in contrast to published studies of other groups as well as our own group, which show immunosuppressive effects and increased pathogen susceptibility of estrogen-exposed fish. It may indicate that the immunological action of estrogens in fish, as in mammals, can be paradoxical, i.e. exerting both immunosuppressive and immune-enhancing actions, depending on the estrogen concentration and the physiological condition of the organism.

122 The impact of various oiled sediments on immune-related transcriptional responses in Southern flounder (Paralichthys lethostigma)

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Previous work in our lab indicates that Southern flounder (Paralichthys lethostigma) exposed to oil-contaminated sediments experience reduced growth and survival, increased occurrence of gill abnormalities, and shifts in the gill and gut microbiomes. We believe that some of these changes can be attributed to suppression of the immune system following oil exposure. In order to elucidate the full suite of immune effects that an event such as the Deepwater Horizon oil spill elicits, we performed RNAseq on livers from Southern flounder collected at an oiled field site post-spill and compared them to livers from lab-exposed flounders to determine transcriptomic differences in wild vs. lab exposures. Overall, only 3 immune-related pathways were significantly dysregulated in the lab-exposed group compared to 26 in the wild-caught group. In order to obtain a clearer understanding of factors that contribute to immune dysregulation following oil exposure, we then exposed flounder to oiled sediment at two different concentrations (13.5 g/kg and 27 g/kg) for 7 days. On the seventh day, half of the control group and half of the...
oil-exposed group were subjected to a one-hour challenge with the pathogen *Vibrio anguillarum*. 24 hours later, fish were harvested, and spleens were taken for RNAseq. For both concentrations, the oil alone, pathogen alone, and oil + pathogen groups showed distinct canonical pathway profiles with relatively few pathways overlapping between all three treatment groups. In comparing dysregulated immune pathways between the oil alone groups, the higher dose exhibited twice as many dysregulated immune pathways than the lower dose (44 vs. 22). Interestingly, both oil doses shared dysregulation of immune pathways relating to acute phase response and various interleukin signaling, but the higher oil dose exhibited unique dysregulation of pathways related to T and B cell processes. While there was nearly universal suppression of immune pathways at the higher oil dose, the lower oil dose exhibited a mosaic pattern of expression with some immune pathways activated and other suppressed. In the oil + pathogen groups, the higher oil dose also led to an increased number of dysregulated immune pathways (31 vs. 16), however, there was a unique and interesting pattern of dysregulation: in the higher oil dose, there was a clear pattern of immune pathway suppression, but in the lower oil dose there was a strong pattern of immune pathway activation.

123 Assessing the effects of microcystin LR ingestion on innate immunity and the gut microbiome of zebrafish


The endangered Lost River sucker (*Deltistes luxatus*) of Upper Klamath Lake (OR) is threatened by a lack of substantial recruitment into older age classes. Despite successful spawning of resident adult fish each spring, juvenile fish do not survive to sexual maturity. Several environmental factors are thought to contribute to juvenile mortality including poor water quality, infectious disease and exposure to the cyanobacterial toxin microcystin. Our group has observed the presence of *Microcystis* cells in the digestive tract of juvenile fish during summer *Microcystis aeruginosa* blooms leading to the hypothesis that ingestion of microcystin contributes to low juvenile survival. However, histopathology consistent with microcystin toxicity is rarely observed for wild caught suckers. In 2017, we conducted a pilot study that revealed dysregulation of the hepatic transcriptome of lost river suckers 24 hours after microcystin ingestion including genes involved in metabolism and reproduction. Based upon these initial findings, we used zebrafish to model the potential effects of microcystin ingestion on immunity owing to the utility of this species. Innate immunity represents the first line of defense against pathogens largely through the response to pathogen associated molecular patterns (PAMPs) that are recognized by pattern recognition receptors on or within leukocytes. This process results in inflammatory and interferon-based responses and is partially regulated by the host microbiome. To address the hypothesis that microcystin LR ingestion affects innate immunity, adult zebrafish were fed a microcystin diet for 7 days—a time span that correlates with average, summer *Microcystis* blooms in Klamath Lake. On the 8th day, fish were injected with microbial PAMPs (peptido-glycan or Poly:IC) to mimic infection. Livers and intestines were sampled from fish on days 3 and 7 post PAMP stimulation to assess both hepatoxic and immunotoxic effects of microcystin ingestion by transcriptome analysis. In addition, microbial community structure was assessed post microcystin consumption to address toxin mediated dysbiosis. Current investigations include assessing differential gene expression and identifying innate immune pathways modulated by microcystin ingestion. Together, this study will provide insight into the interactive or synergistic effects of factors that are implicated in the lack of recruitment of the Lost River suckers of Upper Klamath Lake.

124 The impacts of developmental thyroid disruption on immune function and the immune response in the fathead minnow

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Current evidence suggests that thyroid hormones (THs) may impact development of the immune system. However, studies that explore the role of THs in immune development are limited, and the mechanisms leading to alterations in immune function are poorly understood. It is important to elucidate the role of THs in immune development given that many environmental contaminants have been shown to disrupt TH homeostasis and may also have negative impacts on the immune system. As such, the main goal of this study was to determine the long-term consequences of early life stage (ELS) hypothyroidism on immune function. To achieve this goal, fathead minnows (FHM, Pimephales promelas), a newly developed model for immunotoxicity, were exposed to the model thyroid suppressant propylthiouracil (PTU) from < 1 to 30 days post hatch and reared under normal conditions until adulthood. FHM were infected with Yersinia ruckeri and monitored for 14 days to determine pathogen resistance. At eight hours post injection, the immune response was assessed via a suite of endpoints (i.e. bacterial load, hematocrit, spleen index, leukocyte counts). Respiratory burst and phagocytic cell activity were also assessed. No significant alterations were detected for most endpoints measured. However, phagocytic cell activity was significantly reduced in female fathead minnows exposed to PTU, suggesting that immune cell function or cellularity may have been impacted by ELS hypothyroidism in a sex-specific manner. The potential impact of ELS hypothyroidism will be further explored via the assessment of the renal transcriptomic response in female FHMs.

125 Chemical-induced changes in immune parameters following a lipopolysaccharide challenge in the amphibian Xenopus laevis

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Numerous contaminants present in the aquatic environment have the potential to disrupt immune defences and potentially increase disease susceptibility. Amphibians are known to inhabit contaminated environments, and there is growing concern that known immunotoxic chemicals may magnify the impacts of global emerging infectious diseases. We assessed two environmental chemicals of concern, benz(a)pyrene (BaP), a polycyclic aromatic hydrocarbon and chlorpyrifos (CPF), an organo-phosphate pesticide for their ability to alter immune parameters in juvenile *Xenopus laevis*, alone and following a challenge with simulated pathogen, lipopolysaccharide (LPS). Individuals were aqueous exposed to BaP (70 or 350 µg/L) or CPF (1 or 10 µg/L) for seven days followed by immune challenge. Assessment of differential leukocyte profiles (by flow cytometry) and expression of cytokines in the liver (by qPCR) was conducted in PBS-injected (immune-rested) and 10 µg/L LPS-injected (immune-stimulated) individuals. The highest concentration of BaP impaired the inflammatory response of juvenile *X. laevis* to LPS as indicated by an inability to increase the granulocyte:lymphocyte (G:L) ratio or IL-1β (interleukin-1beta) mRNA expression. Exposure to CPF resulted in an overall reduction in circulating lymphocytes, a decrease in basal circulating monocytes, and increased expression the cytokines TNF-α (tumour necrosis factor-alpha) and CSF-1 ( colony stimulating factor-1). This study demonstrates that chemicals can modulate the inflammatory immune response to a simulated pathogen, providing some of the first evidence of the immunotoxic potential of these compounds in amphibians. Given the fundamental role of inflammation in immune responses, these findings suggest that exposure to BaP and CPF may have consequences for amphibian susceptibility to ecologically relevant pathogens.
126 Immune responses of American kestrel hatchlings exposed to isopropyl triphenyl phosphate flame retardants


Disease dynamics in wildlife are commonly related to changes or increases in environmental stressors that are placed upon an animal. Environmental pollutants are known to evoke immunomodulatory effects that result in impaired resistance to infection and potential increases in disease outbreaks. Immunological effects of contaminants also have implications for animal fitness and reproduction due to the link between the immune and endocrine systems. Organophosphorus flame retardants (OPFRs) have been increasingly used as replacements for brominated flame retardants such as polybrominated diphenyl ethers and hexabromocyclododecane. Because OPFRs show structural similarity to organophosphorus insecticides, their potential toxicity and immunomodulatory effects may also be similar. Raptor species, such as the American kestrel (Falco sparverius), have been shown to be highly susceptible to avian influenza and other emerging infectious diseases caused by various microbial pathogens. We investigated the immunomodulatory effects of the emerging flame retardant isopropyl triphenyl phosphates (ITPs) on kestrel nestlings. ITPs are components of multiple flame retardant mixtures currently on the market (e.g. Firemaster(R) 550) and with their increasing use, both the U.S. Environmental Protection Agency and Environment and Climate Change Canada’s Chemicals Management Plan have prioritized ITPs for assessment. We determined the ability of the nestlings to respond to a novel disease threat (immune-challenge with a viral analogue) when exposed to ITPs and used multiple methods, including histology of immune organs, measurements of phagocytic activity, and examination of immune cell types (heterophils, monocytes, lymphocytes, and CD4+ cells) to assess immune system changes. We will present the results of these assays and discuss their utility for assessing immune responses in non-model birds.

127 Immunotoxicity evaluation as a tool for protecting public and environmental health from PFAS

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One group of per- and polyfluoroalkyl substances (PFAS) that has emerged in the aquatic environment in the past five years are perfluoroalkyl ether acids (PFEAs). Although they are marketed as having a favorable toxicological profile, the reality is that very little is known about the toxicity of these emerging PFAS. Further, data gathered from PFAS that have been phased out of production in the United States demonstrate that these “legacy PFAS” are immunotoxicants in exposed humans and experimental animals. Deficits in immune function occur at doses that do not negatively impact lymphoid organ weight, histopathology, or cellularity. This is a point of concern for PFAS as while standard toxicity studies include assessments of lymphoid organ weight, histopathology, and cellularity, they do not include measures of immune function without a “trigger” such as a histopathological finding in the spleen, for example. Therefore, the weight-of-evidence supports immune function assessment for PFAS, especially for those that have become part of the aquatic environment and that enter drinking water systems as well as wildlife habitat. Our laboratory has applied the suite of immunotoxicological assays recommended for assessment of pesticides as well as environmental chemicals to several PFEAs of concern in the state of North Carolina using a C57BL/6 mouse model. One compound, 2,3,3,3-tetrafluoro-2-(heptafluoropropylo)-propionate (known by the trade name as “GenX”), produced an unbounded no observed adverse effect level (NOAEL) for suppression of the primary antibody response in female mice at an internal dose that was ~90% lower than the internal dose associated with the NOAEL for a legacy PFAS. Neither compound altered spleen weights, cellularity, or splenic lymphocyte subpopulations in a dose-dependent manner or in association with suppression of the antibody response. Work with other PFEAs that have fewer carbons than GenX demonstrates that when orally administered to male and female C57BL/6 mice for 30-days, standard markers of toxicity for PFAS, such as increases in liver weight and peroxisomal enzyme activity, are not observable. Therefore, PFEAs may affect the immune system without producing effects detectable in standard toxicity studies. Our work with PFAS of unknown toxicity and high relevance to the aquatic environment demonstrates that immunotoxicity is a relevant and sensitive endpoint for public and environmental health protection.

Assessing Contaminant Effects in Ecosystems with Multiple Stressors - Part 2

128 A pathway toward the adaptive management of multiple stressors for the Upper San Francisco Estuary region

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Landis et al., in a 2017 publication, describe a workable adaptive management scheme. We have begun to apply this scheme to a classic case study, the Upper San Francisco Estuary (USFE). The USFE, also known as the Bay/Delta, is a region characterized by extensive development, agricultural inputs and iconic species. The goal of our effort is to build an adaptive management process based on the Bayesian network relative risk model (BN-RRM) to ensure the sustainable and resilient region. As is typical for the approach, we catalog sources, endpoints, the habitats, effects and impacts and construct a conceptual model to capture the cause-effect relationships. Data are acquired from a variety of sources and GIS information used to provide context. The study area is then delineated in a series of risk regions constructed in regard to data availability and management goals. We define sustainable and resilient in a risk assessment modality; the boundaries of the sustainability box are defined by the endpoints derived in the risk assessment process. Risk is defined as the probability of exceeding the boundaries of the sustainability box along one of more axes. The resiliency of the system is defined by the change in probability of exceedance beyond the defined parameters of the model subjected to a variety of perturbations. A variety of management options can be examined to evaluate the efficacy in their abilities to affect the system. The analysis provides the framework so that the observation, orient, decide, act (OODA) loop can be employed. At the end of the process the adaptive management process will be available for testing and evaluation.

129 Multi-stressor effects on biological communities in contrasting regions of the USA


Multiple physical and chemical stressors can simultaneously affect the biological condition of streams. To evaluate such complex relations, the U.S. Geological Survey sampled from 75 to 98 streams in each of four regions of the United States from 2013 to 2016. Water and sediment chemistry, streamflow, and temperature were characterized for as many as 14 weeks prior to ecological surveys of habitat and of algal, macroinvertebrate, and fish communities in each stream. Boosted regression tree (BRT) models were developed for biological metrics of algal, macroinvertebrate and fish communities based on in-stream stressors. Results from the BRT models informed the development of structural equation models (SEM) for two of the regions that link landscape drivers, reach-based variables, instream stressors, and ecological responses. Multiple physical and chemical stressors were included in the models for all four regions but the mix of stressors varied by region and by dominant land-use setting. Generally, physical habitat variables explained more variance in the models of the agricultural Midwest Corn Belt whereas chemical contaminants...
explained more variance in the models of the Southeast Piedmont, Pacific Northwest, and Northeast, where urban land uses dominate development. The BRT models identify which specific stressors and stressor combinations have the strongest influence on biological condition and the SEM models provide support to conceptual models that link human activities on the landscape to specific stressors and biological responses.

130 The Role of Pesticide Mixtures as Stressors on Invertebrate Communities in Wadeable Streams


Pesticide mixtures were assessed in five regional multistressor studies done during 2013-2017 by the U.S. Geological Survey’s Regional Stream Quality Assessment. In each region, 225 pesticide compounds were analyzed in weekly water samples from 77-100 wadeable streams over 6-14 weeks, followed by ecological surveys and collection of bed sediment for analysis of 118 pesticide compounds. Potential for invertebrate toxicity in the sampled streams was predicted by comparing measured pesticide concentrations with aquatic-life benchmarks, sediment benchmarks, the Pesticide Toxicity Index, and species sensitivity distributions. Predictions were tested by evaluating relations between pesticides and field-surveyed macroinvertebrate community condition and by mesocosm experiments that assessed effects of key pesticides on natural aquatic communities under controlled conditions. A total of 208 pesticide compounds were detected in water and 44 in bed sediment. Pesticide mixture complexity varied by region and land use. In water, the most pesticides were measured at agricultural sites in the Pacific Northwest and Midwest (median of 37 and 26 compounds per sample, respectively). For basins with minimal agriculture, the number of pesticides detected per water sample increased with urban land in the basin. Potential effects on invertebrates were predicted in all five regions—either from dissolved pesticides (at 18 to 77% of sites, in Pacific Northwest and Midwest regions, respectively), and/or from pesticides in bed sediment (at 2 to 18% of sites, in Pacific Northwest and Northeast, respectively). For dissolved pesticides (all regions combined), 14% of sites exceeded acute thresholds, 46% of sites exceeded chronic thresholds (by 21-d average concentrations) for at least one pesticide, and 14% of sites exceeded chronic thresholds for multiple pesticides. Acute thresholds were exceeded most frequently by imidacloprid and organophosphate insecticides in water and by bifenthrin in sediment. In the Midwest, predictions of pesticide toxicity were supported by quantile regression showing significant associations between concentrations of imidacloprid and bifenthrin and impaired invertebrate communities in the field, and by mesocosm studies demonstrating effects of imidacloprid and bifenthrin on natural aquatic communities under controlled conditions. Multiple lines of evidence suggest pesticides affected invertebrate community condition in about half of the sampled streams.

131 Reproductive Effects of a Multi-Chemical, Multi-Stressor Exposure Across Several Generations of Fathead Minnows (Pimephales promelas)

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More than one third of the Earth’s freshwater is used for agricultural, industrial, and domestic purposes leading to the frequent co-occurrence of nitrate and contaminants of emerging concerns in aquatic ecosystems. However, little is understood about the consequences of long-term exposure of fishes to these complex mixtures. This project examined changes in physiology, behavior and reproduction in fathead minnows across three generations of exposure to these mixtures at environmentally relevant concentrations. Exposure of adult fathead minnows in the first generation to high nitrate concentrations (50mg/L) resulted in a two-fold increase in egg production. In the second generation, only the agricultural mixture contained a stimulatory effect in fecundity (p<0.001; ANOVA). Contrary to prior studies, neither nitrate nor estrogenic agricultural mixtures stimulated vitellogenin production in male fishes. In contrast, feminization (presence of the egg-yolk protein vitellogenin) was found in first generation males following exposure to an urban chemical mixture independent of nitrate concentrations. Behavior does not appear to be affected regardless of treatment and generation. Using a multi-generational fathead minnow exposure, we were able to improve our understanding of the consequences associated with long-term exposures to environmentally relevant chemical mixtures. The interactions between these pollutant stressors require further study for adequate assessment of environmental risk.

132 Developing normal ranges for fish health indicators from a 30-year study of impacts of bleached-kraft pulp mill effluent at Jackfish Bay, ON

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Jackfish Bay, located on the north shore of Lake Superior (48°50’N, 86°58’W), was identified as a Great Lakes Area of Concern in 1987 due to changes in its chemical, physical and biological integrity associated with the effluent from a bleached kraft pulp mill in Terrace Bay, ON. Extensive studies on white sucker (Catostomus commersoni) populations documented reduced gonadal sizes, delayed sexual maturation, and altered levels of circulating sex steroid hormones in the late 1980s. Studies have monitored the impacts following installation of secondary waste treatment (1989), changes in the bleaching process (1990s) and a series of closures associated with changing ownership (2000s). The mill changed ownership again in 2012 with the intention of switching the mill to dissolving pulp, but it has remained operating as a bleached kraft mill. Collections in 2018 and 2019 extended the time series (previous collections stopped in 2013) of spring and fall collections. Differences in body size, liver size, gonad size and condition persist, although changes in liver and gonad are much smaller than in the early years. Reference site variability over the 31 year time period approaches 2 SD, and the long term data has been used to develop normal ranges for Jackfish Bay and the reference site. There have been few studies on the impacts of dissolving pulp mill effluent on wild fish, and the normal ranges for Jackfish Bay will enable future studies to follow responses when the mill changes pulping process.

133 Assessing effects of salmon life treatment (hydrogen peroxide) on shrimp populations in a multi-stressor environment

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Hydrogen peroxide (H2O2) is used as anti-parasitic biocide in salmon farms worldwide. Since the treatment water is discharged to the sea, there are concerns about effects of H2O2 on the coastal ecosystems. Our study focuses on the effects of this biocide on populations of the Northern shrimp (Pandalus borealis), which is an economically and ecologically important species in Norwegian fjords. Shrimp may be exposed to multiple stressors including repeated exposure to salmon lice biocides from surrounding aquaculture farms, commercial harvest, and climate change. Laboratory experiments have demonstrated that even short pulses (3 x 2 h) of exposure to H2O2 in concentrations well below the prescribed treatment concentrations result in mortality of shrimp. Moreover, sublethal effects such as gill damage and reduced feeding
have been observed after a recovery period. The aim of this study is to make the information on these effects more relevant for risk assessment and management of Northern shrimp populations. We apply a mechanistic effect model for individual survival (GUTS) in combination with an age-structured population model to project the effects of H2O2 exposure on population decline under different scenarios of H2O2 treatment and environmental stressors. The GUTS model is calibrated to the experimental data from H2O2 exposure, and used to predict survival probabilities under different scenarios of H2O2 exposure profiles in the field. The population model accounts for additional stressors in the environment: variation in adult survival due to harvest and predation, and variation in larval survival due to fluctuating food availability. Since we have little information on the distribution of H2O2 at different distances from aquaculture farms, we use a set of model scenarios representing different medicine application schemes and different degrees of exposure for the shrimp populations. The purpose of this modelling study is to predict effects of H2O2 exposure in combination with other stressors on population-level endpoints such as long-term abundance and age structure, and to assess the risk of population decline below threshold abundances. Potential future development of this modelling approach include: (1) address more types of commonly used salmon lice medicine by including mixture toxicity in the GUTS model; (2) address additional stressors such as harvest in more detail, to make the results more relevant for coastal ecosystem management.

134 From microbes to fish tumours and their linkages to contaminated sediments in a Great Lakes Area of Concern

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The Detroit River was designated a Great Lakes Area of Concern in 1987 owing to impaired status of several beneficial use impairments (BUIs), many of which were linked to toxic contaminants. In 1999 a comprehensive sediment survey was completed covering the entire connecting channel using a stratified random sampling design. The survey was repeated multiple times up to 2013 providing detailed spatial and temporal perspectives of the system-wide contamination for metals, PCBs, OC-pesticides and PAHs. These sediment surveys were pivotal for generating cause effect linkages between in-place toxic contaminants and several beneficial use impairments in the system. Here, we describe a series of case studies demonstrating disruption of microbial and invertebrate communities, fish tumours and bioaccumulation risks to sport fish that incorporate statistical assessment and mechanistic models. We demonstrate that the major spatial patterns of metals, PCBs and PAHs contamination in Detroit River sediments are associated with significant changes to sediment microbial structure and function, produce limited invertebrate toxicity at the highest contamination sites, are associated with elevated incidence of hepatic neoplasms in brown bullheads and generate spatially distinct chemical bioaccumulation patterns in fish. We discuss the merits of implementing high resolution system-wide monitoring programs used to address multiple stressors and guide remediation priorities that go beyond assessment of BUI impairment status.

135 Assessing changes in the fish community composition in tributaries of the Lower Athabasca River Basin in relation to the Athabasca Oil Sands formation

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The lower Athabasca River watershed geographically overlaps with the Athabasca Oil Sands deposit in northeastern Alberta, Canada. The main stem Athabasca River and several of its tributaries run through the heart of many of the oil sands surface mining operations north of Fort McMurray. Rising concerns about the impacts of industrial activities on ecosystems, particularly in the Athabasca Oil Sands formation, initiated a collaborative relationship between the Government of Canada and the province of Alberta resulting in the Joint Oil Sands Monitoring Plan (JOSM). As part of this project, the present study evaluates aquatic ecosystem health in the watershed through examinations of the fish community composition at 19 tributary locations within the Athabasca Oil Sands deposit. These sites have varying degrees of connectivity to the main stem Athabasca River and proximity to industry. In September 2018, fish community data was collected from six 25-meter transects at each site using backpack electrofishing. For each site, fish community endpoints including species richness, diversity, and abundance were quantified. Habitat variables including wetted/rooted width (m), discharge (m$^3$/sec), substrate composition and water depth (m) among others were recorded for each site. Additionally, water quality readings of temperature ($^\circ$C), dissolved oxygen (mg/L), pH and conductivity ($\mu$S/cm) were recorded as ancillary environmental data to help account for any observed trends in community composition. The preliminary results suggest a trend of decreasing species richness with distance from confluence with the main stem Athabasca River, as well as a shift in the dominant species. Through multivariate statistical techniques relationships among biotic and abiotic endpoints will be developed. The results from this study will help to inform future directions of the current Oil Sands Monitoring (OSM) and associated environmental effects monitoring of wild fish health in the lower Athabasca River watershed.

Advances in Ecotoxicology and Risk Assessment of Reptiles and Amphibians

136 Development of a Standardized Toxicity Test Method Using a Native Amphibian Species

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Although there is growing evidence of the sensitivity of amphibians to contaminants, and thus a growing demand for their use in regulatory frameworks, amphibian toxicity data are currently under-represented in risk assessments. Few standardized methods are available, which in part contributes to this under-representation. In addition, none of the available aquatic methods pair whole-organism chronic endpoints with species that are relevant to Canadian environments. To address this gap, Environment and Climate Change Canada has invested in developing a standardized test method for assessing contaminants with a native amphibian species (*Lithobates pipiens*, Northern leopard frog). We will discuss some lessons learned from laboratory research and data from recent inter-laboratory
testing rounds to validate the new test method. For the inter-lab project, we used sodium chloride, thyroxine and perchlorate as model compounds in this multi-laboratory experiment. The inter-lab is a critical step in the standardization process, and we will present data which demonstrates the reproducibility of the test method. With feedback from participating labs, the inter-lab is also used to develop quality control criteria for the test method. The final steps in standardized test method development will include refinement of methodology text, and peer review. The result will be the first Canadian standardized toxicity test method using a native amphibian species.

137 Dermal Fungicide Exposure at Realistic Field Rates Induces Lethal and Sublethal Effects on Juvenile Rana temporaria

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Amphibians are declining worldwide at alarming rates. Pesticides have been identified as one of the major drivers for these declines. Most ecotoxicological studies examining the effects of pesticides on amphibians are conducted in simplified aquatic laboratory set-ups. Adverse effects on terrestrial life stages of amphibians are probable since their skin is highly permeable and thus, the dermal uptake of pesticides represents a likely exposure route. However, terrestrial stages are mostly neglected in ecotoxicological amphibian studies. The aim of the present study was to investigate the effects of a realistic exposure to the most common German viticultural fungicide folpet on juvenile Rana temporaria in a laboratory study. In addition, a potential effect of the aquatic pesticide history was examined. In spring 2018, R. temporaria tadpoles of an uncontaminated pond were placed in enclosures in eight ponds of different pesticide contamination in the viticultural area around Landau (Rhineland-Palatinate) in southwest Germany to mimic different aquatic pesticide history. After metamorphosis, the juveniles were dermally exposed to soil contaminated with realistic field rates of the viticultural fungicides Folpan(R) 80 WDG and Folpan(R) 500 SC with folpet as active ingredient. After 48 hours, effects on the survival as well as the behavior such as distance moved and foraging on Drosophila melanogaster were investigated. No effect of the aquatic pesticide exposure background on the terrestrial sensitivity could be detected. However, the terrestrial exposure lead to mortality rates of 17-100% and had effects on the foraging behavior. Exposed juveniles fed less drosophila and needed longer to catch the first one. In addition, the results indicated that the toxicity differed between the two tested fungicides, suggesting that the toxicity highly depends on additive ingredients in the formulation. The results of this study suggest that a realistic worst-case exposure of commonly used viticultural fungicides can have detrimental effects on early terrestrial life stages of amphibians. These effects can result in an increasing population decline leading to a possible extinction of the population. Since pesticide exposure was conducted at a realistic field rate, the findings of this study can help to estimate the risk of pesticide applications in agricultural landscapes dominated by viticulture for German Anura.

138 Integrating early-life stage transcriptome analysis with apical outcomes of chronic chlorpyrifos exposure in the amphibian, Xenopus laevis

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Chlorpyrifos (CPF) is one of the most widely used organophosphate pesticides worldwide with extensive occurrence in aquatic ecosystems. Exposure to CPF is associated with adverse effects across a wide range of physiological parameters in fish, most notably neurotoxicity through inhibition of the enzyme acetylcholinesterase (AChE). However, effects of exposure to CPF in amphibians are relatively poorly studied. In particular, little information is available on the underlying molecular mechanisms that drive adverse outcomes. The main objective of this study was to identify key molecular response patterns in a model amphibian, Xenopus laevis, following early-life stage exposure to CPF, which may enable prediction of apical outcomes of ecological relevance. Xenopus laevis were exposed to CPF (0.4, 2, 10 µg/L, nominal) from 24 h post-hatch through to metamorphosis (50-55 d post hatch). A subset of exposed individuals were sampled at 96 h and whole-body transcriptome profiles were assessed using high throughput sequencing (RNASeq). Transcript quantification, differential expression analysis and enrichment analysis were performed using ht-seq count on the Galaxy server (galaxy.ecotoxexplorer.ca), the EdgeR tool in EcoToxXplorer (www.ecotoxxplorer.ca), and ClueGo on Cytoscape, respectively. Pathway analysis revealed a number of significantly dysregulated pathways including those associated with “classic” outcomes of CPF exposure, such as serine hydrolase activity (e.g. AChE) and immune pathways, including immune function, inflammatory response, and cytokine receptor activity. Other affected pathways, not typically linked to CPF exposure, included vasculature development, sensory perception of light stimulus, and blood coagulation. Tadpoles exposed to CPF through to metamorphosis exhibited increased relative liver weight (30% increase in 10 µg/L treatment) and a dose-dependent decreased in brain AChE activity. Disruption of pathways associated with serine hydrolase following CPF exposure during early-life stages is in agreement with decreased AChE activity at metamorphosis. Transcriptomic analysis also revealed a number of novel dysregulated pathways that were not directly linked to apical outcomes measured in this study suggesting that CPF impacts a wide range of biological pathways in amphibians that warrant further study. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

139 Effects of the herbicide triclopyr on the behavior and physiology of juvenile frogs

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Amphibians are highly susceptible to anthropogenic stressors. The application of herbicides to amphibian habitat has been shown to cause mortality and sublethal effects on the behavior and physiology of many amphibian species. Most ecotoxicology studies of amphibians focus on aquatic contaminants encountered by larvae. Few studies have examined the effects of contaminants on juveniles though juvenile amphibians are sensitive to anthropogenic stressors and the survival rate of the juvenile life stage is linked to population persistence. Triclopyr is an herbicide used in forestry to control woody plants and broadleaf weeds via ground and aerial spray. Although triclopyr is commonly applied to upland habitat used by amphibians and can persist in the soil for up to 90 days, no studies have examined the effects of triclopyr on terrestrial amphibians. In this study, we examined the behavioral and physiological effects of triclopyr on juvenile Cuban tree frogs, (Osteopilus septentrionalis). Juvenile frogs were exposed to an ecologically relevant concentration of triclopyr (60 ul of Garlon® 4 Ultra, based on manufacturer-recommended 6 qt/acre concentration) applied to a soil substrate for 48 hours. To evaluate the effects of triclopyr exposure on juvenile performance, we conducted feeding and hopping trials. Additionally, we used a non-invasive water-borne assay to compare stress hormone (corticosterone) levels before and after exposure to triclopyr. We found no evidence that exposure to triclopyr affected feeding performance. However, we did find that triclopyr-exposed individuals had significantly shorter average sprint distances than control individuals. We are currently in the process of analyzing the corticosterone data. For many vulnerable amphibians, impaired juvenile hopping performance following triclopyr exposure could translate to a reduced ability to avoid predators and migrate to suitable overwintering habitat, which may have negative population-level consequences.
140 Effects of Marcellus shale petroleum production water on the survival and development of a common North American amphibian (Lithobates sylvaticus)
E. Green, Towson University / Environmental Science and Studies; P.F. Henry, US Geological Survey / Patuxent Wildlife Research Center; C.J. Salice, Towson University / Environmental Science & Studies Biology

Salinization of freshwater systems is a well-recognized and documented issue. The largest contributors to this worsening issue are anthropogenic. Two specific examples are the application of road de-icing salts and waters produced as part of oil and gas production activities both of which drastically elevate salinity in freshwater systems. For example, a single well at one shale gas development site over 8 years can generate nearly one million liters of high conductivity water potentially contaminated with hydrocarbons and other toxic compounds. We conducted acute and chronic toxicity tests using *L. sylvaticus* (wood frog) larvae to estimate the toxicity of produced water retrieved from a site involved in Marcellus Shale gas development (collected by the USGS and transported to the Applied Ecological and Ecotoxicology Laboratory at Towson University, Towson, MD). In the acute toxicity test, larvae were exposed to a range of concentrations (0.0, 0.1, 0.2, 0.375, 0.75, and 1.5 mL/L) for 96 hours. We estimated an LC50 (± 1 SE) of 1.95 ±0.39 mL/L. To examine chronic effects of the produced water on the survival of *L. sylvaticus*, we exposed larvae to concentrations of 0.0, 0.5, 1.0, 2.5, 5.0, and 10.0 mL/L for 30 days. We then conducted a time-to-event analysis to determine the relative hazard (likelihood of mortality) compared to control animals (0.0 mL/L). We found significantly higher hazard to larvae in the 2.5, 5.0, and 10.0 mL/L treatments. To evaluate the chronic effects of produced water on the development and metamorphosis of *L. sylvaticus*, we are exposing larvae to concentrations of 0.0, 0.125, 0.25, and 0.5 mL/L. Preliminary data suggest that elevated salinity may contribute to an increase in time-to-metamorphosis. Our data suggest that even small amounts of produced water, if allowed to enter amphibian breeding habitats, can exert harmful effects on developing individuals. Relatively low concentrations (2.5 mL/L) can cause significant increases in likelihood of mortality of *L. sylvaticus* larvae. Characterization of produced water and ongoing amphibian research will help to better understand the potential impacts on amphibian communities that may be in proximity to similar oil and gas production activities.

141 Marbled salamander (Ambystoma opacum) metabolomic profiling across an agriculturally intensive landscape gradient
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Throughout the US, many forested areas with ephemeral wetlands have been converted for agricultural use. The conversion process has fragmented critical habitats that provide essential landscapes for obligate vernal pool breeding amphibians. Thus, these amphibians are often restricted to smaller forested patches or must transit long distances through agricultural areas to breeding ponds. Although remnant forest patches can vary substantially in size and abundance of ephemeral pools, in an agriculturally intensive landscape all are subject to impacts from nearby operations. In particular, application of fertilizers and pesticides on crops has emerged as a concern for amphibian populations. In September 2018, marbled salamander adults were collected during fall migration to breeding pools in Queen Anne’s, Caroline and Calvert Counties in Maryland. GPS points were taken at all locations where individual salamanders were collected. Using GIS, a 200m buffer was placed around each GPS point and percent agriculture within the buffer quantified. Agriculturally intensive sites were classified as those with >30% agriculture within the buffer zone, intermediate sites ranged from 5-30% agriculture, and forested sites were those with <5% agriculture. Individuals were sexed, snout-vent length was measured, photographed for identification and then swabbed for chytrid fungus and metabolomics analysis. Swabs were analyzed for presence/absence of chytrid fungus using DNAeasy kits followed by PCR. The remaining ethanol was used for GC/MS-based metabolomic analysis. In total, 34 adult marbled salamanders were collected with a minimum of 11 salamanders for each land use classification. Salamanders were significantly larger (ANOVA p< 0.001) at the forested sites. None of the salamanders collected tested positive for chytrid fungus. Although the sample size is small, this preliminary data suggests that salamanders in more agriculturally developed landscapes are not more likely to serve as vectors for chytrid. With respect to metabolomic analysis, there were distinct differences in the biochemical profile of salamanders collected between agriculturally intensive (>30% ag) and forested (<5% ag) vernal pool habitats. However, salamanders collected from intermediate (5-30% ag) landscapes were metabolically indistinguishable from both the intensive agriculture and forested sites. Further data collection is warranted to better inform risk assessment of the effects of agrichemicals and their impacts in vernal pool breeding amphibians.

142 Primary and Immortalized Gonad and Liver Fibroblast Cell Cultures Derived From Laparoscopic Biopsies and Cytotoxicity of Key Organic Contaminants
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Internal organ biopsies from live, healthy endangered animals are rarely acquired. Here, we report on the successful collection of liver and ovary biopsies, via laparoscopy, in loggerhead sea turtles with subsequent cell culture establishment, immortalization, and cytotoxicity testing. Cell cultures were established from one liver, one testis, and five ovary biopsies. One liver and one ovary culture were exposed to either of two immobilization agents: Simian Virus 40 Tt (SV40Tt) and Human papilloma virus 16 E6/E7 (HPV 16 E6/E7). The result was one SV40Tt liver line, one HPV liver cell line, and one HPV ovary cell line. These are the first experimentally immortalized sea turtle cell lines and the first immortalized cell lines derived from healthy sea turtles. The establishment of these immortalized cultures provides for the expansion of in vitro sea turtle research at a more rapid pace and for organs that are underrepresented. Cytotoxicity assays were conducted using one primary ovary, one HPV Ovary, and one HPV liver immortalized cultures via the MTT mitochondrial integrity and Lactate Dehydrogenase (LDH) leakage experiments after exposure to three ubiquitous contaminants—Benzo[a]pyrene (B[a]P), Polychlorinated Biphenyl 77 (PCB 77), and Perfluorooctanoic Acid (PFOA). Cells were exposed to each contaminant for the toxicologically standard 24, 48, 72, and 96 hours. Concentrations of each contaminant applied are those that have been established as scientifically relevant for cell cultures. MTT data indicate PFOA had statistically significant adverse effects on primary and immortalized liver and ovary cells at the highest concentration of 500 uM, while 10 uM B[a]P negatively affected the immortalized ovary fibroblasts compared to the control but had little effect on HPV liver cells. MTT data indicate adverse effects on HPV transformed ovary and liver fibroblasts at all time points following exposure to 10 uM of PCB 77. LDH assays showed far less effect on cell viability than MTT results in general. These findings provide a critically needed understanding of relative toxicity of known contaminants in these endangered species and highlight the difference in sensitivity between MTT and LDH in detecting cell viability. This study advances the field of sea turtle toxicology through the provision of immortalized cell lines derived from key internal organs, introduction of new cytotoxicity data, and the use of laparoscopy for obtaining biopsies from live animals.
143 A stochastic Sceloporus population model to investigate extinction risk from toxicant-induced reductions in demographic parameters

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There is a growing interest in population-level risk assessment, with some authors suggesting that population growth rate is an important endpoint to consider in ecotoxicology. We previously reported a generalized deterministic population model for Sceloporus sp that could be used as a screening-level tool for risk assessment. Our model is a simple 2 stage model with a juvenile stage (1 year) and an adult stage. We expand on this model by adding parameters stochasticity to provide an additional layer of realism to the model. We performed theoretical simulations of 0 to 100% toxicity to each stage of the model (clutch size, juvenile survival, adult survival). We assessed effects of demographic reductions on quasi-extinction risk (defined as an adult population < 10 individuals). Results indicated that the baseline stochastic model had approximately 30% of the adult population size that was affected. Our model suggests that reptile populations may be more susceptible to reductions in demographic parameters than would be suggested by the results of deterministic models. This susceptibility seems to be the result of relatively low abundance and multiple years in a row with lower demographic parameters. Given the cryptic nature of most reptiles, more investigations of toxic effects along and/or the likelihood of demographic parameter reductions in contaminated areas is warranted. Next steps for the model would be incorporating landscape-level considerations of multiple populations and movement between populations.

Stockholm Convention on POPs: Progress in Monitoring, Research and Risk Assessment of Legacy and Emerging Chemicals - Part 2

144 UN Environment Biennial Global Interlaboratory Assessment On Persistent Organic Pollutants - Fourth Round 2018/2019, Non-Dioxin-Like POPs

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In 2018 the United Nations (UN) Environment Biennial Global Interlaboratory Assessment on Persistent Organic Pollutants (POPs) was organized for the fourth time as part of the UN Environment Programme’s capacity building project. Participants were requested to submit results of organochlorine pesticides (OCPs), indicator polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDE), toxaphenes, and hexabromocyclododecane (HBCD) in test solutions, sediment, air extract, fish and human milk. 117 laboratories submitted results which were statistically analysed, after which assigned values and z-scores were calculated, allowing laboratories to evaluate their own methods and performance. Statistical analyses of the data was performed as described by Cofino et al. (2017)I. The z-scores were calculated for each participant’s data for each matrix/analyte combination, which is given an assigned value. The performance for OCPs and PCBs in the test solution was less good than in previous rounds, even though the concentrations were comparable. Participation of new labs may have caused this result. The performance on the fish matrix was rather poor for all compound classes, which most likely is caused by the low concentrations, 1-30-fold lower compared to the those in the third round for OCPs, 20-50-fold lower for PCBs and 20-200-fold lower for PBDEs. For sediment the performance was better, and the performance on human milk was equal to last round. Plotting the results of the different detection methods used for CB 52 in the test solution showed that for high resolution mass spectrometry the majority of the results were within |z|<2, while results obtained with other detection techniques were more scattered. Results show that laboratories in developing countries are on average still far away from the required measurement quality for POPs. Acknowledgements This work was developed under agreement with UN Environment, Division of Technology, Industry and Economics (DTIE), Chemicals and Waste Branch. Funds have been provided by the Global Environment Facility (GEF) through four regional projects “(Continuing) Support for the implementation of the Global Monitoring Plan under the Stockholm Convention in the African/Asian/GRULAC/Pacific Islands Region. References 1. Cofino WP, Molenaar J, Torfs P (2017). Wiley StatsRef: Statistics reference Online, DOI: 10.1002/9781118445112.stat04068.pub2.

145 Towards mechanistic and comprehensive quantification of emissions of persistent organic pollutants into the global environment

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Accurate and complete information on the sources and emissions of persistent organic pollutants (POPs) worldwide is critical for understanding their environmental fate and behavior, and implementing the Stockholm Convention to minimize their adverse environmental and health effects. To this end, there is a need for temporally- and spatially-resolved estimates of global emissions of POPs, in particular those intentionally produced for industrial and consumer uses (e.g., flame retardants), from various lifecycle stages (e.g., production and industrial processes, use, and/or waste disposal) to multiple environmental media (e.g., the atmosphere, water, and/or soils). For many intentionally produced POPs, however, such comprehensive emission estimates are currently unavailable; there is often a lack of a mechanistic understanding of their accumulation and transformation in the human socio-economic system (the “anthroposphere”) and emissions therefrom. In this presentation, we will present a historical overview of existing efforts aimed at elucidating the global emissions of POPs. We will propose substance flow analysis as a powerful tool for facilitating the development of comprehensive emission estimates of POPs. For illustration, we will introduce a mechanistic, dynamic model named Chemicals in Products - Comprehensive Anthropospherical Fate Estimation (CIP-CAFE), and apply it to derive lifecycle-based, temporally- and spatially-resolved, multimedia emission estimates of polychlorinated biphenyls (PCBs) and hexabromocyclododecane (HBCD). The CIP-CAFE model successfully captures the long-term temporal trend of the two POPs and the hotspots of their geographic distribution; it helps explain the observed transport and transformation phenomena of the two POPs in the global environment. These case studies demonstrate how global anthropospheric and environmental fate modeling complements the global monitoring activities and addresses international risk assessment and management under the Stockholm Convention.
146 How Does Modeling of the Global Environmental Fate of Short-Chain Chlorinated Paraffins Complement the Global Environmental Monitoring?

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Models serve as a powerful tool to complement global environmental monitoring and enable our understanding of the fate and risk of short-chain chlorinated paraffins (SCCPs). However, a gap still exists between modeled and monitored SCCP concentrations in the global environment, likely resulting from the uncertainties associated with (i) the global emission estimates, and (ii) modeling using a single set of physicochemical properties of the commercial SCCP mixture as a collective approximation of tens of complex SCCP homologues with extremely diverse properties. Here, we investigate whether a discrepancy exists between the modeling global environmental fate of SCCPs based on the single set or multiple homologue-specific physicochemical properties, and if so, the conditions (i.e., proximity to the emission source region, and regional temperature) that bring about the most pronounced discrepancy. We applied a mechanistic fugacity-based multimedia BETR-Global model to simulate the environmental concentrations and compartmental distribution of SCCPs. Our modeling results suggest that the discrepancy in modeled air concentrations based on single vs. multiple sets of physicochemical properties is most remarkable in regions with a low temperature and negligible emissions, e.g., the remote and cold background Arctic region. By contrast, in regions with a relatively high temperature and emissions, e.g., South China, the discrepancy is less noticeable due to the influence of local emissions. Lumpng tens of SCCP homologues as a whole and characterizing them using a single set of properties in models, minimize the information required for modeling, but also result in a bias in evaluating the environmental occurrence of SCCPs in cold, remote background areas. In other words, the quality of emission estimates is more relevant than physicochemical properties if we aim to accurately appraise the occurrence and risk of SCCP for warm regions with high emissions, whereas accurate physicochemical properties are more important in the appraisal for cold, remote background regions. Presently, we cannot tell whether using a single set of physicochemical properties in modeling is acceptable in terms of the global risk assessment, because most of existing available measurements are conducted in warm regions with high emissions, where the discrepancy between different sets of modeling is marginal. As such, we argue that future monitoring efforts, in particular those under the Global Monitoring Plan, should be directed to cold, remote background regions.

147 Targeted analysis of organophosphorus and brominated flame retardants in human adipose tissue from Colombia

A.C. Torres Moreno, University of Cartagena / Facultad de Ciencias Exactas y Naturales; B. Johnson-Restrepo, University of Cartagena / School of Exact and Natural Sciences; G.P. Codling, RECETOX, Masaryk University

Torres- Moreno, Carolina; Johnson-Restrepo, Borisl; Codling Garry. 2 IChemistry and the Environment Group, University of Cartagena, Cartagena, Colombia. 2Research Centre for Toxic Compounds in the Environment (RECETOX), Masaryk University, Kotlarska 267/2, 611 37 Brno. Czech Republic Flame retardant compounds were detected in 45 human adipose tissue samples collected during 2017 and 2018 from Cartagena and Cucuta cities in Colombia. Flame retardants (FRs) including twelve brominated (ATE, BATE, TBPE, and nine PBDEs), twenty one novel brominated, two chlorinated flame retardants (a-DP and s-DP), and sixteen organophosphorus were measured using a GC-Q-Exactive MS instrument. The highest concentrations of brominated flame retardants (BFRs) were found for TBP, BDE-47, and BDE-66 on average value of 10.82, 4.20 and 4.01 ng/g lw., respectively. Those concentrations were higher in the Cartagena, located on the Caribbean coast, than Cucuta located at east of the Colombia. T21PPP (mean concentration of 402.12 ng/g lw) TBP (mean concentration of 261.37 ng/g lw), EHP (mean concentration of 215.55 ng/g lw), TCEP (mean concentration of 169.23 ng/g lw), TCPP (mean concentration of 297.07 ng/g lw), TDCPP (mean concentration of 16813.73 ng/g lw) were the highest values of the OPFR compounds. The great finding of this study is the change in the FRs profile for our country, revealing a major presence of OPFRs compounds than PBDEs as it was expected.

148 Polychlorinated biphenyls and chlorinated paraffins in home-produced eggs from an e-waste area in South China: Occurrence and human dietary exposure

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Polychlorinated biphenyls (PCBs) and chlorinated paraffins (CPs) are among the most well-known and studied families of organic pollutants. Rudimentary e-waste recycling activities can result in severe PCB and CP contamination and their hydrophobicity and lipophilicity lead to their bio-accumulation in fatty tissues of animals. However, data on human dietary exposure to PCBs and CPs associated with e-waste recycling are still limited, or in the case of M/LCCPs, are almost non-existent. Therefore, the levels of PCBs and short/median-chain chlorinated paraffins (S/MCCPs) in home-produced eggs collected from an e-waste site in South China were measured and the human dietary exposure to these two classes of contaminants via egg consumption was calculated. The levels of PCBs, SCCPs, and MCCPs varied from 236 to 8870 ng/g lipid weight (lw), 477 to 111,000 ng/g lw, and 125 to 91,100 ng/g lw, respectively. Concentrations of IICES-6 PCBs and TEQs of DL-PCBs strongly exceeded current European maximum limits. Consuming these eggs implicates a serious health risk for local residents, especially for children. There were no significant changes in the PCB, SCCP, and MCCP levels between 2013 and 2016, indicating that these compounds remain at relatively high levels in environmental and biological systems for a long period of time. Therefore, it is necessary to raise awareness among the local population and take appropriate measures to reduce the intake of contaminants by home-produced eggs.

149 PFAS research within the US Environmental Protection Agency: Science to support the Stockholm Convention

A. Gillespie, US Environmental Protection Agency / Atlantic Ecology Division

Per- and polyfluoroalkyl substances (PFASs) are a growing concern among many communities in the US due to increasing reports of potential human exposures. In response, the USEPA is implementing a PFAS Action Plan which advances many of the goals of the Stockholm Convention with respect to understanding, managing and mitigating risk from this class of chemicals. The USEPA’s PFAS Action Plan includes a robust program of research which is already generating results for advancing our understanding of PFAS. This includes an integrated set of research activities aimed at filling gaps in our current ability to conduct scientifically rigorous risk assessment and risk management activities. This research program is designed to address these data gaps and enable stakeholders to begin making effective decisions for identifying and mitigating risk from PFAS in the environment. This information will also be of benefit to the global community working in support of the Stockholm Convention; The science required to protect public health and the environment from PFAS exposure cuts across many applications and disciplines. The risk assessment/risk management paradigm provides a useful means to assess the state of the science available for informing decisions, and to identify gaps in knowledge needed to support risk management. USEPA’s initial scoping of information available for assessing and managing PFAS risks revealed deficiencies in all key areas of the risk paradigm including hazard and toxicity (there are likely hundreds of PFAS in the US environment, and most lack sufficient suitable toxicity information for informing understanding of the potential for human or ecological effects); exposure (information about different PFAS sources, fate and transport, and human and ecological exposure is sparse, both spatially and temporally); and
suitable treatment and remediation approaches (there is little information on effective methods and costs for treating or removing different PFAS from drinking water, groundwater, wastewater, air, soils, and sediments). The purpose of this presentation is (1) to provide an overview of USEPA’s overarching PFAS research program, with a focus on recent advances and ongoing activities, and (2) to highlight the relevance and utility of this science to the Stockholm Convention.

150 Triclosan and methyl triclosan in small fish in estuary waters influenced by wastewater effluent

D. Lin, San Francisco Estuary Institute / Department of Civil and Environmental Engineering; R. Sutton, San Francisco Estuary Institute; C. Hamilton, SGS AXTS / Client Services; J. Hobbs, UC Davis
San Francisco Bay is an estuary of hemispheric ecological importance that receives significant stormwater and wastewater loads from surrounding urban areas. Triclosan is an antimicrobial used in a wide variety of personal care products such as soaps, toothpastes, detergents, as well as other plastic consumer products. Ubiquitous use of triclosan in consumer products has led to widespread detections of triclosan in wastewater, surface waters, sediment, aquatic life, and humans, and there are significant concerns about its persistence and toxic impacts to humans and aquatic life. Methyl triclosan is a major metabolite of triclosan that forms in wastewater treatment plants, and is more persistent than the parent compound. Triclosan and methyl triclosan were analyzed in small fish in Bay waters near a wastewater outfall location to evaluate bioaccumulation and potential impacts to aquatic organisms. A novel analytical method for extraction and analysis of both triclosan and methyl triclosan in tissue was developed and used to quantify triclosan and methyl triclosan. Combined concentrations of triclosan and methyl triclosan were measured up to 240 ppb wet weight. Triclosan and methyl triclosan in fish tissue were related to degrees of wastewater influence at the sampling locations, and calculations suggested bioaccumulation from diet in addition to direct uptake from water. Potential impacts to fish were evaluated by comparing to other toxicity studies. Field sampling occurred in 2016 when the US Food and Drug Administration announced its ban on triclosan and 18 other active ingredients in liquid hand soaps for consumers, which took effect in 2017. Results indicate prey fish are a useful monitoring matrix for triclosan and its metabolites and that ongoing monitoring is needed to ensure management actions are sufficient to mitigate ecological risks.

151 Legacy and Emerging PFAS in Australian WWTPs

B. Clarke, University of Melbourne / School of Chemistry

The Australian environmental community are fast recognising per- and polyfluoroalkyl substances (PFAS) as a contaminant of emerging concern. Traditionally regulators have focussed on a small range of legacy perfluoro carboxylic acids and sulfonates measuring them in environmental matrices. However, to date over 3000 PFAS have been produced and distributed internationally. It is becoming apparent that unidentified PFAS are present in environmental matrices having unknown effect. Worldwide wastewater treatment plants (WWTP) have been recognised as a source of PFAS to the environment. Few studies on newer fluorinated compounds in WWTPs have been produced with only limited data available on PFAS in Australian WWTPs. Influent and Effluent at three Australian WWTPs were extracted and analysed utilising unique workflows to identify anionic PFAS. Targeted analysis was performed using LC MS/MS to quantify a range of PFCAs, PFSAs and FTSs. The samples were then screened for unknown PFAS on LC-QTOF using a custom database with various levels of verification. Finally, software tools such as MassHunter molecular feature extractor (MFE), mass profile professional (MPP) and molecular structure correlator (MSC) were used to propose and identify fluorinated compounds in the wastewater samples not present in the database. This study provides further insight into PFAS cycling and emissions in Australian WWTPs for use by environmental regulators.

Mercury Fate, Biogeochemistry and Risk in a Changing Environment

152 National view of temporal atmospheric anthropogenic mercury deposition across Canada using lake sediments

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Mercury (Hg) is a pollutant of concern globally which is emitted into the atmosphere from largely coal combustion, gold mining and metal smelting, and can be transported over large distances due to its long residence time before it is deposited. Atmospheric Hg is dominated by anthropogenic contributions, and this study provides a national view of spatial temporal trends, from 1850 to 2018 CE, in atmospheric anthropogenic Hg deposition across Canada, using $^{210}$Pb dated lake sediment cores. Over 60 small headwater lakes have been sampled at sites nearby known pollution sources, such as Flin Flon and Thompson Manitoba smelters, Trail British Columbia (BC) smelter and urban centres, as well as within remote locations such as Kejimkujik National Park (NP) in Nova Scotia and Experimental Lakes Area (ELA) in Ontario. This study examines whether atmospheric anthropogenic Hg fluxes (corrected for sediment focussing and catchment effect) decline with increasing latitude and longitude away from known emission sources, and whether anthropogenic Hg fluxes match predictions of the global mercury model for each geographical location. Thus, testing whether anthropogenic Hg fluxes can be used to validate model predictions where Hg wet deposition measurements are limited. Since the 1990’s, anthropogenic Hg fluxes have declined by 4-fold at sites nearby the Flin Flon Manitoba smelter and Trail smelter in British Columbia, whereas at remote sites such as Kejimkujik NP and ELA, anthropogenic Hg fluxes are ongoing. Sedimentary Hg profiles across Canada can therefore be used to assess the effectiveness of national and international mitigation efforts and controls on industrial Hg emissions.

153 Insights into surface water methylmercury patterns in a complex freshwater estuary - production zones and transport mechanisms

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Mercury cycling in freshwater ecosystems involves a complex set of interrelated physical, chemical, and biological processes, many of which remain poorly understood. Our study investigates methylmercury (MeHg) concentrations in the surface water of an ecologically complex freshwater estuary to provide insight into conditions that promote net MeHg production and transport mechanisms that determine its fate in the larger ecosystem. Using the spatial distribution of MeHg in the estuary as a basis, we provide insights into the magnitude of loads introduced into the rest of the system. Predator fish that inhabit the St. Louis River estuary (SLRE) have higher levels of MeHg than those recorded in other parts of the watershed. Bioaccumulation of MeHg in these fish threatens human and ecosystem health and compromises the recreational value of recreational resources. Over the course of 3 years, surface water data was collected from several characteristic ecosystem types. Within each of these ecosystems, replicate plots were chosen along a transect that included near shore environments, the main river channel and locations in between. Our observations show that surface water MeHg concentrations increase from the main channel of the river towards nearshore areas in isolated embayments, which suggests that there are “hotspots,” or net MeHg production zones within the estuary. We use this spatial information with transport parameters derived from hydrologic models and conservative ion tracers to constrain the parameters of a reduced-order-complexity model describing the relationship between MeHg production...
154 Salinity influences on mercury photochemistry in estuarine rivers in Minas Basin, Canada

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Mercury (Hg) loss from natural waters can occur through photoreduction that is controlled primarily by ultraviolet (UV) radiation. The retention of Hg in aquatic systems is largely affected by its reduction-oxidation photochemistry, and the chemical characteristics of estuarine water may significantly affect the photochemistry of Hg and its eventual accumulation in food webs as methylmercury, a potent neurotoxin. Currently, there are limited data on Hg photochemical cycling in estuarine ecosystems compared to freshwater ecosystems. To address these knowledge gaps, the photochemical kinetics of mercury speciation with respect to salinity and dissolved organic matter (DOM) were quantified. It was hypothesized that the rate and absolute amount of photochemical Hg reduction in estuarine waters is facilitated by DOM and inhibited by salinity. Water samples from the Cornwallis tidal river estuary in the Minas Basin, Nova Scotia, Canada were taken in July of 2018. Using tangential ultrafiltration, an array of salinity and DOM conditions were attained and then irradiated over an environmentally-relevant range of five UV intensities between 300-400 nm. Gaseous elemental mercury (Hg(0)) was analyzed every five minutes over a period of 24 hours using a Tekran 2573BS CVAFS automated mercury analyzer. Gross photoreduction and photooxidation reversible pseudo-first order reaction rate constants and total photoreducible Hg in each treatment were determined using curve-fitting software. These data and the correlations with DOM and salinity change will and be presented.

155 Assessing land use impacts in mussels in the Saint John River with mercury and stable isotopes

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The Saint John River (SJR) in New Brunswick, Canada, supports diverse aquatic communities, a population of over 500,000 people, and many different industries. In recent years, the impacts of point and non-point sources of contamination have garnered increased attention in the SJR. Elevated mercury concentrations are of particular concern since mercury is known to bioaccumulate in tissues, biomagnify across trophic levels, and cause adverse health effects in fish and their consumers. The present study used mussels as bioindicators for mercury and stable carbon and nitrogen isotopes to evaluate nutrient inputs at 23 sites across 4 physiographic regions to assess spatial variability in contaminants and to identify specific sites which may pose a risk to wildlife. Foot tissue from Eastern elliptio and Eastern lampmussels was collected at each site in summer 2018, dissected, freeze dried and homogenized. Samples from similarly-sized individuals were analyzed for total mercury on a DMA-80 and were sent to the University of New Brunswick for determination of stable isotopes. Significant differences in mercury were observed across physiographic regions (ANOVA, p = 0.0131), with sites downstream of the Mactaquac dam having notably high concentrations. At 7 sites, mercury levels exceeded the tissue residue guidelines for mink, a predator of freshwater mussels. δ13C decreases and δ15N increases occurred in mussels from upstream to downstream along the SJR, with significant differences between regions for both δ13C and δ15N (ANOVA, p < 0.0001). Overall, the spatial trends in both mercury and stable isotopes of the mussels likely reflected greater inputs from agricultural and urban land use in lower reaches of the river.

156 Assessing variability of atmospheric mercury (Hg 0) trends using tree-rings in Northern Canada

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Atmospheric mercury (Hg), primarily in the form of Hg0 plays an important role in the global Hg cycle and is a significant input of Hg to many ecosystems. An improved quantitative understanding of atmospheric Hg concentrations and historical anthropogenic emissions is key to be able to evaluate the efficacy of regulatory action, such as the Minamata Convention, on Hg concentrations in environmental compartments, food webs, and exposure risks in human and wildlife. Emerging research suggests that annually resolved tree-rings have the potential to be a powerful biomonitoring tool for reconstructing temporal and spatial atmospheric Hg concentrations as previous research demonstrates that atmospheric Hg is reliably incorporated into new trunk growth solely via deposition on the foliage. However, this biomonitoring tool still requires further development to better understand both small and large spatial scale variability. We use tree-rings from white spruce (Picea glauca) to reconstruct spatial and temporal trends in atmospheric Hg spanning from 1600 AD to present-day, across a large geographic region in northern Canada, including continental sites (central and northern Yukon) and coastal sites (Mackenzie River Delta, Northwest Territories). To assess local scale influences in Hg, tree rings are analyzed from Little Fox Lake, Yukon, the site of a historic forest fire (1998), to determine if a signal of local forest fire activity can be detected. Results show regional differences in the timing of the initial increase attributed to anthropogenic emissions and the timing of maximum Hg, the fastest rate of increase in Hg concentrations occurs between 1850 and the mid 20th century at all sites. The enrichment factor in modern Hg relative to the pre-industrial baseline estimated from tree rings appears to be lower compared to enrichment factors calculated from other paleo records such as sediment and peat cores. Comparing samples with known local inputs such as a forest fire provide a better understanding of how local influences can augment tree-ring Hg concentration. Overall, these methods can be used to address gaps and discrepancies in the Hg literature and will help to develop more precise estimates of atmospheric Hg concentration which, will be useful for validating emission inventories and refining atmospheric Hg models.

157 A Case Study of Long-term Risk Management of a Complex Mercury Site

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Complex sites that extend beyond the property boundaries of the primary constituent source often require a long-term strategy to manage risk as exposure paradigms and property ownership change over time and space. This is particularly true for sites for constituents such as mercury, that are persistent in the environment. The risk-based approach to addressing undefined exposure scenarios needs to be collaborative, consensus-based, consistent with regulatory program strategies and efficient to keep pace with often competing program schedules and objectives. A case study will be presented that discusses a long-term risk management strategy being implemented on the South River program in Virginia, that has proven effective in addressing potential exposure scenarios as they arise. Historical mercury (Hg) releases occurred at a textile manufacturing facility on the South River, Virginia, which led to increased Hg concentrations above background for approximately twenty-five miles of floodplain and bank soils downstream of the source. Although the ecological and human health risk assessments have been approved as part
of the site’s RCRA corrective action permit, a framework was needed to address exposure scenarios and outside stakeholder projects (e.g. parks and recreation improvements, dam removals, etc.). Two risk management frameworks will be presented that address these concerns. First a surficial soil strategy that evaluates exposure to mercury impacted floodplain and bank soils at properties identified in the HHRA to be carried forward to the corrective measures study, as well as properties where Interim Remedial Measures focusing on bank stabilization are not necessary based on remedial action objectives. The second approach addresses beneficial reuse and material management concerns associated with mercury impacted soils as part of non-RCRA related projects. An overview will be presented that discusses the data inputs, exposure parameters and the collaborative approach required to achieve regulatory approval. Project examples will also be discussed where each framework has been successfully implemented to achieve mutually beneficial outcomes that are protective of human health and the environment.

158 Diffusive Gradient in Thin Film (DGT) samplers as a biomonitoring tool for Hg bioaccumulation in freshwater wetlands

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Mercury (Hg) is a well-known neurotoxin and common environmental contaminant. After entry into the environment, Hg may form a wide variety of compounds including the bioaccumulative form methylmercury (MeHg). High concentrations of MeHg are often found in upper-trophic level aquatic macrofauna which poses a risk to human health if consumed. Traditionally, bioaccumulative Hg in the environment has been estimated by MeHg measurements in water and soil samples. In reality, though, this sampling strategy may not be effective as the compound may bind to organic matter or sorb to particulates, rendering it unavailable for uptake. These processes are highly site specific and thus sites with similar sediment and/or water concentrations may have very different impacts on human and environmental health. Here, we assess the viability of using diffusive gradient in thin film (DGT) samplers deployed in the water column to estimate bioavailable Hg in the water column and subsequent accumulation in freshwater wetland biota. Mesocosm freshwater wetlands were dosed with four isotopically labeled inorganic Hg endmembers known to span a range of bioavailability and methylation potentials(204Hg2+, 196Hg-humic acid, 199Hg-sorbed to FeS, 200HgS nanoparticles). DGTs were then deployed in the water column at regular time intervals for a three-month period and accumulation of MeHg and Total Hg (TotHg) over a one-week period were measured. During this time period plants, biofilms, snails, and mosquito fish were retrieved from the mesocosms and assessed for MeHg accumulation. As expected, net production of MeHg (as a % of the total) was generally greater for the dissolved endmembers than the particulate endmembers resulting in greater bioaccumulation of MeHg originating from those species. Moreover, accumulation of both TotHg and MeHg on the DGTs correlated with MeHg concentrations in macrofauna, plants, and periphyton biofilms, indicating that they may be useful in predicting bioaccumulation in freshwater wetland organisms. Surprisingly, TotHg accumulated by DGTs correlated more strongly than MeHg. We attribute this to MeHg production in periphyton biofilms entering the food web through grazers, indicating that biofilms may play an important and previously unrecognized role in Hg cycling and bioaccumulation in freshwater wetlands.

159 Mercury in aquatic food webs impacted by two run-of-the-river hydroelectric plants, forest fires, logging and constructed wetlands

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Methylmercury concentrations ([MeHg]) were unexpectedly high in fish from low-impoundment run-of-river reservoirs located in the St-Maurice River (Quebec, Canada). Apart from the flooded zones of few kilometers square, other perturbations occurred in the watershed that could have led to conditions that favored mercury methylation by microorganisms. Among those were: constructed wetland channels, forest wildfire, and current and past logging activities. To observe the dynamic of mercury transfer through food webs in sectors differentially affected by these disturbances, we collected 332 invertebrate samples and 432 fish of different sizes and species. We analyzed [MeHg], isotopic signatures of carbon (δ13C) and nitrogen (δ15N) as well as Esox lucius and Sander vitreus growth rate (using bone structure for age determination). We calculated the trophic magnification slopes (TMS) for each sector using regressions of [MeHg] as a function of adjusted δ13N of all organisms of each food web. TMS were significantly different between sectors and were function of the intercept of the regressions (Log[MeHg] at δ13N = 0) which were significantly correlated to the [MeHg] in primary consumers. Those results gave new insights on the uses of TMS in Hg bioaccumulation studies. In comparison to top predatory fish, low trophic level fish (TL < 3.5) had higher [MeHg] than expected from their δ13N values. Analysis of their δ13C showed that [MeHg] were not function of trophic status but rather of their source of carbon. Indeed, we observed that for those fish as well as for invertebrates, [MeHg] were higher at lower δ13C (depleted in 13C). On the other hand, top predators [MeHg] were negatively correlated with growth rate, indicating that fish in impacted areas grew more slowly and accumulated more MeHg than fish from other sectors. A dynamic model of bioaccumulation taking into account water and food uptakes, growth and physiological loss successfully predicted measured [MeHg] in Northern Pike and Walleye. In conclusion, variation in MeHg in top predators in this river system affected by multiple disturbances was affected by changes in growth rates as well as by changes in methylation rates at the base of the food web that could have been traced with carbon isotopes.

Recent Advances on the Analytical Chemistry, Fate and Mitigation of PFAS from Aqueous Film-Forming Foam (AFFF) Contamination

160 In-Depth Characterization of AFFFs and PFAS Dispersions by High Resolution MS

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Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals of significant interest due to their environmental persistence and unknown ecotoxicological effects. The historical long-chain perfluoroalkyl acids (PFAAs) garnered international regulatory and/or health advisory levels due to their known bioaccumulation and toxicity, and an explosion of novel chemistries has appeared to fill the role of these PFAAs. One of the most common uses for non-polymeric PFAS materials is for their useful surfactant properties, including in aqueous film forming foams (AFFFs), and as dispersants in polymer processing. These mixtures are highly complex and frequently exhibit non-fluorinated materials as major components, including ionic and non-ionic hydrocarbon surfactants. Characterizing the PFAS portion of the mixture by non-targeted analysis can be challenging due to substantial matrix effects and ion suppression, and some knowledge of the non-fluorinated components is extremely useful for toxicological evaluation of the complex mixture (e.g., mixture toxicology). High resolution mass spectrometry offers a solution for screening due to its ability to separate species via mass resolution, determine accurate molecular formula from isotopic information, and perform multiple MS fragmentation to resolve structural information. We applied a repeated injection scheme with iterative inclusion/exclusion lists to fully characterize AFFF and PFAS dispersions samples in industrial use. An initial list of potential masses was collected in a full scan, and inclusion lists were generated for subsequent data dependent MS/MS.
injections until the entire list was collected, allow us to “dig deeply” into less abundant species. Data processing scripts were written to prioritize features for classification and examination, including filtering for (fluoro- and hydrocarbon) homologous series and major diagnostic fragments. MSn fragmentation was used to characterize unknowns and MS data was stored in local MS libraries. The compilation of PFAS mixtures was used as a screening library for waste stream outputs (air and water emissions) for PFAS uses, to identify components of the mixture that were environmentally relevant, and non-targeted analysis was used to identify potential transformation products of processing and/or waste treatment.

161 The Enrichment PFASs and the Discovery of Hydrocarbon Surfactants in Foaming on Surface Waters Impacted by AFFF

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Foaming surface waters near sites where aqueous film forming foams (AFFFs) and other sources of per- and polyfluoroalkyl substances (PFASs) were released have raised public concern. Accumulation of PFASs at the air-water interface is due to the surface active nature of PFASs yet few measurements of PFASs in foam are reported. Foam arises upon agitation of the surface microlayer of surface water bodies (e.g., wind action) that may be enriched in surface active PFASs. After a foaming event in 2018, pairs of foam and the bulk water immediately under the foam were collected. Samples were analyzed by liquid chromatography quadrupole time of flight mass spectrometry for 400+ suspect individual PFASs and 12+ suspect classes of hydrocarbon surfactants. Concentrations in foam and underlying bulk water were ratioed to generate an enrichment factor for PFASs and hydrocarbon surfactants in each pair of samples. Foams were enriched in long-chain PFASs, including PFNA, PFDA, and PFMnDa, and hydrocarbon surfactants such as linear alkylbenzene sulfonate relative to bulk water. These long-chain PFASs were near detection levels (ng/L) in bulk surface water but were in the mg/L level in foam (when collapsed to a liquid). The implications of the concentrations and enrichment factors for public and fresh water organism health will be discussed.

162 Characterization of Per- and Polyfluoroalkyl Substances (PFAS) in Firefighting Training Areas across Eastern Canada

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The extent of PFAS contamination as well as the identity of PFASs at aqueous film-forming foam (AFFF)-impacted sites are not fully understood, which impedes the risk assessment and proper management of such contamination sites. To fill this knowledge gap, the PFAS profiles and levels in soil samples collected from four firefighting training areas (FTA) close to airport across Eastern Canada were characterized by analytical techniques encompassing targeted, suspect-screening, non-targeted, and non-specific methods, e.g. Total Oxidizable Precursor (TOP) assay. This is the first time that a comprehensive PFAS profiling was performed at federal Canadian AFFF-impacted sites. Results showed that a large variety of PFAS species (52 target and 236 suspect PFAS) contributed to the PFAS contamination in these AFFF-impacted soils, with the concentration of known PFASs amounting to 103.2-11093.8 ng g⁻¹ dw. The dominant PFAS included anionic perfluoroalkyl sulfonates, n₂ fluoroelomer sulfonates, neutral perfluoroalkyl sulfonamide, and cationic perfluoroalkyl sulfonamide quaternary ammonium salt. Persistent transformation intermediates (such as 6.2 fluoroelomer trihydroxyxymethyl sulfoxide (6.2 FTSAs-SO), 8.2 fluoroelomer mercaptopalkamidol sulfonate fluoride (8.2 FTSAs-SO2) were also prevalent in these contaminated soils. Clear differences in PFAS profiles at these sites were observed, such as a high concentration of 6.2 fluoroelomer sulfonamide betaine (FTAB) and n:3 and n:1.2 fluoroelomer betaines (n=5, 7, 9 and 11 FTBs) in soils from one FTA site whereas rather low concentrations in the other three sites. The differences in PFAS profiles and levels among these FTA sites may be associated with AFFF use volume and history, variations in sorption and bioavailability of PFASs depending on soil and PFAS properties, different transport potential of PFASs related to varied hydrogeological conditions, etc. Furthermore, comparison between the concentrations of known PFAS and total PFAS revealed the presence of a large fraction of unknown PFAS in these soil samples. Finally, the use of non-target analysis method enabled the discovery of several new classes of PFASs among these unknowns. The comprehensive PFAS profiling for soil samples impacted by either historical or current use of AFFFs is helpful for in-depth understanding of their environmental behavior, fate, and their impacts after release into the soil environment.

163 Detection and Transformations of Poly- and Perfluoroalkyl Acids Downstream from Fire Training Areas in Groundwater-fed Coastal Watersheds


Poly- and perfluoroalkyl substances (PFAS) are a class of more than 4,700 aliphatic fluorinated compounds manufactured for use in commercial and industrial applications. Adverse human health effects including dyslipidemia and immunosuppression in children have been associated with PFAS exposures. Aqueous film forming foam (AFFF) for firefighting and training activities near military bases and airports is a major point source of PFAS contamination. Prior work has shown many PFAS in AFFF are highly mobile in groundwater. However, the spatial extent of PFAS transport and precursor transformations during transport away from contaminated source zones are uncertain. Here we present new surface water and groundwater discharge data of 24 PFAS, bulk precursors determined by the Total Oxidizable Precursor (TOP) assay, and extractable organofluorine collected between 2016-2019 in six coastal watersheds (three with known AFFF point sources and three without AFFF point sources) on Cape Cod, Massachusetts. Levels of PFAS in the watersheds contaminated by AFFF point sources were one to two orders of magnitude higher than levels in non-AFFF impacted watersheds. Principal component analysis confirmed by hierarchical clustering indicates that the AFFF fingerprint is distinct from the non-AFFF fingerprint and is characterized by PFAS with less than nine perfluorinated carbons. The fingerprint is persistent throughout the AFFF-contaminated watersheds. This result is supported by mass budgets for a river that originates from an AFFF-contaminated lake. The budgets, developed by paired flowrate and concentration measurements, indicate conservative transport in the river of PFAS with less than nine perfluorinated carbons. At the discharge point of the river to a saltwater bay, bulk precursors represent 16-26% of the total PFAS signal, indicating that precursors persist in the river and are transported more than 6 kilometers under oxic conditions. These findings suggest that PFAS from AFFF with less than nine perfluorinated carbons propagate far downstream from the source and serve as an ongoing source to the marine environment.

164 The Use of PFAS onboard marine vessels: Impacts to Halifax Harbour

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PFAS are presently essential ingredients in aqueous film forming foam (AFFF) used for fire-fighting, but are also persistent and pervasive environmental contaminants. For example, AFFF used onboard a marine vessel can wash overboard resulting in addition of PFAS to the surrounding ocean environment. A hydrodynamic model (Delft3D) was used to predict the transport of PFAS released into Halifax Harbour at different locations over differing environmental conditions. The initial AFFF input was relatively conservative representing 10 minutes of firefighting using one standard hose. Results indicate that PFAS released in the presence
of strong winds and waves during a storm will travel up to 31 km in 2 days, approximately 40% farther than PFAS released during a time period dominated by tidal currents with calm wind and no waves. When PFAS was released from inner harbor locations, during environmentally calm periods, PFAS concentrations reached 500 ng/L after 12 hours, but dissipated to 300 ng/L after 48 hours, and 60 ng/L after 10 days. These levels are close to some international guidance values for recreational water use. Given the relatively conservative AFFF input used here, some risk is identified. The methods used here could be further refined and used to develop best practices for fire fighting near shorelines while aboard marine vessels. These results also indicate that PFAS use on marine vessels should be considered in further assumptions underlying long range PFAS transport.

165 Fingerprinting AFFF, Landfill, and Municipal Wastewater Sources of Per- and Polyfluoroalkyl Substances

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Per- and polyfluoroalkyl substances (PFAS) impart unique water and oil repellent properties. As such, they are applied to a number of consumer products and are used in aqueous film forming foams (AFFFs), which are used to suppress hydrocarbon fuel fires. Consequently, use and disposal of PFAS-containing products have the potential to contribute to environmental PFAS loading from sources including landfill leachates, wastewater treatment plant effluents, and AFFF releases. To date, attempts to differentiate PFAS sources rely on discerning differences between perfluoroalkyl carboxylates (PFCAs) and sulfonates (PFSAs) from various sources. However, because PFCAs and PFSAs are common to many sources, differentiation of sources is very challenging. To remedy this situation, groundwater collected from AFFF source zones, an archive of landfill leachates from a US national survey, and select wastewater effluents from around the US were fingerprinted by liquid-chromatography-quadrupole time-of-flight high-resolution mass spectrometry for 400+ individual PFASs. The number of individual PFASs, PFAS concentration and their ratios, and the ratio of branched to linear isomers were evaluated by hierarchical clustering and principal component analysis in order to differentiate PFAS fingerprints from landfill leachate, wastewater effluent, and AFFF source zones.

166 Effects of ‘Traditional’ and ‘Novel’ Perfluoroalkyl Substances on Early Life Stages of Salmonid Fishes

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Emerging substitutes for traditional perfluoroalkyl substances, purported to pose lower risks to humans and the environment, have been raising concerns over the past few years. There is a clear need for additional toxicological information on these ‘novel’ perfluoroalkyl substances to better describe their environmental impact profiles. As representative salmonid species, arctic char (_Salvelinus alpinus_) and rainbow trout (_Onchorhynchus mykiss_) were exposed to three typical substitutes, perfluorobutanesulfonic acid (PFBS), perfluorobutyric acid (PFBA), and undecafluoro-2-methyl-3-oxahexanoic acid (GenX) as well as the well-known perfluorooctanesulfonic acid (PFOS). Survival and development of these two species were both most affected by PFOS when compared with the other perfluoroalkyl substances. Exposure to the chemicals was done in early life stages, and the portion of chemicals delivered into the fishes showed different patterns among the different perfluoroalkyl substances. Additional experiments, including bioavailability studies and determination of affected metabolic pathways, need to be done to better explain the possible risks of these substitutes for traditional perfluoroalkyl substances.

167 Identification of genes involved in per- and poly-fluoroalkyl substance metabolism in the soil bacterium, _Gordonia sp._ NB4-Y

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To date, perfluoroalkyl and polyfluoroalkyl substance (PFAS) biodegradation pathways have been inferred by studying mass loads in sewage treatment plants, or determined experimentally with in vitro studies examining PFAS biotransformations using mixed sewage inocula, sediment in microcosms, or in mammalian cell cultures, and extracts. While these studies are valuable, developing a deep understanding of the biochemical machinery driving biological PFAS biotransformations in the environment demands detailed examination of the specific genes and proteins involved. Building on pathways elucidated for fluorotelomer sulfonamidoalkyl betaine (6:2 FTAB) and 6:2 fluorotelomer sulfonate (6:2 FTSA) metabolism by the soil bacterium, _Gordonia sp._ NB4-1Y, the present study compared gene expression profiles of NB4-1Y exploiting either 6:2 FTAB, 6:2 FTSA, octane sulfonate and magnesium sulfate as the primary source of sulfur for growth. High-throughput sequencing of mRNA from exponentially growing NB4-1Y allowed for the identification of 2 nitriotriacetate monoxygenase genes (ntaA) as being differentially expressed on exposure to 6:2 FTSA, enzymes which are hypothesized to catalyze 6:2 FTSA desulfonation, a novel activity for this enzyme class. Other genes that were observed to be differentially expressed include: 4 genes putatively involved in C-N bond cleavage in 6:2 FTAB; 4 genes putatively involved in dehalogenation and acetyl-CoA addition to the fluorinated alkane backbones of 6:2 FTAB and FTSA; 17 stress response genes; and 8 genes related to sulfur starvation. Of 14 genes annotated as taurine dioxygenase (_taud), alkanesulfonate monoxygenase (ssud) or nitritotriacetate monoxygenase (_ntaA), 4 were upregulated on 6:2 FTSA, 6:2 FTAB and octanesulfonate, 6 were upregulated on 6:2 FTSA and 6:2 FTAB, 1 was upregulated on 6:2 FTSA, and 3 were not expressed under any condition. In combination with proteomic analyses, genes of interest are being cloned and expressed to allow for identification of structural features that allow the enzymes to interact with PFAS breakdown products. This work is improving understanding of the molecular mechanisms of PFAS metabolism and will allow for the development of site assessment tools to inform remediation practitioners of the biological potential for PFAS removal, thus guiding treatment decision making processes.

Environmental DNA (eDNA) Approaches to Enhance Biodiversity Monitoring and Risk Assessments - Part 2

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Environmental risk assessments require accurate and timely information regarding occurrence and distribution of ‘at risk’ and invasive species. Conventional survey methods generally rely on direct observation that can be stressful to the target species and damaging to their habitat. For species that are cryptic or low density, the likelihood of detection is low. A new approach involves sampling DNA in sediments, soil, or water that is sloughed off target organisms. Environmental DNA (eDNA) detection is accomplished through the identification of unique sequence segments of genetic material without the necessity of coming into direct contact with the target organisms. The high sensitivity of eDNA methods can dramatically increase detection rates, particularly for species that occur at low densities, have secretive ecologies, feature discontinuous distributions, or share morphological traits that confound accurate identification. Furthermore eDNA methods are more cost-effective, non-invasive, and more accurate than conventional survey methods. eDNA methods...
require an effective synergy between field and DNA detection methodologies with several points of consideration that require attention during development, adoption, and implementation. Analytical techniques and technologies are rapidly evolving and the methods chosen depend upon the desired purpose to 1) detect taxa in a targeted fashion or 2) assess community biodiversity. Environmental samples are complex and the quality and quantity of DNA can vary substantially. As such, field and analytical components of eDNA methods face particular challenges that require a heightened awareness and attention to methodological requirements. Best practices strive to mitigate sources of false positive and false negatives, utilize eDNA methodology appropriate for study design objectives with appropriate regard to statistical power, include attention to quality control, and provide transparency in assessment of test performance. We present the highlights of a recent consensus-based synthesis of the current needs in eDNA practice in order to address specific issues to remove barriers to the adoption of eDNA methods for environmental risk assessment. These include addressing quality issues with accuracy and reliability, lack of accredited national standards for both sample collection and analysis, and the need for demonstrated competency and proficiency testing by practitioners.

169 Seasonal variation in detection of vertebrates at a uranium mine containment pond using environmental DNA (eDNA) metabarcoding
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Development of new uranium mining in northern Arizona was halted in 2009 by the federal government until studies assessing the potential impact of radionuclide and other heavy metal contamination were conducted. In order to understand the possible toxicological effects on wildlife, a better understanding of the local food web and exposure pathways was needed. One potential source for exposure to heavy metals associated with mining activity are the containment ponds required at each mine site. We have previously shown that eDNA metabarcoding can detect vertebrates utilizing these water sources and identify taxa to species level. We have conducted quarterly water sampling at one, pre-production mine site to assess seasonal variation in vertebrate usage of the containment pond. By using a metabarcoding approach with 12S and 16S rDNA markers, we identified species and assessed temporal variation in detection rate and read number. We recovered large numbers of sequence reads from taxa expected to be in the area, as well as from less common or hard to observe taxa such as the Mexican free-tailed bat and the tiger salamander. Detection of the tiger salamander is of note because this species was not observed by the traditional biological survey techniques used. eDNA is quickly becoming a popular tool for wildlife surveys and has unique advantages and as well as limitations relative to traditional survey methods. Ultimately this tool will enable us to better understand the overall biodiversity of the area and potential movement of heavy metal contaminants through the food web.

170 Environmental DNA Survey in Lake Ontario to Assess Presence of Round Whitefish During Known Spawning Periods and General Fish Community Composition

Environmental DNA (eDNA) analysis is an emerging and non-intrusive tool to detect species in the environment. It is supplemental, or in some cases, may be an alternative to traditional methods for surveying biota. Industrial applications of eDNA approaches have primarily been in rivers, streams and small ponds, whereas studies in large water bodies such as the Great Lakes are scarce. In the current study, a winter field program was developed to survey eDNA from Round Whitefish in tandem with gillnetting in Lake Ontario. The objective was to evaluate the potential for eDNA analysis to be used as a tool for detecting Round Whitefish during spawning. In this study, size-selective gillnets were deployed in December to capture Round Whitefish in a known spawning location in Lake Ontario. Different volumes of water were collected along the nets before, during, and after fish capture, followed by on-site DNA extraction. Primers were developed to detect Round Whitefish DNA using quantitative polymerase chain reaction (qPCR) in a highly sensitive and specific manner. Metabarcoding was also investigated for assessing fish community composition. Results from qPCR and gillnetting were consistent, as both approaches demonstrated the presence of Round Whitefish in the spawning area, with no detections at the control site. Round Whitefish DNA was more frequently detected at sampling locations in close proximity to the nets. The most promising approach for detecting Round Whitefish DNA is collecting larger volumes of water along a transect within a spawning location. Metabarcoding of Lake Ontario water samples yielded results indicating a relatively small number of fish species including Round Whitefish, White Sucker, Rainbow Trout, while only Round Whitefish, White Sucker and American Eel were captured by nets. Limitations associated with metabarcoding were noted, including not being able to distinguish between closely related species (genetically), and not being able to detect American Eel that were caught in the nets. Overall, this study successfully demonstrates the potential for using eDNA to assess fish presence in the Great Lakes during winter spawning and the potential to provide additional information on fish community composition. It is the first study to use eDNA to demonstrate Round Whitefish presence in the Great Lakes and that transect sampling to collect large volumes of filtered water greatly improves eDNA detection sensitivity.

171 Environmental DNA (eDNA): Opportunities and Constraints for Advancing Ecological Risk Assessment and Environmental Effects Monitoring
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There are a large number of studies published over the last decade that support the use of eDNA surveys for aquatic ecosystems as a sensitive and highly efficient approach for evaluating the presence and distributions of biota of interest. The major portion of targeted species eDNA studies have focussed on at-risk or invasive species, while metagenomic approaches have focussed on biodiversity. There are merits, however, to the wider use of eDNA approaches in the types of eco-epidemiological approaches that underpin multi-species ecological risk assessments and environmental effects monitoring (including cumulative effects monitoring). This is based on (i) the increased complexity and especially geographic and temporal scales of the issues we seek to address, and (ii) the inherent potential of eDNA approaches for increasing our capacity per unit of effort to acquire both more extensive and intensive knowledge about biota distributions over space and time. Furthermore, to the extent that eDNA collection, analytical and interpretative data standards can be developed and implemented in not-too-distant future, eDNA results produced by different parties may exhibit a higher level of accuracy and reproducibility than is typically achieved through more traditional ecological monitoring methods. This is important to the extent that we wish to resolve the big environmental issues through greater access to crowdsourced environmental data and big data meta-analytical approaches (as is currently achievable for air quality and water quality data, for example). One substantial limitation of eDNA surveys in their current state of development is that they provide taxon presence-absence but not abundance data. Nonetheless, we discuss the potential applications of both targeted taxa eDNA and metagenomics methods for ecotoxicological / ecological risk assessment application, with a discussion of both the merits and limitations. The species sensitivity distribution (SSD) is an important precept in modern applied ecotoxicology and this is discussed in the context of new eDNA-based approaches for identifying where and when potentially sensitive species occur relative to the observed environmental conditions.
We also discuss challenges with reconciling existing ecological impact metrics (e.g., for stream invertebrate communities) with the data characteristics associated with eDNA methods.

172 Assessing freshwater mussel restoration efforts in the Clinch River with environmental DNA metabarcoding


The Clinch River is located in the Appalachian Valley of southwestern Virginia and northeastern Tennessee, USA and contains the highest concentration of extant federally listed aquatic species in the United States. The fauna includes a diverse mussel assemblage of 46 extant species, 20 of which are listed as endangered, and a diverse fish assemblage of 132 species, 3 of which are listed as either endangered or threatened. Habitat alterations and contaminants have led to major declines in the mussel fauna. In 1998 a chemical spill in Virginia killed 18,000 mussels of 16 species, and was followed by a Natural Resource Damage Assessment and Restoration (NRDAR) case to propagate and reintroduce mussels to depleted populations. Our objective was to test the utility of eDNA metabarcoding for monitoring mussel populations and restoration efforts. We developed and tested a metabarcoding assay to detect all freshwater mussel species with known mitochondrial COI gene sequences that occur in the Clinch River. The degenerate PfaCOI2 primers, with a 241 bp amplicon, amplified all tested Unionid mussel swab and tissue samples, and did not amplify tested outgroups, including human, emerald shiner, blue mussel, Dreissena spp., and silver carp. However, we found an unexpected non-target amplification product that interfered with sequencing depth. Removal of the non-target amplicon allowed a final sequencing depth of approximately 12 million reads, with approximately 6.5 million reads suitable for the analyses. We detected 18 freshwater mussel species. Trends in mussel diversity from site to site were in agreement with data from traditional mussel surveys. We concluded that robust sequence data for the target species and related species, as well as careful assay design, primer optimization, water sampling, lab practices, controls, and bioinformatics are critical for confident interpretation of eDNA metabarcoding results. The metabarcoding field has a need for consistent methods to avoid or remove sequencing errors, contamination, and tag jumping.

173 Application of environmental DNA methods for detecting species at risk fish

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Environmental DNA (eDNA) is DNA released into an organism’s habitat that can be used to infer species presence/absence without sampling the organism. Application of eDNA as a rapid, indirect environmental monitoring technique is gaining traction in conservation and invasive species studies. Indeed, eDNA is emerging as a particularly powerful tool for detecting covert Species at Risk (SAR), but has not been applied to the environmental consulting sector. We applied eDNA methods to test for presence/absence of Redside Dace (Clinostomus elongatus) (Endangered) and Lake Sturgeon (Acipenser fulvescens) (Endangered) using mitochondrial DNA markers and occupancy analyses for populations in Southern Ontario, Canada. Traditional field survey data were used to identify positive and negative control sites a priori. Results from two years of discrete and continuous transect sampling indicated that positive control sites showed presence of the target species’ eDNA. Using environmental metadata as covariates, we calculated the probability of detection and occupancy to explain patterns of variance in eDNA presence/absence. This novel study is part of a four-year collaborative eDNA project to develop field-tested protocols to determine presence/absence of several SAR. Environmental DNA promises to revolutionize SAR assessments in the consulting sector by providing a faster, more efficient method of species detection compared with traditional field surveys.

174 The Critical Need to Assess the Variables Applied to Survey Design and Analysis of Environmental DNA

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Environmental DNA (eDNA) detection technology has the potential to greatly contribute to the understanding of species distribution and to inform conservation efforts. This presentation builds on the previous research that has noted the particular benefit of eDNA analysis when attempting the detection of imperiled species, where conventional means of detection are intrusive, entail risk of harm, or have lower efficacy. Our presentation highlights multiple case studies that include the use of eDNA for the endangered and imperiled Redside Dace (Clinostomus elongatus) in Irvine Creek; the remediation of the Lower Seymour Conservation Reserve abandoned gun range, home to a number of endangered amphibian and mammals; identification of source microbial contamination in a municipal wellhead; and more. During the design and implementation phases of eDNA surveys, the many variables that factor into the survey design, and the various means of sample collection, processing, and analysis available within the emerging field, have come to light. Through trial and error, the surveys designs have evolved, and multiple pieces of equipment have been tested, resulting in varying degrees of detection and confidence. Our case study results stress the importance of tailoring and optimizing the equipment, methods, and survey design to the objective of the survey, thereby maximizing confidence in the results. This is of particular importance when results pose an implication on the protection or recovery of the species.

175 Archived Environmental DNA (eDNA) Samples: An Evaluation of Sample Performance Over Time

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Reliable detection of target species using environmental DNA (eDNA) is a significant and valuable scientific tool. Based on the premise that animals shed their DNA into their environment, key advantages of using eDNA compared with conventional detection methods include: enhanced sensitivity and accuracy; lower sampling effort and cost; an expanded time-frame for sample collection; and reduced invasiveness to the habitat and organism. eDNA samples may also be archived for future testing for additional species of interest without the need to return to the field site to collect additional samples, provided that samples are properly preserved and stored. Confidence in eDNA results can be achieved by following best eDNA practices in the field and laboratory. It is important that the quality of eDNA samples be assessed prior to analysis to control for false negatives (type II errors). eDNA samples that are too degraded or that contain assay inhibitors, found naturally occurring in the environment, may not generate a positive signal during analysis and could be falsely interpreted as a “non-detect” for the target species, when in fact the sample quality is unsuitable for analysis. This applies both to newly-collected samples and historical samples that are retrieved from archive for testing. Little is known about the performance of archived eDNA samples over time and the ability to generate meaningful data on species presence when stored samples are analyzed at a future date. Providing metrics to this question will enable users to appropriately incorporate eDNA sample archiving into their eDNA programs with the intent that samples can be interrogated in the future with confidence. Two filter preservation methods are commonly used: ethanol immersion and silica preservation. We will provide perspectives on the utility of each of these preservation methods. Of the two, silica preservation has many advantages over ethanol while
not compromising on effectiveness. We also will discuss the results of a performance experiment of archived eDNA filter samples preserved with silica over time under different storage conditions.

**Soil Contaminants: Fate, Bioavailability, Environmental Toxicology in Ecological and Human Health Risk Assessment**

**176 Environmental Fate of Saflufenacil, a New Fluorinated Herbicide**

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Saflufenacil is a protoporphyrinogen IX oxidease (PPO) inhibitor herbicide used for the treatment and control of dicot weed species in crops such as corn, wheat, and soybean. Recently, PPO inhibitor herbicides have seen significant increase in use, particularly for the treatment of a growing number of glyphosate-resistant species. While previous saflufenacil research has focused on metabolic profiling and mode of action in target species, there remains limited knowledge surrounding the environmental fate and distribution of saflufenacil. In this research we apply saflufenacil on an agricultural field to directly monitor its potential to undergo photolysis, biological degradation, and environmental transport. Soil samples taken over the course of the growing season were analyzed using a modified high-throughput dispersive liquid-liquid extraction technique. This was combined with LC-MS/MS resulting in method detection limits (MDLs) for saflufenacil and its metabolites of 0.034 ng/g in soil with recoveries of 87% +/- 10%, sufficient for analysis below the application rate of 63 g a.i./ha. Additional partitioning experiments were conducted to examine transport through soil, water, and non-targeted crop species; while high-resolution mass spectrometry and fluorine NMR were employed to probe potential degradation pathways. The predominant metabolic breakdown pathway in soil yielded three key metabolites which were detectable above the MDL in all field samples as long as 7 months following initial exposure. Notably, saflufenacil was also found at high levels in non-targeted species, suggesting the potential for environmental persistence and unintentional distribution. Through this research we have gained a more thorough understanding of the environmental fate of saflufenacil, and techniques developed for monitoring its fate and distribution are readily applied to other novel fluorinated agrochemicals, providing a more comprehensive overview of environmental contamination in soils.

**177 Reducing mobility/bioavailability of metals, metalloids and PFAS contaminants simultaneously using mixed mode remediation materials**

*M. McLaughlin, University of Adelaide / Soil Science*

Contaminated soils are rarely contaminated by just one chemical; sites are often contaminated by a cocktail of metals, metalloids and organic compounds which often makes remediation of the contamination problematic. For example, removal of hydrophobic metals and metalloids requires polar solvents (acids/chelates) which will not displace hydrophobic organic contaminants. Furthermore, in situ remediation of one contaminant may exacerbate the mobility and/or bioavailability of another e.g. remediation of lead-contaminated soils by addition of phosphate to precipitate lead phosphates may mobilise arsenate. We have developed mixed-mode remediation agents using a variety of materials which have the ability to bind metals, metalloids and hydrophobic contaminants simultaneously. Some of these remediation agents are developed from relatively low cost materials and have now found commercial use, but development continues using new materials such as metal-graphene composites which offer similar or enhanced properties. Data for remediation of a metalloid anion (arsenic), a metallic metal cation (cadmium) and hydrophobic/hydrophilic contaminants (PFAS chemicals) indicate that mixed-mode remediation agents have significant potential for use in remediating soils contaminated by a variety of chemicals. Graphene-based products have significant potential but costs of graphene production need to drop for these materials to have wide application.

**178 The Role of Naturally Occurring Colloids in the Transport and Fate of Antibiotic Resistant Genetic Debris**

*N. Chowdhury, Duke University / Civil and Environmental Engineering*

The association of extracellular DNA (eDNA) and naturally occurring colloids is evaluated to elucidate the role of particles in the transport and fate of antibiotic resistant genetic debris in natural soil and aquatic environments. DNA fragments are isolated from common antibiotic resistance genes. The impact of DNA fragment length, DNA GC (guanine-cytosine) percent, particle association with organic components and water hardness are evaluated. Adsorption isotherms are developed for fragments of eDNA to model colloids - kaolinite and silica nanoparticles. Adsorption isotherms of DNA to kaolinite fit to the Langmuir model indicate that shorter DNA fragment length is favorable for adsorption and DNA guanine-cytosine content within the range tested (34%-54%) does not significantly impact equilibrium adsorption. The fit to the Langmuir model also suggests that adsorption abides by Langmuirian assumptions - mono-layer coverage of the particle and an equal energy of binding sites. Equilibrium adsorption is established within an hour, fits pseudo-second order kinetics and is size dependent. DNA fragments adsorb to silica nanoparticles when humic acid or high (but not environmentally relevant) concentrations of divalent ions (10 mM CaCl₂) are present in solution. Adsorption isotherms of DNA to humic acid functionalized silica nanoparticles fit the Freundlich model - an empirical model that doesn’t assume mono-layer coverage or equal energy of binding sites. Smaller DNA fragments preferentially adsorb to humic acid-silica and GC content has no significant effect on adsorption. The addition of CaCl₂ at environmentally relevant concentrations (2 mM) does not allow DNA to adsorb to silica nanoparticles, but does enhance adsorption to humic acid-silica. The addition of CaCl₂ and humic acid have an interactive effect in promoting adsorption of DNA to the surface of the nanoparticles. This suggests that water hardness, presence of organic material and eDNA fragment size are important predictors for adsorption of antibiotic resistance genes to naturally occurring colloids. Future aims will investigate the role of particle association in regulating the persistence of genetic materials and the bio-availability of particle associated genetic material in uptake by bacteria.

**179 Incorporating community data into risk assessment schemes using community similarity dose-responses**

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Current Ecological Risk Assessment schemes use mostly single species test data at lower tiers to extrapolate/predict effects in the field (higher tier). Inter-species sensitivity can be incorporated by using data on multiple species combined in models such as species sensitivity distributions. However, this approach does not take into account important ecological interactions between species. Microcosm experiments using natural soil communities can be used to include species interactions and are specially suited for site-specific approaches using a relevant community and soil from a site of interest. Some species disappear in contaminated environments while others may thrive from reduction in competition/predation. This increased complexity in the response of communities to environmental stressors poses issues in the interpretation of results, especially to define environmental thresholds. In this study we propose a novel statistical approach, using community similarity, to interpret community responses to stressors in a microcosm community experiment. Laboratory community experiments were performed using a natural community.
and increasing doses of metal mixtures of lead, copper, nickel, zinc and cobalt in three fixed ratios. Two ratios based on regulatory guidelines (CSQG and ARL) and a third ratio based on average metal concentrations in a metal contaminated site (SUD). Each ratio was tested using a control and ten mixture doses in toxic units. Metal mixture effects on the soil community were analysed using the proposed community similarity dose response curves. The community similarity between test and control treatments decreases as contamination increases, producing a dose response curve that allowed the calculation of community effect concentrations (ECx). Under this concept, a community ECx provides the percentage of change x caused by a contaminant in a community. These community ECx values could potentially be used directly to establish environmental protection thresholds, in a transparent manner, which does not require expert judgement, and is supported by data.

180 Introducing adverse ecosystem service pathways (AESP) as a tool in predictive soil ecological risk assessment

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The soil ecosystem is complex and is responsible for providing several benefits to humans, benefits known as ecosystem services (ES). These benefits result from the interactive processes and activities of soil organisms with support from the physicochemical properties of the soil. Risk assessment of multiple stressors on complex systems requires understanding of the relationships between components of the system, both in the presence and absence of stressors. We developed adverse ecosystem service pathway (AESP) models to study the soil ecosystem and its response to a metal mixture containing Cu, Pb, Zn, Co, and Ni. We sampled 47 soils and measured 15 soil processes that represents five ES including food production and water purification. Using a Pearson bivariate correlation matrix, we confirmed that ES were interrelated and linked to soil properties. Results from t-tests showed that the processes underlying ES were significantly reduced in metal impacted soils except for the soil enzyme activities measured ($p < 0.05$). We built two AESP models using soil properties as the main predictors of ES and predicted the regional impacts of metal mixtures in the Prairie Provinces of Canada. The predictions showed areas sensitive to metal contamination in the Prairies and estimated the depreciation of benefits we derive from the Prairies. The results confirm that AESP models could be a useful tool in understanding complex ecosystems and in predictive risk assessment, management of natural resources and climate change.

181 Evidence of anthropogenic pollution in playground soil throughout Oklahoma City, Oklahoma

S. Hileman, J.B. Belden, Oklahoma State University / Integrative Biology

Polycyclic aromatic hydrocarbons (PAHs) and metals are generally ubiquitous in the environment and have been found to be of concern with regards to human health. PAH and metal contamination may correspond with atmospheric deposition, and in urban environments soils may contain elevated levels of both categories due to proximity to sources like vehicular traffic. Sampling in the Oklahoma City Metropolitan Area has indicated that PAH accumulation (and especially carcinogenic PAHs or cpAH concentration) has been significant, and in many cases cpAH load has been measured above the USEPA’s residential soil screening level of 1100ppb. The Oklahoma City Metropolitan Area varies in urban landscape causing school proximity to major areas of traffic to differ. Included in this initial sampling were soils from public elementary school playground areas. Because schools in this metropolitan range tend to have a high degree of concern, there is the potential for oral exposure to these contaminants in sensitive age groups by way of hand-to-mouth actions involving soil. Recent data from playground soil at elementary schools throughout the Oklahoma City Area have shown elevated but varied cpAH levels. This preliminary investigation has also shown metals to be present, but in lower levels. These sites should be further investigated to determine potential sources of contamination.

182 Gastrointestinal Mobilisation and Oral Bioaccessibility of Polycyclic Aromatic Hydrocarbon Nonextractable Residues from Soils and Related Cancer Risks

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Highly sequestered polycyclic aromatic hydrocarbons (PAHs) residues in soils are difficult to extract by exhaustive solvents, particularly in long-term aged soils. As a result, it has been speculated that these PAH residues do not pose risks to human health following incidental ingestion of PAH-contaminated soils. Whether PAH nonextractable residues (NERs) in soils will be mobilised in the human gut fluid and in sufficient concentrations that may pose unacceptable levels of cancer risks remain largely uncertain. In this study, we first subjected soils collected from historically contaminated manufactured gas plant (MGP) site soils to exhaustive solvent extractions to remove total-extractable fractions and to produce soils containing only PAH NERs. Another aliquot of the unextracted soils was subjected to gastrointestinal digestion using a physiologically based gastrointestinal model that incorporates a silicon rod (Si-Org-PBET) as an intestinal sink for PAHs. In addition, gastrointestinal mobilisation of PAH NERs from the solvent-extracted soils using Si-Org-PBET was assessed. The incremental levels of cancer risks following incidental ingestion of PAH-contaminated soils was then determined, following a widely used deterministic cancer risk assessment approach. The oral bioaccessibility of 6 carcinogenic PAHs that were monitored ranged from 24 - 36%, indicating that only a small fraction of total PAHs in soils were bioaccessible in the gastrointestinal solution. Hence, total-extractable PAH concentrations overestimated risks from exposure to PAHs in the long-term contaminated soils. In addition, the in vitro gastrointestinal fluid mobilised small amounts of PAH NERs from the soils and associated cancer risks were within acceptable target levels (> 10E-6). Overall, gastrointestinal mobilisation of long-term contaminated soils containing highly sequestered PAH nonextractable residues is unlikely to exert unacceptable levels of cancer risks and therefore do not need to be considered in human health risk assessments. These observations may be useful for risk-based approaches for contaminated land management and decision-making, particularly where incremental levels of cancer risks following exposure to PAH residues in long-term contaminated soils are of interest.

183 Bioavailability of Organic Chemicals from Soil for HHRA: Study Design Considerations

Y. Lowney, Alloy, LLC / Health Sciences

Incorporating bioavailability adjustments into human health risk assessment (HHRA) for chemicals in soil is gaining regulatory acceptance. Continuing development of guidance from USEPA and state health/environment agencies facilitates greater acceptance of bioavailability adjustments in the risk assessment process. This is enhanced by efforts such as the documentation and training efforts by the Interstate Technology and Regulatory Council (ITRC). To date the guidance on bioavailability of chemicals from soil has largely focused on inorganic chemicals in soil, particularly lead and arsenic. Site-specific evaluations have addressed bioavailability adjustments for organic chemicals from soil, such as dioxins and polycyclic aromatic hydrocarbons. However no broad guidance for incorporating adjustments, or even appropriate research methods have been endorsed by regulatory agencies in the U.S. This presentation will outline some of the study design challenges that are different between inorganic and organic chemicals, and discuss the potential implications, in terms of quality and potential biases in final results.
**Life Cycle Assessment - Advancements and Applications**

184 Life cycle impact of titanium dioxide nanoparticle synthesis through physical, chemical, and biological routes

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The sustainable manufacturing of nanoparticles (NPs) has become critical to reduce life cycle energy use and the associated environmental impact. With the ever-growing production volume, titanium dioxide (TiO2) NPs have been produced through various synthesis routes with differing input materials and reactions, which result in differential reactivity, crystallinity, surface areas, and size distributions. In this study, life cycle assessment is used to analyze and compare the environmental impact of TiO2 NPs produced via seven routes covering physical, chemical, and biological syntheses. The synthesis routes are chosen to represent mainstream NP manufacturing and future trends. Mass-, surface area-, and photocatalytic reactivity-based functional units are selected to evaluate the environmental impact and reflect the corresponding changes. The results show that impact associated with the upstream production of different precursors is dominant for the chemical route. Compared to the chemical route, the physical route requires substantial quantities of supporting gas and high-energy inputs to maintain high temperature; therefore, a higher environmental burden is generated. A high environmental burden is also modeled for the biological route due to the required bacterial culture media. This present study aims to identify the most efficient synthesis route for TiO2 NP production, lower the potential environmental impact, and improve green synthesis and sustainability.

185 Global Environmental Impacts of Single-Walled and Multi-Walled Carbon Nanotube Synthesis Methods and Implications of Scaling Up

*S. Temizel Sekeryan, University of Wisconsin / Civil and Environmental Engineering; F. Wu, Jinan University / School of Environment; A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering*

Carbon nanotubes (CNTs) are well known for their mechanical resistance, durability, and flexibility, which make them preferable for a wide variety of industries including electronics, optics, composites, energy and environment, automotive, aerospace, coatings, paints and pigments. The average production volume of CNTs was approximately 4000 tons/year in 2018, and this is expected to reach about 5 times more by 2024, globally. CNTs are categorized by their wall numbers as single-walled (SCWNTs) and multi-walled (MWCNTs). Although there is not a clear distinction between the volume of SWCNTs and MWCNTs produced, it is in consensus that MWCNTs are the dominant form in the market. CNTs may be synthesized by several chemical and physical methods and their synthesis have greater impacts on the products they are embedded in. This research performs a cradle-to-gate life cycle impact assessments (LCIAs) on 7 different SWCNTs and 5 different MWCNTs synthesis methods in order to evaluate global environmental footprints associated with manufacturing. A mass-based functional unit is selected as 1 kilogram of CNTs produced, and LCIA are conducted using SimaPro 8.5.2 Software with Cumulative Energy Demand (CED) and TRACI 2.1 Impact Assessment Methodology. Inventories are compiled both from CNTs synthesis papers and previously applied LCIA. The results showed that manufacturing SWCNTs with high-pressure carbon monoxide method is the most environmentally conscious method, whereas chemical vapor deposition (CVD) is the most impactful method. Furthermore, manufacturing MWCNTs with arc discharge method is found to be the most environmentally friendly, while CVD is the most impactful one among different methods considered. Switching methods would save up to 0.4 billion tons of CO2-eq. per year, which corresponds to 8% of the total greenhouse gases emitted in the United States in 2016. Given that the production is anticipated to peak in the next years, scaled up processes may offer lower environmental impacts. However, the literature on industrial scale production is currently limited. In order to address the significance of large-scale production, scaling up factor is developed in the current study by using LCIA for both laboratory and large-scale inventories. It is found that scaling up would save releasing 65% of emissions annually. This study aims to show that it is worthwhile to shift methods to have more environmentally friendly products.

186 Evaluation of new solar cells technologies for transparent photovoltaics in the United States

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Transparent organic photovoltaics (TPV) can harvest energy from the near-infrared and ultraviolet region of the solar spectrum and used in new applications such as windows. In addition to producing electricity, TPV absorption can change the energy demand of the building. There is a need to design materials that maximize both the energy efficiency and solar energy production. This study quantifies the annual net energy benefit of three new classes of organic materials by simulating electricity and heating demand from different types of buildings in various locations. Experimental work included material synthesis, device fabrication, solar power efficiency measurement, degradation measurement and spectral properties which was used to calculate the embodied energy of TPV manufacturing using life cycle assessment. The overall net energy benefit was calculated by combining the change in energy consumption, the photovoltaics electricity production and the manufacturing energy for each type of solar cells. The energy payback time (EPBT) and energy return on investment (EROI) were calculated and for C3AIPc based TPV the EPBT ranged from 51 days to 1.1 year depending on the location and type of module. Additional results for other types of solar modules will be presented.

187 Effect of Sediment Chemistry on Life Cycle Impact Assessment for Metals in Freshwaters

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The USEtox Life Cycle Impact Assessment (LCIA) modeling approach for freshwater compartments was originally developed to describe the fate and transport of non-polar organic chemicals. For metals, water chemistry (e.g., pH, DOC, competing cations) plays a significant role in determining metal partitioning. Recent research addressed this issue using the Windermere Humic Aqueous Model (WHAM) to compute water column KD values based on defined input parameters for freshwater and marine archetypes for use in USEtox LCIA model simulations. However, the effects of sediment chemistry on LCIA has not been considered. The purpose of this study is to evaluate the effects of sediment chemistry on LCIA for metals using the risk assessment screening-level model, TICKET-UWM, to calculate LCIA Comparative Toxicity Potentials (CTPs) directly for freshwater environmental compartments. TICKET-UWM includes simultaneous consideration of dissolved and particulate phase transport between a well-mixed water column and an (oxic or anoxic) sediment layer, along with detailed chemical speciation calculations for metal binding to inorganic ligands, dissolved (DOC) and particulate organic carbon (POC), and Fe/Mn oxide surfaces; precipitation of metal hydroxides, carbonates, and sulfides; and dissolution kinetics for metal concentrates/massives and metal sulfide precipitates. The model also provides a direct evaluation of toxicity using either Free I on Activity Model (FIAM) or Biotic Ligand Model (BLM) calculations.
The modeling approach presented above provides a simple method for linking risk assessment models such as TICKET-UWM to LCIA model calculations. The approach allows non-linear responses associated with metal partitioning (in the water column and sediment) to be considered in developing LCIA CTPs for freshwaters. TICKET-UWM simulations will be presented for aluminum (Al), copper (Cu), nickel (Ni) and zinc (Zn) to highlight the effects of sediment chemistry (pH, sediment POC, redox conditions), sediment-water transfer processes and metal-sulfide oxidation rates on computed LCIA CTPs for freshwaters.

188 An exposome-based approach using Big Data to compare the health impacts of multi-stressor exposures
O. Jolliet, University of Michigan; K. Stylianou, University of Michigan / Environmental Health Sciences

High-throughput exposure strategies comparing exposure to various nutritional, chemical and physical stressors are needed for exposome wide associations. This presentation shows how recent Big Data and models enable us to predict exposure and impacts for multiple stressors. Occupational exposures were assessed across the entire US industry, based on a) measured noise levels, and noise-induced hearing loss burden rates for 287 sectors and sector-specific job occupation distributions, as well as b) observed organic chemical concentrations at work place for 49,000 measured sector-based concentration values for 235 organic chemicals. c) Dietary exposures and nutritional impacts were assessed using NHANES survey and the decomposition of individual diet into 16 dietary risk factors, accounting for 400 risk-outcomes, stratified by 15 age groups and gender, coupled with food composition and consumption data for 20,000 individuals. d) Physical activity is charaterized using MET and outcome-specific relative risks, and e) Consumer exposures to chemicals in multiple products are assessed using stochastic usage and chemical contents databases for more than 9,000 product-chemical combinations. f) PM2.5 environmental exposures are assessed based on residence location and a multiscale model predicting local concentrations. All exposures are then coupled with corresponding dose-responses to obtain individual burden in uDALY/pers-day. Potential impacts are highly variables depending on individual behavior and can typically range a) from 0 to 14 uDALY/pers-day depending on job occupation for hearing impairments due to noise; b) from 0 to 1600 uDALY/pers-day depending on industry sector for impacts of organic pollutants on workers; c) from a typical impact of 250 uDALY/pers-day lost from detrimental food, up to a benefit of 300 avoided uDALY/pers-day depending on selected diet, with main impacts associated with cardiovascular disease, diabetes and cancers; d) from a benefit of 0 to 400 avoided uDALY/pers-day as a function of physical activity; e) from 0 to 300 uDALY/pers-day for exposure to chemicals in consumer products and f) from an impact of 0 to 40 uDALY/pers-day lost associated with fine particulate 2.5um, depending on residence location. We enter an exciting era in which you can “Tell me when and where you lived and worked, what you consumed, exercised and ate... and I will tell you who you are (your exposome!).

189 Circular Economy: Life Cycle Assessment perspectives
W.H. Motta, Latec/UFF / Sustainable Managing System

Since the industrial revolution, natural resource use and waste had constantly grown. This is due a “take-make-consume and dispose” pattern of growth - a linear model which assumes that resources are abundant, available and cheap to dispose of. This study addresses the circular economy, this means an environmental performance from: product design through eco-design, productive and operational eco-efficiency, the use of renewable sources of energy, and also re-using, repairing, refurbishing and recycling existing materials and products. One of the proposals of the circular economy states that the raw material used in the product has other “lives” in other new products. The aim is that all resources need to be managed more efficiently throughout their life cycle to confront the ecological crisis. To support and direct the necessary efforts for this transition to a more circular economy a life cycle approach is needed, in this case specifically the use of LCA, that is a methodology that has been increasingly accepted as a way to assess the environmental impacts associated with all stages of a product’s life cycle. By providing detailed information of all the impacts throughout the product life cycle. LCA has a crucial role in the transition to a circular economy, as this methodology is able to validate, for example, the option to reuse a residue or change a production process, demonstrating the reduction of environmental impacts resulting from these decisions. The discussions underline the need of understanding and integrating these axes of knowledge, considering the huge potential to provide new means to overcome the ecological crisis. This bibliographical study, seeks to present the importance of LCA as supporter to the path for a circular economy.

190 Lowering the actor’s footprints and increasing their handprints: a win-win methodological approach to achieve the net positive development
J. Burek, Massachusetts Institute of Technology / Materials Systems Laboratory; G. Norris, Harvard School of Public Health / Sustainability and Health Initiative for NetPositive Enterprise SHINE; J. Gregory, Massachusetts Institute of Technology / Materials Systems Laboratory/ MIT Concrete Sustainability Hub; R. Kirchain, Massachusetts Institute of Technology / Materials Systems Laboratory

Footprints are the negative environmental, economic, and social impacts of production and consumption activities. Their scope spans the upstream supply chains and for many products it includes the downstream customer chain as well. Life cycle assessment (LCA) method has been the most prominent methods for calculating footprints. The main goal of the footprint paradigm is to reduce the negative impacts. However, the scale and rates of footprint reductions are falling short of reaching the set climate change goals. The limitations of the footprint assessment include inability for actors to achieve a zero footprint, reducing the actors’ own footprint will not make more than a minor reduction compared to the scope of the total problem being addressed, and the actor’s positive or negative change(s) outside their footprint is invisible in the footprint-only frameworks. Thus, researchers have introduced the handprints. This research focuses on developing a robust, comprehensive, and standardized method for handprint assessment in addition to footprint assessment. The paradigm shift consists in expanding the scope and moving towards net positive development in which footprints (negative impacts) become less than or equal to handprints (positive impacts). The expansion in the scope, in which there are no boundaries to the zone of impacts, stimulates actions and enables ripple effects. The overall positive impact then becomes a measurable contribution to solving regional and global environmental problems. Also, actors are held accountable for change(s) they create and incentivized to bring about positive change anywhere in the world. The method for measuring footprints and handprints is based on the LCA method. We will work closely with US-based and international industry stakeholders and the MIT Sloan School of Management sustainability program and assess their handprints. The study will examine how corporate stakeholders and sustainability programs might affect changes and increase their positive impacts. This will help achieve a widespread implementation and use of handprints. Broader goal of the study is to promote innovation in reducing their negative impacts and creating positive solutions to societal challenges.

191 Environmental Payback and Life Cycle Impact of Carbon Nanotube Supported CO2 Capture Technologies
F. Wu, Jinan University / School of Environment; Z. Zhou, Brigham Young University / Department of Chemistry and Biochemistry; S. Temizel Sekeryan, University of Wisconsin / Civil and Environmental Engineering; R. Ghakhrar, A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering

The current global climate change caused by excessive carbon dioxide (CO2) emissions has attracted widespread public concern in recent years. Current industrial methods generally utilize monoethanolamine (MEA) for CO2 capture; however, the CO2 regeneration requires a high temperature and energy demand during every adsorption/desorption (A/D)
process, along with nearly 0.5% of MEA loss. Carbon nanotubes (CNT) have high durability, stability, large surface areas and relatively low cost, making them preferable supportive materials for amines as adsorbents for post-combustion CO2 capture. Thus, CNT supported polyethyleneimine (CNT-PEI) was developed in previous studies to overcome these limitations. To identify the most impactful processes during the manufacture and improve synthesis efficiency, the environmental impacts of two CNT-PEI, physically adsorbed (Phy-CNT-PEI) and covalently bonded (Cov-CNT-PEI), were assessed through life cycle assessment (LCA). Meanwhile, the environmental payback periods were analyzed to recognize the sustainability of the newly developed systems. Results suggest CNT and PEI syntheses contributed greatly to the overall environmental impacts for both types of CNT-PEI. The environmental payback periods were compared between the MEA and Phy-CNT-PEI, with the break even point at 23 and 912 A/D cycles, respectively. However, Phy-CNT-PEI saves up to 60% energy demand compared to the MEA method for every A/D cycle due to its lower heat capacity. With the relatively high and stable CO2 capacity, additional 38 A/D cycles (954 in total) for Phy-CNT-PEI could reach equivalent lifetime CO2 remission with 1 kg MEA (11.76 kg CO2 remission/kg MEA). Moreover, the rate of cumulative CO2 remission for Phy-CNT-PEI is much higher than MEA, indicating the potential of being adapted for future industrial CO2 capture. Future development of CNT-PEI for CO2 capture should focus on lowering the impact caused by CNT and PEI syntheses in particular.

**40 Years of SETAC Science: Past, Present and Future - Part 2**

**192 A spotlight on environmental modeling**

D. Mackay, Trent University / Chemistry; J.A. Arnot, ARC Arnot Research & Consulting; D.M. Di Toro, University of Delaware / Civil and Environmental Engineering

In its broadest sense environmental modeling encompasses a wide range of efforts to understand and quantify the behavior, fate, exposures and effects of chemicals in ecosystems. It includes disparate activities including prediction of key chemical properties from molecular structure, estimation of partitioning properties between abiotic media and to biotic phases, especially lipids, inter-media transport processes, assessments of toxicity and assembly of multi-compartment mass balance models at scales ranging from planktonic biota to whales and humans and over a range of scales from indoors to urban, local contaminated sites to regions and to continental and global. A brief and incomplete historical and personal selection of major modeling milestones is presented, showing that SETAC has played a key role in these advances by bringing together players from governments, business and universities to share perceived needs and advancements for both scientific and chemical management purposes. Turning to the future, problematic and potentially fruitful future topics for modeling are outlined recognizing changing needs and capabilities in this information age. These include the perplexing issue of model validation to achieve greater regulatory acceptance (or reduce regulatory reluctance), treatment of mixtures and bioavailability, the advent of high throughput testing for toxicity and biotransformation, and especially the need to promote and support complementary and mutually supportive monitoring and modeling thus demonstrating the strengths and weaknesses of both. Finally, SETAC can play a critical role by promoting greater cooperation between modeling groups across sectors and internationally.

**193 Environmental measurements and modelling: Fruitful interactions over 40 years**

D.C. Muir, Environment and Climate Change Canada / Aquatic Contaminants Research Division

Environmental measurements are a key part of the conceptualization and validation of models for bioaccumulation and chemical fate. Usually the measurements have come first and models have followed to try to explain observations. The interaction between the two areas, often at SETAC conferences, has led to many advances in knowledge. An example is the debate that occurred in the 1980s over whether bioconcentration factor (BCF) estimated using log Kow, or in lab studies, was sufficient to predict concentrations of PCBs and other halogenated organic compounds (HOCs) in fish. Measurements showed elevated concentrations top predators like lake trout were under-predicted by BCF models using simple partitioning from water. However models that included predator-prey relationships, dietary uptake, and bioenergetic information, successfully explained the observed concentrations. Subsequently an explanation for biomagnification based on fundamental physical chemistry principles of diffusion from compartments of high fugacity (GI tract) to lipid pools of lower fugacity was advanced which supported the empirical based modelling. Trophic magnification factors (TMFs), in which food web biomagnification is estimated across trophic levels defined using stable nitrogen isotope ratios of individual organisms, represent the ultimate in field-based measurements. Here again TMF results often conflict with lab based BCFs due to biotransformation, omnivorous feeding, or non-steady state conditions due to local emissions. Measurement and modelling have also had a fruitful relationship in studies of global distribution and fate of HOCs. The discovery in the 1970s and -80s of HOCs in air and biota in the Arctic, an area viewed as being too remote to be subject to chemical contamination from human activities, led to concepts such as “global fractionation” and “cold condensation” which explained the presence of more volatile substances, e.g. less chlorinated PCBs relative to mid latitudes. Measurements of PFOS in arctic animals, and later in seawater, came as a surprise initially because PFOS was water soluble and non-volatile. But modelling were eventually able to explain the observations based on ocean transport, volatile precursors and biomagnification via protein binding. SETAC has an important role to play in bringing together environmental analytical chemists and modelers to broaden the range of chemicals for which there are measurements as well as environmental fate data.

**194 What’s Past is Prologue: Identifying Priority Research Questions for Aquatic Toxicology**

B.W. Brooks, Baylor University / Department of Environmental Science

Identifying strategic research needs represents important exercises for individual researchers and organizations in the academic, government, business and nongovernmental organization sectors. Pursuit of sustainable environmental quality by the “SETAC sciences” represents a noble goal, yet over the past 40 years research in aquatic toxicology has often been reactionary, necessarily and pragmatically responding to the next challenging class of contaminants or uncertainties associated with risk assessment and management. We partnered with SETAC World Council (and the American Chemical Society’s Environmental Chemistry and Agrochemicals Divisions in North America) to launch the Global Horizon Scanning Project, which aimed to identify geographically specific research needs to address stressor impacts on environmental quality. Priority research questions were solicited from SETAC members and other environmental professionals within the five SETAC geographical units (GU), then synthesized by expert teams of academic, industry and government representatives to form lists of the top research questions that, if answered, would substantially advance our understanding of how a range of environmental stressors (chemical, physical, biogeochemical) impact environmental quality in different geographic regions. We then held workshops for SETAC Africa (in Langebaan, South Africa), SETAC Europe (in Barcelona, Spain), SETAC Latin America (in Buenos Aires, Argentina), SETAC North America (in Salt Lake City, USA), and SETAC Asia-Pacific (one workshop focused on Oceania (in Nelson, New Zealand); another workshop in Singapore focused on other parts of Asia-Pacific). Each workshop was chaired by SETAC members representing academic, business and government sectors. Questions received were scientific in orientation, and covered diverse aspects of fields related to SETAC’s mission to advance sustainable environmental quality. This presentation provides synthesis of major research themes within and across SETAC GUs related to priority research questions in aquatic toxicology, with a particular focus on biologically active substances. Addressing
these questions will not be easy, but doing so promises to fuel innovation, support the workforce and decrease uncertainty when assessing and managing threats to water quality.

195 Aquatic Toxicology Has Evolved Via Environmental Toxicology & Chemistry; But Where Is It Going?
G.A. Burton, University of Michigan / School for Environment and Sustainability; H. Callow, Univ of Michigan / School for Environment and Sustainability; E. Nelson, University of Michigan / School of Natural Resources & the Environment; J. Lynch, SETAC

A few of us have been around since ET&C began, so have benefited from reading high quality science through our long careers. It has been interesting to follow the rise of different focus areas within SETAC and ET&C and how the science quickly improved as scientists benefited from other publications. Typically, the initial publications simply identify a possible concern, such as presence, persistence or bioaccumulation, focusing on the exposure side of risk assessments. As the science improves, the effects side of risk is determined, but initially at elevated concentrations to identify risk. The science matures when exposure and effects in the environment are linked accurately. Several examples will be provided of these trends over the past 40 years. Our science is now Excelling in the genomic area, just as in human toxicology and these tools will provide for more complete ecosystem impairment surveys, better assessments of biodiversity impairments and decrease the costs of assessments. Nevertheless, the lack of many reliable Adverse Outcome Pathways and the unknown linkages between biomarkers and population/community impairments will limit the use of genomic tools by regulatory agencies in the foreseeable future. SETAC and ET&C must seize the opportunity to better achieve our motto’s goal of “Environmental Quality Through Science” by providing environmental managers with useful tools that produce realistic assessments of which stressors matter most, even if they are not chemicals.

196 Evolution of Wildlife Toxicology Through SETAC
B.A. Rattner, US Geological Survey / Patuxent Wildlife Research Center

Wildlife toxicology is a component of ecotoxicology, and from a phylogenetic perspective it includes amphibians, reptiles, birds and mammals. Its focus is principally on assessing toxic chemical exposure and effects on reproduction, health and well-being of wildlife. This field encompasses a range of integrated activities (e.g., monitoring, hypothesis-driven research, forensics, assessment of exposure, effects and risk), biological scales (molecular through ecosystem), research venues (e.g., vivarium, mesocosm, field), and is multidisciplinary in nature. It has been shaped by chemical use and misuse, ecological mishaps, catastrophic poisoning, and research in the allied field of human toxicology. Initially wildlife toxicology had a strong emphasis on laboratory tests (LD50, LC50) in bobwhite (Colinus virginianus) and mallards (Anas platyrhynchos), and then evolved to include large-scale field studies as part of re-registration requirements of many pesticides. Between 1980 and 2000, the focus was on hazard and risk to wildlife of halogenated and organophosphorus pesticides, industrial contaminants, petroleum hydrocarbons and various metals, biomarker development and application, exposure routes, bioaccumulation and biomagnification, interspecific toxicity extrapolation, and food web studies. Prior to the establishment of SETAC, discussions of hypotheses and presentation of data were thinly spread among scientific societies (e.g., North American Wildlife Conference, Wildlife Disease Association, and various biomedical, ecological, ornithological, and zoological societies) and meetings of conservation groups and regulatory bodies. SETAC provided a recognized forum for discussion, presentation and publication of wildlife toxicology data, and fostered academic training programs in this area. Recently, a global SETAC Wildlife Toxicology Interest Group has been established to enhance communication of research findings and promote the use of non-destructive, sublethal, and scientifically sound methods, and when possible animal alternative models, in support of risk assessment, environmental management and policy processes.

197 Interacting Environmental Stressors Impact Wildlife-Human-Ecosystem Health: Considering One Health as a Conceptual Framework
M. Ottinger, University of Houston / Department of Biology and Biochemistry

Emerging contaminants, including those that are endocrine disrupting chemicals (EDCs) as well as legacy chemicals combine to expose wildlife and human populations to complex mixtures with the potential for short-term toxicity and long-term impaired physiological function. Chemical mixture exposure may also coincide with exposure to metals, thereby potentially exacerbating deleterious effects of chemicals, even those present as body burdens. Vulnerability to chemical exposure varies with species and life stage. Moreover, effects of EDCs may not correspond to risk as assessed by toxic equivalents. One Health provides a platform to conceptualize the close interactions and interdependence of human and ecosystem health. Stressors, both environmental and disease are critical factors in maintaining optimal One Health of both. Birds provide unique clades of organisms that reflect both regional and global health, particularly the migratory populations. The focus of this presentation will be considering response of birds, at individual and population levels to anthropogenic stressors, particularly exposure complex mixtures associated with industry and urbanization pressures as well as in the context of impacts of habitat loss and climate. Metrics of health will be considered as key indices for ascertaining the health of avian populations; these metrics will also be considered in the context of the contributions of SETAC members to policy/regulatory development. The availability of retrospective data from long-term datasets in avian populations will be discussed as an approach to ascertain changes over long time periods. These retrospective and ongoing data collection are critical for the development of predictive tools that provide reliable guidance for managers. The availability of other long-term datasets for avian populations from a global view will also be considered as a key component of global One Health.

198 Panel Discussion on Past Successes and Future Needs in Aquatic and Wildlife Toxicology
R.J. Kendall, Texas Tech University / Environmental Toxicology; E.J. Dorward-King, Newmont Mining Corporation / Sustainability and External Relations

A spotlight session at the 40th Annual Meeting of the Society of Environmental Toxicology and Chemistry (SETAC) represents an opportunity to reflect on our progress, consider the current state of the science, and look to the future in environmental toxicology and chemistry in the day-long session “40 Years of SETAC Science: Past, Present, and Future.” There will be two panel discussions during this session: one from the morning session and this one from the afternoon session reflecting speeches in environmental fate and modeling, aquatic toxicology, and terrestrial and wildlife toxicology. The six representative speakers and several invited guests will participate in the panel discussion to allow questions and interaction with the SETAC audience. The speakers will address development of the science of environmental fate and modeling, aquatic toxicology, and terrestrial and wildlife toxicology, particularly through SETAC over the past four decades, will evaluate and address the current state of the science and will give perspectives on future scientific needs that could be encouraged through SETAC. This is an excellent opportunity for coordinated discussions from the audience with key leaders in the field that represent long-standing contributions to the science of environmental toxicology and chemistry. We appreciate the opportunity to contribute to this spotlight session as SETAC’s 40th Annual Meeting in Toronto, Canada. We believe this session will be of historical significance since some of the participants in this panel will represent expertise in environmental toxicology and chemistry and in SETAC since its founding. We welcome SETAC members and guests to join us for this anticipated and very interesting panel discussion where they will have the opportunity to ask questions and interact with significant leaders in our field of science.
Aquatic Toxicity Testing of ‘Difficult-to-Test’ Substances - Meeting the Multi-Faceted Challenge

199 Design and Conduct of Aquatic Toxicity Tests with Difficult Test Mate
A. Samel, FMC Corporation / Environmental Sciences; A.J. Jones, FMC Agricultural Solutions / Environmental Sciences; T. Scown, FMC / Environmental Sciences; H.O. Krueger, Eurofins Agroscience / Science and Reg Affairs

Test material with certain physicochemical characteristics can affect exposure concentrations in aquatic systems and make it especially challenging to design and conduct regulatory aquatic toxicity tests. For core regulatory aquatic toxicity tests, exposure concentrations not maintained within a certain range or with precipitate present are often rejected by regulatory reviewers. Test material properties that can impact the maintenance of test concentration levels throughout the test include volatility, sorption potential, hydrolytic or photolytic instability, and very low solubility in dilution test media. Because of the requirement to maintain constant exposure levels to the test organisms, study design is critical from preparation of test solutions, to test solution delivery to test chambers, to analytical confirmation of test solutions. The stability of the test material will determine if the test design will be a static, static-renewal, or flow through test system and test material solubility will determine the highest test concentration for the test. If a solvent is needed, the solubility and stability data for the test material in the organic solvent is necessary. If the test material sorbs to surfaces, the test system will need to reach equilibrium before the test can be begin. Water samples for analytical confirmation may need to include organic solvent to mitigate any potential for the test material to adsorb to the sides of the analytical sample vials. Volatile test material will require specially designed test chambers to minimize head space where test material could partition. The purpose of the presentation is to discuss measures to consider when designing tests for difficult to test compounds.

200 Interpretation of algal growth rate data for aquatic classification and hazard assessment of rapidly degrading substances; ZPT as a case study
S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; K. Clark, Lonza AG / Product Safety and Toxicology

Algal growth rate inhibition at 72 hours, expressed as 72h ErC50s and ErC10s, is the preferred algal endpoint for aquatic classification according to the European CLP Regulation. OECD 201 Test Guideline is preferred to meet objectives of classification, labelling and hazard assessment. Neither the CLP regulation nor OECD 201 are well adapted to address rapidly degrading substances and taxonomic diversity in assessments. The use of 72h ErCx values based on mean measured concentrations of rapidly degrading substances can significantly overestimate toxicity. Characterizing acute toxicity of rapidly degrading substances with a 72h ErC50 can also be inconsistent with the definition and concept of acute toxicity in the CLP regulation, which is an effect during a short term exposure relative to lifecycle. The use of shorter study durations could be a solution for rapidly degrading substances, but the first validity criterion in OECD 201 relates to biomass increase and may not be fulfilled in less than 72h, particularly for slower growing taxa than those described in OECD 201. These points are illustrated by recent studies conducted with zinc pyrithione (ZPT) with the marine diatom, Skeletonema costatum. ZPT is photolytically unstable and rapidly degraded in algal toxicity studies due to required lighting conditions. Concentrations drop rapidly to < 50% of initial concentrations by 24h and continue declining to ~ 10% of initial by 72h. The 72h ErC50 based on mean measured concentrations is less than an initial concentration that caused no discernible growth rate inhibition at any time point. S. costatum growth in the controls was constant, consistent and exponential but did not reach 16x increase before 72h. According to the guideline, shorter study durations were not considered valid.

Similarly, OECD 201 does not allow for use of nominal concentrations in this case. The conclusion that the 72h ErC50 is the most relevant for classification in this situation, despite being lower than an initial concentration showing no effects, is neither reasonable nor consistent with the principle of acute aquatic toxicity. For rapidly degrading substances, a better approach to assessing acute and chronic algal inhibition (toxicity) is needed. Options could include use of nominal concentrations for toxicity estimates, use of recovery tests to assess algalicidal concentrations, shorter test durations and specific considerations of the taxa under evaluation.

201 Challenges with use of Water Accommodated Fractions and Alternative Methods for Ecotoxicity Testing of Difficult Substances
L. Sweet, Lubrizol; Z. Rong, Lubrizol Corporation; J. Liu, Nanjing Institute of Environmental Sciences, MEP; D. Jie, Yaxintechn

Ecotoxicity testing with algae, invertebrates, and/or fish on registered substances is required by many global chemical regulations. Although aquatic toxicity testing is relatively straightforward for mono-constituents, testing on multicomponent, poorly soluble, and UVCBs (Unknown, Variable composition, Complex reaction products or Biological material) substances can be very challenging from study performance and regulatory acceptance standpoints. The number of UVCBs requiring ecotoxicity testing is significant, with thousands of substances registered under EU REACH identified as UVCBs. The multi-dimensional complexity of UVCBs requires that aquatic toxicity tests be reliably designed to address their unique properties. Unlike the mono-constituent substance in which a clear dose-response relationship can be demonstrated, complex substances like UVCBs do not exhibit clear properties (e.g. toxicity, water solubility). For mono-constituents, the measured concentration is distinct and aquatic toxicity can be reliably identified based on the measured concentrations in exposure solutions. However, it is difficult to validate toxicity results with measured concentrations for UVCBs because the relative solubility in exposure solutions is impacted by the loading rate of each individual component, which may or may not be able to be measured. Moreover, the interaction of components in the UVCB can cause complex changes in their relative solubility. Water accommodated fraction (WAF) method is a technique developed for ecotoxicity testing of difficult substances like UVCBs and is recommended by OECD. The mass fraction in a series of WAF solutions is not in a linear relationship with the nominal loading rate. Hence, toxicity cannot reliably be attributed to a single measured component or a mixture of components but rather to the loaded UVCB as a whole. Here, we present an overview of challenges with WAFs from ecotoxicity testing on over 100 UVCBs. It was shown that regulators have different views about how much to load WAFs past the UVCB’s water solubility limit, e.g., 10 to 100 fold. We also show that use of filters to remove undissolved material can lead to studies being deemed unreliable. Further, studies can be deemed unreliable if nominal loading rates vs measured components are used to report study endpoints. We also provide an overview of the pros and cons of alternative methods to WAFs like passive dosing. Side by side comparisons of measured UVCB components in water are shown to differ depending on WAF, passive dosing, or saturated column study designs. The importance of understanding the technical and regulatory challenges of WAFs and alternative designs for testing UVCBs is highlighted.

202 Deriving bioconcentration factors of complex mixtures using in vivo benchmarked dietary exposure studies
R. Samson, Stockholm University, ACES; K. Knudmark Sjøholm, Technical University of Denmark (DTU) / DTU Environment; P. Mayer, Technical University of Denmark / Department of Environmental Engineering; C.L. Chen, South China Normal University / Environmental Research Institute; M. MacLeod, Stockholm University / Department of Environmental Science and Analytical Chemistry, ACES

The bioconcentration factor (BCF) is an established criterion for the (regulatory) assessment of chemicals. While BCF testing is standardised for single component chemicals, there is a lack of standard methods for
the assessment of complex mixtures. The main challenges for the BCF measurement of complex mixtures is the lack of available analytical standard as well as ensuring the reproducibility and general quality of the individual measurements. In previous work, we developed a robust method for the measurement of key components of two complex mixtures, cedarwood and pine oil, using a single dietary exposure experiment on rainbow trout with internal benchmarking. The use of dietary exposure with internal benchmarking allowed for measurements of hydrophobic substances in a mixture with correction for growth-dilution and differences in uptake. However, the challenge regarding the availability of standards to assess all relevant constituents of complex mixtures still needed to be addressed. In this study, we combined the internal benchmarking approach with a suspect screening method using SPME-headspace sampling and gas-chromatography (GC) coupled with high-resolution (Orbitrap) mass-spectrometry (MS): Following a single dietary exposure, the SPME-headspace method allowed for the analysis of samples without the need for extraction or clean-up. Using the high resolution and sensitivity of the Orbitrap-MS we were able to analyse the chemical activity and depuration rate constant of a variety of substances as a mixture. The method was validated using aliquots of fish exposed to cedarwood oil, which had previously been analysed for the BCF of the main constituents using conventional analysis with standards. The methods showed good agreement for the analysed main constituents. In addition to the cedarwood oil, we analysed the chemical activity and depuration rate constants of a certified reference diesel oil. Our novel method for the determination of depuration rate constants and estimation of BCFs of many chemical components of complex mixtures in a single test provides new information for assessing the bioaccumulation potential of complex mixtures, as well as an opportunity to reduce the need for test animals in regular BCF tests.

203 Passive dosing and aquatic toxicity testing of complex organic mixtures - Linking toxicity to concentrations in the silicone and lipid donors

L.N. Trac, Technical University of Denmark / Environmental Engineering; K. Knudsmark Sjøholm, Technical University of Denmark (DTU) / DTU Environment; P. Mayer, Technical University of Denmark / Department of Environmental Engineering

Environmental hazard and risk assessment of complex organic mixtures can be complicated, because the individual constituents in the mixture have various physicochemical properties and toxicity. One important experimental challenge is to establish and maintain well-defined exposure concentrations to such mixtures in an aquatic toxicity test. The present study aims to (1) enable aquatic toxicity testing of complex mixtures at defined and controlled exposure and (2) provide approaches to assess whether the test mixtures exhibit baseline or excess toxicity based on their concentrations in the silicone or lipid donor. Two passive dosing (PD) methods were applied to dose-response testing of complex mixtures with the fresh water crustacean Daphnia magna. The first method used a polydimethylsiloxane (PDMS) silicone rod as donor (i.e. silicone PD), which was placed in the aqueous solution and headspace, whereas the second method used a lipid donor (Miglyol oil) for the passive dosing only via the headspace (i.e., headspace PD, HS-PD). The test mixtures were several petroleum products and essential oils. These mixtures were loaded to PDMS rods and Miglyol oil by weighing to desired mass concentrations (% in these donors. The exposures to test mixture at the saturation level in the two PD systems were analytically confirmed against the pure test mixtures using headspace GC-MS and it was also shown that these two PD methods cross validated each other. The EC50 values for the petroleum mixtures and essential oils in the D. magna acute immobilization tests ranged between 5-6 % and 0.6-3.2 % mass concentration, respectively, on the silicone base. The EC50 values for all tested mixtures on the lipid base ranged between 85-390 g mixture per kg lipid, which corresponds to 425-1590 mmol kg⁻¹ lipid when assuming an average molecular mass of 200 g mol⁻¹ for the tested mixtures. These lipid based EC50 values were well above the reported concentration range of 40-160 mmol kg⁻¹ lipid, which thus indicates baseline rather than excess toxicity. The present study provided an improved experimental basis for aquatic toxicity testing and assessment of complex organic mixtures.

204 UVCB risk assessment framework: Substance identity and characterization considerations

S.E. Deglin, ILSI Health and Environmental Sciences Institute (HESI); M.R. Embry, Health and Environmental Sciences Institute (HESI); J. Arey, ExxonMobil Biomedical Sciences, Inc; M. Fernandez, Environment and Climate Change Canada / Ecological Assessment Division; R. Hoke, DuPont / Electronics & Imaging; J. de Knecht, RIVM / Environment Health and Safety Division; D. Lyon, Shell Oil Company / Shell Health Risk Science Team; K. Jenner, Givaudan / Global Regulatory Affairs & Product Safety; M. Lampi, ExxonMobil Biomedical Sciences, Inc. / Toxicology & Environmental Sciences; E. Leinala, OECD; M. MacLeod, Stockholm University / Department of Environmental Science and Analytical Chemistry; P. Mayer, Technical University of Denmark / Department of Environmental Engineering; D. Salvito, Research Institute for Fragrance Materials RIFM

Assessing the risks associated with substances of Unknown or Variable Composition, Complex Reaction Products, and Biological Materials (UVCBs) presents numerous challenges. International regulatory programs have highlighted the complexities of UVCB fate and exposure characterization, risk assessment, and registration. As such, this work aimed to develop approaches for assessing the ecological risks of UVCBs to meet regulatory needs. As an initial step, a framework was developed for grouping UVCB substances according to chemical and/or functional classes, exposure and use patterns, production volume, potential toxicity and other criteria. This ongoing effort will provide a better understanding of the nature of these substances and their sector of use, as well as insight into which UVCB classes may present the most significant challenges for testing and assessment. Additionally, a tiered approach to substance identification and characterization was developed to provide guidance on the minimum amount of information needed for a confident, risk-based assessment. The first step of this approach (Tier 0) relies on basic and readily available information. For example, Tier 0 substance identity and characterization information includes substance specifications, QA data, and basic chromatographic and/or elemental analyses. Tier 0 exposure and hazard information were also considered in the development of the Tier 0 substance identification and characterization information to ensure it would work towards an overall risk assessment framework. This work presents an initial effort to determine the minimum level of substance identity information required to perform a robust and fit-for-purpose ecological risk assessment for UVCB substances, along with criteria that could be used in a weight of evidence approach for substance identification and characterization, and exposure assessment. Examples are presented of UVCB mapping and classification as well as application of the tiered approach for substance characterization for risk assessment purposes. The results are anticipated to help streamline the data gathering and testing requirements for the risk assessment. [The views of the authors of this presentation are those of the authors and do not represent the views of their respective organizations]
Epigenetics and Environmental Exposures: Mechanisms and Effects from Invertebrates to Fishes

207 Pharmaceutical and climate change stressors alter microRNA and protein abundance in zebrafish (Danio rerio)
H. Ikert, B.A. Katzenback, P.M. Craig, University of Waterloo / Department of Biology

As the human population continues to grow, increased anthropogenic stress is placed on the aquatic environment. A greater understanding of the possible effects that this increase in anthropogenic stressors is having on aquatic organisms is needed. Pharmaceuticals such as venlafaxine (VFX), a heavily prescribed and readily detectable antidepressant, are found downstream of wastewater treatment plants. As a result of climate change, increased surface water temperatures and decreased dissolved oxygen levels have been observed. The result of combining these stressors is unknown. In this study, a multi-stressor approach was used to determine the cumulative, sublethal effects of VFX, temperature and oxygen levels on microRNA (miRNA) and proteins in adult zebrafish (Danio rerio). miRNA are small, conserved, non-coding RNA which act by decreasing mRNA translation, effectively decreasing protein abundance. Therefore, these miRNA changes impact the functional responses of downstream targets and are a method of environmental and epigenetic regulation of phenotypic responses. We can predict which miRNA will change, use these as biomarkers, and validate functional changes by quantifying protein abundances. Adult zebrafish were exposed to control (27°C, 100% O2, 0 μg/L VFX) or stressed (32°C, 50% O2, 1.0 μg/L VFX) conditions for 24 hours (acute) or 21 days (chronic). RNA was extracted from liver, gonad, and muscle tissue and RT-qPCR (reverse transcription - quantitative polymerase chain reaction) was performed on specific miRNA predicted in silico to respond to the exposure. The livers were also used for protein quantification using iTRAQ (isobaric tags for relative and absolute quantification). This allows for identification and differential abundance analysis of all protein levels in the liver. Comparison between stressed and non-stressed fish demonstrated altered miRNA abundance. Interestingly, miRNA changes were different between sex, tissue, and length of exposure. The changes in miRNA will be compared to changes in protein abundance in order understand the functional impacts of altered miRNA. This functional linkage of miRNA response to target protein abundance is crucial in understanding how epigenetic responses to environmental disruption affect fish health and fitness, and will allow us to use miRNA as biomarkers of stress exposure.

208 Individual variation in sensitivity to AHR ligands in birds; does epigenetics play a role?
J. Head, McGill University / Natural Resource Sciences; C. Goncalves Athanasio, Ontario Tech University / Biosciences; K. Mittal, E. Boulanger, McGill University / Natural Resource Sciences

Lipophilic environmental contaminants such as dioxin-like compounds (DLCs) and polycyclic aromatic hydrocarbons (PAHs) can be found in high concentrations in the eggs of wild birds. We are interested in how this early-life exposure to contaminants relates to individual differences in sensitivity to re-exposure later in life, and whether epigenetic mechanisms are involved. In the current study, the DLC, tetrachlorodibenzo-p-dioxin (TCDD), or the PAH, benzo[k]fluoranthene (BkF) was injected into fertilized chicken eggs prior to incubation. At embryonic day 19, livers were harvested and slices of the tissue were grown in culture. Liver slices were then re-exposed to graded concentrations of each of the test chemicals. Both BkF and TCDD were associated with dose-dependent induction of several genes associated with the aryl hydrocarbon receptor (AHR) response pathway including cyp1a4, cyp1a5, and ahr (but not ahr or ahrn). A large degree of variability was observed in the responsiveness of liver slices cultured from different individuals, with a larger proportion of highly responsive individuals present in the BkF pre-treated group. This sensitivity to induction was associated with small but significant...
increases in methylation of the cypla4/5 shared promoter. Ongoing work is examining the role of histone acetylation in the response to re-exposure to AHR ligands at this locus. We are also investigating whether embryo mortality associated with a low degree of cypla inducibility, is responsible for the effects we have observed. Understanding the molecular basis for individual variability in sensitivity to DLCs is important for improving risk assessment for these ubiquitous environmental chemicals.

209 Dynamics of environmentally induced DNA methylation signatures in germ cells

X. Wang, R. Bhandari, University of North Carolina, Greensboro / Biology

Exposure to environmental chemicals can have far reaching health effects especially when it occurs during the sensitive windows of embryonic development. In our previous study, A 7-day embryonic BPA exposure resulted in transgenerational male sub-fertility in medaka. To further understand the mechanisms associated with transgenerational inheritance of impaired male fertility, we surveyed bisphenol A-induced epimutations in PGCs, soma, and sperm at crucial time points of life history stages across three generations. Here, we show that medaka PGC reprogramming undergoes a global erasure of methylation marks from the 8 day post-fertilization (dpf) stage until 15 dpf stage, and de novo methylation starts at 25 dpf stage and ends at the time of gametogenesis (50 dpf), during which several additional new methylation marks are also established. Low concentration BPA caused hypomethylation of germ cell genome globally. BPA-specific epimutations escaped epigenetic reprogramming in PGCs and that additional epimutations were specifically established in PGCs de novo in response to embryonic BPA exposure. Only a fraction of the BPA-specific epimutations that escaped reprogramming or that were established during gametogenesis were subsequently inherited by sperm. A subset of BPA exposure-specific epimutations were transmitted to somatic cells during blastula stages in subsequent generations. In summary, we found that the BPA-induced epimutations can survive reprogramming; germ cells establish unique BPA-specific epimutations during gametogenesis and sperm formation de novo; and a germline-to-soma transfer of epimutations occurs during early embryogenesis of subsequent generation causing alterations in expression pattern of the target genes in somatic tissues.

210 Early life exposure to endocrine disruptors causes multigenerational and transgenerational epigenetic changes in a fish model

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The inland silverside, Menidia beryllina, is a euryhaline fish native to the Eastern United States and a model organism in ecotoxicology. We previously showed that low-level exposure to endocrine disrupting chemicals (EDCs) can cause a variety of effects in M. beryllina, from changes in gene expression to phenotypic deformities. In the present study, we explore the potential for early life exposure to EDCs to cause epigenetic changes in inland silversides, with a particular focus on transgenerational effects. EDCs included contaminants of emerging concern (the pyrethroid insecticide bifenthrin and the synthetic progestin levonorgestrel), as well as an estrogen (ethinylestradiol), and an androgen (trenbolone) at exposure levels between 3 and 9 ng/L. In a multigenerational experiment, we exposed parental silversides to EDCs from fertilization until 21 days post hatch (dpf). We assessed DNA methylation patterns for three generations (P0, F1, and F2) in whole body larval fish using reduced representation bisulfite sequencing (RRBS). We found significant (p < 0.05) differences in promoter and/or gene body methylation in treatment fish relative to controls for all EDCs. Using gene ontology enrichment and pathway analyses, we found that differentially methylated genes in EDC treatments included hormone receptors, genes involved in steroidogenesis, prostaglandin synthesis, sexual development, DNA methylation, protein metabolism and synthesis, cell signaling, and neurodevelopment. Differential gene methylation relative to control was often present in the F1 generation, exposed as primordial germ cells within larval parents, and sometimes noted into the F2 generation, which was unexposed to EDCs. These findings show that EDCs can cause altered methylation in genes that are functionally relevant to impaired phenotypes documented in EDC-exposed animals, and that EDC exposure has the potential to have effects on subsequent generations of unexposed fish.

211 Reprogrammed: Venlafaxine disrupts early neural development and behaviour in larval zebrafish across multiple generations

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The antidepressant venlafaxine is a serotonin and norepinephrine reuptake inhibitor (SNRI) commonly prescribed to treat depression. As a result, this drug is routinely detected in the municipal wastewater effluent outfalls in our waterways in parts per billion concentrations. Recently we showed that venlafaxine deposition in the embryos alters neurogenesis and early life stage behaviour in zebrafish (Danio rerio) larvae. However, it is not known whether venlafaxine impact is associated with changes in developmental programming events. In this study, we tested the hypothesis that venlafaxine deposition in embryos affects developmental programming, leading to impacts on brain development and behaviour in zebrafish that are evident in multiple generations. Zebrafish embryos were microinjected with either vehicle, 1, or 10 ng venlafaxine immediately after fertilization. Zebrafish larval behaviour, neurogenesis, and serotonin distribution was assessed in the F0 (exposure), F1, and F2 generations. In the F0 generation, venlafaxine treatment led to a dose-dependent reduction in larval activity, which was also evident in the F2, but not the F1 generation. Both venlafaxine doses disrupted neurogenesis at 24 hours post-fertilization (HPF) in the diencephalon of treated fish (F0 generation). This effect on neurogenesis was also evident in the F2 progeny but only in the 10ng venlafaxine treated fish. Venlafaxine exposure reduced serotonin in specific brain regions at 48 and 120 HPF in the F0 generation, and a similar decrease was also seen in the F1 and F2 generation at 48 HPF. We also assessed the methylome of exposed adult gonads in the F0 generation, to determine potential epigenetic markers in response to venlafaxine exposure. Venlafaxine appears to alter the methylson of genes associated with cell proliferation, vesicular transport, and cell adhesion. Taken together, these results suggest that venlafaxine exposure at early critical life stages can shift developmental programming, leading to changes in brain development and behaviour that persists across multiple generations of zebrafish.

212 Changes in Transgenerational Plasticity in Daphnia magna Under Thermal Stress Across Ten Generations

H. IM, J. Jung, Korea University / Environmental Science and Ecological Engineering

Effect of temperature on zooplanktons such as Daphnia magna is concerned due to thermal effluents and global warming. The purpose of this study was to evaluate the effect of elevated temperature (25°C) on oxidative stress responses, growth, reproduction and cellular energy allocation of D. magna across ten generations compared to optimum temperature (20°C). We found that F3 generation acts as a turning point with the lowest number of offspring, the highest adult somatic growth rate and the highest oxidative stress responses at elevated temperature. D. magna responded with rapidly changing phenotypic plasticity from F0 to F3 generation, but showed no more phenotypic change between F6 and F9 generation. This result suggests that D. magna has entered a new phase of equilibrium state where no more plasticity occurs after an acclimation phase for prolonged high temperature exposure.
Long-term exposure to environmental contaminants can cause genetic adaptations in populations of aquatic organisms. Evolutionary toxicology and resurrection ecology offer powerful tools for the investigation of changes in sensitivities and adaptive trajectories of populations exposed to contaminants and environmental stressors over decades to centuries. Dormant resting eggs produced by Daphnia species as a result of unfavourable environmental conditions are archived in sediments and can be dated and hatched to produce clonal lineages (i.e., same genotypes) of historical populations. However, these tools have not previously been used to examine impacts from environmental contaminants, particularly in combination with the changes in temperature that are expected to occur with future climate change scenarios. Our research examines how genotypes of clonal lineages of Daphnia species from single populations, separated through generations of evolution, differ in their response to exposure of environmental stressors. Specifically, 20 resurrected D. magna lineages collected from the field (Lake Ring, Denmark), spanning approx. 100 years and previously sequenced, were exposed in 48-h immobilization tests (OECD 202) to phenanthrene (Phe), a common polycyclic aromatic hydrocarbon (PAH) ubiquitous in aquatic environments. The EC50s observed among the clonal lineages ranged from 6 to >30 μM, indicating a wide response in sensitivity of the daphnia. Follow-up studies with 21-d daphnia tests (OECD 211) will further investigate the effects of aqueous Phe exposure in combination with changes in temperature on the sensitivity and fitness, as well as genomic analysis of the clonal lineages of D. magna. The genomic analysis, including metabolomic profiling and transcriptomics, of tolerant and non-tolerant daphnia populations will aid in elucidating the micro-evolutionary adaptations of genes in response to changing environments, providing further insight into the mechanisms of stress tolerance and adaptation. Overall, the toxicological and genomic data obtained from exposure of daphnia populations to environmental stressors will provide unprecedented opportunities to gain insight into long-term and potentially future evolutionary responses of a keystone sp., providing feedback for risk assessment and future management of lake systems (e.g., collapse of grazers/impacts on upper trophic levels).

214 Transgenerational fitness of ocean acidification in marine rotifer: Genetic toxicology and epigenetic approach
Y. Lee, H. Kang, C. Jeong, J. Lee, Sungkyunkwan University

Ocean acidification (OA) is caused by alteration of global ocean chemistry due to increased pCO2 in the atmosphere and is predicted to cause deleterious impacts on the marine ecosystem. While the potential impact of OA for most of marine species are known to be sensitive, its transgenerational effects remained largely unknown. In this study, we show the capability of the marine rotifer Brachionus koreanus to adapt to low pH conditions (pH 7.7 and 7.3). In B. koreanus, growth rate, fecundity, and life span were retarded with induction of DNA damages in response to low pH seawater, whereas their offspring had exhibited the alleviating effects along with the increased parental exposure period, showing positive carryover effects to cope with low pH stresses. In consistent, DNA damage was fully repaired in the offspring from 7 days of OA-experienced adults, indicating that DNA repair system would be a possible adaptive mechanism. To gain a better understanding on DNA repair system in B. koreanus, we measured DNA repair activity at the transcriptional level and found significantly increased level of genes related to DNA repair in offspring. This transcriptional modulation was regulated by histone modification, as the enhanced histone acetylation was observed by ChIP-qPCR that is targeting for those of DNA repair genes. Here we show positive carryover effects of OA on DNA repair system in B. koreanus that were enhanced by histone acetylation. This study provides valuable insights into the potential impact of ocean acidification and survival strategy of aquatic invertebrates as shown in rotifer.

Unraveling Complexity: Characterizing the Toxicity and Risk of Chemical Mixtures in the Environment

215 Combining chemical and ecotoxicological monitoring of emerging polar micropollutants: Towards an integrated environmental risk assessment approach
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The ever-increasing production and consumption of chemicals worldwide is associated with their increasing release into the aquatic environment and ultimately into marine waters. The need for characterizing the real impact of complex mixtures to aquatic organisms is recently receiving increased attention. This requires the development of alternative methods for the assessment of the toxicity of environmentally realistic contaminant mixtures (ERCMs). The generally low contaminant concentrations in marine waters are not only a challenge for analytical methods but also require adaptations for the effect assessments. In this research, we combined chemical and ecotoxicological monitoring of the Belgian part of the North Sea (BPNS) by using passive sampler extracts. We developed and applied a novel margin of safety (MoS) approach for marine waters combining passive sampling, high-resolution mass spectrometric analyzes of a broad range of emerging micropolllutants and ecotoxicity testing with the marine micro-algae Phaeodactylum tricornutum. This MoS approach is based on testing of concentration series of up-concentrated passive sampler extracts. MoS are ultimately defined as the factor of concentration increase of ERCMs resulting in no-observed effects (the highest test concentration with no statistically significant effects). Chemical analyses of a total of 179 substances revealed the presence of a variety of personal care products (highest measured concentration of 13 ng/L for piperonyl-butoxide), pesticides (65 ng/L for thiacloprid), pharmaceuticals (156 ng/L for sotalol), steroids (39 ng/L for prednisone) and phthalates (2,500 ng/L for monomethyl phthalate) in Belgian marine waters. The use of passive samplers allowed us to combine chemical analysis and ecotoxicity testing of contaminant mixtures at realistic concentration levels but also in up-concentrated samples. This further enabled the determination of MoS for ERCMs of approximately 6 - 10 times the current seawater levels for the representative marine diatom P. tricornutum in the BPNS. Overall, our research provides a novel approach for a combined chemical-analytical and ecotoxicological based MoS approach as tool for (predictive) risk assessment and management in marine waters. This presentation will summarize the final results of the NewSTHEPS project (for further information, see www.newstheps.be).

216 Risk assessment for pesticide mixtures on aquatic ecosystems in China: a proposed framework
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With an increasing number of registered mixture formulations in China, environmental risk assessment of pesticide mixtures to aquatic ecosystems is of increasing interest to local scientists, risk assessors, and risk
A pragmatic approach has been proposed based on widely accepted scientific concepts and strategies. The proposed approach has three tiers, tier 0 (preliminary stage), tier 1, and tier 2 (refinement stage). Because of the large number of pesticide mixtures available in China, a unique tier 0 stage is proposed with practical criteria to identify mixtures requiring further evaluation. For Tier 1 assessment, exposure is assessed based on specific application schemes and local scenarios in China; hazard is evaluated using the concentration addition model as the default approach. Given the unique characteristics of environmental mixtures, data variability and ratio changes of active ingredients are also evaluated for hazard assessment. More accurate assessments with decreased uncertainties can be achieved by refinements in Tier 2, such as alternative models, consideration of co-formulants, and higher-tier effect and exposure analyses. The proposed risk assessment approach will be demonstrated using a case study.

217 Interactive effects of cadmium and benzo[a]pyrene in zebrafish (Danio rerio) during acute aqueous exposure

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Anthropogenic activities have resulted in the contamination of cadmium (Cd), a highly toxic trace metal, in many aquatic ecosystems around the world. Similarly, anthropogenic activities have also led to the release of a multitude of organic pollutants including polyaromatic hydrocarbons (PAHs) into the aquatic ecosystems. Benzo[a]pyrene (BaP) is of particular concern among PAHs because of its ubiquitous nature. While guidelines have been established to regulate these pollutants in the environment (e.g., Canadian water quality guidelines restrict concentrations to 1 µg/L and 0.015 µg/L for Cd and BaP, respectively), such guidelines have primarily been established using single-toxicant exposure data. Thus, there is a crucial gap in our knowledge regarding how these toxicants interact and alter the toxicological effects in aquatic organisms. The present study examined the effects of acute (72-hr) aqueous exposures of Cd (5.8 and 22 µg/L) and BaP (0.45 and 1 µg/L), both individually and in binary mixtures, in adult zebrafish. Our results demonstrated that tissue accumulation of Cd increased significantly in the presence of BaP relative to Cd-only exposures. Cd tissue burden was found to be 18.5 ng/g tissue in fish exposed to only 5.8 µg/L, whereas Cd tissue burden was recorded to be 104.5 ng/g and 46.9 ng/g in fish exposed to 0.45 or 1 µg/L of BaP in combination with 5.8 µg/L Cd, respectively. Additionally, while single-toxicant exposures caused a strong induction of metallothionein-2 (MT) and cytochrome p450Ia (CYP1a) mRNA in the gills, co-exposures generally resulted in the downregulation of these genes. For example, 0.45 µg/L BaP caused an approximately 10-fold increase in CYP1a transcript levels relative to the control; however co-exposure to 5.8 or 22 µg/L Cd and 0.45 µg/L of BaP caused a 2- and 0.5-fold decrease in CYP1a gene expression, respectively, relative to the control. Moreover, lipid peroxidation (LPO) was measured in the gill and liver as a marker of oxidative damage induced by Cd and/or BaP. While individual exposures to both toxicants increased LPO relative to the control, no significant increase in the LPO level was observed in any of the Cd and BaP co-exposures. Overall, our findings indicated that although the interaction of Cd and BaP resulted in increased Cd body burden and downregulation of detoxifying genes (MT and CYP 1a), it did not translate into additive or more-than-additive toxic effects (oxidative damage) in zebrafish.

218 Tackling The Toxicity Of Metal Mixtures To Daphnia Magna: A Biotic Ligand Model Approach

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Metal mixture toxicity has drawn world-wide attention by both scientists and policy makers due to an increasing recognition of the occurrence of mixtures of metals in surface waters. The present study was undertaken to determine the acute toxicity of binary mixtures of nickel, copper, zinc, and cadmium to the freshwater invertebrate, *Daphnia magna*, to increase understanding of the impacts of metal mixtures. The experimental approach included single and binary metal toxicity tests based on the 48h acute toxicity bioassay protocol of Environment Canada. The acute toxicity of single metals followed the order of Cd > Cu > Zn > Ni. Based on the calculated 48h EC50 value of single metals, a toxic unit (TU) approach was used to combine two metals in a binary mixture, in which ITU was equal to the 48h EC50 value of a metal in single exposure. The toxicity of binary metal mixtures to *D. magna* followed the order of Cu-Cd > Cu-Zn > Zn-Cd > Cu-Ni > Zn-Ni > Cd-Ni, which demonstrated three types of interactions (i.e., less than additive, additive, and greater than additive). For comparison, the toxicity of binary metal mixtures was predicted using a biotic ligand model (BLM) based on the free ion concentrations of metals, the affinity constant of metals, and the toxic potency of each metal. In this model, it was hypothesized that the toxicity of metal mixtures is the result of competition of metals with Ca2+ at the biotic ligands, which can lead to whole-body deficiency of Ca2+ in *D. magna*. The BLM model calculated the toxic potency of single metals with the following order of Cu > Cd > Zn > Ni. Although the mortality in binary metal mixtures tests was often overestimated using the BLM model in this study, the BLM or a revised version could be promising in conservative environmental risk assessment.

219 Alterations to Juvenile Mahi mahi Swimming Performance and Respirometry Following Acute Exposures to Flowback and Produced Water

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Worldwide, horizontal hydraulic fracturing is an emerging industrial practice used to extract oil and natural gas reserves from nominally permeable geological formations. Despite its increasingly prevalent use, toxicological investigation on the wastewater by-product of these processes, flowback and produced water (FPW), is relatively understudied. Recent chemical characterization of this heterogeneous mixture has revealed the existence of numerous potential cardio-respiratory toxicants. The aim of this study was to determine if acute FPW exposures alter swimming performance and respirometry in juvenile Mahi mahi (*Coryphaena hippurus*); an aerobic fish with an extreme pelagic lifestyle. Previous work on isolated Mahi cardiomyocytes identified certain contractile properties to be affected following exposure to low concentrations of FPW. We theorize that these FPW induced deleterious cardiac effects observed at the cellular level may contribute to changes at the whole organism level, i.e. fish swimming performance and respirometry. After acute 24 hr exposures to sub-lethal concentrations of FPW, significant impacts to juvenile Mahi critical swim speed (*Ucrit*) were observed. These findings were accompanied by significant reductions in aerobic scope. To eliminate salinity as a contributing factor, a saline control exposure was employed. No changes to swimming performance and respirometry were observed in saline matched controls. We conclude that contaminant stressors besides major salt ions (such as organics and/or metals) are responsible for the observed effects. Mahi tissue analyses corroborate these whole organism findings and support the notion that acute FPW exposures negatively impact cardio-respiratory systems of Mahi. This is one of the first studies associating deleterious effects at the cellular level with changes to whole organism physiology and performance following FPW exposure. Our results validate the cardio-respiratory system as an important endpoint to consider for FPW risk assessment and adverse outcome pathway analysis.
220 Determination of Mixture Neurotoxicity Using the Hyper- and Hypoactivity Behavior of Zebrafish Embryo in the Spontaneous Tail Coiling Test

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Recently, there has been an increase in the number of people suffering from neurological diseases and incidents of nervous system-related diseases are increasingly associated with exposure to pesticides and pharmaceuticals. These chemicals interfere with the functioning of the nervous system and very little disruptions can lead to long term neurological diseases such as Parkinson and autism. Generally, chemicals occur in the environment as mixtures and it is therefore more realistic to assess the toxicity of chemical mixtures rather than single chemicals. To detect mixture neurotoxicity, it is important to be able to differentiate neuroactive mode of action for single chemicals within a mixture of other chemicals. Even more important is to investigate the additive, synergistic and antagonistic effects of neuroactive chemical mixtures within a pool of other substances. Zebrafish embryo is a suitable tool to test mixture effects. While only few studies have studied behavioral effects of mixtures, most studies on zebrafish embryo were based on lethal and sublethal endpoints. Since behavioral endpoints might be more sensitive to detect neuroactive substances and also more relevant for ecological effects, then it is probably more reasonable to encourage the use of behavioral tests for screening neuroactive chemical mixtures. In this study, we employed the use of the spontaneous tail coiling (STC) of the zebrafish embryo to detect the effect of both single and mixed neuroactive substances. We addressed the questions: 1) Can the STC test predict the mode of action of neuroactive substances i.e. acetylcholinesterase inhibition by chlorpyrifos or activation of Gamma aminobutyric acid receptor by abamectin. 2) What is the resulting effect of a mixture of neuroactive substances with similar and dissimilar mode of action? First results showed that chlorpyrifos and abamectin caused hyperactivity (EC50 = 2.57μM) and hypoactivity (EC50 = 0.54μM) of the STC respectively and this was assumed to be indicative of their mode of action in zebrafish embryo. The results for similar and dissimilar mixtures with varying mixture approaches predicted by concentration addition and independent action models will be discussed.

221 Comparison of Fine Particulate Matter from Biomass and Non-biomass Burning Households

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Household air pollution is a global public health disparity issue with nearly 3 billion people using highly polluting fuels in their homes for cooking and heating. A disproportionate amount of those exposed are women and children of low socioeconomic status. Fine particulate matter (PM2.5) is a component of household air pollution with well-established health effects and is significantly elevated in households burning biomass fuel compared to non-biomass burning households. There is a lack of exposure-response data to determine the health impacts of different fuel sources and outside of concentration, little is understood about these complex exposures. We performed a robust characterization of PM2.5 from biomass and non-biomass burning households through concentration, composition, oxidative potential, and bioactivity assessments. As part of the Prospective Urban and Rural Epidemiological (PURE-Air) study, PM2.5 was collected with a stationary monitor in the kitchen and personal monitors on female and male participants in 24 households. Filters were stratified into groups based on fuel source, monitor type, and participant sex. Chemical analysis via quantification of polycyclic aromatic hydrocarbons (n=115) and elements (n=75) was conducted. Assessment of oxidative potential was performed for the stratified groups as well as for individual filters. Bioactivity was determined using a range of concentrations in the developmental zebrafish assay (n=32/treatment) with mortality and morphological/behavioral changes being assessed at 24 and 120 hours post fertilization. Significant differences in chemical concentrations were observed between PM2.5 from kitchen monitors in biomass and non-biomass burning households. Bioactivity was observed in zebrafish with an earlier incidence of significant mortality and morphological effects following exposure to PM2.5 from biomass burning compared to the non-biomass households. Data analysis is underway for zebrafish behavior, oxidative potential, and personal monitors worn by male and female participants in the households. Associations between concentration, composition, oxidative potential, and bioactivity will be made and we hypothesize to find suites of constituents associated with multiple endpoints. This research provides robust characterization of that will be applicable to epidemiology studies to identify additional characteristics of for health effects associations.

222 Combing chemical analysis and quantitative toxicogenomics approach to assess the impact of Hurricane Maria on drinking water quality in Puerto Rico

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Hurricane Maria (HM) devastated Puerto Rico (PR) on September 20th, 2017, and one majorly overlooked problem is the water quality degradation for municipal and private well water systems due to the releases of various mixture of chemicals via flooding. This project aims to evaluate the impact of HM on drinking water quality across PR from both temporal and spatial scales, by focusing on chemical contaminants and water toxicity. Tap water samples were collected from participants’ households across PR from December 2017 to February 2018 and compared with samples prior to the hurricane. A high-throughput quantitative toxicogenomics assay with yeast cells targeting genotoxicity, oxidative stress, and other cellular toxicity, and a RT-qPCR assay with human A549 cells targeting inflammation, genotoxicity, oxidative stress, EDC, AHR and apoptosis effects, were employed for toxicity assessment. In parallel, water samples were analyzed for 18 metals on ICP-MS, and organic extracts were subjected to targeted and suspect screening for 234 organic micropollutants including PR human exposure-relevant chemicals on high-resolution LC-MS. Drinking water in PR showed higher average contamination levels after Hurricane Maria. The average concentrations of 14 out of 18 metals detected and 20 out of 27 organic micropollutants increased after the HM with the concentrations of As, benzophenone, perfluorooctanoic acid and sucralose being significantly higher (p<0.05) in the 20 samples after the HM. Higher contamination levels for both metals and organics, as well as higher molecular toxicity levels were observed in the 28 samples collected at northern PR where 7 active superfund sites were located. Compared to pre-hurricane samples, biomarkers involved in genotoxicity and general stress (osmotic stress, trehalose synthesis, signal transduction, apoptosis, etc.) showed higher up-regulation levels in yeast cells upon exposure to post-hurricane tap water extracts. Correlation analysis indicated that the occurrence of benzophenone, PFOA, and certain...
pesticides such as 2,4-D, MCPA and mecoprop was significantly correlated with genotoxicity, oxidative stress and AHR pathway (p < 0.05). Our combined approach of targeted chemical analysis and a HTS quantitative toxicogenomics assay provides a feasible and efficient alternative for time-sensitive research such as post-disaster toxicity responses, providing bases for further assessment of potential risk and health outcomes.

Emerging Landscape for Toxicity Testing: WET Method Challenges and Refinements to Applied In Vitro Assays for Effluents

223 National Pollutant Discharge Elimination System (NPDES) Permitting Whole Effluent Toxicity (WET) - An Implementation Perspective from Permit Writers

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The USEPA WET methods have been questioned, litigated, validated, updated, and reaffirmed by the EPA; however, concerns still exist regarding their efficacy. As new chemical compounds are manufactured, approved and utilized; the use of these WET methods to detect the additive and synergistic effects from dischargers on receiving streams is still the only approved test method available to NPDES permit writers. Yet questions regarding; the efficacy of these methods, the need for improved methods, and the overall value of these methods are ever present. This session will provide an NPDES permitting perspective on the current implementation practices, proposed methods development concerns, and research needs for treatment options to assist in supporting the currently effective and approved WET test methods. It will also explore the perspective that many of the problems associated with the WET test are implementation problems due to NPDES permit requirements lacking specificity to control variability amongst WET laboratories, not necessarily issues with the methods themselves. These issues, coupled with excessive focus on statistical endpoints, replicates, data variability, and lack of effective training, may be causing confusion and lead to NPDES permit writers being reluctant to incorporate WET concepts into effective permit writing and WET laboratory data analysis.

224 Recommendations for practical considerations in reviewing WET testing results and laboratory operations

W.L. Goodfellow, Exponent / Ecological and Biological Services Practice

Whole Effluent Toxicity (WET) testing methods and procedures have been refined over several decades; however, there are often minimal to no barriers to entry for laboratories without credentials for or experience performing WET testing methods unless the testing is being performed in a state with a certification program or under the National Environmental Laboratory Accreditation Program (NELAP). Even when testing is performed by laboratories that are state or nationally accredited, it does not guarantee that the results are of high quality, only that they met a minimum level of acceptable quality. WET results are used for important activities such as determining regulatory compliance (NPDES) that have real cost implications if not performed adequately and could impact organizational reputation. Furthermore, additional tests used in toxicity reduction evaluation (TRE) and toxicity identification evaluation (TIE) may not be subject to state or national accreditation; however, the need for high quality data still exists. This presentation will explore practical considerations for evaluating WET testing results and assessing laboratory operations, such as reviewing laboratory reports, result outputs, and raw bench sheets, and provide recommendations about what to look for in laboratory operations outside of reviewing test protocols and other laboratory quality assurance documentation.

225 What’s the buzz: EPA-ORD is developing method guidance for more species for effluent and ambient toxicity testing methods

T.J. Norberg-King, US Environmental Protection Agency / ORD/ NHEERL/Mid-Continent Ecology Division; J.M. Lazorchak, US Environmental Protection Agency / ORD/NERL/Systems Exposure Division

EPA currently has toxicity testing methods for effluent and ambient testing that were promulgated under the Clean Water Act Part 136. The promulgated freshwater methods for acute lethality include cladocerans (Daphnia magna, D. pulex, Ceriodaphnia dubia) and three fish species (fathead minnow (Pimephales promelas), rainbow trout (Oncorhynchus mykiss), and brown trout (Salvelinus fontinalis)). The short-term chronic freshwater methods that are promulgated include three species, a cladoceran (C. dubia), the fathead minnow (P. promelas), and a green alga (Raphidocelis subcapitata). Beginning in 2019, EPA’s Office of Research and Development (ORD) has begun to focus on additional species or test methods to add to the suite of freshwater test species to provide additional options for species sensitivity. In the first stage, EPA will be developing protocols for the short-term chronic test with the cladoceran, D. magna, and acute and short-term chronic test protocols for the freshwater mussel (fatmucket, Lampsisilis siliquoides). Both the Duluth and Cincinnati laboratories within the Office of Research and Development will be developing these test protocols and refining the various test conditions for each species within the EPA laboratories. These standardized procedures will aid in the detection of both known and unknown chemical and biological contaminants in wastewater and ambient water in support of EPA’s Office of Water, EPA regions, State and others. The second phase includes plans to develop effluent and ambient water protocols for additional species, such as acute and short-term methods for the mayflies, amphipods, midges, a short-term procedure using trout, and possibly another plant species. In this presentation, we will outline the general study plans for the daphnids and the mussels. We will discuss options for joining a listserv (or a similar system) to communicate the methods and to incorporate the public review of the methods during this development stage. Disclaimer: This presentation does not necessarily reflect the views or the policies of the USEPA.

226 Evaluation of In Vitro Fish Alternatives in Ecotoxicology and Their Role in WET Testing: A Review of the Development of Currently Available Models

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Whole effluent toxicity (WET) testing has been vital to ensure wastewater discharges are properly monitored and assessed to reduce harmful environmental impacts. While the current scope of WET testing methods has maintained integrity through a set of standardized aquatic toxicity testing, advancements in ecotoxicological techniques has been gaining momentum. Moreover, moving away from live vertebrate testing and enhancing toxicological measurement capabilities are major ethical and practical drivers in both the research and private sectors. Recently, the Organisation for Economic Co-operation and Development (OECD) and the International Organization for Standardization (ISO) have accepted methods for the use of in vitro alternative (i.e. zebrafish embryo test: OECD 236:2013, ISO 15088:2007; and fish gill cell line, RTgill-W1: ISO 21115:2019 ) for acute toxicity testing of chemicals and effluents. Successful approval is based on previous studies showing significant correlations between in vitro and in vivo acute toxicity tests. Moreover, these methods have shown high repeatability (low intra-laboratory variability) and reproducibility (low inter-laboratory variability) in predicting the toxicity of a broad range of chemicals. The use of the RTgill-W1 cell line have shown potential as a replacement of fish in WET testing, as well as a complementary tool to current toxicity identification and reduction evaluation strategies in wastewater treatment facility operations. The use of this in vitro assay for WET testing offers a high throughput approach which allows simultaneous measurement of multiple toxicological endpoints, cost efficiency and expedited results. However, considerations of in vitro limitations must also be made to better understand their role
towards advancing WET testing methods. The compliance of in vitro technologies with the 3Rs (replacement, refinement, and reduction) is certainly a strength which emphasizes their ethical value. However, their utilization as an alternative to fish may be best driven by economics rather than ethics. Thus, a close comparison of the cost of in vivo and in vitro test should be evaluated. This review aims to inform on the applicability and reliability of these technologies and discuss whether they should be accepted as either an all-encompassing alternative to live animals in WET testing, a complimentary screening process, or a more relevant toxicity forensic tool.

227 Refining culturing and effluent testing methods for the mayfly, Neocloeon triangulifer


Fordecades, toxicity tests with aquatic invertebrates have been conducted and yet a small number of model organisms are routinely used. Test organisms are usually easily cultured in the laboratory, have rapid life-cycles, exhibit sensitivity to a variety of pollutants with reproducible results, and are generally available year-round. The USEPA effluent testing program uses short-term chronic freshwater tests (4d to 8d) with cladocerans (Cladocera, Ceriodaphnia dubia), green algae (Sphaeroptela, Raphidocelis subcapitata) and fish (Cypriniformes, Pimephales promelas). EPA also has standardized Hyalella azteca (Amphipoda) and Chironomus dilutus (Diptera) test methods for sediments; yet EPA's effluent and ambient testing manuals do not provide acute or short-term test methods for H. azteca, C. dilutus or mayflies (Ephemeroptera). Because mayflies have been shown to be among the most sensitive species to major ions, metals, and pesticides, we have focused on effluent method development for the mayfly, Neocloeon triangulifer, a parthenogenetic species with a short life cycle (~30d at 25C). While methods for conducting acute 4d and chronic (~25-30d) toxicity tests with this mayfly have been published, a need exists to extend and standardize the methodology for applicable methods for testing in short-term exposures (e.g., 7d or 10d). Studies began with identifying an optimal starting age, test duration, and optimal sub-lethal endpoint for whole effluent toxicity testing. We found that chronic values from tests using < 24-h-old organisms were ~4-fold more sensitive than those using 7-d-old organisms. Survival was never a more sensitive endpoint than either calculated weight or biomass. Efforts to refine the various aspects of diatom culture technique on food quality and therefore mayfly growth are underway and optimizing the diet for these organisms may be critical for achieving consistently high growth rates with low intra-treatment variability. We also determined the influence of amendments to culture water and food, and temperature on sensitivity to reference contaminants and effluents. Results of the study should provide data needed to guide the development of a toxicity test method to support NPDES permit decision-making. Abstract does not necessarily represent the position or policy of the USEPA.

228 Key factors affecting laboratory variability in the chronic Ceriodaphnia dubia test

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The US Environmental Protection Agency (USEPA) freshwater chronic toxicity manual (EPA-821-R-02-013) provides guidance for performing the chronic Ceriodaphnia dubia test with effluents and receiving waters. The method was specifically designed to provide flexibility for laboratories to perform testing under various test conditions, including recommendations for control/dilution waters, food type and preparation, and test chamber material, whereas other factors such as organism age are tightly controlled. However, such flexibility in how the method is performed, in addition to other factors (e.g., personnel experience, laboratory experience, etc.), can influence intra- and inter-laboratory variability.

Such variability has resulted in increased attention by regulated parties and some regulatory agencies as to what can be done to improve the performance of testing with this species. With a consistent training program for >15 years, we believe that we have minimized personnel and laboratory experience as significant drivers for test variability, and transitioned to evaluations of different foods and waters. Through those efforts, we identified food source and type as key factors that influenced both culture and test variability. In this presentation, we evaluated a historical record of nearly 4,000 chronic C. dubia tests performed in our laboratory from 2008-2019 for patterns of test variability. Over the temporal period of this testing, we observed a considerable decrease in intra-laboratory variability once we began to prepare our own Pseudokirchnerella subcapitata (previously Selenastrum capricornutum) and Yeast-Cerophyll-Trout Chow foods. Following that adjustment, we observed remarkably consistent test performance and reduced variability over an extended period of time. To investigate other factors that influence intra-laboratory test variability, we evaluated organism age (e.g., 0-8, 9-16, and 17-24 hrs) and individual organism performance (e.g., mortalities, fewer than three broods. With this study, we hope to highlight factors influencing test variability to aid groups discussing method variability and approaches to harmonize method performance across laboratories.

229 Comparison of three LED light correlated color temperatures on Ceridaphnia dubia survival, fecundity, and neonate reference toxicity test performance

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LED lights come in a variety of correlated color temperatures (e.g. soft warm white, cool white, daylight) and their ability to maintain stable culture and test conditions for laboratory organisms is unknown. Therefore, over a three-month period we tested for a difference in Ceridaphnia dubia survival and fecundity, as well as neonate performance in reference toxicity tests (NaCl) from culture boards maintained with LED lights at three correlated color temperatures (3000K, 4000K, and 5000K) with comparable light intensity. We compared survival, 14-d average total neonates, number of broods and days to third brood of 8 or more neonates, and number of days to first brood for culture boards. Endpoints for reference toxicity tests included NOEC, LOEC, and control group percent variation. We found no significant differences between any parameters tested, and conclude that there is no difference between LED lights at comparable light intensity over the three evaluated correlated color temperatures for C. dubia cultures.

230 Characterization of effluent discharges from a mobile offshore drilling unit - learnings from a remote arctic whole effluent toxicity testing study


A study was performed to evaluate the potential biological impacts from 6 types of miscellaneous discharges from a remote arctic oil and gas mobile offshore drilling unit (MODU) including: deck drainage, desalination unit waste, boiler blowdown, fire control system test water, non-contact cooling water, and bilge water. Samples were evaluated for toxicity using a rapid (< 1 h) initial screening test (echinoderms [Dendraster excentricus] fertilization test), and if toxicity was found, further testing was conducted using 3 chronic whole effluent toxicity (WET) tests. This additional testing included the embryo larval development (72-h echinoderm [D. excentricus]; 7-d mysid [Americamysis bahia] survival, growth, and fecundity invertebrate test; and 7-d topsmelt [Atherinops affinis] survival and growth fish test). Toxicity identification evaluations were performed on effluents that consistently elicited a toxic response during WET testing. To place the results of the toxicity testing into the
context of environmental risk, the spatial extent of potential biological effects was investigated using the CORMIX mixing zone model. The output of the modeling indicated that discharge of selected effluents did not result in concentrations or duration of exposure that would elicit toxic effects to organisms living in the surrounding environment. This study provides a comprehensive data set that was used to characterize potential toxicity and environmental risk of MODU “miscellaneous discharges” which could help inform future risk assessments of these discharges. Furthermore, this study overcame significant logistical constraints related to performing routine effluent testing in offshore arctic environment. Aspects related to optimization for future WET testing programs and considerations for alternatives assessment methods based on the data collected will be discussed presented.

Canadian Oil Sands Part 1: Advances in Chemical Characterization, Reclamation and Monitoring Research

231 Polycyclic Aromatic Compound (PAC) Source Characterization within In Situ Oil Sands Operations, Cold Lake, Alberta

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Most of the published environmental research on Canada's oil sands concentrates on open-pit mines and bitumen processing operations. Less is known about the environmental impacts attributed to in situ operations; which in 2012 surpassed open-pit mining as the dominant method of oil sands extraction in Canada. The Cold Lake oil sands deposit in Central-Eastern Alberta is unique as it is isolated by approximately 150km from open pit mines, upgraders, refineries, tailings ponds and other bitumen processing operations. The Cold Lake oil field requires the use of in situ steam injection to extract bitumen as its reserves are situated deep below the surface, making them inaccessible through open-pit mines. Here we examine polycyclic aromatic compound (PAC) profiles in Pb-210 dated sediment cores from 11 lakes throughout the Cold Lake area to track temporal changes in PAC deposition between pre-industrial and present levels. We use alkylated PACs, predominantly petrogenic contaminants, to evaluate in situ operations as potential contamination sources to surrounding lakes. We predict that similarly to open-pit operations, concentrations of alkylated PACs in lakes sediments will increase with industrial activity and will correspond to proximity from in situ operations. Preliminary trends demonstrate increasing concentrations of alkylated PACs at the onset of industrial activity in lakes heavily surrounded by in situ operations, however those less heavily surrounded by in situ activity do not show a consistent increase in the total concentration of alkylated PACs. These results suggest that in situ operations are a potential source of contamination to the surrounding areas however may not be a dominant source of PAC enrichment to lakes situated farther away. With >80% of Canadian bitumen reserves requiring in situ techniques for extraction, there is still limited research on the contamination attributed to this method. We address this shortcoming by providing a spatial and temporal analysis of the contamination attributed to in situ techniques to highlight the importance of ongoing monitoring surrounding these operations. Additionally, this study allows for the environmental implications of open pit mining operations to now be compared to that of in situ techniques.

232 5 Years of Monitoring Polycyclic Aromatic Compounds in Air in the Athabasca Oil Sands Region: Temporal Trends and Source Attribution

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The Athabasca Oil Sands Region in Northern Alberta is the largest deposit of bitumen in the world. The activity of the petroleum industry in the area encompasses surface mining, in situ mining and upgrader facilities as well waste tailing ponds. Polycyclic aromatic compounds (PACs) are chemicals of concern released from the oil sand industrial activity. They are detrimental to human and ecological health and as semi-volatile pollutants can undergo long-range atmospheric transport. PACs such as polycyclic aromatic hydrocarbons (PAHs) have a wide range of sources in addition to the petroleum industry. Other PACs such as halogenated PACs (alkPAHs) and dibenzo-3,4-thiophenes (DBTs) are predominantly present in bitumen but were also observed as products of forest fires. PAC levels in air in the Athabasca Oil Sands Region were monitored continuously from 2011-2015 with both passive and active air samplers. The data from samples collected with high volume air samplers at three sampling sites gives a 6-day temporal resolution of PAC concentrations in air over 5 years. The data from the passive air samplers (PAS) represents 2 months integrated air concentrations from 15 sampling stations close to industry, in local communities and at background sites. Levels of PACs in air over the 5-year period did not vary substantially temporally and were dominated by alkPAHs. Concentrations in air were in the ranges of 0.3-43, 0.15-460, and 0.04-130 ng/m3 for ∑PAHs, ∑alkPAHs, and ∑DBTs, respectively. Elevated concentrations were observed in vicinity of mining areas and during seasonal forest fire events. The impact of different sources is expressed in different PAC fingerprints at the individual PAS sampling sites. The combined PAC data over 5 years delivers a comprehensive picture of temporal and spatial trends of PACs in the Athabasca Oil Sands Region.

233 Identification of Halogenated Polycyclic Aromatic Hydrocarbons in Biological Samples from the Alberta Oil Sands Region

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Polycyclic aromatic compounds (PACs), a complex class of compounds, can be formed from incomplete combustion or diagenesis of plant matter forming petroleum oils. A preliminary study in our group has shown that halogenated polycyclic aromatic hydrocarbons (HPAHs) can also be detected in environmental samples from the Alberta Oil Sands Region (AOSR). Here we extend our earlier work and present information on the detection of HPAHs in the region using comprehensive two-dimensional gas chromatography coupled with high-resolution time-of-flight mass spectrometry (GCxGC-HRTOF-MS) at a resolving power of 25,000. Knowledge of the electron ionization (EI) fragmentation behavior of individual HPAH isomers, achieved by injecting authentic standards in full-scan MS mode, was paramount in identifying the suite of HPAHs in samples from the AOSR. Confirmation of compounds in biological samples was based on the measured mass accuracy of 2 characteristic ions prominent in the EI mass spectra of each compound.
234 Remediation of Organic and Inorganic Constituent of Oil Sands Process Water by Boron-doped Diamond (BDD) Electrolysis Treatment

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The current bitumen extraction processes in Alberta, Canada from oil sands produce large volumes of process water termed oil sands process water (OSPW), which contains various compounds such as petroleum related hydrocarbons - naphthenic acids (NAs), polycyclic aromatic hydrocarbons (PAHs), surfactants, trace elements, anions, and other treatment chemicals, which do not pose a problem while the OSPW is being recycled. Most of these compounds are below the toxicity threshold for aquatic life untreated and undiluted but a few, particularly the dissolved organics, must be treated if this water is to be returned to the Athabasca watershed. There have been records of toxicological effects of OSPW on several aquatic organisms and plants, and it is highly recalcitrant to many water treatment technologies. In this study, the fate of organic and inorganic constituents of OSPW during electrooxidation treatment with highly potent boron-doped diamond (BDD) electrode was investigated. The efficiency of the process was followed by monitoring the decay of dissolved organic carbon (DOC), classical and oxidized naphthenic acids, aromatic hydrocarbons, acute toxicity as well as reduction/transformation of the inorganic ions. Complete degradation of classical and oxidized NAs and PAHs can be achieved within 2 h of electrolysis at current density above 2.5 mA cm⁻². The DOC removal efficiency of 14%, 25%, 50%, 67% and 85% was obtained at current densities of 1.25, 2.5, 5, 10 and 20 mA cm⁻², respectively, after 2 h. Interestingly, the energy consumption per volume of OSPW and DOC removal were minimum, in the range of 0.9 - 17.4 kWh m⁻³ and 0.08 - 0.6 kWh g DOC⁻¹, respectively. The inorganic ions such as C₁⁻, SO₄²⁻ and CO₃²⁻ were transformed mostly into reactive species that participated in the oxidation of the organic pollutants. Finally, the electrolysis treatment with BDD electrode is a very exciting and efficient technology for the reclamation of OSPW.

235 Comparison of the effects of extraction techniques on mass spectrometry profiles of dissolved organic compounds in oil sand process-affected water

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Recent advances in mass spectrometry have facilitated chemical characterization and profiling of complex environmental mixtures such as oil sands process-affected water (OSPW) and identification of previously unresolved chemicals. However, because OSPW is a complex mixture of salts, metals, suspended particulate matter and dissolved organics, extraction techniques are required to reduce effects of signal suppression/enhancement. In this work, Orbitrap, ultrahigh resolution mass spectrometry was used to perform a comprehensive comparison of solid phase extraction (SPE), and liquid-liquid extraction (LLE) techniques on profiling of dissolved organic chemicals in OSPW. When operated in negative ion mode, extraction of naphthenic acid (NAs-O₂⁻) was observed on acidicification of OSPW samples for C18 and LLE techniques. However, when applying a hydrophilic lipophilic balance sorbent (ABN) SPE technique, the extractability of NAs was independent of pH. When operated in positive ion mode, for all extraction methods, nitrogen- and sulfur-containing species were more abundant and diverse in basic extracts than in acidic extracts and ABN extracted the greatest number of chemical species including nitrogen, sulfur and oxygen containing species. Overall, this study supports the utility of hydrophilic lipophilic balance SPE techniques for the profiling of species of dissolved organic chemical in OSPW at environmentally relevant pHs.

236 Biodegradation of dissolved organics in Base Mine Lake: Is it happening and how long does it take?

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Introduction: The current strategy for the remediation of over 1 billion cubic metres of oil sands process-affected water (OSPW) employs the use of end pit lakes (EPLs). In this method, OSPW will be stored in evacuated mines until overall toxicity is reduced through natural or managed processes. Base Mine Lake (BML) is the only existing oil sands EPL. Using BML OSPW, the in situ biotransformation of thousands of dissolved organic species was monitored here for the first time. Laboratory microcosms containing BML OSPW (n=3, T=21°C) were monitored alongside positive (Merichem added) and negative (autoclaved) controls for over one year and aliquots analyzed using high pressure liquid chromatography-Orbitrap mass spectrometry in positive and negative mode. Additionally, BML OSPW samples taken every August from 2013 to 2017 were analyzed to review the changes which have occurred in the last 5 years. Objective: To evaluate the in situ microbial biotransformation of the dissolved organics in BML and identify persistent classes of compounds which may remain in the future. Results: The profile of organics in BML OSPW showed no difference compared with negative controls after 272 days. A closed bottle experiment containing BML OSPW showed intervention could stimulate biotransformation and as such, nutrients were added to the experimental incubations on day 379. A decrease in the concentrations of naphthenic acids (NAs, O₂⁻) was observed in BML microcosms after the addition of acetate (day 409) but NA concentrations decreased by only 7% by the last day of the experiment (day 424). Some heteroatomic groups (O₃⁻, O₂S⁻) also decreased following intervention while others increased (O S⁻, O₅⁻). All other groups (O⁻, O₄⁻, O₅⁻, O₄S⁻, O₄S⁰) did not change during the experiment. In the field-based project, relative distributions of organics in BML from 2013 to 2017 demonstrated no change. However BML 2017 displayed the lowest concentrations of all BML samples studied. Conclusions: Results confirm NAs in OSPW are recalcitrant and that microbial biotransformation in BML may be suppressed due to low nutrient availability. Furthermore the majority of heteroatomic groups appear to be at least as persistent as NAs. Changes in the chemical profile following intervention show that the microbial community in BML OSPW is able to change its chemical environment and that biostimulation may be necessary to decrease concentrations of toxic organics in future EPLs. Implications: Additional management strategies may be required to increase the efficiency of oil sands EPLs and promote biodegradation of toxic dissolved organics found therein.

237 Non-Target Profiling of Bitumen Influenced Waters to Identify Tracers Unique to Oil Sands Process-Affected Water in the Athabasca Watershed

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The objective of this study was to identify unique chemical tracers of oil sands process-affected water (OSPW) to enable future discrimination tailings pond seepage from natural bitumen influenced waters from the Alberta McMurray formation. The approach involved comparing a unique sample set of OSPW (n=4) and OSPW-affected groundwater (n=15) to natural bitumen influenced groundwater (n=20), using high resolution mass spectrometry (HRMS). This identified four potential tracers of OSPW seepage that were then subjected to structural elucidation. One potential tracer, tentatively identified as a thiophene-containing carboxylic acid (C₁₀H₁₂O₂S) was only detected in OSPW and OSPW-affected samples, thereby showing great diagnostic potential. The remaining three
unknowns, postulated to be two thiochroman isomers with a ketone functional group on the S-containing cyclic moiety and two hydroxyl groups likely located on an alkyl side-chain (C<sub>12</sub>H<sub>21</sub>O<sub>3</sub>S<sup>-</sup>), and an ethyl-naphthalene (C<sub>9</sub>H<sub>11</sub>), were found in either one or two background groundwaters, respectively. Additional unknown ions with diagnostic potential were also detected at lower concentrations, or evident as co-eluting isomer mixtures, and with improved sample preparation and/or separation could further augment differentiation of industrial and natural sources of bitumen influenced waters.

238 Quantifying the relative contributions of mining-related and naturally occurring naphthenic acids in groundwater near oil sands tailings ponds


A relatively straightforward method to differentiate naphthenic acids (NAs) associated with oil sands process-affected water (OSPW) from those found naturally in groundwaters in contact with the bituminous McMurray Formation remains the Holy Grail for environmental scientists working in Canada’s oil sands region. Despite recent advances in high- and ultrahigh resolution mass spectrometry, the data generated by these analyses do not lend themselves to an easily interpretable format suitable for quantification and apportionment of anthropogenic and natural sources of NAs. A previous novel approach to this challenge utilized intramolecular carbon isotope values generated by online pyrolysis (δ13C-pyr) to characterize and quantify the acid extractable organics (AEOs) fraction containing NAs (Ahad et al., 2013). This method was able to distinguish bitumen- from non-bitumen-derived AEOs but could not discriminate between mining-related and natural sources of bitumen-derived AEOs. This study builds upon those results using data analysed from samples collected across two different study sites and four field campaigns (2014-2017). In conjunction with δ13C-pyr and high-resolution Orbitrap mass spectrometry analysis, we employed an additional isotopic tool — sulphur isotope analysis (δ34S) of AEOs. As observed previously, OSPW was characterized by elevated δ13C-pyr values and high proportions of O2 and O25 species classes, and δ13C-pyr values in groundwater reflected mixing between various sources. The combined use of both δ13C-pyr and δ34S allowed for discrimination of AEOs into three relevant groups: 1) OSPW-derived; 2) naturally occurring bitumen-derived (i.e., McMurray Formation), and; 3) naturally occurring non-bitumen-derived. The relative proportions of these three sources determined in groundwater samples utilizing an isotopic mixing model revealed seepage of low levels of OSPW-derived AEOs at both study sites. Relatively higher proportions of OSPW at one of the sites highlighted the potential for this technique to verify preferential flow-paths of tailings pond seepage. (Reference: Ahad, J.M., Pakdel, H., Savard, M.M., Calderhead, A.I., Gammon, P.R., Rivera, A., Peru, K.M. and Headley, J.V., 2013. Characterization and quantification of mining-related “naphthenic acids” in groundwater near a major oil sands tailings pond.

New and Existing Chemical Contaminants in Changing Arctic and Antarctic Environments - Part 1

239 Organochlorine pesticide and industrial compound fluxes to surface snow from four glacial sites on Svalbard, winter 2013-1014

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During spring 2014, seasonal surface snow was collected from 4 glacial sites on Svalbard and analyzed for 35 organochlorine pesticides and 8 industrial compounds (mostly chlorobenzenes) using high-resolution GC-MS. The sites were Holtsedalffonna, Kongsvegen, Lomonosovfonna and Austfonna, roughly trending from west to east, a maximum distance of 220 km. Lomonosovfonna and Holtsedalffonna are high-elevation sites (> 1000 m.a.s.l.), and are above the tropospheric boundary layer (TBL) all year and receive inputs only from long-range atmospheric transport. Kongsvegen and Austfonna are both at about 700 m.a.s.l. and above the TBL during summer and may receive local inputs during winter, although that is unlikely because all land-based surface sources would be frozen. The most concentrated of all 43 substances was current-use pesticide chlorpyrifos, and was highest at Lomonosovfonna where it was 5 times greater than Holtsedalffonna and Austfonna. The most concentrated of the industrial compounds was pentachloroanisole (PCA) which again was highest at Lomonosovfonna, and was 67% greater than the second-most abundant site, Kongsvegen. Most compounds varied by less than a factor of 2 among sites, and include pentachlorobenzene, hexachlorobenzene, 3,4,5,6 tetrachloromethoxybenzene, heptachlor epoxide B, heptachlor, delta-HCH, dactal, cis-chlordane, dieldrin, and 4, 4'-DDE. This suggests a common source or a common process involving transport to each site. All other pesticides were below detection, including all other compounds in the DDT group, toxaphene paralrs 26, 50, 62, endosulfan II and endosulfan sulfate, endrin aldehyde and endrin ketone, methoxychlor, dicofol, and mirex. Air mass back trajectories, showing the frequency of flow from likely contaminant source regions to each of the sites, are similar, suggesting that differences in contaminant amounts are not a result of different flows from likely long-distance source regions. Fourteen of 35 pesticides were below detection, all of them legacy compounds, suggesting that limitations on use have been effective at lowering long-range atmospheric transport of these substances. On the other hand, the high amounts of PCA, which is on the Stockholm Convention Annex A (elimination) in association with pentachlorophenol, indicates that some substances remain in the environment and are moving in comparatively large amounts.

240 Partitioning of emerging contaminants to Arctic dissolved organic matter

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Anthropogenic organic pollutants have been commonly detected in the Arctic, and include new classes of brominated flame retardants (BFRs) and current use pesticides (CUPs). In this study, we focus on the environmental fate of chlorpyrifos (CUP) and tetrabromobisphenol A (TBBPA, which is a flame retardant). These chemicals are produced and used at lower latitudes and transported to higher latitudes through global distillation processes. These two chemicals have been detected in various environmental compartments in the Arctic where they are both used or manufactured. These chemicals have been found in the indigenous Alaskan Yupik communities at relatively high concentrations, and we believe that the exposure pathway is through bioaccumulation up the food chain. One process that can limit exposure and bioaccumulation of these compounds is through their interactions with Arctic dissolved organic matter (DOM). We hypothesize that the presence of DOM in Arctic surface waters at sufficiently high enough concentrations (> 10 mg/L) will bind these chemicals making them less bioavailable. Solubility
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enhancement studies for chlorpyrifos and TBBPA) were conducted with various types of Arctic DOM (Innavait Creek and a tundra seep adjacent the Sagavanirktok River). The DOM concentrations ranged from 5 mg/L to 90 mg/L with two controls at 0 mg/L and the compounds were analyzed by liquid chromatography. Our measured solubility values for TBBPA and chlorpyrifos were in excellent agreement with reported those reported in the literature (0.3 and 9 μM respectively). Surprisingly, we observed loss of TBBPA in the presence of DOM, which was unexpected. Solubility enhancement experiments of chlorpyrifos are ongoing.

241 Photochemical Degradation of Polycyclic Aromatic Hydrocarbons and BTEX in Snow and Ice

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As the Arctic warms and new shipping routes become available, human activity in the Arctic will increase, causing perturbations to biogeochemical cycles. In the Arctic, these cycles are heavily influenced by chemical processes in snow and ice. Therefore, in order to quantify and predict the effects of human activities on these cycles - and to mitigate harmful effects - we need to understand ice's role as a chemical reactor. We do not yet have this understanding. Many environmentally-relevant reactions proceed via different mechanisms and rates in snow and ice compared to in liquid water, but the reasons for these differences remain largely unknown, and we lack predictive capabilities for pollutant fate in snow-covered regions. We have measured photolysis rates for several pollutants associated with fossil fuel usage, including PAHs (polycyclic aromatic hydrocarbons) and BTEX (benzene, toluene, ethylbenzene, and xylenes) in artificial snow and ice. We show that photolysis is accelerated in frozen aqueous solution compared to in the liquid phase, and that it occurs via different mechanisms. Photolysis rates are greatly affected by the presence of common environmental co-solutes such as dissolved organic matter (DOM) and sodium chloride (NaCl). We have used Raman microscopy to investigate the surface properties of solute-containing ice and to help relate sample composition to reactivity. Our results indicate that pollutant fate in polar regions will depend strongly on the composition of the ice; for example, photolysis rates for a given pollutant can be very different in relatively pristine ice compared to in sea ice. Our results will improve our ability to predict pollutant fate in polar regions, and may inform evidence-based emission regulations.

242 Strong signals of remobilized margin PAHs to the basin in a warming Arctic

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Arctic warming will amplify the margin inputs coming from the continent and shelf, yet their effects remain poorly understood for persistent organic pollutants (POPs), such as polycyclic aromatic hydrocarbons (PAHs), which gain concern due to their high carcinogenicity and burden on the ecosystem. Here we present how distribution and transportation (PAHs), which gain concern due to their high carcinogenicity and burden on the ecosystem. Here we present how distribution and transportation of dissolved PAHs in the Arctic Basin can be explained by a new insight into the Arctic Oscillation. This hypothesis was further visualized by ice-back trajectories and the different relationships of PAHs with the fraction of river and ice melting water. The mass balance model of PAHs revealed a new scenario with overwhelming input by margin sources (68%) and output by volatilization (84%). Our study highlights the strong signals of remobilized margin POPs (especially from Eurasia) in the Canadian Basin, suggesting significant changes in their pathways, balances and ecological consequences are underway with climate change.

243 Organophosphate Esters in Water of the Largest High Arctic Lake and its Tributaries

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Organophosphate esters (OPEs) have been detected in Arctic aquatic ecosystems, but the influence of glacial melt on the environmental behavior of OPEs in the recipient aquatic ecosystems is still unknown. In this study, water samples were collected from Lake Hazen (the world’s largest High Arctic Lake by volume) and its tributaries to investigate the distribution and depth profiles of 14 OPEs in Lake Hazen and to explore the input of OPEs to Lake Hazen and the output of OPEs from Lake Hazen by glacial rivers in 2015 and 2018. The concentrations of Σ14OPEs in water of Lake Hazen and its tributaries in 2015 ranged from 6.81 to 19.3 ng/L and from 4.51 to 31.6 ng/L, respectively. Tris(2-butoxyethyl) phosphate and three chlorinated-OPEs (tris(2-chloroethyl)phosphate, tris(2-chloroisopropyl) phosphate, tris(1,3-dichloro-2-propyl)phosphate) were the dominant OPEs in Lake Hazen watershed. Levels of Σ14OPEs in Lake Hazen water column showed a decreasing trend from 0 to 225 m, began to increase below 225 m and peaked at 250 m. Concentration of Σ14OPEs in water of Lake Hazen (mean ± SE, 12.3 ± 0.77 ng/L) were lower those in inputs to Lake Hazen from glacial rivers (15.8 ± 4.04 ng/L) and output from Lake Hazen (Ruggles River, 15.1 ng/L). The concentration of Σ14OPEs in Skeleton Creek (20.9 ± 5.05 ng/L) was higher than those in glacial rivers, indicating that small stream may be a more important input source of OPEs into Lake Hazen. A mass balance was estimated for OPEs in the Lake Hazen watershed. Glacial river inputs to Lake Hazen and the output from the Ruggles River in 2015 were 15.5 and 16.5 kg, respectively, suggesting glacial inputs of OPEs can be completely discharged by the Ruggles River. The concentrations of Σ14OPEs in glacial rivers in 2018 (4.48 ± 0.52 ng/L) were significantly lower than those in 2015 (15.8 ± 4.04 ng/L), indicating that the melting of glaciers may play an important role in determining the concentrations of OPEs in the tributaries of Lake Hazen. This study highlights that OPEs can be subject to long-range transport to the Arctic and the melting of glaciers can release OPEs into aquatic ecosystems in the High Arctic of Canada.

244 Wastewater sources of per- and polyfluorinated alkyl substances (PFAS) and pharmaceuticals in Canadian Arctic Communities

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Effective removal of organic contaminants in wastewater effluent pose a challenge to small communities worldwide. Treatment in the Canadian Arctic is exceptionally challenging due to infrastructure demands and harsh climates. To better understand the efficacy of current treatment options and risks posed by pharmaceuticals on receiving waters in the Arctic, four representative communities within the Canadian territory of Nunavut were evaluated: Iqaluit, Baker Lake, Cambridge Bay, and Kugluktuk. Per- and polyfluorinated alkyl substances (PFASs) were also investigated in Cambridge Bay. These communities have treatment
ranging from primary lagoons, engineered wetlands, and natural lakes. Pharmaceuticals were measured using the organic diffusive gradients in thin film (o-DGT) passive sampler in summer 2018. Of the 34 compounds studied, seven were found at least once: atenolol, carbamazepine, metoprolol, naproxen, sulphapyridine, sulfamethoxazole, and trimethoprim. Concentrations varied (10 - 5000 ng/L) between communities and treatment method showed no distinction in removal performance towards specific compounds. Iqaluit had the poorest overall performance while Baker Lake had the best. Measured pharmaceutical concentrations do not appear to pose a significant hazard to receiving waters at this time, based on known toxicological endpoints. PFAS concentrations were found to be over 100-fold greater in Cambridge Bay wastewater than previously reported Arctic seawater. Results suggest that wastewater may be an important point source of PFASs in Arctic communities. The o-DGT passive samplers performed well in marine Arctic settings. We recommend further testing of wastewater efficiencies in Arctic communities along with evaluations of seasonal variations.

245 Intensive fishing as a method to reduce mercury concentrations in a Northern Pike population in a small subarctic lake

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Sanguez Lake is a small (1.8 km²) Subarctic lake in the Dehcho region of the Northwest Territories, which has traditionally been fished by Jean Marie River First Nation. However, high levels of mercury (Hg) in the Northern Pike (Esox lucius) population from this lake have led to concerns regarding the use of this species as a subsistence food source. In an effort to mitigate the level of Hg in Northern Pike, an intensive fish-down was implemented, where large (>500 mm) Northern Pike were removed from the lake to reduce competition and promote faster growth, which should result in lower Hg levels. Sanguez Lake was originally sampled in Fall 2013, and the fish-down began in 2016, with fishing occurring in Fall of 2016, 2017 and 2019, as well as in Spring of 2018 and 2019. To determine the effectiveness and extent of stimulating growth-dilution in this species, Hg concentrations in Northern Pike tissue were compared between years and seasons. Significantly higher Hg concentrations were measured in 2013 compared with later years during the fish-down. The slope of the relationship between mercury and fork length decreased in this species, suggesting their long-range transport and the transfer of multiple contamination to the Euro-Arctic marine trophic webs.

246 Multiple exposure of the Boreogadus saida populations to legacy and emerging pollutants from inner and outer Bessel fjord (NE Greenland)

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NE Greenland, the remote region of the Northern hemisphere, has attracted considerable scientific interest due to the peculiar characteristics and the biological, ecological, and eco-toxicological adaptations of the organisms living in this area, which is still few investigated. Reports by Arctic Monitoring and Assessment Program (AMAP) highlight that the list of chemicals found in Arctic ecosystems are continuously growing and show increasing temporal trends for some current-use chemicals. Specimens of the marine gadoid Boreogadus saida were caught from RV Helmer Hanssen in Bessel Fjord (BF), NE Greenland (76°N), in September 2017, during the scientific expedition TUNU-VII (UiT The Arctic University of Norway). The general aims were to evaluate the bioaccumulation of legacy end emerging contaminants in populations of B. saida from mid and outer Bessel Fjord (BF) waters, and from the continental shelf. Liver and muscle samples were analysed to determine the concentration of Polyaromatic Hydrocarbons (PAHs), Bisphenol A (BPA), Nonylphenols (NPs) and Organochlorine Pesticides (HCHs, Endosulfan, DDE, DDT) including some Current Use Pesticides (e.g. Chlorpyrifos, Dacthal). PLE extraction and analytical determination using LC-MS and GC-MS showed the occurrence of these contaminants in the majority of samples. The contaminant longitudinal pattern was outer BF ≥ mid BF > shelf. Only for NP1-2EO, BPA and 4-NP we found the muscle more contaminated than the liver; a possible reason is that the detoxification/removal of these compounds from the liver occurs more rapidly respect to other POPs resulting in a continuous and chronic exposure. The pesticides concentration pattern was the same between the different areas. The ΣDDT residue was due to the metabolite p,p'-DDE (>80%). The Endosulfan technical formulations is dominated by the α-isomer; the increase in β-Endosulfan is consistent with increasing distance to possible application sites, the α- and β-isomers degrade at different rates in temperate aquatic systems and there is some evidence suggesting that the β-isomer can be converted to the α-isomer in the environment. Results confirm the presence of selected legacy and emerging contaminants in this species, suggesting their long-range transport and the transfer of multiple contamination to the Euro-Arctic marine trophic webs.

Sequencing the Exposome Using Nontarget Mass Spectrometry: Aims, Perspectives and Challenges - Part 1

247 A Novel High-Resolution Mass Spectrometry Toolbox for Unravelling the Chemical Exposome

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Non-target analysis (NTA) combined with high resolution mass spectrometry (HRMS) is considered the most comprehensive monitoring approach for characterization of the chemical exposome. NTA has thus far not fulfilled its promise of comprehensive analysis and been adopted as a routine approach due to the richness of HRMS data, sample complexity, and the challenges faced by the analysts to perform NTA. NTA data are typically very large (3-4 GB per sample), noisy, and complex so analysts must perform multiple data pre-processing steps to be able to identify features in a sample. These steps may include feature detection, feature prioritization, and database matching. Due to the complexity of these datasets, each step taken in an NTA workflow is prone to error and thus false detection. Here we present a collection of open source tools that we have developed to specifically improve and simplify the NTA workflow from feature detection to identification, while maintaining maximum transparency. These tools have been tested on complex environmental samples such as wastewater influent and wastewater sludge and have outperformed commonly used methodologies. Additionally, we present the implementation of these tools within the framework of an open access web platform. This cloud-based web platform will provide both a hub for data processing and a repository for data. The repository facilitates future analysis (i.e. retrospective NTA and/or suspect screening). We envisage that the platform will be a focal point for future developments in NTA.
248 Non-targeted analysis supported by data and cheminformatics delivered via the USEPA CompTox Chemicals Dashboard

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Non-targeted analysis (NTA) uses high-resolution mass spectrometry to better understand the identity of a wide variety of chemicals present in environmental samples (and other matrices). However, data processing remains challenging due to the vast number of chemicals detected in samples, software and computational requirements of data processing, and inherent uncertainty in confidently identifying chemicals from candidate lists. Analysis of the resultant mass spectrometry information relies on cheminformatics to identify and rank chemicals and the USEPA has developed functionality within the CompTox Chemicals Dashboard (https://comptox.epa.gov/dashboard) to address challenges related to this analysis. These tools include the generation of “MS-Ready” structures to optimize database searching, retention time prediction for candidate reduction, consensus ranking using chemical metadata, and in silico MS/MS fragmentation prediction for spectral matching. Combining these tools into a comprehensive workflow improves certainty in candidate identification. This presentation will review how the CompTox Chemicals Dashboard via its flexible search capabilities, rich data for ~875,000 chemical substances, and visualization approaches within this open chemistry resource provides a freely available software tool to support structure identification and NTA. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

249 Use of LC-HRMS to assess transformations of anthropogenic chemicals during anaerobic digestion

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Anaerobic digestion is an increasingly used technology to produce energy and recover resources from materials such as animal manure, food waste and sewage sludge. In the case of manure, the digested material is often applied on agricultural land as a fertilizer. Manure contains a variety of anthropogenic chemicals including antibiotics, antifungals, and insect repellents used to treat animals, as well as pesticides used on feed crops. Little is known about how these contaminants transform during anaerobic digestion, and whether they still have biological activity when they are land applied. This project focused on the application of liquid chromatography coupled with high resolution mass spectrometry (LC-HRMS) for the elucidation of contaminant degradation kinetics for several anthropogenic compounds and the identification of transformation products that are formed during anaerobic digestion of dairy manure. Digestion media samples were extracted using a modified QuEChERS method and analyzed using LC-HRMS in full MS mode with data dependent MS2 acquisition. We used a combination of literature review and pathway prediction software tools to compile a list of potential transformation products which were used for suspect screening analysis. We also used statistical methods including principle component analysis and volcano plots to visualize changes in the overall composition of the digestion media over time. In our initial experiments, we observed degradation of three out of eight tested compounds which were investigated further to identify potential transformation products. We were also able to demonstrate significant differences in the chemical composition of digested material between samples with and without contaminants added.

250 Mapping the chemical contaminant burden in lake trouts using a combination of targeted and non-targeted approaches

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Humans are exposed to a larger number of chemicals, notably through food consumption. In particular, fish is known to be a major route of exposure for a range of well-known toxic contaminants. To date, many efficient targeted analytical strategies allow for the determination of their concentrations in biological tissues. Such approach is however limited to known, regulated and/or suspected substances. This study proposes to establish a comprehensive strategy for characterizing the chemical contamination of fish samples using a combination of targeted and innovative untargeted mass spectrometry-based analytical procedures. Fish homogenates (n = 37, Lake trout Salevelinus namycush) were collected from Lake Ontario and Lake Superior (Canada) in August 2018. Several classes of organic contaminants of emerging concern (new brominated flame retardants, phthalates, bisphenols, chlorinated alkanes, organophosphate esters flame retardants) were analyzed using sensitive targeted analytical strategies. These methods rely on conventional extraction and purification steps, followed by analysis combining liquid or gas chromatography (LC/GC) systems coupled to conventional or high-resolution mass spectrometers (MS/MS or HRMS). In addition, an innovative untargeted global profiling was implemented to highlight emerging organo-halogen compounds. This strategy was applied to purified solvent extracts characterized with LC-HRMS (Q-Orbitrap spectrometer, scan mode analysis). The new ergonomic interface HaloSeeker v1.0 was used to automatically screen halogenated (Cl, Br) compounds on the basis of two properties: the discriminating mass defect engendered by heteroatoms and the highly specific isotopic patterns. Initial results from targeted methods show the presence of several halogenated compounds, including hexabromocyclododecane (HBCD, 9.2-26.6 ng g^-1) and lipids for the sum of α, β, and γ congeners). The compilation of data, via chenomometric methods, will be presented in the context of the exposure.

251 Identifying Toxicologically Significant Compounds in Urban Wildfire Ash using in Vitro Bioassays and High Resolution Mass Spectrometry

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As the risk for urban wildfires increases, a greater understanding of the potential chemical exposures associated with these fires is needed. The urban landscape includes not only trees and brush, but also building materials, including paints and other coatings, furniture and other durable goods, solvents, pesticides, plus all the other consumer products found in a typical home. A wide range of yet-to-be identified chemicals is likely to form when the broader mix of chemicals in homes are burned at high temperatures, with particular concern for combustion products resulting from burning chlorinated, brominated, or other halogenated compounds. Household-level composite ash samples were collected in Sonoma County, California, USA, soon after the Tubbs fire on November 1, 2017 (3 destroyed homes in each of 4 neighborhoods) along with 3 samples from an undeveloped site upwind of the burned residential areas. Samples were solvent extracted and the extracts were analyzed using high resolution mass spectrometry (gas and liquid chromatography with quadrupole time-of-flight mass spectrometers; GC-Q/TOF-MS and LC-Q/TOF-MS). Separate extracts were analyzed using a suite of in vitro bioassays for their bioactivity toward nuclear receptors (aryl hydrocarbon
receptor (AhR), estrogen receptor (ER), androgen receptor (AR)) and their influence on the expression of genetic markers of stress and inflammation (interleukin-8b (IL-8b), cyclooxygenase-2 (COX-2), and cytochrome P450 (Cyp1A1)). All genetic markers (Cyp1A1, IL-8b, COX-2) as well as the AhR activity were significantly higher in wildfire samples than in controls, while AR and ER activity were not. Samples from residential areas were not significantly different from ash samples from the reference site but substantial variability in bioactivity was observed across samples. Results of extensive suspect and nontarget screening to identify the chemicals responsible for elevated bioactivity using the multiple streams of HRMS data acquired and open source data analysis workflows based on the programs MS-DIAL and MS-FINDER are reported.

252 Suspect Screening of Indoor Pollutants with Reduced and Statistically Controlled False Discovery Rate
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Non-targeted analysis (NTA) with high-resolution mass spectrometry (HRMS) is a promising strategy to identify unknown pollutants in the environment. However one of the primary issues in NTA is a high false discovery rate (FDR). In addition, manual interpretation of mass spectrometry results leads to limited reproducibility. In this study, we developed a one-step automatic platform (R package) for suspect screening of pollutants in indoor dust, with reduced and statistically-controlled FDR. A post-acquisition mass calibration algorithm was also developed to improve the mass accuracy of Orbitrap mass spectrometers to sub-ppm. This reduced the searching space of indoor pollutants from the USEPA Toxic Substances Control Act (TSCA) chemical database by 4.3-fold. A robust scoring algorithm was established by incorporating isotopic peak distribution, mass tolerance, neutral loss, retention time prediction and in silico MS2 fragmentation patterns to rank the detected pollutants. A target-decoy database searching strategy was also proposed to statistically control FDR and determine the cutoff score. The in silico target-decoy based FDR matched well to the experimental FDR determined by authentic standards, indicating the good performance of the proposed strategy. With this platform, 596 pollutants were detected in 24 house dust samples in under 2 days, at 5% FDR. Many well-studied pollutants such as fatty acids, bisphenol A, phthalates, and flame retardants were detected as the most abundant chemicals. 46 chlorinated compounds were also detected including well-known triclosan and chlorine-containing organophosphate flame retardants. But the majority of detected chlorinated compounds have never been reported before in indoor environments and several of them were validated by commercially available standards. The automatic data analysis platform developed in this study will provide an important basis for future reproducible and FDR-controlled suspect screening studies.

253 Top-down exposomics of persistent and bioaccumulative organics
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The exposome represents all environmental exposures during the course of a lifetime. Persistent organic pollutants (POPs) are an important subset of environmental toxicants that exhibit common characteristics, such as persistence, toxicity and a tendency to bioaccumulate in wildlife and humans. The identity of most environmental toxicants and their impact on the environment and human health are unknown. This contribution reports on a sensitive, quantitative and high-throughput approach to identify new exposures, viz. Top-down analysis of 200 μL of serum using polydimethylsiloxane sorptive extraction. A set of legacy and emerging halogenated POPs were targeted by gas chromatography-high resolution mass spectrometry (GC-HRMS). Unknown and suspected POPs were screened from the complex HRMS data sets based on accurate mass and isotope ratio measurements using a script tool (R code). Experiments performed with standard reference materials (SRM 1957/1958, (non)fortified serum; and SRM 2585, household dust) showed good agreement with certified values. Method detection limits were constrained by background levels, in line with traditional methods. However, for polychlorinated biphenyls (PCBs) and selected organochlorine pesticides (OCPs), the detection limits are comparable to those reported by the National Health and Nutrition Examination Survey (NHANES). These methods were applied to a cohort (n=125) of pregnant mothers at low (n=57) and high (n=68) risk of placental insufficiency. Previous studies have established that exposure to PCBs can impact the vascular structure of the placenta, resulting in limited oxygen and nutrient transport with concomitant fetal growth restriction. Correlation analysis was performed to identify potential associations between unknown POPs and birth weight. Preliminary results indicate the presence of multiple classes of POPs, including number of unrecognized halogenated chemicals whose identities have not yet been reported.

254 Quantitative and Qualitative Assessment of Silicone Wristbands to Characterize the Personal Exposome using QC-HRAM MS
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Silicone wristbands are becoming an increasingly important tool for characterizing personal exposures to organic contaminants. They have been used in a variety of applications to measure a wide range of chemicals including organophosphate flame retardants (OPFRs), brominated flame retardants, pesticides, polycyclic aromatic hydrocarbon, nicotine and others. Levels of SVOCs found on wristbands have been shown to correlate with levels in both serum and urine, suggesting they are capturing representative exposure data. In this study, wristband samples (n=110) from a pregnancy cohort in New York were analyzed with targeted methods for OPFRs, phthalates, PCBs, and pesticides, and a suspect screening approach was employed to characterize additional exposures in the wristbands using a Q-Exactive GC/IT and Orbitrap GC/MS- MS system (Thermo Scientific(TM)). In addition, all samples were analyzed for brominated flame retardants using a single quadrupole GC-MS (Agilent 6890N and 5975, respectively) operated in negative chemical ionization (ECNI) mode. Average percent recovery across all 21 isotopically labelled internal standards was 94%. Of the 85 target compounds 43 were detected above the MDL in more than 50% of the samples. Phthalates were the most prevalent chemical class, with Bis(2-ethylhexyl) terephthalate (DEHT) having the highest median concentration. Organophosphate flame retardants were the second most prevalent chemical class, triphenyl phosphate (TPHP) having the highest median concentration. More than ~8500 features were identified after deconvolution of the mass spectra when performing suspect screening. Approximately 350 of these features matched one or more of the three spectral libraries used and were detected in more than 50% of the samples. Unsurprisingly, many of these high confidence compounds were plasticizers and personal care product additives. Many of the compounds detected on the wristbands were significantly and positively correlated, and, based on responses, are likely present at levels similar to that of targeted plasticizers and personal care product additives, such as DEHT. These results suggest that pregnant women are exposed to hundreds of different chemicals in the ambient environment daily, and emphasize a need to further characterize these mixtures and their potential health impacts.
Microplastics in the Environment: Transport, Fate and Ecological Effects - Part 1

255 Microplastics in a global, multimedia context

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Microplastics in the marine environment have garnered considerable attention recently. Some have suggested that they present dire consequences. Others have dismissed the issue as inconsequential. However, it is clear that plastic production and debris generation, the precursors to microplastics, are increasing globally at an alarming rate. Early research on microplastics has largely been descriptive. Published samplings vary widely in regards to what they collect. Analytical techniques are improving, but are still limiting (particularly for microplastics < 20 um). Thus, most studies underreport actual amounts in samples. Much research on environmental behavior, even in the lab, overlooks the reality that the plastic products in use are compositionally complex in terms of polymer type and additive content (on average 7% by weight). Add to that size, shape, form and texture elements. Understanding and solving issues related to the microplastics problem must consider their transient physical nature, i.e., as an intermediary class between macro- and nanoplastics. Also, most plastics are manufactured, used, and eventually discarded in the terrestrial environment. Thus, trying to solve the ocean microplastics issue by solely focusing on the oceans is destined to disappointment. Data on microplastic levels in vast expanses of the globe are still lacking. The African and Asian Pacific regions are expected to drive the increase in plastic demand in coming decades, but lack the infrastructure to manage resulting wastes. The effectiveness of wastewater treatment is over-estimated, as in many regions treatment is non-existent or primitive. Interestingly, waivers still exist for “primary-only” treatment for several large US and Canadian plants that discharge to the ocean based on a dilution of degradable contaminants argument. Even advanced treatment systems falter during severe storm events. Wastewater sludges, the repository for many of the microplastics removed, are often “recycled” into soils. This restarts their journey to the oceans via circuitous routes. We spend >90% of our lives in increasingly airtight enclosures (homes, workplaces, vehicles). Therein we are in close proximity to a vast array of plastics. Such plastics also have the greatest loads of toxic additives. Thus, consumption of microplastic-contaminated seafood is likely far less of a risk than indoor exposure.

256 A comprehensive model of macro-, micro- and nano-plastic fate and transport in catchment soils and surface waters

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Here, we present a new, catchment-scale model of plastic fate and transport built upon the existing INCA-Microplastics modelling tool. The new model operates at a daily time step and is forced by readily available climate and land use data. When available, observations of plastic stores and fluxes can be used to aid model calibration. The new model supports an arbitrary number of plastic types and size classes, facilitating simulation of the behavior in aquatic and terrestrial environments of macro-, micro- and nano-plastics. The model includes all key processes needed for credible simulation of plastic fate and transport in the terrestrial environment, including etheroaggregation. Time-varying plastic inputs associated with atmospheric deposition, biosolid application or unintentional release can be represented. The model simulates vertical movement of plastic particles in soil and lateral fluxes to surface waters. Physically based hydrologic and sediment mobilization routines allow for realistic simulation of plastic mobilization from and deposition to the streamed. Effects of weathering on plastic physical properties (e.g., density, mean particle size, surface charge, etc.) can be simulated. Importantly, this allows the model to capture the behavior of both virgin and aged plastic particles in soils and freshwaters. The model is implemented in the MOBIUS framework, a generic, open access model building platform which facilitates rapid prototyping of new model structures. We demonstrate the capabilities of the new model using data collected from urban and agricultural catchments in the UK, Canada and Spain. Our results highlight both the need for a comprehensive model of plastic fate and transport as well as unanswered research gaps needing further empirical study.

257 Primary and secondary nanoplastics have limited acute toxicity but chronic effects on Daphnia magna

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Microplastics (MPs) are ubiquitous in aquatic environments and their potential environmental impacts are of increasing global concern. Moreover, weathering of a single MP particle can yield billions of nano-plastics (NPs < 0.1 um), and the NPs are speculated to be a bigger threat due to higher environmental concentration and bioavailability. Primary NPs are originally manufactured to be that size, while secondary NPs originate from fragmentation. To date, little is known about the long-term impact of NPs in freshwater systems, particularly secondary NPs. Thus, we employed a freshwater model invertebrate, Daphnia magna, to investigate the chronic impacts of model primary NPs, fluorescence-labeled polystyrene NPs (PS-NPs), as well as plastic leachate that contained secondary NPs and plastic-associated chemicals. In the first experiment, parent Daphnia (F0) was exposed to 20 nm PS-NPs until the production of the first neonates (F1) followed by a two-generation recovery period. The PS-NP fluorescence was mainly detected in the gastrointestinal tract and brood chamber in F0 and transferred to the next two generations. Exposure to PS-NPs caused a concentration-dependent decrease in appendage curling rate but increased reproduction in F2. In the second chronic experiment, Daphnia exposed to plastic leachate showed reduced appendage curling rate but increased growth and reproduction, which could be due to the release of endocrine disrupting compounds. These results provide evidence that the acute toxicity of primary and secondary NPs was low even at high concentrations but their sublethal effects over long-term exposure should not be overlooked.

258 Microplastic co-occurrence with chemical contaminants in invasive mussels (Dreissena sp.) in the Milwaukee river watershed, Lake Michigan, USA

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Invasive zebra and quagga mussels (Dreissena sp.) in the Laurentian Great Lakes of North America serve as biomarkers for common legacy contaminants, but are also exposed to microplastic particles (<5nm in size), a contaminant of emerging concern. Little research has examined microplastic ingestion by dreissenid mussels, or the relationship between microplastic and common mussel contaminants. We measured microplastic abundance in mussels within the Milwaukee River and harbor of Lake Michigan, USA. Reference mussels were collected from open water in Lake Michigan and deployed in cages at 4 locations in the river and harbor in June 2018, representing a gradient of influence from wastewater effluent and river discharge. Mussels were collected after approximately 30 and 60 days in situ, sorted according to size class, and analyzed for microplastic and legacy contaminants in the soft tissue.
Surface water samples were collected simultaneously with caged-mussel recovery and analyzed for microplastic and legacy contaminants. We expect the largest mussels from sites adjacent to wastewater outfalls to have the greatest abundance of microplastic and legacy contaminants. These data will also be combined with concurrent research on microplastic in surface water, sediment, and fish in the Milwaukee River watershed. Overall, results will reveal the potential utility of dreissenid mussels as biomonitor of microplastic pollution, the impact of microplastic on mussels, the relationship between emerging and legacy chemical pollutants, and inform models of chemical contaminants in the Great Lakes and other freshwater ecosystems.

259 Microplastics in municipal mixed-waste organic outputs induce minimal short to long-term toxicity in key terrestrial biota

J. Judy, University of Florida / Soil and Water Science; M. Williams, A. Gregg, CSIRO Land and Water; D. Oliver, CSIRO; A. Kumar, CSIRO / Land and Water; Program- Environmental Contaminant Mitigation and Biotechnology; R.S. Kookana, CSIRO / Land and Water; J. Kirby, CSIRO / Advanced Materials Transformational Capability Platform Land and Water

Sustainable alternatives to landfill disposal for municipal mixed wastes represents a major challenge to governments and waste management industries. In the state of New South Wales (NSW) Australia, mechanical biological treatment (MBT) is being used to reduce the volume and pathogen content of organic matter isolated from municipal waste. The product of this treatment, a compost-like output (CLO) referred to as mixed waste organic output (MWOO), is being recycled and applied as a soil amendment. However, the presence of contaminants in MWOO including trace organics, trace metals and physical contaminants such as microplastic fragments has raised concerns about potential negative effects on soil health and agriculture following land application. Here, we used multiple lines of evidence to examine the effects of land application of MWOO containing microplastics in three soils to a variety of terrestrial biota. Treatments included unamended soil, MWOO-amended soil and MWOO-amended soil into which additional high-density polyethylene (HDPE), polyethylene terephthalate (PET), or polyvinyl chloride (PVC) microplastics were added. Tests were conducted in soil media that had been incubated for 0, 3 or 9 months. Addition of microplastics had no significant negative effect on wheat seedling emergence, wheat biomass production, earthworm growth, mortality or avoidance behaviour and nematode mortality or reproduction compared to controls. There was also little evidence the microplastics affected microbial community diversity, although measurements of microbial community structure were highly variable with no clear trends.

260 Fragmentation rate of micro and nano-particles from expanded polystyrene by sunlight exposure

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The expanded polystyrene (EPS) is one of common plastic debris items in both freshwater and marine environments worldwide. In addition, its gas-blown foamed structure can be susceptible to physical and chemical weathering. However, fragmentation process of EPS, making a micro- and nanoplastics, by sunlight exposure remains largely unknown. We aimed to quantitatively determine micro- (0.8-500 µm) and nanoparticles (2-800 nm) of EPS produced by sunlight exposure including size distribution. The unique ‘foamed’ structure which has many pores inside produced micro- and nano-sized particles in flat, laminar and irregular shape by sunlight exposure. The abundance of produced particles increased by increasing sunlight exposure duration (micro particles: 3.4 x 106 ± 1.7 x 105 – 6.7 x 107 ± 1.1 x 107 particles/cm2 exposed EPS surface area and nanoparticles: 4.0 x 107 ± 1.2 x 107 – 5.7 x 108 ± 2.9 x 108 particles/cm2), and the average size of fragmented EPS particles were in the range of 2.03-2.88 µm for microparticles and 138-189 nm for nanoparticles, respectively. The abundance of microparticles increased by decreasing size, but nanoparticles showed bimodal size distribution based on 100 or 80 nm. The 50% weight loss of EPS cube by sunlight weathering is estimated to be in 3.49 years, and approximately 2.6 x 108 particles/cm2 fragmented particles could be produced in one year by sunlight exposure according to linear regression equation ($y=99.3-0.00283x$, $r^2=0.98$, $p<0.01$ for weight loss and $y=-16295045+55231x$, $r^2=0.94$, $p=0.01$ for produced particles). Many of EPS debris in the environments directly exposed to sunlight can produce substantial number of micro- and nano-sized particles within relatively short time.

261 Leaching of additives and fragmentation of plastics in semi-terrestrial environments

T. Hüffer, T. Hofmann, C. Henkel, University of Vienna / Environmental Geosciences

The pervasive use of plastics together with inadequate waste management has led to a global contamination of ecosystems with end-of-life plastic products. Global plastic pollution has been shown to pose a planetary threat because it is causing planetary-scale exposure that is not readily reversible. Plastic particles released in the environment are subjected to various aging process including biotic (biofilm formation) and abiotic aging (UV radiation, oxidation, and physical stress). These processes lead to an alteration in the physical and chemical properties of the polymeric particle and may ultimately result in an embrittlement and fragmentation. The additive release in turn depends on the chemical compatibility of the additive with the polymer, the exposure and aging of the plastic in the environment, and the type of bonding between the additive and the polymer (chemical or physical). The aging of plastic particles under environmental conditions, the leaching of plasticizers, and the fragmentation of are among the most pressing research priorities in microplastic exposure and risk assessment. In this contribution, the current understanding of abiotic polymer aging in the aquatic environment and its role in the release of polymer plasticizers will be addressed for the example of polyvinyl chloride. While the release for example of bis(2-ethylhexyl) phthalate from polyvinyl chloride used as medical devices (e.g. blood bags) or children articles has been studied quite intensively there is very little information on the release of plasticizers from polyvinyl chloride plastics into aquatic environmental systems, and how aging influences polymer properties and additive release. Results from a recent mesocosm study within the AQUACOSM project will be presented, where these processes were investigated for polyvinyl chloride plastic test bodies containing two most commonly encountered additives using stream pond systems mimicking semi-terrestrial environments.

262 Riverine plastic inputs to global oceans

L. Mai, E.Y. Zeng, Jinan University / School of Environment

Plastic pollution has caused increasing global concern. Currently, model estimates of the riverine plastic inputs to global oceans based on the concept of Mismanaged Plastic Waste (MPW) varied substantially, and no field measurements of riverine inputs are available. We have conducted sampling at the eight major river outlets of the Pearl River Delta, South China with rapid economic growth and urbanization, to provide field measured data for developing a more objective model. Here we present a robust model for accurate estimation of riverine plastic inputs to global oceans, based on the Human Development Index (HDI), population density and water discharge. We estimate that approximately 1.73-2.46x10^6 tons of plastic waste enters the oceans annually from global rivers. Riverine plastic pollution stresses global oceans, especially the North Pacific Ocean, which receives about 0.12 million tons of plastic waste from rivers every year. Finally, we predict the future riverine plastic inputs trend. With the development of humanity, annual riverine plastic inputs will reach a peak of 0.27 million tons by 2025 and decrease gradually.
Creating Pathways to Restoration in the Great Lakes: Addressing Beneficial Use Impairments in Areas of Concern

263 Tracking Restoration Progress in the Great Lakes

B. Benson, ORISE at USEPA / GLNPO; A. Pelka, US Environmental Protection Agency / GLPO; M. Tuchman, USEPA / Great Lakes National Program Office; M. Loomis, US Environmental Protection Agency / HQ

Within the Great Lakes Restoration, significant funding has made for multiple opportunities to restore the Great Lakes. In Focus Area 1, the Environmental Protection Agency’s Great Lakes National Program Office (GLNPO) oversees the restoration of the Areas of Concern (AOCs) in the Great Lakes. There are 43 AOCs between the US and Canada and are in various stages of remediation and restoration, including sediment remediation and habitat restoration. There are a variety of metrics that have been employed to track specific projects within the AOCs. However, due to the variations and complexities of projects, habitat specific metrics are difficult to standardize and quantify. Project area size and level of degradation vary widely between AOCs. These variations along with the different restoration approaches state and local groups choose, lead to a host of issues tracking habitat restoration effectiveness in a uniform manner. The implementation of a habitat tracking matrix will allow for better tracking of environmental improvement using habitat specific metrics to assist in decision making and reporting, as well as, establishing efficacy and best practices. This presentation will describe the matrix, what measures are being tracked and preliminary analyses of projects tracked thus far.

264 Community Revitalization in the Great Lakes: assessing ecological indicators in stimulating a water-based community identity in Areas of Concern

C. Norris, USEPA GLNPO / Remediation and Restoration; A. Pelka, US Environmental Protection Agency / GLPO; K. Fritz, USEPA / ORD NHEERL; M. Mills, US Environmental Protection Agency / National Risk Management Research Laboratory

The Great Lakes region has a rich history as the “rust belt” of the U.S. This industrialization around the Great Lakes resulted in economic prosperity as well as environmental contamination. As an outcome, 43 highly degraded coastal communities throughout the Great Lakes were designated as Areas of Concern (AOCs) in the 1987 Great Lakes Water Quality Agreement. The AOC program utilizes 14 predefined Beneficial Use Impairments as indicators of ecological health, including Restrictions on Dredging Activities and Loss of Fish and Wildlife Habitat. When remediation and restoration actions have occurred such that a beneficial use impairment can be removed, this is an indication of significant environmental improvement. As remediation and restoration work is completed and BUIs are removed communities have begun to see not only environmental improvements but subsequent social and economic benefits. Communities have embraced these benefits and their newly cleaned waterways creating a new water-based identity and investing in revitalization. This is known as the R2R2R framework: Remediation to Restoration to Revitalization. Except for economic measures, measures of revitalization in AOCs and the linkage to environmental health have only been anecdotally reported. As a complex and potentially contentious topic, holistically understanding the features of revitalization is imperative. We compiled and analyzed over 15 datasets on revitalization in the Great Lakes and delineated themes and metrics representing social, economic, and environmental factors and examined their prevalence, diversity, and distribution. This will aid in normalizing the conversation on what revitalization is and means. This exploratory study then utilizes the R2R2R framework to examine how restoring beneficial use impairments in AOCs (R1+R2), leads to community revitalization (R3) as seen in the investment and community involvement in forming a sustainable water-based identity.

265 Using a weight of evidence approach and design optimization to balance remediation and restoration design goals at Spirit Lake


Spirit Lake is part of the St. Louis River Area of Concern. Under the Great Lakes Legacy Act, the U.S. Environmental Protection Agency is working with a non-federal project partner to collaboratively design environmental remediation and restoration for the lake to address chemical constituents in sediment potentially associated with beneficial use impairments. The remedy includes capping, enhanced monitored natural recovery, monitoring natural recovery, and dredging, with placement of dredged material in on-site confined disposal facilities. First, chemical analytical data and lithology were spatial modeled to determine the general extent of chemical constituents. Next, a point by point review of chemical and lithologic data was performed together with project regulators and stakeholders to better understand the conceptual site model and match remedial technologies to target areas and target depths. Target areas were then considered in light of 5 factors: minimum capping thicknesses indicated by Minnesota Pollution Control Guidance; target post-remedy depth regimes for habitat restoration which seeks to restore fisheries and wetland vegetation; total anticipated dredge volumes and capacity limitations of the confined disposal facilities; shoreline and slope stability factors that may constrain the geometry of dredge cuts. All of these factors were weighed when developing dredging prisms. The result was a multi-component design that optimized the use of each remedial technology to achieve goals for chemical concentrations while constraining CDF size and providing desirable depth regimes for habitat restoration.

266 Attention to organizational and operational processes underpins effective public engagement in environmental remediation and restoration

P. Seelbach, J. Wondolleck, University of Michigan / School for Environment and Sustainability

Community perspectives are a desired and required component of ecosystem-scale environmental remediation and restoration efforts. It is common for remediation programs to set a process for community engagement in motion, often as some form of Public Advisory Council (PAC), assuming that such processes will work effectively. However, our close examination has revealed notable variation in Michigan AOC PAC form, function, and effectiveness (and too often, ineffectiveness). Group process elements that are generally accepted and perhaps initially implemented are often forgotten in the everyday hustle to accomplish on-ground project results. PAC effectiveness requires active attention to some generally accepted organizational and operational process principles that are a required compliment to standard outcome-focused activities. PAC experiences over many years and across numerous ecosystem-scale initiatives provide insights for improved practice. Here we synthesize key lessons about effective public process from global case studies of marine ecosystem management combined with those from recent assessments in Michigan Areas of Concern. We present: (1) convergent lessons from our two ecosystem sets emphasizing that active attention to organizational and operational processes is required to achieve effective and durable public engagement; and (2) a menu of key process strategies and principles. This guidance is applicable to remediation and restoration efforts within and beyond the Great Lakes.

267 Early Stage Post-Remediation Recovery of Benthic Invertebrate and Fish Communities Within the Buffalo River, NY

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The Buffalo River sediment remediation was completed in 2015 under the Great Lakes Legacy Act. The 79-acre remedy included dredging 440,000
cubic yards of material, cap placement in an adjoining area, and backfill at selected locations. The remedy was designed to achieve remedial goals for PCBs, mercury, lead, and PAHs within five years following remediation. Five habitat restoration projects were also constructed within the Buffalo River Area of Concern (AOC). In agreement with USEPA’s Great Lakes National Program Office, post-remediation monitoring was required two and five years after remedy construction to assess the effectiveness of the remedy and document progress towards achieving remedial goals. In 2017, Year 2 verification monitoring was implemented, including sediment sampling, bathymetric surveys, benthic invertebrate and fish community surveys, and habitat restoration area monitoring. Benthic and fish community surveys were conducted to contribute to the data needs required for removal of Buffalo River AOC beneficial use impairments. Community survey locations were generally consistent with locations used during the 2008 baseline (pre-remediation) sampling. Benthic surveys included both sediment grab samples and multiplate samples, consistent with New York State Department of Environmental Conservation and USEPA Rapid Bioassessment Protocols. Benthic surveys were conducted at five locations within the Buffalo River, one in-stream reference location, and one out-of-watershed reference location. Fish community surveys used a boat-mounted electrofishing unit and were conducted at three locations within the Buffalo River and one in-stream reference location. Results of the Year 2 monitoring were compared to baseline conditions using a variety of species-specific metrics to determine community condition and impairment of the water body along a spectrum from no impact to severe impact. Benthic community data show modest improvement over time in some areas, while other areas show slight declines or no change over time. Overall, fish community data show no change or a very slight improvement over time. The Year 2 community survey results represent a snapshot in time during an early stage of the recovery and will be used to reassess the recovery during the next sampling event in 2020.

268 A program for assessing Beneficial Use Impairments and emerging contaminants in fish-eating birds at Areas of Concern and other Great Lakes sites

K. Grasman, Calvin University / Biology; L.L. Williams, M. Annis, C. Eakin, US Fish and Wildlife Service

Significant concentrations of persistent organic pollutants (POPs) including polychlorinated biphenyls (PCBs), chlorinated dioxins and furans, and organochlorine pesticides have contaminated the Great Lakes since their introduction during the 1940s-60s. Studies from the late 1960s onward have shown that fish-eating birds of the Great Lakes are excellent sentinel species for assessing and monitoring effects of contaminants including reproductive problems, deformities, and immune suppression. Two wildlife-related Beneficial Use Impairments (BUIs) at Areas of Concern (AOCs) are recognized by the Great Lakes Water Quality Agreement: 1) bird or animal deformities or reproductive problems and 2) degraded fish and wildlife populations. A current question under the Great Lakes Restoration Initiative (GLRI) and other federal and state AOC programs is whether these impairments continue. Furthermore, more recently bioaccumulative contaminants of emerging concern (CECs) have been found in Great Lakes wildlife, raising the question of whether these CECs are associated with reproductive, health and (or) population-level effects. This talk will present the tools and key results of a monitoring program studying fish-eating birds to reassess these BUIs and potential associations with legacy POPs and CECs. In the Saginaw Bay and River Raisin AOCs and Grand Traverse Bay during 2010-19 under the GLRI and AOC programs of the US Fish and Wildlife Service and US Environmental Protection Agency. Embryonic nonviability (elevated infertility and mortality) through late incubation in herring gulls in the Saginaw Bay (6.6%) and River Raisin (8.1%) AOCs and in Grand Traverse Bay (8.7%) was significantly higher than at the reference site (3.1%). Deformities associated with PCBs and dioxins were found in several embryos and chicks only at AOCs. Chick productivity in Caspian terns in Saginaw Bay was significantly below that of reference sites. In the River Raisin AOC, productivity of gull chicks was very poor in 4 of 9 years, with complete reproductive failure during 2010. The mean phytotoxemagglutinin (PHA) skin response for T-cell mediated immunity was suppressed 54-56% in gull chicks at both AOCs and 48% in terns and 39% in herons in Saginaw Bay and also was suppressed 50% in Grand Traverse Bay gulls. This monitoring program has demonstrated continuing wildlife BUIs at two AOCs and provides a model for assessments that could be applied at other AOCs to support management decisions.

269 Voluntary Investigation, Remediation and Restoration of a Segment of the Detroit River Area of Concern


The Monguagon Creek-Upper Trenton Channel (MCUTC) Site is located within the Detroit River Area of Concern (AOC) and is being investigated, remediated and restored under the Great Lakes Legacy Act by US Environmental Protection Agency (EPA), US Army Corps of Engineers, and Bridgestone Americas Tire Operations, LLC (BATO). Nine beneficial use impairments (BUIs) remain in this AOC. Largely channelized and culverted, MCUTC is located within an industrialized area of Riverview, MI, which had received direct discharges of manufacturing wastes for decades. BATO proposed to cooperate with EPA to ensure that the MCUTC portion of the Upper Trenton Channel would be addressed. EPA led the preparation and completion of the remedial investigation in YEAR, and BATO led the preparation and completion of the feasibility study (FS) in 2018. Of four site-specific remedial action objectives (RAOs) developed in the FS, one aimed to restore beneficial uses within the Detroit River AOC by reducing the mass, volume, and concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), mercury, and lead in MCUTC sediment. Cleanup goals were set equal to a PAH toxic unit of 1 to 4 and remedial alternatives focused on four areas of interest (AOIs). Remedial technologies were first screened to allow detailed evaluation of only the five most feasible, effective and cost-effective remedial alternatives. Those five alternatives were evaluated with respect to overall protection of human health and the environment, attainment of RAOs, long-term effectiveness and permanence, reduction of mass, toxicity, mobility or volume through treatment, short-term effectiveness, implementability and cost. Remediation Alternative 3 (enhanced monitored natural recovery in AOI-C and dredging in AOI-D) was selected as the preferred alternative. Benefits of this remedy include its implementability, given the underground utilities in AOI-C and the steep bathymetry in AOI-D, and its short-term and long-term effectiveness. BUIs expected to benefit from this remediation project include fish tumors and other deformities, degradation of aesthetics, degradation of benthos, and loss of fish and wildlife habitat. Planning is underway to complete a pre-design investigation this year.

270 Characterizing sources, biogeochemistry, and accumulation of Hg in food webs of the St. Louis River Area of Concern


The St. Louis River Area of Concern (AOC) was designated in 1987 due to Beneficial Use Impairments (BUIs), including “Restrictions on Fish and Wildlife Consumption” (BUI 1) from historical pollutants. Minnesota and Wisconsin posted fish consumption advisories for the St. Louis River, in part, because fish have elevated mercury concentrations.
Mercury bioaccumulation in the food web can be from legacy sources in sediment and from present-day ambient sources (from both local, regional, and global sources). In 2017 a study was conducted which had four goals to support the understanding of Hg sources in the AOC: 1) Compare mercury methylation and bioaccumulation by characterizing the macroinvertebrate assemblages, geochemistry, ecosystem type, and food web structure between the AOC and a reference location (Bad River); 2) Compare age- and size-specific mercury residues in select fish species between the AOC and Bad River; 3) Trace food web pathways and identify mercury sources in select fish species using stable isotopes of carbon and nitrogen. 4) Develop a mercury-specific BUI restoration target for the AOC derived from the long-term, post-remediation projected change in fish mercury residues based on the inferred differences in mercury-source bioaccumulation between the AOC and Bad River. For each location, up to five samples each were collected for mayfly (Hexagenia) larvae, dragonfly larvae, riparian spiders, and a composite benthic invertebrate assemblage sample using multi-plate artificial substrate samplers. We deployed artificial substrates to collect macroinvertebrates in order to assess Hg accumulation and biotic condition across the St. Louis AOC and Bad River. When artificial substrates were retrieved, 12 of 14 were disassembled, scraped, sieved and then picked for biomass. The remaining two samplers were set aside for identification and metabarcoding to assess similarity in benthic communities. Macroinvertebrate assemblage (traditional identification and metabarcoding), stable isotope analyses, water, sediment and biota mercury, plus other water quality analyses will be presented and discussed.

Systematic Review for Robust Reporting and Evaluation of Environmental Toxicology Data for Risk Assessment

271 Systematic Review for Robust Environmental Assessments

J. Nichols, E. Lavoie, US Environmental Protection Agency / National Center for Environmental Assessment

Chemical and environmental assessments are the scientific basis of many policies and regulations aimed at protecting human health and the environment. As the breadth and depth of scientific evidence has expanded, the complexity of weighing, integrating and synthesizing the evidence has grown. Major elements of risk assessment development are literature identification, study evaluation and data extraction, synthesis, and integration of evidence to draw conclusions, and systematic review requires structured, predetermined and transparent process. Systematic review methodologies are being adapted and expanded in the field of environmental risk assessment and present an important opportunity for rigor in assessments. The attributes of systematic review are advantageous to assessors, decision makers and the public in being able to understand what evidence conclusions are based on and the degree of confidence in the conclusions. While the structured methods and frameworks provide transparency and consistency, expert scientists remain critical to the success of a systematic review and interpretation of the evidence. In this presentation, we will provide a succinct introduction to the systematic review paradigm with specific examples of systematic review steps in chemical and environmental assessments, including the benefits and challenges that are commonly encountered. This presentation is designed to introduce the session and set the stage for the audience.

272 SETAC Strides Towards Toxicity Data Transparency

T.H. Schlekat, J. Lynch, SETAC

Current practices in environmental management of chemicals rely heavily on human and ecological toxicity data. More specifically, chemical hazard and risk evaluations used to inform management decisions are often based on exposure and effects data related to biological pathways. There is a clear need for a global knowledge base of toxicity data that is comprehensive yet flexible. However, setting up such a database, curating data, and making it open and accessible is a daunting task due to the vast amount of chemicals currently in commerce and those entering the industrial stream every day, and the accompanying number of research studies on those chemicals. This is a global conundrum that would benefit from a global harmonized approach. SETAC, as a global society open to all stakeholders, is uniquely placed to lead the way in tackling that challenge. SETAC has the ability to reach across boundaries whether geographic or organizational, build bridges, and facilitate fruitful knowledge exchange and collaboration. SETAC staff and volunteers have teamed together to develop a roadmap for collaboration with the goal of advancing the current state of various toxicity data curation. They are identifying initiatives at every point in the cycle of developing toxicity data that should encourage data transparency and study reporting and ultimately lead to more comprehensive and flexible toxicity knowledge bases. This presentation will identify a few of those initiatives, action taken, and tasks yet to be claimed with the hopes of reaching enthusiastic volunteers willing to help SETAC lead the way.

273 Application of Systematic Review in Ecological Hazard Evaluations under the Toxic Substances Control Act

A. Nguyen, US Environmental Protection Agency / ORD; K.M. Eisenreich, US Environmental Protection Agency / Office of Pollution Prevention and Toxics

EPA’s Office of Pollution Prevention and Toxics (OPPT) is implementing systematic review for ecological hazard assessments under the Toxic Substances Control Act (TSCA) as amended by the Frank R. Launtenberg Chemical Safety for the 21st Century Act. It consists of developing a structured process to search, screen, evaluate, extract and integrate ecological hazard data to support the TSCA risk evaluations on existing chemicals that EPA designated as high priority substances. In May 2018, EPA issued guidance titled “Application of Systematic Review in TSCA Risk Evaluations.” As discussed in the guidance, OPPT leveraged EPA’s ECOTOXicology knowledgebase (ECOTOX) as a source of single chemical toxicity information. Title/abstract and full-text screening decisions were based on the modified ECOTOX minimum applicability criteria that parsed citations into “on-topic” and “off-topic” bins. The “on-topic” references were further subjected to a full-text screening step to confirm relevancy. Only citations that fulfilled the full-text screening criteria moved to the data evaluation step. Reviewers used a newly developed scoring method to assess the quality of data sources as acceptable (i.e., high, medium, or low), not applicable, or unacceptable for risk evaluation purposes. According to the “Application of Systematic Review in TSCA Risk Evaluations” guidance document, OPPT considered the ECOTOX criteria and the Criteria for Reporting and Evaluating ecotoxicity Data (CRED) along with professional judgment when developing the data evaluation criteria. Information with acceptable quality served as the basis for hazard characterization and were extracted and integrated into the TSCA risk evaluations on high priority substances. This presentation will provide details about the systematic review process for ecological hazard information using examples from the first ten TSCA risk evaluations. It will also discuss how OPPT is leveraging systematic review tools for ecological hazard data and share current challenges as well as opportunities geared towards improving the current process.
274 Using Deep Learning and Active Learning Methods to Streamline Literature Curation for the Ecotoxicology Knowledgebase

B.E. Howard, R. Shah, A. Tandon, Sciome, LLC; A. Merrick, NIEHS; J.H. Olker, US Environmental Protection Agency / Office of Research and Development / National Health and Environmental Effects Research Laboratory / Mid-Continent Ecology Division; C. Elonen, D.J. Hoff, US Environmental Protection Agency / Office of Research and Development

The ECOTOXicology Knowledgebase (ECOTOX) is a comprehensive, publicly available knowledgebase providing single chemical environmental toxicity data on aquatic life, terrestrial plants and wildlife. The ECOTOX database (as of March 2019) contains data for 11,695 chemicals and 12,713 species manually extracted from 48,464 references. The database is updated quarterly, and to identify relevant references and extract pertinent data, the ECOTOX data curation pipeline employs a methodical, multi-step process roughly equivalent to the initial stages of systematic review. This labor-intensive workflow requires human curators to regularly evaluate tens of thousands of candidate references, the majority of which are then rejected as not relevant. To streamline this process, we have recently evaluated the feasibility of using machine learning methods to automatically classify documents according to relevance, and to identify the exclusion rationale for those references that are excluded. Using a massive historical database containing hundreds of thousands of manually-screened references, we train a deep learning, neural language-model classifier to predict the relevance of new candidate references. References designated as excluded are further classified according to exclusion rationale and, using an attention mechanism built into the deep learning classifier, supporting passages are highlighted in the abstract. These models serve as a baseline classification method, subject to human intervention, which is then refined for each chemical-centric batch of new candidate articles according to user feedback within an active learning framework. Our approach is operationalized in the form of a modified version of the SWIFT-Active Screener software application, a collaborative web-based reference screening platform. We anticipate that deployment of this tool as part of the ECOTOX curation pipeline will result in more than a 50% reduction in the time spent screening references for relevance.

275 USEPA Office of Water’s Systematic Review Process for Aquatic Life Water Quality Criteria and Coordination with Environment and Climate Change Canada


The US Environmental Protection Agency (USEPA) Office of Water’s (OW) Ecological Risk Assessment Branch develops national aquatic life and aquatic-dependent wildlife Ambient Water Quality Criteria (304(a) criteria). Criteria are recommendations that states and tribes can use in developing their state water quality criteria and standards. State water quality criteria are used in setting permit limits of chemical releases in effluents under the National Pollutant Discharge Elimination System (NPDES) program, assessing water bodies, making impairment listings, and setting Total Maximum Daily Loads (TMDLs) for impaired waters. In developing robust Ambient Water Quality Criteria, OW completes systematic reviews of open literature publications, government reports and other data reports on the ecotoxicity of various chemicals. OW has recently formally documented its long-standing systematic review process in a Systematic Review Standard Operating Procedure and associated fillable Data Evaluation Record templates for various aquatic and aquatic dependent taxa. OW has been harmonizing its systematic review approach, where appropriate, with EPA’s Office of Pesticide Program and Office of Pollution Prevention and Toxics, and has initiated an effort with EPA’s Office of Research and Development to examine the feasibility of automating aspects of OW’s data quality review to streamline and expedite the process. OW has also been working with Environmental and Climate Change Canada to compare systematic review processes in order to examine opportunities to collaborate on data quality review and maximize efficient use of resources. This presentation will provide an overview of OW’s systematic review process and will describe OW’s vision and ongoing efforts to harmonize and streamline data quality review working across EPA and with external partners.

276 Separating the wheat from the chaff: objective evaluation of ecotoxicity data for use in ecological risk assessment

J.M. Guidings, C. Habig, Compliance Services International; L.W. Brewer, Compliance Services International / Department of Wildlife Toxicology; J.R. Wirtz, J.M. Stafford, Compliance Services International

While much of the progress made in ecological risk assessment has come through improvements in methodology, it has always been recognized that any assessment must be demonstrably based on sound, relevant data. Incorporating data into risk assessment involves searching for and selecting publications and reports, acquiring the selected documents, evaluating each study for relevance and reliability, extracting study data pertinent to the objectives of the assessment, and analyzing the data with a consideration of their quality. This presentation will review typical data evaluation criteria with particular attention to study relevance, test substance identification, methodological details, and exposure-response trends. Examples will be presented from aquatic, avian, and pollinator studies with pesticides. An aquatic toxicity database for pyrethroid insecticides will be discussed as a case study. The database includes data from more than 300 registrant-submitted Good Laboratory Practice (GLP) studies and a similar number of open-literature publications and reports. A large fraction of the open-literature studies were incompletely documented, making data evaluation difficult and resulting in reduced data quality scores. Some studies were considered unusable and rejected due to ambiguities (e.g., test substance identity, exposure concentration units); very rarely, data were rejected because they were evidently erroneous or (in one case) apparently fraudulent. The presentation will discuss the kinds of information that should be reported (or made available as supplementary information) in an open-literature publication to enable data quality evaluation as well as interpretation of results. We will also address the use of data quality evaluation results (e.g., scores for relevance and reliability) in a Weight of Evidence analysis.

277 Lessons learned from three systematic reviews of mercury and selenium across multiple models and use contexts

N. Basu, McGill University / Faculty of Agricultural and Environmental Sciences

Here I outline three systematic reviews recently completed (or underway) in my research team, and focus on lessons learned. The first review was a World Health Organization (WHO)-led initiative that aimed to increase worldwide understanding of human exposures to mercury in support of the 2018 UN Global Mercury Assessment. The work captured 424,884 mercury biomarker measures taken from 336,015 individuals represented in 312 articles from 67 countries, and was recently published in Environmental Health Perspectives. The second review is underway and aims to increase understanding of mercury exposure worldwide through cosmetics. The third review is also underway and aims to assess study quality and relevance (physiological, environmental) of in vitro studies concerning selenium. I will offer a brief overview of each study, and then I will focus the presentation on lessons learned in conducting systematic reviews of environmental toxicological data. Specifically, I will highlight: a) the need to plan carefully, pilot ideas, and iterate and scale-up activities prior to conducting the definitive review; b) strategies to remain organized and document steps; c) concerns over sustaining and updating the reviews; and d) concerns of study quality in the peer reviewed literature.
278 Evidence mapping for use in human health and ecological chemical assessments

Transparent, methodologically rigorous, and rapid approaches are needed for conducting and updating human health and ecological chemical assessments. Evidence maps, also referred to as systematic maps, are useful for systematic review analysis. An evidence map includes a systematic and documented literature and/or toxicity data base search strategy and efficient review of potentially applicable toxicity data. Ideally, an evidence map also includes a quality evaluation of the applicable data, a summary of informative effect thresholds for pertinent biological endpoints and a process that encourages quality reviews. The utility of an evidence map is demonstrated by its ability to inform the scope and level of effort required for a full assessment and to reveal gaps in knowledge and/or future research needs. Data summaries are presented in a user-friendly visualization format, or a searchable database. With the use of specialized software applications and integrating results of existing data curation databases (e.g. ECOTOX Knowledge base), preparation of an evidence map can be rapid, on the order of weeks. This presentation will present examples of integrated human health and ecological evidence maps with a focus on the application of each to risk assessment. In addition, this presentation will discuss the usefulness of evidence maps in determining whether updates are needed for existing assessments. Finally, the presentation will discuss software, staffing model, and project management approaches to track and expedite systematic reviews and the development of evidence maps.

Pesticides and Pollinators: Assessing Potential Risks at Colony and Population Level

279 Challenges and successes with tiered testing for pollinator protection in a regulatory framework

With the recent development of the harmonized pollinator risk assessment framework for the U.S. and Canada, there is increased emphasis on a tiered approach for assessing risk of pesticides to bees. The Tier I level includes consideration of laboratory studies which assess both acute and chronic effects to larvae and adults at the individual level. Studies considered at higher tiers include semi-field, residue and feeding studies (Tier II), and field studies (Tier III), which are intended to provide more realistic information on exposure and include colony level effects. Tier II colony feeding studies, can provide dose related colony effects over longer observation periods. However, these studies have typically focussed on exposure through sucrose solutions rather than exposure from contaminated pollen. Tier III field studies can also provide longer observation periods, however, the amount bees forage on the test crop can be highly variable. Overall, each level of the tiered approach provides useful information in the pollinator risk assessment, however, each tier and related studies also include uncertainties which must be considered when evaluating the potential risk from pesticides. This presentation highlights the challenges and successes we have experienced from a regulatory perspective working within the pollinator protection framework, and in particular for higher tier studies.

280 USEPA’s Neonicotinoid Bee Risk Assessments

In 2016-2017, the U. S. Environmental Protection Agency (EPA) issued Preliminary Bee Risk Assessments for the neonicotinoids imidacloprid, clothianidin, thiamethoxam and dinotefuran. We present the results from the tiered risk assessment that integrates lines of evidence from individual level and colony level effects, including laboratory toxicity studies, colony feeding studies, empirical residues and incident reports. We based dietary exposures on empirical pollen and nectar residue concentrations from residue studies from crops treated via foliar spray, soil or seed applications. We compare these residues across the different active ingredients, crop use sites and application methods and consider potential sources of variability. For thiamethoxam and imidacloprid, we used a total residues of concern approach to account for exposure of the parent and degradates with similar toxicities, while for clothianidin and dinotefuran, we considered parent-only. We based honey bee colony level endpoints on large semi-field Colony Feeding Studies (CFS) which established endpoints based on consumption of spiked sucrose solution over an extended exposure period. Each assessment also quantitatively accounts for potential consumption of exposed pollen. Although the focus in these quantitative assessments is for honey bees, which we view as a suitable surrogate for assessing quantitative risk to all bee species, we also qualitatively considered risks to non-Apis bees.

281 Applying the Mechanistic Honey Bee Colony Model BEEHAVE to Inform Large Colony Feeding Study Design
E. Abi-Akar, A. Schmolke, C. Roy, Waterborne Environmental, Inc; N. Galic, Syngenta Crop Protection, Inc. / Environmental Safety; S. Hinarejos, Sumitomo Chemical Agro Europe / AgroSolutions Division International

In higher-tier studies aiming to assess pesticide exposure and effects to honey bees at the colony level, other factors can impact colonies and confound the analysis of potential pesticide impacts. Large colony feeding studies (LCFS) are sometimes affected by high losses of control colonies, indicating that stressors such as limited resource availability, weather, diseases and beekeeping activities may be influential. In the current project commissioned by the Pollinator Research Task Force, we assessed the study design and environmental conditions experienced by the untreated control colonies across seven LCFSs. Overwintering success in these control colonies differed considerably among the studies. In addition, the studies differed with respect to initial colony conditions, amount and timing of sugar feeding, landscape composition around study apiaries and weather. We applied the mechanistic colony model BEEHAVE to systematically assess the impact of study design and environmental conditions on control colonies. We first calibrated BEEHAVE to a subset of the studies, validated it with the remaining studies, and then used it to run simulations that changed only one variable at a time. The goal of the project was to inform study design that leads to increased likelihood of control colony overwintering success. From the simulations, the initial status of the colonies as well as the sugar feeding pattern were more important for fall colony condition than resource availability in the landscape and weather. Larger honey stores present in the colonies at study initiation, greater feeding amounts and earlier supplemental feedings (beginning in late summer to early fall) were the main factors that led to larger colony sizes and honey stores in the fall. This information can be used to inform the standardization of a study design, which in turn can increase the likelihood of overwintering survival in untreated controls and help ensure that studies are comparable. This project demonstrates how a mechanistic model can be used to inform study designs for higher-tier effects studies. Mechanistic models like BEEHAVE could further be applied to supplement higher-tier risk assessments, for instance, by extrapolating to non-tested exposure scenarios and environmental conditions and therefore potentially reducing the number of higher-tier studies.
282 Non-invasive metrics of honey bee (Apis mellifera) colony condition for selecting study colonies and evaluating tunnel stress

P. Moore, S. Krentz, M. Hill, J. DiMartino, Eurofins Agroscience Services; V.J. Kramer, Dow Agro Sciences, LLC / Ecotoxicology

Higher-tier studies, conducted in the field environment, present unique challenges in assessing honey bee colony impacts and in ascertaining whether a use scenario poses an unreasonable risk to pollinators. Although no guidelines for conducting semi-field studies in the U.S. have been released, the EPPO 170 document describes the basic elements that should be considered. Honey bee colonies are confined to an enclosure for a limited time and exposed to a test substance while foraging on the treated target or surrogate crop. Because confinement can only be tolerated for a limited period, due to the confinement-related stress, the colonies are moved out of the enclosure to freely forage after the exposure period ends. Typical endpoints in tunnel studies include: bee mortality, colony strength, development, food storage, flight activity, and abnormal behavior. Colony condition assessments (CCAs) involve a beekeeper observer removing each frame of a colony and estimating the number of colony constituents to calculate the total population and food reserves as colonies change over time. These measurements, however, are disruptive to the colonies, labor intensive, and subject to bias of the observer and variation in weather and time. Because of the combined tunnel stress and CCA disruption there is a need to develop metrics for hive strength and homeostasis without disturbing the hive. Here we present results of non-invasive hive assessments which were recorded in a pilot study of 5 colonies over two weeks in September 2018. Measurements identified as informative, including colony weight and entrance activity and brood nest temperature and humidity, in the pilot study, were used to evaluate colonies for study inclusion and measure tunnel stress in a conventional EPPO 170 environment. Results may warrant further research on non-invasive colony assessments in semi-field tunnel studies.

283 Fluvanilate contamination in beeswax and bioaccumulation in larval and adult honey bees

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Insects are responsible for pollination of 70 percent of the main crops used for human consumption worldwide; a service valued over 100 billion US dollars. Honey bees in particular have been shown to increase yield of animal-pollinated crops by over 90 percent. Large-scale honey bee colony loss has led to rapid population declines in the United States and Europe, resulting in decreased availability for pollination services, increased colony replacement costs, and reduced sales of hive products. Colony loss has been attributed to anthropogenic pressures such as urbanization and pesticide use within the foraging area and the hive itself. Exposure of honey bees to pesticides can lead to behavioral changes, poor reproduction, and lethality. The current study provided a multi-pesticide residue analysis in adult honey bees, stored bee bread, and beeswax throughout Virginia, USA. The high detection frequency and concentration of miticides in wax led to an examination of fluvanilate contamination in wax from five major North American beekeeping suppliers, and fluvanilate was detected in all wax samples. A wax/pollen partition coefficient was experimentally defined to highlight the fluvanilate exposure routes from wax to the pollen food source for larval and adult honey bees. These exposure routes were confirmed by measuring bioaccumulation of fluvanilate in larval and adult bees exposed to frames with fluvanilate-impregnated treatment strips, fluvanilate-dosed foundation wax, and a combination of the two treatments. Both larval and adult honey bees had detectable concentrations of fluvanilate in all treatments, with a significant interaction between treatment type and application time in adult bees. These results indicate that fluvanilate residues were comparable between hives that only had fluvanilate-dosed foundation to those that were actively being treated, suggesting that transfer of fluvanilate from wax to honey bees is an important exposure route. Exposure of not only fluvanilate, but other pesticides that may accumulate in beeswax, must be considered when evaluating risk for colony loss.

284 Field and model-based approaches to estimate pesticide exposure and effects on bee individuals, colonies and populations

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Pesticides used to control pests have the potential to expose bees and can affect their health and survival. We have limited understanding of pesticide exposure and its effects on bees, particularly for non-Apis bee species, for mixtures and in real landscapes. We aim to quantify exposure of pesticide mixtures to bees and evaluate effects on individual bees, their colonies and populations, using experiments and modelling. Pesticide exposure is estimated by quantifying residues in pollen and nectar collected by five bee species and by extending bee foraging models to include spatially explicit pesticide use. This information is used to select environmentally relevant mixtures of pesticides for laboratory experiments on individuals and on free-foraging bumblebee colonies, a potentially more sensitive social bee model than the honeybee. We use replicated landscape scale studies to capture relations between pesticide use, exposure and individual and colony level performance. Data from our experiments are used to expand bee foraging and colony models, to project population-level effects of pesticide exposure. We go beyond standard toxicity testing by evaluating from individuals to populations, from the lab to the field and from single compounds to pesticide mixtures. Understanding of potential exposure to such mixtures and possible effects is essential for the long-term safeguarding of bee populations and their pollination services. The project outcomes are relevant for monitoring pesticide residues in terrestrial environments and ecological risk assessment of chemical mixtures for bees.

285 Risk Assessment Approaches for Solitary Bees—Determining Impacts of Exposure Routes for Organosilicone Spray Adjuvants in Alfalfa Leafcutting Bees

D. Cox-Foster, USDA-ARS

Pollinators are keystones of both agricultural and natural ecosystems and vital to agriculture and food security. Over 3,600 species of bees are known to inhabit the United States. Among those, the honey bee Apis mellifera is the most used pollinator; however, several other species are managed and extensively used for orchard, field crop, and greenhouse pollination. Grave concerns over decline of bees is warranted, given that wild pollinators significantly increase crop productivity even in the presence of honey bees. Populations of honey bees and other pollinators have documented declines. In order to promote the health of pollinators, factors impacting their health need to be defined. Implicated drivers of decline include climate change, pesticides, habitat loss, parasites, diseases, competition from exotics, and interactions of these factors. Much focus has been placed on the active ingredients of pesticides; however, other agrochemicals can play a role in decreased bee health. Adjuvants are used in tank mixing to enhance pesticide efficacy; and, in particular, the use of globally-marketed organosilicone (OSS) spray adjuvants has increased in the United States. Detected in pollen, wax, and bees, OSS has been shown to impair honey bee learning, cause toxicity to honey bee workers, and synergize with viral pathogens. Data will be presented on assessing impacts of the OSS via different exposure routes (pollen/nectar sources vs. foliar exposure) for the alfalfa leafcutting bee, Megachile rotundata.
286 Effects of exposure to systemic insecticides applied to Cucurbita crops for the ground-nesting hoary squash bee (Peponapis pruinosa, Apidae)

D. Willis Chan, N. Raine, University of Guelph / School of Environmental Sciences

Seventy percent of solitary bee species nest in the ground, yet no information exists in the literature about the effects of soil-persistent systemic insecticides on this group of bees, many of which are crop pollinators. The hoary squash bee (Peponapis pruinosa) is a ground-nesting bee that provides important pollination services to Cucurbita crops (pumpkins, squash, and gourd). Because this species nests in the ground within agricultural fields and its diet comes primarily from Cucurbita crops in agricultural landscapes, it may be exposed to systemic insecticides in soil, pollen, and nectar of those crops. Here, for the first time, in a controlled, field-realistic experiment, we evaluated the effects of three crop-applied systemic insecticides (active ingredients: imidacloprid, chlorantraniliprole, and thiamethoxam) on health measures (nesting activity, number of nests/mated female, pollen harvesting, and number of offspring) for hoary squash bees foraging on those crops and on production measures (percentage fruit set, marketable yield and fruit weight of the crop) important to farmers. Few treatment-related negative effects on production measures were found. Statistically significant negative effects on nesting, pollen harvesting, and number of offspring were found for hoary squash bees exposed to imidacloprid via treated crops, suggesting that exposure to imidacloprid, although not immediately noticeable in production measures, will result in population decline over time.

Understanding Risks from Exposures to Per- and Polyfluoroalkyl Substances (PFAS)

287 Screening of PFAS in aqueous film forming foam for binding to human serum albumin and characterization of mechanisms

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Aqueous film forming foams (AFFF) developed in the 1960s by the United States Navy and the 3M Company have been widely used. Exposure to poly- and perfluoroalkyl substances (PFASs) in AFFF products has been linked to elevated concentration in blood serum. Although multiple C8-PFASs (e.g., PFOS and PFOA) have been phased out of production due to toxicity, persistence in the environment, and bioaccumulative potential, PFASs with similar structures continue to serve industrial needs. Emerging PFASs with shorter perfluorinated carbon chain length were suggested to be less bioaccumulative, thus are used to replace legacy C8-PFASs in the industry. However, emerging PFASs are found more mobile and harder to treat as water contaminants. Due to the large number of commercially available and environmentally detected PFASs, the bioaccumulative potentials of PFASs are difficult to assess. In this study, a comprehensive PFAS screening library was compiled, and HPLC-Qtof-MS method was applied to identify and quantify PFASs in an AFFF product. Human serum albumin (HSA) was then exposed to a series of AFFF dilutions using equilibrium dialysis to screen for preferential associations of specific PFASs with the protein. A broad spectrum of PFASs, including C4-PFASs, exhibited strong associations with HSA. Application of non-linear binding models implied high affinity binding at specific sites. After precipitation of the protein and removal of free PFASs in solution, the hydrolyzed HSA pellet contained low levels of strongly bound PFASs. Further analysis using 19F NMR titrations provided insight into protein binding mechanisms. Different interactions with HSA were observed for PFASs in AFFF compared to individual PFAS compounds. The combination of experimental and modeling techniques applied provides value in rapidly assessing the bioaccumulate potential of emerging PFASs in commercial products.

288 Legacy and Alternative PFAS Compounds in Private Wells on Cape Cod, Massachusetts, USA

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Domestic wastewater may contain per- and polyfluoroalkyl substances (PFASs) due to their widespread use in consumer products and may be a source of PFASs to drinking water wells in areas served by septic systems. In this study, we collected untreated water samples from 101 private wells on Cape Cod, Massachusetts, USA, a region where 85% of residences are served by septic systems. Samples were analyzed for 25 legacy and alternative PFAS compounds, as well as nitrate and boron, which are markers of septic system impact. Nitrate concentrations ranged from < 0.1 to 16 mg/L. Of the 25 PFAS analytes, nine were detected at least once (detection limits generally ranged from 1 to 6 ng/L), with detection frequencies up to 26% for PFOS, and 53% of wells had at least one detectable PFAS compound. Detected concentrations were generally below 10 ng/L, with maximum concentrations of 13 ng/L PFHxS, 15 ng/L PFPeA, 25 ng/L PFOA, 43 ng/L PFBS, and 51 ng/L 4:2 FTS. Total detected PFAS concentrations were correlated with nitrate (Spearman rho=0.44, p<0.001) and boron (Spearman rho=0.31, p<0.01), consistent with septic systems as a likely source of PFASs in these wells. Future analysis will also investigate associations between land use and PFAS concentrations in these wells to identify other potential sources of PFAS contamination to groundwater in this region.

289 Development of Toxicity Reference Values for Per- and Polyfluoroalkyl Substances in White-Footed Mice

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Per- and polyfluoroalkyl substances (PFAS) are compounds manufactured for use in paints, cleaning agents, fire suppressants, non-stick cookware and food containers, and water-resistant products. Concerns about PFAS stem from their ubiquitous presence in the environment, widespread reports of general toxicity, and the resistance of these compounds to degradation. Initial experiments sought to determine the rate at which steady state concentrations were reached for six PFAS [perfluorooctanesulfonate (PFOS), perfluorooctanoate (PFOA), perfluorohexanesulfonate (PFHxS), perfluorobutanesulfonate (PFBS), 6:2 fluorotelomer sulfonate (6:2 FTS), and perfluorononanoic acid (PFNA)] in the white-footed mouse (Peromyscus leucopus) following 28 consecutive days of oral exposure. Animals exposed to PFNA had increased liver weights and decreased ovarian weights. Male animals exposed to PFOS had increased liver and decreased thymus weights. Female animals exposed to PFOS has decreased uterine weights. No adverse effects were observed from exposure to 6:2 FTS, PFOA, PFHxS, and PFBS. Subsequent reproductive/developmental toxicity studies will serve to derive wildlife Toxicity Reference Values (TRVs) to assist in the development of appropriate site-specific risk assessment and decisions related to mitigation of exposures and/or future cleanup. Data from a reproductive/developmental toxicity test with PFOS suggest reduced pup survivability (0% at 5.0 mg/kg-day and ~50% at 10.0 mg/kg-day). Preliminary data from another reproductive/developmental toxicity test suggest that pup survivability is not influenced by exposure during gestation and lactation to PFNA.
290 Developing Protective Aquatic Life Values for Data-Limited Chemicals - Considerations for PFAS


USEPA’s Office of Water 1985 Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses specifies Minimum Data Requirements (MDRs) for developing national Aquatic Life Ambient Water Quality Criteria (WQC) under Section 304(a) (i) of the Clean Water Act. MDRs define minimum toxicity test data, by representative taxa, that are needed to derive WQC. The 1985 Guidelines state that data are typically needed for (at least) eight specified taxa to develop freshwater WQC, with similar requirements for the development of estuarine/marine WQC. Comparable requirements, based on taxa representation, have been established by several other countries for the development of aquatic life criteria. Although specific MDRs may differ, they have a similar objective of ensuring adequate taxa representation, consistent with the goal of protecting the broader aquatic community. USEPA’s Office of Water is in the process of developing protective aquatic life values for selected per- and polyfluoroalkyl substances (PFAS). PFAS encompass a broad suite of chemicals, representing thousands of individual compounds. Although available toxicity data are expected to achieve MDRs for some data-rich PFAS, principally perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) chemicals, data are more limited and would not achieve traditional MDRs for most PFAS. This presentation explores opportunities for addressing data limitations to achieve the underlying objectives of MDRs in the development of protective aquatic life values for data-limited PFAS chemicals. Approaches being considered include opportunities for: 1) “tailoring” toxicity data needs for the development of protective aquatic life values, when supported by applicable chemical-specific knowledge, 2) augmenting data that are available through the use of extrapolation approaches and tools, and 3) combining or “binning” chemicals for the development of protective aquatic life values.

291 Per/polyfluoroalkyl substances (PFASs) in human serum from communities impacted by contaminated drinking water in El Paso County, CO

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Per- and polyfluoroalkyl substances (PFASs) are a class of highly fluorinated synthetic organic compounds that have become ubiquitous water pollutants due to their remarkable persistence. More information is rapidly needed to understand health risks posed by widespread, long-term contamination of drinking water by PFAS-containing aqueous firefighting foams (AFFFs). This study investigated PFAS contamination of public water systems in El Paso County, Colorado. Wells in this area were found to be contaminated with PFASs from AFFF above EPA health advisory levels between 2013 and 2016. Raw drinking water and human serum from throughout this region were collected from April to June, 2018. Serum samples were re-collected from a subset of the initial cohort one year later to track changes in PFAS levels after exposure ended. All samples were analyzed via quadrupole-time-of-flight mass spectrometry (QToF-MS) suspect screening to understand the extent of PFAS contamination in human blood resulting from this exposure. Data were screened for >1000 previously characterized and theoretical AFFF-associated PFASs using a high-resolution mass spectral (HRMS) library and an extensive extracted ion chromatogram (XIC) list. Suspect screening of drinking water samples using HRMS libraries tentatively revealed the presence of cyclic sulfonates as well as sulfonamide precursors. Screening of human serum samples revealed that the average concentration of perfluorohexane sulfonate (PFHxS; 25 ng/mL) was elevated compared to the general population as well as most previous data from impacted communities, and showed that C5-C8 sulfonates were prominent and ubiquitous in blood from residents. Suspect screening suggests the presence of additional substituted PFASs, such as chloro- and oxy-sulfonates that have previously been seen in blood from occupationally-exposed firefighters. Relationships between composition and concentration of PFASs in drinking water and human blood will be discussed, along with changes in blood levels over time.

292 Developmental toxicity of in utero exposure to perfluoroalkyl ether acids: Comparison of GenX, Nafion byproduct 2, and Perfluoro-2-methoxyacetic acid


Perfluoroalkyl ether acids (PFEAs) are a sub-class of per- and polyfluoroalkyl substances (PFAS) and includes the compounds hexafluoropropylene oxide dimer acid (GenX), Nafion byproduct 2 (NBP2), and perfluoro-2-methoxyacetic acid (PFMOAA). PFEAs are currently used in the production of fluoropolymers following the phase-out of the legacy PFAS, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). Recent monitoring studies have detected GenX, NBP2, PFMOAA, and other PFEAs in a wide range of matrices including surface water, drinking water, and/or human serum. Little to no published research is available regarding the potential toxicity of these compounds compared to the legacy PFAS. We previously investigated the fetal, neonatal, and maternal toxicity of GenX in the Sprague-Dawley rat following short term (gestation day (GD) 14-18 and GD 16-20) and longer term (GD 8 - postnatal day (PND) 2) oral dosing and found that it produced similar effects, but was less potent than PFOA. Here, we assessed the in utero toxicity of PFMOAA (0.01-200 mg/kg/d, GD14-18 and GD9-13) and NBP2 (0.1-30 mg/kg/d from GD14-18 and 0.3-30 mg/kg/d from GD8-PND2) for comparison to GenX and the legacy PFAS, PFMOAA produced no adverse effects on maternal weight gain, maternal liver weight, fetal viability, or fetal liver weight at any dose in either dosing interval. In contrast, NBP2 reduced maternal weight gain (GD14-18 and GD8-PND2 dosing) and produced neonatal mortality (>=10 mg/kg) shortly after birth (< 24 hours) and reduced pup weight (GD8-PND2 dosing). Neonatal mortality and low pup weight has also been reported in the rat for PFOS and GenX following gestational exposure. Comparison of oral ED50s indicates that NBP2 is only a factor of ~4 less potent than PFOS (ED50s of 3 mg/kg versus 12 mg/kg for PFOS and NBP2, respectively); whereas, GenX is a factor of ~40 less potent than PFOS. Data collected to date indicate that the spectrum of adverse developmental effects is similar between some of the PFEAs and the legacy PFAS and that the oral potency is also relatively similar for some compounds. Ongoing research in our group is investigating the putative mechanism(s) of action and key events that lead to adverse maternal and neonatal outcomes, comparison of internal dosimetry for extrapolation to human exposures, and mixture-based effects of exposure to multiple PFAS. Abstract does not necessarily reflect USEPA policy.
Tuesday Platform Abstracts

293 Toxicological Response of Chironomus dilutus to Six Perfluoralkyl Compounds

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A multi-faceted bioassay study was conducted on six different perfluoralkyl substances with the intent of obtaining data to evaluate relative or toxicological toxicity between the substances. The six substances were selected from the US Environmental Protection Agency (EPA) Third Unregulated Contaminant Monitoring Rule (UCMR3) list, the Health Canada (January 2017) Drinking Water Screening Values, and available Environment and Climate Change Canada guidance documents. Two of the substances, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), are well studied. The other four substances (Perfluorononanoic Acid [PFNA], Perfluorobutanesulfonic Acid [PFBS], Perfluorohexanesulfonic Acid [PFHxS], and Perfluorohexanoic Acid [PFHpA]) are commonly detected in groundwater, particularly near aqueous film-forming foam releases (AFFF), but far less is known about their toxicological potential. 10-day acute range finding tests and 20-day chronic definitive renewal bioassays were run on all six compounds using the freshwater midge, Chironomus dilutus. Exposure doses were established above and below environmentally relevant concentrations. Measurement endpoints included: larval survival; larval growth as ash free dry weight and as biomass; and number of larvae, pupae, and emergent adults at test termination. Results from the 10-day acute survival tests were used to inform dosing for the 20-day chronic growth tests. Statistical analyses were performed with the DRC package of the R statistical software. Results are in concert with previous work showing PFOS to be the most toxic per- or poly-fluoroalkyl substance (PFAS). There is evidence of a concentration response relationship for PFOS and PFOA in both survival and growth and log-logistic models were fit to the data. Concentration responses were not apparent for single chemical exposures of PFNA, PFBS, PFHxS, and PFHpA suggesting limited toxicity, particularly at environmentally relevant concentrations. Based upon analysis of 219 surface water samples from various DoD installations that used AFFF, 81% of sampling sites included PFOS and PFHxS as the dominant PFAS. A second round of chronic testing will be performed with PFOS and PFHxS to investigate potential additive and synergistic toxicity of the most dominant PFAS in surface waters next to AFFF sites.

294 State regulatory challenges for per- and polyfluoroalkyl substances (PFAS) in the food chain

K. Fritz, Michigan Department of Agriculture and Rural Development

Environmental contaminants can migrate to food by several different routes: starting from soil, water, and air to plants and animals, plants to human food, plants to animal food, and animals and animal products to human food. Federal agencies such as the U.S. Food and Drug Administration, the U.S. Department of Agriculture, and the U.S. Environmental Protection Agency help keep the nation’s food supply safe. Additionally state agencies such as the Michigan Department of Agriculture and Rural Development (MDARD) ensure food safety at the state level. For almost two years the state of Michigan has been engaged in an intense investigation of locations and sources of per- and polyfluoroalkyl substances (PFAS) to protect drinking water and public health (www.michigan.gov/pfasresponse). MDARD is tasked with the identification of any food establishments and animal facilities in Michigan that may be impacted by PFAS sources. Also agricultural inputs such as fertilizer, soil conditioners, liming agents, biosolids, and compost are being scrutinized for possible PFAS contamination. Although MDARD has legal authorities on food safety and animal health, in this situation the lack of federal standards for PFAS concentrations in agricultural inputs, food, and feed makes decisions to use these authorities challenging. PFAS sources that MDARD has investigated thus far have included water used for home canning of human food, soil used for a community garden, and hay fed to dairy cattle. After consideration of the available literature, similar cases, and site-specific conditions, MDARD recommended 1) the canned food not be consumed by the family, 2) mitigation steps could be used for the garden, and 3) there were no food safety nor animal health concerns for the hay.

Approaches for Understanding Diversity in Species Sensitivity to Chemicals

295 Interspecific Variation in Nematode Responses to Metals

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Nematodes are a major group of organisms that have great potential for multi-species toxicity studies due to their small size, low resource requirements, abundance of species/isolates that can be tested, and availability of molecular biology tools and mutant lines. We tested lethality of the essential trace metals, copper and zinc, on 5 different nematode species (Caenorhabditis elegans, C. briggsae, Oscheius myriophila, O. tipulae, and Pristionchus pacificus). Toxicity tests with all five species generated robust LC50 measurements using only basic laboratory space, equipment, and resources, indicating that multi-species testing with more (perhaps even dozens of) species is feasible. Results indicate that P. pacificus is the most sensitive species to both metals, fitting with its phylogenetic position as outgroup to the four other test species. The higher sensitivity of P. pacificus may be due to the absence of or higher divergence from metallothionein genes identified in C. elegans and C. briggsae, although this requires further comparative genomic examination. Patterns of sensitivity in Caenorhabditis and Oscheius species differed by metal, with C. elegans being the second most sensitive species to zinc, but the least sensitive species to copper. Together, these results suggest that P. pacificus may be a better indicator of metal lethality than the model, C. elegans, and that additional genetic, physiological, and behavioral factors may be needed to explain patterns of metal sensitivity in nematodes. The ease of testing multiple species in our study shows that nematodes are a good candidate for cross-species toxicology and adverse outcome pathway comparisons.

296 Correcting for phylogenetic autocorrelation in species sensitivity distributions

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A species sensitivity distribution (SSD) is a modeled cumulative distribution function of toxicity endpoints for a specified receptor group. SSDs are frequently used to derive environmental benchmarks or to characterize risk to hypothetical sensitive species or to entire taxonomic groups or communities. A key statistical assumption when deriving an SSD is that the toxicity data points are independent and identically distributed (iid). This assumption is tenuous, however, as closely related species tend to have similar sensitivities, whereas more distantly related species often have divergent sensitivities. When the response of one species can be at least partially predicted by the response of another species, there is a dependency or autocorrelation in the dataset. To date, phylogenetic relationships and the resulting dependencies in input datasets have been ignored in deriving SSDs. In this paper, we explored the importance of the phylogenetic signal in deriving SSDs using a case studies approach. The case studies involved toxicity datasets for aquatic autotrophic species exposed to atrazine and aquatic and avian species exposed to chlorpyrifos. Full and partial datasets were included to enable exploration of the influences of differing phylogenetic signal strength and sample size. The results indicated that the phylogenetic signal was significant for some of our toxicity datasets (i.e., the chlorpyrifos datasets for all aquatic species, all vertebrate species, all invertebrate species, and fish species) but not for others (i.e., the atrazine full and sub datasets, the chlorpyrifos datasets for...
all insects, crustaceans and birds). When a significant phylogenetic signal did occur, the result was a reduced effective sample size. The reduction was rather large when the signal was strong. In spite of the reduced effective sample sizes, significant phylogenetic signals had little impact on fitted SSDs, even in the tails (e.g., HC5 values). The lack of a phylogenetic signal impact occurred even when we artificially reduced original sample size and increased strength of the phylogenetic signal. We conclude that it is good statistical practice to account for the phylogenetic signal when deriving SSDs because many multi-species toxicity datasets do not meet the independence assumption. That said, SSDs and HC5 values appear to be robust to deviations from the independence assumption.

297 Do Daphnia magna and Ceriodaphnia dubia Acute and Chronic Tests Show Equitoxic Results?
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Environmental risk assessments are typically based on toxicity data derived from only a handful of standard model organisms. Some standard regulatory assays limit the species in scope, others like the OECD 203 acute fish assay can be considered valid if one of seven recommended species are tested. While it is important to consider the relative sensitivity of other species, it is equally important to understand the sensitivity variation that is already contained within the standard regulatory assays. The OECD 202 Acute Daphnia Immobilization Toxicity Test requires the use of Daphnia magna or another "suitable Daphnia species (e.g., Daphnia pulex)." The daphnid species, Ceriodaphnia dubia, is not considered a standard test species for chemical registration in Europe despite the availability of ISO, USEPA, ASTM, Environment Canada standard acute and chronic test methods and its wide use and acceptance in other countries. Previous comparative work by Versteeg et al. (1997) suggests that D. magna, D. pulex, and C. dubia are acutely equisensitive. Here, we employ a big data approach to critically evaluate the comparative sensitivity between D. magna and D. pulex and contrast that to the similar species sensitivity of D. magna and C. dubia. These big data approaches will then be contrasted against the smaller, more curated web-ICE regressions. A total of 207 chemicals that had both D. magna and D. pulex acute toxicity data were identified (5,443 studies). This orthogonal regression has a slope of 0.881 and an intercept of 0.484. As both D. magna and D. pulex are accepted OECD 202 standard test species, this inherent biological difference in sensitivity is accepted under the regulatory guidelines. A total of 193 chemicals that had both D. magna and C. dubia toxicity data were identified (5,465 studies). The orthogonal regression for the acute toxicity studies has a slope of 0.919 and an intercept of 0.599. The relative species sensitivity differences between D. magna and D. pulex and D. magna and C. dubia are of the same magnitude and have nearly identical slopes. D. magna and C. dubia chronic toxicity (83 chemicals, 1062 entries), also showed similar sensitivity with a slope of 0.841. Interspecies modeling demonstrates similar sensitivity for Daphnids and C. dubia and the interchangeability of these taxa is recommended for chemical testing.

This presentation does not necessarily reflect the views or policies of the US Environmental Protection Agency.

298 PhyloTox: A Phylogenomic Approach to Predicting Species Sensitivity Across the Tree of Life
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Knowledge of the evolutionary reasons for why genes are functionally bound to one another is needed to extrapolate from laboratory models to humans and decode their health functions, including their responses to chemical pollutants. However, this puzzle remains largely intractable due to three major obstacles. (1) Many of gene are not expressed under standard laboratory conditions to reveal what traits they encode. (2) Genetic tools that break gene functions or genome scans that identify associations between genes and phenotypes are designed for interrogating single genes rather than coordinated gene networks. (3) Functional studies of genomes often do not account for their evolutionary origins. To address these needs, we developed PhyloTox, a novel predictive toxicology approach, that identifies the functions of evolutionarily conserved groups of interacting genes, while simultaneously delineating molecular toxicity pathways that are critical to solving the enormous public health crisis caused by human exposure to chemical pollutants. PhyloTox draws insights on gene functions by disrupting entire networks via chemical ablation, just as genetics does with individual genes. To demonstrate the utility of PhyloTox, we are exposing a group of six model species/cells, i.e., human cell lines, zebrafish, frog, fruit fly, water flea, worm, which together represent major branches of animal evolution and are recognized biomedical model systems, across dose and time to a panel of four chemicals, arsenic, cadmium, ethoprophos, wyeth 14,643. By applying fit-for-purpose computational, statistical, phylogenetically driven analyses of data that integrate biomolecular information (i.e., transcriptomes and metabolomes), we identify core networks of interacting genes and reveal their toxicological functions. These results will be discussed in their ability to identify the evolutionary origins of toxicity pathways and improve cross-species extrapolations. Presented on behalf of the Environment Care Consortium (https://www.environmentcareconsortium.org/).

299 Glucuronosyltransferases in Lower Vertebrates: Phylogenetic Signals and Implications for Species Sensitivity to Pollutants
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Now that completely sequenced genomes are rapidly becoming available for a wide variety of organisms, information can be gathered about the presence of genes that are involved in the detoxification of environmental pollutants in these species. This allows for the analysis of phylogenetic signals in closely related taxa, and may be used to predict the sensitivity of species to pollutants. However, annotation of genes found in lower vertebrates, like in alligators, but do not have the same activity. In fish taxa, the primitive jawless lamprey and hagfish species appear to be missing the phenol-type UGTs, while in the bony fish, isoforms that are distinctly different from mammalian ones are widespread, but appear to have comparable substrate specificity. Recent studies have analyzed the UGTs in bird species and found several unique sequences for the UGTs. Among the birds, top predators like birds of prey and vultures have less
UGT isoforms than omnivores and herbivores, indicating that ecological niche plays a role in the presence and expression of UGT isoforms. This pattern is also seen in some hyper carnivores among mammalian species. All these observations indicate that the phylogenetic history of UGTs in vertebrate species is a complicated story, driven by a variety of factors. This may make it complicated to use phylogenetic signals to predict species sensitivity to environmental pollutants or their metabolites that need to be conjugated by UGTs for detoxification and excretion.

300 Are we looking close enough? Genetic diversity despite morphological uniformity affects cryptic species’ sensitivity towards stress

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Over the last decades, genetically distinct but morphologically uniform lineages within nominal species (i.e., cryptic lineages complexes) have been uncovered for many species, including those used as standard test species in environmental risk assessment (ERA) such as Lumbricus variegatus, Eisenia fetida, and Hyalella azteca. From an applied perspective, it remains uncertain whether and to which extent the genetic differentiation - which is comparable to an interspecific level - affects cryptic species’ sensitivity and therefore ERA on the basis of a single assessed lineage. We therefore tested for potential sensitivity differences between chemical stress between the two cryptic lineages A and B found for the sentinel species Gammarus fossarum (Crustacea: Amphipoda) using the fungicide tebuconazole (up to 600 µg/L), the insecticide thiacloprid (up to 50 µg/L), and ammonia (up to 1.3 mg/L) as model stressors. Test organisms were exposed individually towards the stressors (n=15-20) for 5-7 days applying their feeding rate on leaf discs as a measure of sensitivity. Cryptic lineage A showed a biologically meaningful and statistically significant higher sensitivity towards the applied chemical stressors compared to cryptographic lineage B, with up to six-fold (pesticides) and two-fold (ammonia) sensitivity differences between lineages. As we either actively controlled for or observed only marginal deviations between lineages in potential confounding factors that could have influenced the outcome of the studies - namely the season of collection, gammarids’ life stage, parasitism, and physiological fitness - we presume the considerable genetic differentiation between cryptic lineages A and B to be the driving factor for the observed sensitivity differences. Although we only concentrated on one single trait of species (i.e., sensitivity), our studies indicate that it seems to be adequate to assume traits of individual species to only vary around one mean value. Environmental monitoring and ERA should therefore proactively consider the discussed genetic heterogeneity in terms of cryptic lineage complexes by including a correct genetic differentiation to avoid implications in their reliability and quality.

301 Transcriptomics explains differential sensitivity to pesticide exposure through a novel off-target mechanism

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In silico tools that use omics data-sets to ‘flag’ sensitive species can improve risk assessment. However, to achieve such insights, we need to know how both toxicokinetics (TKs) and toxicodynamics (TDs) contribute to differential species sensitivity. As a case study in the use of such data, we investigated the TK and TD characteristics underlying differences in sensitivity for five earthworm species for the widely used neonicotinoid pesticide imidacloprid known to inhibit neuronal synaptic function by targeting Nicotinic Acetylcholine receptors (nAChRs). We identify that earthworms have a lower sensitivity to imidacloprid than a soil arthropod (Folsomia candida) and that there is a large-magnitude (>30-fold) within earthworm taxa variations from Eisenia fetida and Lumbricus rubellus (least sensitive) to Amythys gracilis (most sensitive). Species sensitivity was not linked to TK traits that determine either total body imidacloprid concentrations or rates of uptake or loss. Analysis of TD traits by characterisation of the known insect nicotinic acetylcholinesterase receptor (nAChR) orthologue targets of imidacloprid through genome sequencing and transcriptomics identified a greatly expanded gene family in earthworms, including numerous highly expressed AChRs and also multiple nicotinic acetylcholinesterase binding proteins (AChBP). Splicing implied by gene architecture, a mainly nervous system expression and ligand binding domain analysis indicated that earthworm nAChRs have similar sub-unit structure and potential for imidacloprid and acetylcholine binding as the insect receptors. Thus, nAChRs structure could not explain the differences in sensitivity. AChBP are also highly expressed in earthworms. Their potential to bind imidacloprid off-target away from the synapse may explain the lower sensitivity of earthworms compared to springtails in which these genes are absent. Ligand binding domains of expressed AChBPs in low sensitivity E. fetida and L. rubellus dominantly have high imidacloprid affinity YPPC ligand binding domains. A. gracilis predominantly show low-affinity ligand binding domains that provide lower protective off-target imidacloprid binding in this sensitive species. Our work, thus, defines a predictive model for imidacloprid sensitivity based on off-target AChBP presence, expression and especially off-target ligand binding that advances beyond the state-of-the-art of primary receptor target sequence analyses only.

302 Study on taxon-toxicity sensitivity of fish to representative transition metals

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Transition metals, an important class of metals, are a group of elements in groups IIIB to IIB of the Periodic Table of the elements. The last electron of the transition metal is often filled in the d orbital of the outer layer of the atomic orbital, which leads to a variable valence state for transition metals. As a result, transition metal plays a transitional role during the periodic characteristic change of elements. Transition metals widespread in aquatic environments that can seriously affect the species diversity and species distribution of aquatic organisms when concentrations exceeding threshold values. For example, cadmium, a representative toxic metal, can affect the embryonic development, the larvae survival and the reproduction of aquatic organisms. The United States and many other countries/organizations have worked on water quality criteria (WQC) of metals to protect aquatic life since the 1960s. However, different taxa are protected by use of unified WQC thresholds, which are derived to protect most creatures and rarely considers the ecological status and economic value of different species. At present, there are lots of experimental researches of aquatic toxicity of metals to different taxa, especially fish. It is the time to study taxon-toxicity sensitivity to metals through the dose-effect relationships and massive bioaccumulation data obtained from laboratory exposure experiments. The present study established the species sensitivity distributions of nine representative transition metals (Cr(VI), Mn, Fe, Ni, Cu, Zn, Ag, Cd, Hg) for protecting Chinese fish based on non-parametric kernel density estimation models and then derived their HCS values. The results showed that Ag has the lowest HCS value, which has the highest toxic potency to fish; Ni has the largest, the least. Moreover, it suggested that the toxic potency of the transition metals to fish may be periodic and Cyprinidae is more sensitive to these nine metals than other fish. The study will provide some reference for future research on the toxicity sensitivity of fish to other transition metals.
Adverse Effects of Chemicals on the Microbiome

303 Challenges and opportunities for microbiome analysis in toxicology

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Microbiome analyses are growing in popularity, with broad applications in biomedical, agricultural and environmental research. We have been performing analyses relevant to these areas, including toxicological applications such as: Characterizing the bullfrog skin microbiome over their life cycle and when exposed to endocrine disrupting chemicals; Investigating the utility of skin microbiome analysis as a non-invasive method of contaminant monitoring in endangered St. Laurence estuary belugas (vs more invasive skin/blubber biopsies currently performed); Identifying riverine bacteria potentially involved in aquatic copper bio-remediation at a proposed northern Canadian mine site; Characterizing western Canadian watershed microbiomes over time and space in agricultural- and urban-impacted environments to identify new biomarkers of water quality (viral, bacterial and protist). Through this array of studies, we have identified components of microbiome analysis methodology that are critical for robust analysis, and common pitfalls to watch out for. These will be presented along with fundamental insights/common themes identified from these studies regarding microbial community changes over time and location that must be considered for toxicology-based analyses. We also report the development of new computational tools, named PSORTm and AMRTime, for metagenomics-based analyses of potential microbial cell surface diagnostic targets, and prediction of antimicrobial resistance (AMR) genes, respectively. The utility of Metagenomics Assembled Genomes (MAGs) for microbial community analysis, versus direct sequence read-based analysis, has also been compared, and we present our recent simulated data analyses, showing how both approaches are important, and complement each other. Analyses of the impacts of chemicals on microbiomes is one key component of more holistic assessments in environmental toxicology, so collectively a framework will be presented for the mitigation of common challenges, that will help researchers fully capitalize on the opportunities that microbiome analysis provides for toxicology.

304 Acidic rock drainage and remediation induce shifts in sediment bacterial community composition at the Callahan Mine superfund site

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The production of acid rock drainage (ARD) results in an increased release of metals and metalloids into the environment. ARD is generated naturally as a result of the oxidation of sulfide minerals; however, the process is accelerated at active and abandoned mine sites where increased rock surface area results in increased oxidation of sulfur, which results in lowered pH that hastens demineralization of metal ores. The Callahan Mine (CM) Superfund Site has been impacted by ARD over nearly a century of interspersed mining operations for copper (Cu) and zinc (Zn). Currently, the EPA is attempting to remediate two classes of contaminants, metals and polychlorinated biphenyls (PCBs), that were prioritized after an initial investigation. Previous studies have identified a seepage site at the base of a waste mine tailings pile, which drains into an adjacent marsh site. This study aims to characterize the spatial and temporal changes of free-living bacterial community compositions in sediments and commensal communities in fish gut and gill samples within CM’s marsh and between CM and a clean reference marsh, Horseshoe Cove (HC). Here we show that in each of four sampling years, the locations closest to the seepage site had vastly different sediment community structures and lowered alpha diversity compared to sampling sites farther seaward. In the fish gut microbiome samples, we identified no significant differences in the composition of the gut microbiome by site, but large differences by year of sampling. We also identified the presence of a genus of bacteria in the sediment that naturally remediates PCBs in the environment, Dehalococcales. This suggests a novel contamination event of PCBs within the marsh, most likely related to the relocation of PCB contaminated soil to an impoundment site at the freshwater end of the Superfund Site. Thus, as of 2015, leachate from a metal laden waste tailings pile continues to modify sediment-borne bacterial community structures towards inclusion of metal tolerant bacterial taxa. Additionally, PCB-contaminated soil relocation resulted in a correlative appearance of PCB degrading bacteria into the marsh sediment microbiota.

305 Is Biosynthesis of OH-BDEs an Adaptation Strategy for Bromobacteria?

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Hydroxylated polybrominated diethers (OH-BDEs) are naturally produced as secondary metabolites by marine microbes, including Marinomonas mediterranea MMB-1. But the biological function of OH-BDEs in marine bacteria remains elusive. 6OH-BDE47, the major natural OH-BDE was discovered in our recent study to kill bacteria by inhibiting enoyl-acyl carrier protein reductase (FabI). This study further confirmed this result by testing the antibacterial potencies of 15 OH- or MeO-BDEs, and found that E. coli could be only inhibited by the natural OH-BDEs with MICs 1 - 33 μM, which were further rescued by overexpression of FabI protein. In vitro FabI activity inhibition was in accordance to the growth inhibition, confirmed that all natural OH-BDEs targeted FabI. However, the natural OH-BDEs producer, MMB1, could tolerate 6OH-BDE47 as high as 50 μM, about ~25 fold less sensitive than E. coli. The genome of MMB1 as well as two other bromobacteria was sequenced, and another functional homologue FabV presented in all three bromobacteria. Function of FabV of MMB1 was illustrated by restoration of fatty acid synthesis in E. coli fabI (Ts) mutant strain, JP1111, by transformation with a plasmid carrying genes encoding MMB1-FabV. JP1111 containing MMB1-FabV was also more resistant to 6OH-BDE47 (MIC 25 μM) compared to JP1111 with vector only (MIC 3.1 μM). The binding affinity of 6OH-BDE47 to FabV is much weaker than FabI, as evidenced by in vitro assays. In TILS (target identification by ligand stabilization) plus SDS-PAG and western blot assay, FabI was stabilized by 6OHBDE47 while precipitated in DMSO at 65 °C, while no change was observed in FabV. In affinity pulldown assay, 6OH-BDE47 was remarked pull-down by FabI, but not FabV. When the natural lysates of E. coli and MMB1 incubated with 7 OHBDEs, 6OH-BDE47 was detected in HPLC-co fractions 14, 16, 18, and 20 of E. coli lysate, while no OHBDEs were detected in any fractions of MMB1 lysate. FabI protein also presented in fractions 14, 16, 18, and 20 with the same concentration trend of 6OH-BDE47. This the first study to clarify that OH-BDEs may be a natural adaption strategy for marine bromobacteria to kill other bacteria in the high-dense space (i.e., sponge). It is also evidenced in field studies that 16s rRNA gene diversity profiles were significantly impacted by high concentrations of OH-BDEs in sponge.
306 The gut microbiome of invertebrates upstream and downstream wastewater treatment plants on the Grand River
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The composition of the gut microbiome is being increasingly linked to overall organismal health and function. Gut microbiota can influence various physiological traits (e.g. weight, immune function, disease), and is sensitive to a variety of factors (e.g. diet, environment, pharmaceutical use). Effluents from the Kitchener and Waterloo wastewater treatment plants (WWTPs) in Ontario contain antibiotics and other pharmaceuticals that could negatively impact the gut microbiome of aquatic biota living in the Grand River. To assess this, in the Fall of 2018 we collected mussels (Lasmigona costata), several species of macroinvertebrate larvae (rimed with ethanol), and riparian spiders (Tetragnathidae) that consume emerging insects from sites upstream and downstream of the Waterloo WWTP, as well as sites downstream of the Kitchener WWTP along the Grand River. The microbiomes of mussel and invertebrate gut contents, as well as whole spiders, were analysed following the extraction, nested PCR amplification, and sequencing of bacterial genomic DNA using the V3-V4 hypervariable region of the 16S rRNA genetic barcode. Mussels samples (n=43) had a total of 10,664 unique bacterial taxa. Alpha diversity varied significantly among locations (one-way ANOVA; Simpson F=6.258, df=2, p=0.004), and decreased from upstream to downstream Kitchener locations (Tukey HSD: Simpson p=0.005) as well as from the downstream Waterloo to downstream Kitchener locations (Tukey HSD: Simpson p=0.026). Bray-Curtis beta diversity was significantly different between locations (Permanova, F=4.1586, df=2, p=0.001). Spiders (n=98) had a total of 3,553 unique bacterial taxa. Alpha diversity indices varied significantly among locations (one-way ANOVA; Simpson F=6.783, df=2, p=0.002), and increased from the downstream Waterloo to the downstream Kitchener locations (Tukey HSD: Simpson p=0.001). Bray-Curtis beta diversity was also significantly different between locations (Permanova, F=3.2068, df=2, p=0.001). At present, the composition of the gut microbiome and factors affecting it are still poorly understood in aquatic organisms, but these initial results suggest some effects of contaminant exposure on their microbial community.

307 Dietary exposure to bis(2-ethylhexyl) phthalate on the zebrafish (Danio rerio) microbiome-gut axis: A multi-omics approach
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Diethyylhexyl phthalate (DEHP) is an endocrine disrupting chemical and a commonly used plasticizer, notably in polyvinyl chloride. As such, DEHP is relatively ubiquitous, and it is detected in aquatic environments. Microplastics are also a concern, and DEHP can leach directly from these small plastic fragments in the water column. To better quantify risk to aquatic organisms, this study aimed to determine the impact of dietary DEHP exposure in the zebrafish (Danio rerio) gastrointestinal system by (1) assessing histopathology of the gut; (2) assessing the effects of DEHP on the host microbiome (16S RNA sequencing) and host gut transcriptomics; (3) targeting expression levels of transcripts related to Gl hormone signaling and nutrient uptake. We hypothesized that DEHP would shift the microbiome to a state of dysbiosis, leading to pathological changes in the tissue. A two-month dietary exposure was conducted in which male zebrafish were fed DEHP (3 ppm). There was no discernible pathology nor evidence of inflammation in the GI tract. DEHP significantly affected the composition of microbiome and Fusobacteriaceae and Enterobacteriaceae, both disease causing bacterial genera, were increased in relative abundance while the abundance of Verrucomicrobiaceae was decreased with DEHP. In zebrafish gut tissue, a peroxisome proliferator-activated receptor gene network was altered in expression, consistent with reports of DEHP acting as a lipid regulator. Host transcriptome changes included genes of the immune system, metabolism, gut integrity and homeostasis (cell-cell communication). Using real-time PCR, we measured a number of key gut hormones and peptides. There were no changes in the expression of gastro-intestinal hormones (cck, ghrelin, sst1, sst2), nor were there any changes in neuropeptides active in the brain-gut axis (opn, cattl, grp) with DEHP treatment. These data suggest the microbiome-gut axis is a target for metabolic disruptors and emphasizes the value of multi-omics approaches to study microbiome-host interactions.

308 Influences of life stage at first exposure on the disruption of the gastrointestinal microbiome by a phthalate plasticizer
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Phthalate plasticizers, such as diethylhexyl phthalate (DEHP), have become ubiquitous in the environment due to their leaching from products including food containers, personal care products, and PVC pipes. These chemicals are suspected to contribute to the global obesity epidemic in conjunction with poor diet and lack of exercise. One possible mechanism by which exposure to DEHP may contribute to obesity is through dysbiosis of the gastrointestinal (GI) microbiome. We hypothesized that life stage at exposure to DEHP will impact the alterations observed in the GI microbiome profile of zebrafish (Danio rerio), and that an earlier, more prolonged exposure will have more pronounced effects on this dysbiosis. Two feeding studies were conducted to examine this hypothesis. In the first, adult zebrafish (~6 months old) were fed ad libitum with either control or DEHP (3 mg/kg) food for 60 days. In the second study, zebrafish were fed ad libitum for 6 months, starting at 3dpf, to control of DEHP (3 mg/kg) food. At the end of each exposure period, zebrafish were euthanized and gut and fecal matter were excised for gene expression analysis and microbial sequencing, respectively. In the adult study, 16s sequencing revealed significant changes in b diversity, increases in Bacteroidetes, and decreases in Fusobacteria and Tenericutes in Overfed + DEHP zebrafish compared to Overfed fish. Additionally, PICRUSt functional analysis revealed significant changes in carbohydrate, galactose, inositol phosphate, and taurine and hypotaurine metabolism, which suggests alterations in nutrients available to the host from the microbiome. RNAseq analysis and qPCR of adult zebrafish guts revealed alterations in functions related to host metabolism and gut function. These alterations will be compared to 16s data forz ebrafish exposed to DEHP in the 6 month study for to assess microbial diversity and function, as well as expression of genes related to lipid metabolism and gut function in the host. Thus far, evidence suggests that DEHP does alter zebrafish microbial diversity and function, which is paralleled by metabolic alterations in the host. We expect that earlier and prolonged DEHP exposure will increase dysbiosis and further altered host gene expression related to lipid metabolism and gut physiology than a shortened adult exposure, highlighting the importance of life stage during exposure in toxicology studies.

309 The Effect of Wastewater Effluent on the Gut Content Microbiome of Rainbow Darter (Etheostoma caeruleum)
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The microbiome represents a community of bacteria integral in maintaining host health. At present little is known about the gut content
microbiome of fish, but emerging research suggests that it is influenced by environmental stressors, diet, and habitat. This study evaluates how exposure to wastewater treatment plant (WWTP) effluent in the central Grand River, Ontario, Canada, affects the diversity and composition of the gut content microbiome of the rainbow darter (Etheostoma caeruleum), a sentinel species common in this system. In October 2018, gut content was steriley collected from rainbow darter at 10 sites (n=15/site) located at varying distances upstream and downstream of two major WWTPs. Genomic DNA was extracted, and PCR amplification of the 16S rRNA gene V3-V4 region and Illumina sequencing were performed. Amplicon sequence variants (ASV) were mapped back to bacterial species using the SILVA database and DADA2 pipeline. Diversity of the gut content microbiome increased significantly downstream of both WWTP outfalls (Shannon Diversity, ANOVA, F=4.829, p<0.001) when compared to upstream samples. There was an increase in dominance (Berger-Parker Dominance) at upstream locations compared to locations downstream (Tukey, p<0.05). There was a change in microbiome composition, with dominant bacteria in upstream samples belonging to the phyla Proteobacteria, and Firmicutes, while downstream samples had higher relative abundances of Proteobacteria and Cyanobacteria, and decreased abundances of Firmicutes. Mammalian literature suggests that an increased abundance of Proteobacteria is indicative of dysbiosis between the host and its gut microbiota and leads to a decline in host health. However, much of the functionality of bacteria in the fish gut is unknown and cannot yet be linked to fish health outcomes. Bray-Curtis beta diversity and principle coordinate analysis showed that individuals within and between sites were significantly dissimilar (Permanova, F=5.422, p<0.001). This research suggests that the fish gut content microbiome is affected by exposure to complex mixtures of emerging and legacy contaminants found in WWTP effluent. Laboratory exposures are underway to assess the magnitude of WWTP effluent effects on the gut content microbiome of the rainbow darter, and for comparison to the field results.

310 Gut microbiota in fishes from the North Saskatchewan River following an oil spill
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The gut microbiota of animals has been described as an additional host ‘organ’ with beneficial roles. However, little is known about the impact of chemical exposures on the structure and function of gut microbiota of fishes. In July 2016, a Husky Energy pipeline spilled 225,000 liters of diluted bitumen (dilbit), with much of the dilbit entering the North Saskatchewan River near Maidstone, SK. This event provided a unique opportunity to assess the shifts of gut microbiota in native fish species following exposure to dilbit. In summer 2017, goldeye (Hiodon alosoides), walleye (Sander vitreus), and shorthead redhorse (Moxostoma macrolepidotum) were collected at six locations upstream and downstream of the spill, and in summer 2018, these same species were collected at four sites. Muscle and bile were sampled from each fish for chemical measurements, and intestinal contents were collected for gut microbial analyses. Gut contents from these species were also collected at additional sites within the province as controls for the North Saskatchewan River. Gut microbiota were assessed using 16S rRNA metagenetics. Results suggest that host species are a significant driver in determining gut microbiota, with significant differences among the species across sites (p = 0.01). Furthermore, increased concentrations of polycyclic aromatic hydrocarbons (PAHs) in fish muscle tissues are negatively correlated with alpha diversity of fish gut microbiota (p = 0.003). This research is one of the first studies to investigate the community composition of fish gut microbiota from wild species in response to chemical stressors.

Advances in Contaminant Bioaccumulation

311 Biotransformation of benthic invertebrates impacts persistence and bioaccumulation of sediment-associated cyclic siloxanes (D4, D5, D6)
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Concerns regarding the environmental fate and effects of cyclic volatile methyl siloxanes (cVMS) have been raised due to their hydrophobicity. Generally, regulatory frameworks assess risk of hydrophobic organic chemicals (HOCs) based on their persistence, bioaccumulation and toxicity using water exposure setups and microbial degradation only. This study assessed the impact of dietary uptake (i.e., via sediment ingestion) and benthic invertebrate biotransformation for risk assessment of cVMS. A radiotracer technique was employed to examine uptake- and depuration kinetics as well as biotransformation of sediment-associated cVMS (octamethylcyclotetrasiloxane, D4; decamethylcyclopentasiloxane, D5; dodecamethylcyclohexasiloxane, D6) by a freshwater oligochaete ( Tubifex tubifex) and a marine polychaete (Capitella teleta). Overall, sediment-associated D4, D5 or D6 did not adversely affect the benthic invertebrates, uptake, depuration and biotransformation was dependent on compound, BSAF was low due to biotransformation and fast elimination of parent and metabolites; and especially presence of C. teleta, reduced sediment concentrations of compared to microbial degradation due to biotransformation and flushing. It, thus, appears that cVMS have little impact on sediment-dwelling organisms at environmentally realistic concentrations, and that a focus on water-only setup alone and ignoring invertebrate biotransformation will misjudge risk and increase uncertainty in B and P assessment of HOCs, like cVMS.

312 Bioconcentration of cationic surfactants in rainbow trout
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Cationic surfactants are an important class of environmental contaminants, given that they are released to the environment in large quantities. In vitro experiments have shown that they have a strong tendency to partition into membranes, which suggests that they may bioaccumulate strongly. There is, however, a dearth of bioaccumulation data. Here we report on in vivo experiments to determine the bioconcentration factors of a series of methyl alkyl amines in rainbow trout. The test chemicals included primary, secondary, tertiary and quaternary amines ranging in chain length from C9 to C16. In an initial set of experiments we explored the tissue distribution of the test chemicals in ~130 g rainbow trout. All of the alkyl amines except for the two quaternary amines were quantified in blood, muscle, liver, gills, skin and skin mucus, and it was concluded that all of these tissues must be included when assessing the bioconcentration of these substances. In a second set of experiments we measured uptake and depuration of mixtures alkyl amines in ~11 g rainbow trout and determined bioconcentration factors (BCFs). The experiments were conducted at 2 different pHs (7.8 and 6.3), with an exposure phase of 14 days and a depuration phase of 28 days. The concentrations of the test chemicals in water were relatively constant during the exposure experiment, with relative standard deviations ranging from 2-9%. The BCFs ranged from <1 to ~9000 L kg⁻¹. There were clear positive relationships between alkyl chain length and BCF for the methyl alkyl amines, while the permanently charged quaternary amine cations showed markedly lower bioconcentration than amines of similar alkyl chain length. Marked lower BCFs were measured at pH 6.3 than pH 7.8 for the alkyl amines, but not for the quaternary ammonium cations. The results will be valuable for developing a quantitative understanding of how chemical properties such as pKa, membrane-water partition coefficients and biotransformation rate constants influence the bioaccumulation of cationic surfactants.
Toxicokinetic (TK) processes such as chemical absorption, distribution, biotransformation and excretion are fundamental to better understand relationships between external and internal exposures, and to assess bioaccumulation in various organisms, i.e., fish, mammals. The biotransformation rate can be estimated using in vitro tests to obtain the in vitro intrinsic clearance (CL\text{int}). Then in vitro-in vivo extrapolation (IVIVE) and Quantitative Structure Activity Relationship (QSAR) models can be used to maximize the information available from in vitro measurements. Unfortunately, the quality of existing data is not always adequate and critical information may not be available. Moreover, there is a high degree of variability in the assay methods that may negatively impact the biotransformation rate estimates. This presentation describes new methods to address data gaps in biotransformation rates through the development of validated QSARs. More than 30 years of existing in vitro TK data for mammals (i.e. rodents approximately 9000 data, human approximately 12000 data) are assimilated and critically evaluated. A scoring system to evaluate the confidence and consistency of existing in vitro data with new standardized guidelines is developed and applied to all the in vitro data to address variability and uncertainty in the datasets. This data confidence scoring method seeks to identify high quality data that are most appropriate for QSAR development and for other potential applications (e.g., bioaccumulation screening, prioritization). Multi-variate analysis is applied to evaluate the statistical distribution of experimental responses, correlations, and to investigate the presence of structural patterns. In addition, QSAR models are generated using multiple training sets created on the basis of similar reactivity patterns. Case studies are presented to illustrate how the variability in the existing experimental data can be addressed to improve the quality of QSAR models. These results demonstrate that QSAR methods can predict biotransformation rates for mammals to improve bioaccumulation assessment and optimize other chemical hazard and risk assessment objectives.

**314 Bioaccumulation kinetics of model pharmaceuticals in the freshwater Unionid Pondmussel, Ligumia subrostrata**

*S.R. Burket, Baylor University / Environmental Science; J.L. Sims, Baylor University / Biology; B.W. Brooks, Baylor University / Department of Environmental Science*

Though biomonitoring of in situ biological tissues for pharmaceutical accumulation has increased over the last decade, most reported tissue concentrations in wildlife from the field or laboratory experiments are from fish. Few studies have examined bioaccumulation of pharmaceuticals by freshwater bivalves; however, our laboratory’s recent field studies of effluent dependent wadable streams indicate bioaccumulation of multiple pharmaceuticals in bivalves. In addition to being important priorities for conservation biology (~70% of freshwater mussel species in North America are endangered or threatened), the presence of robust bivalve populations provides important ecosystem services by improving water quality and clarity in lotic systems. Unfortunately, factors influencing bioaccumulation of pharmaceuticals by bivalves are not well understood. In the present study, we investigated bioaccumulation kinetics of model acidic and basic pharmaceuticals in the freshwater pond mussel, *Ligumia subrostrata*. Specifically, when compared to fish, we have observed some of the highest levels of antidepressants in bivalves in the field. Reasons for these marked differences are unclear. In this laboratory study, we evaluated bioaccumulation kinetics following exposure to a weak acid, acetaminophen (mean measured (±SD) = 4.66 ± 0.32 µg/L), and a weak base, sertraline (mean measured (±SD) = 2.89 ± 1.14 µg/L) during a 14-day uptake experiment. Following exposure, mussels were transferred to contaminant free water to measure depuration for 7 days, which supported derivation of bioaccumulation kinetic parameters. Pharmaceutical concentrations were evaluated in water and tissue at 11 time points, and samples were analyzed via isotope dilution LC-MS/MS. By day 14, mussels accumulated orders of magnitude higher concentrations of sertraline (31.72 ± 8.17 µg/g) compared to acetaminophen (0.32 ± 0.05 µg/g).

Considering these laboratory observations and our recent field studies, bioaccumulation differences between fish and bivalves potentially result from differences in exposure, biotransformation, and elimination.

**315 Evaluating polymeric sampling as a tool for predicting the bioaccumulation of hydrophobic organic contaminants by fish and shellfish**

*S.N. Schmidt, R.M. Burgess, US Environmental Protection Agency / Atlantic Ecology Division*

Predicting the bioaccumulation of hydrophobic organic contaminants (HOCs) by aquatic organisms is often labor and cost intensive. However, recent research has shown that polymeric sampling can reduce costs and accurately predict the bioaccumulation of HOCs by benthic and sessile organisms (within a factor of 10). Research is now needed to evaluate polymeric sampling as a tool for predicting the bioaccumulation of HOCs by pelagic and mobile organisms. In the current study, scientific literature on polymeric sampling (i.e., equilibrium sampling and passive sampling) and bioaccumulation by fish and shellfish was reviewed to investigate (1) the strength of the correlations between lipid-normalized concentrations and equilibrium polymer concentrations, (2) the ability of polymeric sampling techniques and data to predict bioaccumulation, and (3) the advantages, limitations, applicability domains, and data gaps associated with this approach. Data on a wide range of HOCs, polymers, fish, and shellfish were retrieved from scientific studies. Polymeric sampling data was expressed as the polymer concentration at assumed, adjusted, or confirmed equilibrium with the water column or sediment interstitial water (ng HOC/g polymer) while bioaccumulation was expressed as the lipid-normalized concentration in fish or shellfish (ng HOC/g lipid). Coherent data were then plotted in a log-log system and fitted with a linear regression. Generally, strong log-log linear regressions existed between lipid-normalized concentrations and equilibrium polymer concentrations across non-degradable HOCs, polymers, fish, and shellfish. Further, for non-degradable HOCs the regressions were generally within a factor of 10 from the 1:1 relationship, suggesting that the polymers accumulated a concentration comparable to the actual body residue (i.e., lipid-normalized concentration). These findings support using equilibrium polymer concentrations as surrogates for lipid-normalized concentrations of non-degradable HOCs and thus using polymeric sampling as a tool for predicting fish and shellfish bioaccumulation. Interestingly, the findings suggest that bioaccumulation models may not be necessary for predicting body residues when using polymeric sampling data. Ideally, this research will provide a tool for regulatory agencies to assess the risk associated with contaminated sediments and waters in terms of their potential to contaminate commercially and recreationally important fish and shellfish.

**316 Hydrodynamics May Influence Field Bioaccumulation of Organic Contaminants - a Meta-analysis on Bivalves Data**

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Prediction and understanding of bioaccumulation of organic contaminants in aquatic environments have been hampered by substantial variability in field measurements. This study examined the variability in field bioaccumulation sediment accumulation factor (BSAF) in bivalves in various water bodies and investigate the role of flow condition on BSAF measurements. Over 3000 field BSAFs for close to 40 species of bivalve for some 100 PCBs, PAHs, and legacy organochlorine pesticides were compiled
from existing field sampling literature. Analysis of compiled bivalves bioaccumulation shows that field BSAFs vary by 4 to 6 log units for the selected chemicals. Both the BSAFs and their variation appear to exhibit little correlation with physicochemical properties of the compound or the sediment (i.e., log KOW, log KOC, and log KBC). Then, BSAFs were classified into three types based on the hydrodynamic condition or nature of the waterbodies: (i) low flow environment (e.g., lake), (ii) high flow environment (e.g., river), and (iii) complex hydrodynamic environment (e.g., intertidal zone). BSAFs measured at low flow sites are generally closer to the theoretical value prescribed by equilibrium partitioning (EqP). BSAFs reported at high flow sites, however, are substantially lower than those predicted by EqP. The greatest variability and unpredictability are observed in BSAFs from the complex hydrodynamic environment. Field BSAFs from low flow and high flow sites were found to exhibit a strong dependence on mean flow velocity of the waterbody such that at low velocities BSAFs converge toward the EqP limit while they decline dramatically with increasing velocity at high flow conditions. The observed BSAF-velocity dependence could be adequately derived and explained by considering hyporheic or benthic mass exchange using a simple box model. Findings from this work are expected to have major implications on bioaccumulation monitoring practices and the modeling of field bioaccumulation and biomagnification behavior.

317 Bioaccumulation and Trophodynamics of Substituted Diphenylamine Antioxidants and Benzotriazole UV Stabilizers in Aquatic Food Webs

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Substituted diphenylamine antioxidants (SDPAs) and benzotriazole UV stabilizers (BZT-UVs) are anthropogenic additives widely used in industrial and commercial products such as plastics, rubbers, fuels, lubricants, and personal care products. They are very persistent in the aquatic environment, and chronic exposure to these contaminants may lead to adverse effects in organisms. Recent in vitro studies have reported that some BZT-UVs are associated with the aryl hydrocarbon receptor-mediated effects in human and fish, indicating the dioxin-like toxicities of these contaminants. Despite an increasing number of reports on the occurrence and distribution of SDPAs and BZT-UVs, the knowledge of their bioaccumulation and trophodynamics remain extremely limited. Thus, the present study collected water, sediment and various organisms such as plankton, insect, mussel and fish to investigate the fate of SDPAs and BZT-UVs in food webs from Hamilton Harbour (HH) and Lake Joseph (LJ), Ontario, Canada. Field-based partitioning data such as bioaccumulation factors (BAFs) and biota–sediment accumulation factors (BSAFs) of these chemicals will be reported in this study. Organisms from HH generally showed higher detection frequencies and concentrations of SDPAs and BZT-UVs compared with samples from LJ. This is the first time to report the levels of SDPAs and BZT-UVs in insects. SDPAs such as 4,4’-bis(a,a-dimethylbenzyl)-diphenylamine(diAMS) and dinonyl-diphenylamine (C9C9), as well as BZT-UVs 2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol (UV234) and 2-(2H-benzotriazol-2-yl)-4,6-di-tert-pentylphenol (UV328) were frequently detected in insects (e.g., dragonfly (Anisoptera)) with concentration up to 22 ng/g for UV328 (wet weight). Biodilution of SDPAs was found in both food webs from HH and LJ. The levels of SDPAs were positively correlated with δ13C, indicating benthic species had higher exposure to SDPAs compared to pelagic species. In contrast, UV234 showed biomagnification in the HH food web, suggesting greater exposure risks of higher trophic level organisms to this contaminant. Such variations of trophodynamics indicate the differences in accumulation and elimination pathways of SDPAs and BZT-UVs and require further elucidation of underlying mechanisms.

318 Quantifying the Biomagnification Potential of Polychlorinated Biphenyls in Arctic Wolf and Domestic Dog by Equilibrium Sampling

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Biomagnification is the process through which organisms can have higher lipid-normalized concentrations of hydrophobic contaminants in their bodies than are prevalent in the food that they eat. The underlying mechanism is the decrease in the fugacity capacity (Z) of the food for the biomagnifying contaminants during digestion and assimilation in the gastrointestinal tract. Traditionally biomagnification is quantified by measuring contaminant concentrations in tissues collected from dead animals. Here we propose a non-invasive way to quantify the Maximum BioMagnification Factor (MBMF) by determining the ratio of the Z-values of the undigested and digested food using equilibrium sampling. We quantify the Z-values by equilibrating homogenized food and feces samples with silicone films of variable thickness coated on the inside of glass vials that are being rotated for several days. Contaminants that have migrated to the silicone are extracted and quantified using gas chromatography-mass spectrometry. Equilibration is confirmed if the amount of contaminant in the film is proportional to the volume of silicone in a vial. The content of contaminants in food and feces samples is also quantified. We demonstrate the feasibility of this method for wolf (Canis lupus hudsonicus) and domestic dog (Canis lupus familiaris). For adult wolf eating a relatively lean meat diet, MBMFs of approximately 3 were observed, whereas the MBMFs reached 10 for a juvenile domestic dog eating a lipid-rich diets. Beside the dietary lipid content which strongly affects the Z-value of the diet, the capability of an animal to digest its diet also influences the MBMF by influencing the Z-values of their feces. Cooperating with the Toronto Zoo, we have the opportunity to study the impact of an organism’s assimilation capability on the MBMF by feeding the same diet to a wide range of carnivores (e.g. Felidae, Canidae and Ursidae) with different physiological properties.

319 Effects of diluted bitumen exposure on seawater tolerance of salmon smolts

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Diluted bitumen, a heavy type of crude oil, is the main export product from Canada’s oil sands, which are the third largest crude oil reserve in the world. Millions of liters of diluted bitumen travel across North America every day in a vast network of railways and pipelines, posing a real and continuous risk for spill and environmental contamination. Yet surprisingly little is known about the specific sub-lethal toxicity of diluted bitumen, particularly in native Canadian species and in the context of critical life history stages. This study tested the hypothesis that diluted bitumen exposure would impair the ability of salmon smolts to transition between freshwater and seawater, a key event in their natural life history. Atlantic salmon smolts were exposed in freshwater to one of three environmentally relevant concentrations of the water soluble fraction of diluted bitumen for three weeks, and then transferred directly to seawater for up to seven days. The capacity for smolts to acclimate to seawater...
was assessed across a suite of standard endpoints related to osmoregulatory capacity and tissue integrity. In the gills, diluted bitumen exposure did not affect gill morphology, nor were seawater-induced changes in Na+/K+ ATPase expression or activity altered; however, the transient increase in gill *cytochrome p450 1a* expression after one day in seawater was abolished in fish exposed to diluted bitumen. In the kidney, there was a dose-dependent effect of diluted bitumen exposure on *aquaporin 3a* expression before and during seawater acclimation, and mild histopathological changes in tubule morphology. There was no effect of diluted bitumen exposure on plasma osmolality or sodium concentrations. Results of this study show that sub-chronic exposure to realistic concentrations of diluted bitumen do not adversely impact the ability of Atlantic salmon smolts to acclimate to seawater. This research is funded by the National Contaminants Advisory Group at Fisheries and Oceans Canada.

320 Effects of weathered diluted bitumen on early-life stages of zebrafish (Danio rerio)
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Due to the potential of spills, transport of diluted bitumen (dilbit) in pipelines poses a risk to aquatic ecosystems. Although previous research has assessed the toxicity of fresh dilbit to aquatic vertebrates, few studies have investigated effects of dilbit that has been weathered by evaporation and sedimentation. The objective of this study was to determine the effects of weathered dilbit to early-life stages of zebrafish (Danio rerio) as a more accurate representation of a spill of dilbit in aquatic environments. Embryos were exposed, from 30 minutes post-fertilization to 120 hours post-fertilization, to one of two water accommodated fractions (WAFs) of weathered bitumen, referred to as the SD-WAF (sediment derived WAF) and WAF. Exposure to either WAF caused a concentration-dependent increase in mortality and malformations in early-life stages of zebrafish. Exposure to the WAF at 10, 50 and 100% concentrations resulted in 17.5, 100, and 100% mortality respectively. Exposure to the SD-WAF at 10, 50 and 100% concentrations resulted in 32.3, 23.1 and 99.3% mortality respectively. Malformations and gene expression were only assessed for embryos exposed to the control, WAF 10%, SD-WAF 10% and SD-WAF 50% treatments due to high mortality in the other exposures. Prevalence of yolk sac edema was 33.8, 2.2 and 86.7% when exposed to WAF 10%, SD-WAF 10% and SD-WAF 50% treatments, respectively. Prevalence of pericardial edema in the same treatments was 59.9, 3.5 and 95.1%, respectively and prevalence of uninflected swim bladder was 75.2, 170 and 100%, respectively. Analysis of mRNA abundance of glutathione S-transferase (GST), glutathione peroxidase (GPx), glutamate cysteine ligase catalytic subunit (GCLC) and superoxide dismutase (SOD) suggest that the observed effects are not a result of oxidative stress. Greater mRNA abundance of CYP1A1 indicated presence of dioxin-like compounds in weathered dilbit that might have contributed to the observed effects. Overall, the results show that weathered dilbit has adverse effects on early-life stages of zebrafish. Currently, transcriptomic and metabolomic analyses are being used to identify potential mechanisms of toxicity of weathered dilbit.

321 Exposure to Diluted Bitumen Affects Cardiac Output, Metabolism and Swim Endurance in a Freshwater Fish Species (Pimephales promelas)
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Transport of diluted bitumen (dilbit) is becoming an increasing public and political concern due to the potential for impacts on aquatic ecosystems as a result of oil spills. Further study is required, as the current understanding of dilbit toxicity is limited. Much existing research focuses on early-life-stage developmental toxicity, however limited evidence suggests that there may be sublethal effects in other life stages. The focus of this study was to assess effects of dilbit exposure on cardiac function, metabolism, and swim endurance of sub-adult Fathead Minnows (*Pimephales promelas*). Fish were exposed to concentrations of either 0% (Control) 3%, 10%, or 30% of dilbit water accommodated fraction (WAF) for 7 days. Following the exposure period, one group of fish (n=16/treatment) were assessed for cardiac function using ultra-high frequency ultrasound. A second group (n=12/treatment) were assessed for critical swim speed (Ucrit) and active metabolic rate (AMR) using swim tunnel respirometry. A third group (n=4-6/treatment) was assessed for standard metabolic rate (SMR) using intermittent flow respirometry. Dilbit exposure was shown to significantly increase heart rate and cardiac output in the highest dose group. The high dose group also showed greater increases in AMR in response to increasing swim speeds (p<0.001, 2-way ANOVA with repeated measures), and lower Ucrit. SMR was significantly reduced in fish exposed to high doses of dilbit WAF. The physiological data from this experiment will be compared to physiological data from fish exposed to conventional heavy crude oil in the future. The results of this research will add to our understanding of sublethal toxicities of complex petroleum mixtures to advanced life stage fishes in a freshwater environment.

322 BE-SPME (Biomimetic Extraction Solid Phase Microextraction) as an Analytical Tool for Predicting Toxicity in Oil Sand Process-affected Water
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Oil sands operational activities lead to the production of oil sands process-affected water (OSPW) which will eventually be treated and returned to the environment. The constituents of OSPW make up a complex mixture which varies by source and producer, with challenges in determining risk for exposure and toxicity. Biomimetic extraction with solid phase microextraction fibers (BE-SPME) coated with polydimethylsiloxane (PDMS), have been used as a measurement of bioavailable organics in OSPW and as a predictor for toxicity in prior work where critical threshold values were derived. Here we present new toxicity data from exposures to OSPW, single constituents, and simple mixtures with accompanying BE-SPME analysis using algae, daphnids, chironomids, blackworm, zebrafish, fathead minnows, and rainbow trout. An updated species sensitivity distribution (SSD) that includes these species is provided. BE-SPME continues to be a valuable analytical tool to predict toxicity accounting for bioavailability of complex organic compound mixtures and as a tool for predicting toxicity of OSPW. Additionally, we discuss applicability of a BE-SPME-derived SSD as an exposure metric to predict toxicity, and decrease the need for traditional toxicity endpoints to evaluate acceptable levels for safe release of treated OSPW.

323 Monitoring Ecological Responses to Air Quality and Atmospheric Deposition in the Athabasca Oil Sands Region
K. Foster, Owl Moon Environmental, Inc.

The expansion of oil sands resource development in the Athabasca Oil Sands Region in the early 1990’s led to concerns regarding the potential ecological and health effects of increased emissions and deposition of acidic substances. Conditions attached to a 1994 approval for an oil sands facility expansion led to the creation of the Wood Buffalo Environmental Association, and its Terrestrial Environmental Effects Monitoring committee. This multi-stakeholder body was tasked with development and operation of an environmental (forest health) monitoring program for the detection of ecological responses to atmospheric emissions and deposition. Initially focused on acid deposition monitoring, jack pine forest, growing on sandy soils with limited acid buffering capacity, was selected as the receptor system. An initial set of 10 monitoring locations was established using the Canadian Acid Rain Network Early Warning System methodology (since increased to 27, with three lost to development). Ecological monitoring is on a 6-year cycle, with concurrent measures of soil, needle and lichen chemistry, and tree and understory condition,
together with ongoing measurements of air quality and atmospheric deposition. Because jack pine forest edges facing the emissions sources were expected to be more exposed to acidic emissions, evaluation of stand edge monitoring locations began in 2008. Monitoring of a targeted suite of indicators began in 2012 at 25 jack pine stand edge monitoring sites. The virtual special issue presents the results derived from biophysical sampling campaigns (1998 to 2013), coupled with ongoing ambient atmospheric, deposition and epiphytic lichen monitoring (data through 2017) and source apportionment studies, as well as papers contributed by others engaged in regional research and monitoring programs. The Forest Health Monitoring Program provides data supportive of regulatory and stakeholder evaluations of environmental quality, and is adaptive to new needs, extreme environmental events and technological development while providing continuity of monitoring.

324 Forest Health Effects due to Atmospheric Deposition: Findings from Long-Term Forest Health Monitoring in the Athabasca Oil Sands Region

C. Davidson, Endeavour Scientific, Inc.

Oil sands development releases acidifying compounds [sulphur dioxide (SO2), nitrogen dioxide (NO2)] leading to concerns from stakeholders regarding the potential for acidifying deposition. Recent modeling results have suggested that acidic deposition is widespread and should exceed critical loads to forest health. The Wood Buffalo Environmental Association’s Forest Health Monitoring (FHM) Program has been in operation since 1996 to address concerns about acidifying deposition. The program is guided by a clear conceptual model of the stressor-response relationship and is recognized by the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests operating under the UNECE Convention on Long-Range Transboundary Air Pollution. It has expanded to include metal and organic deposition, more robust air quality measures, deposition monitoring programs, and source apportionment studies. Assessment of data from multiple campaigns reflects the dynamic nature of deposition in this landscape. Key program findings include: deposition of sulphur, nitrogen, base cations, polycyclic aromatic compounds and trace elements decline exponentially with distance from emission sources; there is little evidence for acidification of forest soils or acidification effects on understory plant communities or tree growth, but there is evidence of fertilization effects on jack pine needles and understory plant communities on sites within 25km of oil sands operations. Source apportionment studies suggest fugitive dust is a key driver of base cation, trace element, and organic compound deposition, confirming earlier work suggesting that base cation deposition may be neutralizing acidifying deposition. While better dust management practices are important and highly desired by local communities like Fort McKay, better control may reduce this apparent neutralization effect and contribute to acidification. The FHM Program is guided by a clear conceptual model of the source to effect pathway of acidifying deposition. Given that the FHM Program has detected effects of eutrophying emissions in the receiving environment via a pathway other than acidification, it suggests that the FHM Program is well placed to adapt its conceptual model and guide future forest health monitoring.

325 The oil sands, not just surface mines. An assessment of potential risks to aquatic health and resources from Solvent Assisted SAGD operations

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The Peace, Cold Lake and Athabasca Oil Sand deposits in Alberta comprise 167.2 billion barrels of crude oil and the 3rd largest reserve in the world. The oil sands consist of crude bitumen suspended in an ore that is a mixture of sand, clay and water found beneath boreal forest, prairie and muskeg. Reserves that are within 80 meters of surface are considered mineable and represent most images the public equate with the oil sands. Since the late 1960s, only 3.6% (4.5 billion barrels) of the total reserve has been extracted through mining. The other 80% of oil sands reserves (~100 billion barrels) are too deep for mining and require external stimulation to decrease bitumen viscosity and allow reserves to flow to surface through wells. This process, commonly referred to as Steam Assisted Gravity Drainage (SAGD). However, recent technological advances have increased the efficiency of this process by adding the same hydrocarbon-based solvents and diluents used to dilute bitumen. The solvent/diluent is a complex mixture of propane, butane, benzene, toluene, ethylbenzene, xylene, and other hydrocarbons. Many of these chemicals are associated with adverse effects in both humans and aquatic life as evidenced by federal and provincial drinking water and protection of aquatic life guidelines. The chemicals used in solvent injection are not well understood and at the discretion of individual operators not fully reported to the regulator, much like the regulatory process for hydraulic fracturing. A review of regulatory applications and environmental impact assessments (EIAs) for pilot and commercial scale solvent assisted-SAGD applications identified gaps in the assessment of releases of these chemicals to groundwater and subsequently interconnected surface water. In order to understand the risk of this emerging solvent-based technology to contamination of groundwater and hydraulically connected surface water a screening level aquatic health risk assessment was conducted. The modelling and risk assessment methods, regulatory gaps, key learnings, and potential risks of this emerging technology based on the independent risk assessment will be presented.

326 Exposure to airborne and waterborne oil sands chemicals of concern can cause immediate or latent effects on amphibians in field-based experiments

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Whereas the spatial extent of pollution from Canadian Oil Sands mines has received considerable attention, the ecological implications on aquatic biota, and especially amphibians, remain poorly understood. Our team investigated the chronic effects of airborne and waterborne oil sands chemicals of concern on early life stages of the wood frog (Lithobates sylvaticus) using controlled outdoor mesocosm experiments. Here, we present the findings from two experiments conducted at the Queen’s University Biological Station using environmental samples collected in Alberta. In the first experiment, we exposed wood frog embryos to melt waters from snowpack collected from near-field sites in close proximity (< 50 km) to major bitumen upgrading facilities or from more distant far-field sites. Contaminants in snow near industrial facilities are likely derived from atmospheric emissions from bitumen upgraders as well as fugitive dust from petroleum coke piles. In another experiment, we exposed wood frog embryos to environmentally-relevant concentrations of naphthenic acids extracted from oil sands process affected water - that is, the waste water currently stored in large tailings ponds - and then caged the animals in a natural wetland until metamorphosis. In both experiments, we observed immediate and latent effects of exposure to oil sands chemicals of concern on the growth, development, and survival of wood frogs, an amphibian species that is native to the Canadian oil sands region.
New and Existing Chemical Contaminants in Changing Arctic and Antarctic Environments - Part 2

327 Effects of changes in species composition and distribution on contaminant accumulation in an Arctic marine food web

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Arctic marine organisms are susceptible to multiple stressors, including climate change, contaminant exposure and increased human activities such as fisheries and tourism. Combined, these stressors are expected to alter food web composition and the transport, fate, and effect of contaminants within it. Contaminants in the Arctic derive predominately from range-long transported contaminants originating at lower latitudes, as well as from local sources of pollution, e.g. human settlements, petroleum activities and shipping. Contaminant availability, uptake, and transfer are influenced by several factors characteristic of the Arctic environment, such as high seasonality in irradiation, sea ice cover and thus, primary production. But the Arctic is altered by climate change and thereby contaminant dynamics in the food web, by influencing water temperatures, sea ice distribution and thickness and consequently species distribution and composition, as well as lipid dynamics and energy transfer within the food web. This study is part of the Nansen Legacy project which promotes holistic research to identify, investigate and predict the underlying mechanisms of the changing Arctic. To better understand and predict these climatic changes, understanding of seasonal dynamics is needed. Seasonal food web data from the Arctic is difficult to obtain, and so far, mostly available from fjords rather than the productive Arctic shelf seas with its marginal ice zone, which is the focus of the Nansen Legacy project. The present study aims at identifying and comparing bioaccumulation and biomagnification processes of legacy and emerging contaminants (e.g. persistent organic pollutants and mercury) related to energy use and availability between an Atlantic-influenced and an Arctic marine food web in the Barents Sea throughout the year. Four research cruises in different seasons are undertaken, and key species of zooplankton, fishes, and seabirds are collected. Chemical and dietary descriptors are analyzed to determine how seasonal changes in energy acquisition and allocation affect annual dynamics of species composition, contaminant accumulation and transfer in the food web.

328 Avian wildlife: contaminant temporal trends and the bipolar perspective

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After decades of research in the Arctic, recent years’ research on contaminants in Polar Regions has shifted focus to the Antarctica and southern polar region. Here, we summarize results from our recent project, which aimed at comparing avian wildlife contaminant occurrence between the two Polar Regions, to assess temporal trends in Antarctic avifauna, and to identify relations between temporal trends and climate, ecological and physiological drivers. By comparing contaminant occurrence between the Polar Regions and differentiating between migratory and resident species (Arctic: great skuas and black guillemots; Antarctica: south polar skuas and Adelie penguins, respectively), we found generally higher levels of most contaminants such as polychlorinated biphenyls in Arctic wildlife compared to Antarctica. In both regions, we find generally higher contaminant levels of e.g. per- and polyfluoroalkyl substances in migratory species (great skuas and south polar skuas) compared to year-round polar residents such as black guillemot and Adelie penguins. The exception is the organochlorine pesticides Mirex and hexachlorobenzene (HCB), which are found in high levels, dominating the profile in the Antarctic birds. Levels of chlorinated paraffins and new brominated flame retardants were below detection limit in both Polar Regions. Cross-sectional temporal trends in King penguin chicks (11 months) in the sub-Antarctic Crozet archipelago show declining levels of Mirex and no changes in HCB over a 16-year period. Rather than a chronicologic signal, the levels of other contaminants are explained by years with additional stress on penguin parental care and energetic constraints caused by a prolonged distance to the polar front when moving into sub-Antarctic water, reflected in sea surface temperature and shifting δ13C signal. The polar front is an important foraging area for the adult King Penguins during chick rearing. Contaminant levels were not related to any indicators of toxicological effects, neither oxidative stress, nor survival, growth and reproduction. A longitudinal study, following the King penguin chicks in two adult years, indicate an increase in contaminant levels from chick to adult, but only minor differences in levels between the two adult years. Our results provide important knowledge on contaminant temporal trends in the changing Antarctic ecosystem, and emphasize the importance of understanding of climate, ecological and physiological drivers.

329 The Arctic tundra and its soil-dwelling springtails (Collembola) reflect nitrogen and contaminants biotransported by seabirds

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Arctic-breeding seabirds contain high levels of many anthropogenic contaminants, which they deposit through guano to the tundra near their colonies. The resulting nutrient-rich soils in the vicinity of seabird colonies are favourable habitats for soil invertebrates, such as springtails (Collembola), and may expose the springtails to seabird-derived contaminants. We quantified a wide range of lipid-soluble and protein-associated environmental contaminants in two springtail species (Megaphorura arcticae and Hypogastrura viatica) and their respective habitats (soil/moss) collected underneath different seabird cliffs. Although springtails are commonly used in laboratory toxicity tests, this is to the best of our knowledge the first study to measure concentrations of persistent organic pollutants (POPs) and mercury (Hg) in springtails from natural habitats, and the first to document biotransportation of contaminants by seabirds to soil fauna. We categorised the study sites a priorias having low, medium or high influence of seabirds based on colony composition regarding seabird species and their density. This ranking was reflected in increasing δ15N values with increasing seabird influence in the springtails’ habitat (soil and/or moss) and springtails themselves. We found clear indications of seabirds impacting the terrestrial soil environments with organic contaminants, and the contaminant concentrations were higher in soil sampled close to the bird cliff, compared to further away.

330 Elucidating Emerging Perfluoroalkyl/Polyfluoroalkyl Substances (PFAS) in Arctic Beluga Whales in Canada

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Many Inuit living in the Arctic value subsistence foods for nutrition and culture, which include harvested beluga whales (Delphinapterus

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leucas). Common dietary preparation includes maktaaq (fresh, fried, frozen, boiled, fermented blubber with skin), nikuk (dried meat/intestines), throat/trachea, misarq (fermented and liquefied blubber), and cartilage. Contaminant monitoring in traditional foods is a priority of the Northern Contaminants Program in Canada and includes assessment of Arctic temporal trends and long-range transport of contaminants. Biomagnification of certain PFASs has been confirmed in Arctic marine and freshwater food webs. In this study, we quantified 23 PFASs (including perfluorooalkylcarboxylates (PFCAs), perfluoralkylsulfonates (PFSA$s), and perfluorooctanesulfonamide (FOSA) and extractable organic fluorine (EOF) in beluga livers from three different areas of Arctic Canada: Hendrickson Island (HI) in the Beaufort Sea, Sanikiluaaq (SQ) in eastern Hudson Bay, and Pangnirtung (PG) in Cumberland Sound, Baffin Island. Samples found to have unaccounted EOF were subjected to additional suspect screening using high resolution mass spectrometry (HRMS). Total targeted PFAS (ΣPFAS$_{targ}$ = ΣPFCA$s$+ΣPFSA$s$+FOSA) corresponded to 81±9 ng/g wet weight in HI, 62±8 ng/g in PG, and 88±8 ng/g in SQ. Approximately 40–60% of PFAS$_{targ}$ was accounted for by perfluorodiacetate (PFUnDA) and perfluorooctane sulfonate (PFOS). Ratios of PFOS:PFUnDA concentration were 0.47±0.03 in HI, 1.16±0.06 in PG, and 1.21±0.18 in SQ. Emerging PFAS including monochloro-perfluorooctane sulfonate (Cl(CF$_2$)SO$_3$-, 8Cl-PFOS) and the major monochloro-perfluorooctyl ether sulfonate component in F53B (Cl(CF$_2$)OCF2CF2SO$_3$-, 9Cl-PF3ONS) was site-specific: 0.64±0.27 ng/g 8Cl-PFOS in HI and 0.11±0.01 ng/g 9Cl-PF3ONS in PG. The fraction of EOF accounted for by PFAS$_{targ}$ corresponded to 50±4% in HI, 42±5% in PG and 87±11% in SQ, suggesting that further study of the unknown organosulfonamide in HI and PG beluga is warranted. Using high resolution Orbitrap mass spectrometry, several fluorotelomer acids and perfluoro-butanesulfonamide were identified demonstrating the exposure of beluga to PFCA$_s$ and PFSA$_s$ precursors. The authors gratefully acknowledge the provision of beluga samples by participating Indigenous communities and the Northern Contaminants Program funded by the federal department, Crown-Indigenous Relations and Northern Affairs, in Canada.

331 Blubber persistent organic pollutant levels in Icelandid killer whales (Orcinus orca), 2014-2016

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Killer whales (Orcinus orca) are among the most heavily polluted animals in the world. In particular, recent studies have highlighted the critical threat posed by persistent organic pollutants (POPs). POPs biomagnify, and cetaceans show limited biotransformation and elimination capacities, thus top-trophic feeding killer whales are highly exposed. The main risks associated with these high POPs levels are altered immune system function, reproductive impairment, and carcinogenicity. Although tissue concentrations of POPs are reasonably well documented for North Pacific killer whales, considerably less is known for North Atlantic conspecifics regarding POP concentrations, especially for more recent/current-use chemicals including brominated flame retardants. In the present study, a broad suite of POPs were determined in beluga biopsies of 51 killer whales (16 females, 33 males and two of unknown gender) sampled between 2014 and 2016 around Vestmannaeyjar, Kolgrafafjördur and Grundarfjörður, Iceland. The POP groups analyzed include polychlorinated dibenzo-p-dioxins (PCBs), organochlorine pesticides (OCPs) including dichlorodiphenyltrichloroethane and its metabolites (DDTs), hexachlorobenzene (HCB), lindane (HCHs) and chlordane (CHLs), and polybrominated diphenyl ethers (PBDEs), and 23 other flame retardant compounds, including hexabromocyclododecane (HBCDD) and polybrominated biphenyl (PBB) congeners. We hypothesize that there will be high levels of these POPs in the killer whale blubber. PCBs especially will be at the highest concentrations, followed by DDTs, and CHLs. As some killer whales in Iceland appear to be hering-specialists, while others show a mixed diet including fish and higher trophic level prey, such as seals, we nonetheless hypothesize that POPs concentrations will be lower than in some other North Atlantic killer whales, which may feed to a greater degree on marine mammals. We also hypothesize that concentrations will vary between males and females due to maternal transfer. Results from this study will be interpreted in combination with POPs data from other North Atlantic locations to provide insight into differential exposures and risks posed by POPs for North Atlantic killer whales, likely related to a combination of region-specific POPs contamination and foraging strategies. Knowledge on differential exposures among North Atlantic groups will be useful for more targeted conservation strategies across the North Atlantic.

332 Distribution of Short-Chain Chlorinated Paraffins in Ringed Seal Blubber from Eight Arctic Sites Using Gas Chromatography-Orbitrap Mass Spectrometry

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Chlorinated paraffins are complex mixtures of polychlorinated n-alkanes used in various commercial and industrial applications, including as plasticizers, flame retardants, and metal working fluid additives. Since 2017, short-chain chlorinated paraffins (SCCPs), whose carbon numbers range from C10 to C13, have been listed in Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs) due to their persistence in the environment, their long-range transport and bioaccumulation potential, and their toxicity to many laboratory model organisms. SCCPs are challenging to quantify in environmental and biological samples because they comprise dozens of congeners and possibly thousands of unique chemical structures which vary in amount, degree of chlorination, and detectability. As a result, the extent of SCCP pollution in Arctic environments and elsewhere is not well understood. Data from the Arctic is invaluable for assessing the long-range transport and bioaccumulation potential of SCCPs and other POPs. For example, other persistent chlorinated pollutants are known to bioaccumulate in ringed seals (Pusa hispida), an important food source for polar bears, killer whales, and indigenous people in the Arctic. This study examines the bioaccumulation and spatial distribution of SCCPs in ringed seal blubber samples from four Arctic locations in Canada during 2016 (Arviat, n = 4; Nain, n = 5; Resolute Bay, n = 4; Sachs Harbour, n = 5), two Arctic locations in Greenland during 2016 (Ilulissat, n = 7; Qeqertarsuatsiaq, n = 5), two Arctic locations in Norway during 2017 (Ekmannfjorden, Svalbard, n = 1; Yoldiabukta, Svalbard, n = 3), and one (1) Arctic location in Greenland during 2018 (Qaanag, n = 5). The study uses a selective sample fractionation process to remove possible interferences, gas chromatography-electron capture negative ionization-Orbitrap mass spectrometry to detect and distinguish SCCP congeners at trace levels, and a chlorine content-dependent calibration approach to quantify total SCCP amounts. The initial total SCCP concentrations range from ~50 to 1000 ng/g ringed seal blubber (w/w) and vary with location. This study will provide new insights into the spatial distribution and bioaccumulation of SCCPs in ringed seals, and help to provide a baseline for future temporal studies of SCCPs in the Arctic, including studies to examine the effects of climate-related change.
333 Profiling the hepatic metabolome of High Arctic versus Subarctic polar bears and ringed seals to investigate relationships with contaminants and diet

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Environmental metabolomics have been applied to identify relationships between endogenous metabolites and contaminants in a range of species, including polar bears (Ursus maritimus) and ringed seals (Pusa hispida). Here, a targeted metabolomics approach was used to identify differences in hepatic, endogenous metabolite profiles in polar bears from Western Hudson Bay (WHB, Subarctic) and Baffin Bay (High Arctic, HA) and in nearby populations of ringed seals. Relationships were assessed between these metabolites and hepatic concentrations of legacy and new persistent organic pollutants (POPs) as well as total mercury (THg). Tissue samples were collected from the populations of both species by subsistence hunters in 2015-2016. Metabolites (239, e.g., fatty acids (FAs), amino acids, bile acids, phospholipids and their metabolites) and POPs such as polychlorinated biphenyls, organochlorine pesticides, flame retardants, perfluoroalkyl substances (PFASs) and total mercury (THg) were determined in the liver. Stable isotopes of carbon and nitrogen, quantitative FA profiles, and oxidized lipids (oxylipins) were also quantified in muscle, fat/blubber and liver (respectively) to evaluate diet. The stable isotope signatures were more variable in WHB than HA populations of both species, likely due to influxes of inland nutrients from the massive catchment of the bay, and regional shifts in food web composition and diet. Differences in POP and THg concentrations created unique exposure profiles as expected, but these were inconsistent between species; e.g., the PFASs and THg were greater in HA over WHB bears, but were greater in WHB over HA seals. The hepatic metabolite profiles for the HA and WHB seals and bears were distinct, and were differentiated using a three component, partial least squares discriminant analysis model (46.8 % of the total variation). Assessed across all samples, the PFASs were correlated with FAs, amino acids, some phospholipids, bile acids and acylcarnitines, while THg was weakly correlated to phospholipid metabolites. These contaminant and metabolite groups were also correlated with stable isotopes in both species, indicating complex interactions between metabolites, contaminants and diet. Species-specific statistical analyses on the bears and seals separately, and on location-specific predator-prey interactions will be performed once profiles of POPs and FA-based dietary indices are complete and can be included in the analytical profiles.

334 Metabolomic and transcriptomic signatures reveal PCB related effects in ringed seals (Pusa hispida) in Labrador

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Causal evidence linking PCBs to adverse health effects in free-ranging marine mammals is generally confounded by the highly complex contaminant mixtures to which they are exposed. A local PCB “hotspot” on the Labrador coast provided a rare opportunity to evaluate the effects of PCBs on the health of a marine mammal as this chemical dominated their persistent organic pollutant (POP) burdens. The release of approximately 260 kg of PCBs by a military radar facility over a 30 year period (1970-2000) contaminated some local marine biota, including 60% of the ringed seals (Pusa hispida) along the coast. In order to assess the implications for ringed seal health, we evaluated the abundance profiles of eight health-related gene transcripts in liver. The mRNA transcript levels of five gene targets, including aryl hydrocarbon receptor (Ahr), interleukin-1 β (Il1b), estrogen receptor α (Esr1), insulin like growth factor receptor 1 (Igf1), and glucocorticoid receptor α (Nr3c1) correlated with increasing levels of blubber PCBs. Threshold values were calculated for these five genes, with the most conservative value being 1,370 ng/g lw for Il1b. Approximately 14% of the seals in the region exceeded this threshold. We further examined 254 metabolites to add insight to the consequences of PCBs on their health. These included 18 energy metabolism metabolites, 18 endogenous steroid metabolites, 21 amino acids, 22 biogenicamines, 40 acylcarnitines, 89 phosphatidylcholines, 15 sphingomyelins, 2hexose, 13 bile acids, and 18 fatty acids in liver, plasma, and serum samples collected from 43 ringed seals in the affected area. Preliminary metabolomics results suggest that variability between metabolites is attributed to PCB concentrations and year of collection with those collected during 2010, an unfavourable ice condition year, differing from the other years. The dominance of PCBs in the seals studied enabled an assessment of the effects of this chemical on gene transcripts and metabolites involved in regulating the health of a highly mobile predator, something that is rarely possible in the world of complex mixtures.

Sequencing the Exposome Using Nontarget Mass Spectrometry: Aims, Perspectives and Challenges - Part 2

335 Identifying bioaccumulative per/polyfluoroalkyl substances (PFASs) in complex mixtures using a mouse model and nontarget mass spectrometry

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Per- and polyfluoroalkyl substances (PFASs) are a global research priority because they have been found at levels exceeding health advisory limits in the drinking water of millions of people. Aqueous firefighting foams (AFFFs) are a common source of complex mixtures containing hundreds of PFASs to drinking water. Understanding the full extent of human exposure to PFASs via these complex mixtures requires innovative analytical methodologies, including high-resolution mass spectrometry for suspect screening and nontarget analysis. In this study, a mouse model was dosed with a commercial AFFF mixture. Serum and urine samples from dosed mice were analyzed by quadrupole time-of-flight mass spectrometry (QToF-MS). Suspect screening was conducted using an extensive in-house extracted ion chromatogram (XIC) list and fragmentation library for hundreds of AFFF-associated PFASs. Screening of serum revealed that several substituted perfluoroalkyl sulfonates, for which no toxicological data is available, were enriched in blood from AFFF-dosed mice. Screening of urine revealed a mixture of PFASs distinct from those accumulating in the blood, with normalized peak areas increasing over the exposure period. Additionally, non-target analysis of mouse serum revealed the presence of fluorinated compounds that were not included in the original suspect screening list and had not been detected previously in the AFFF product. This highlights the use of in vivo models as an effective tool for prioritizing novel bioaccumulative PFASs that may be overlooked because they are minor components in drinking water and AFFF products.
336 Development of a database infrastructure for analytical reference data for the identification of per- and polyfluoroalkyl substances

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There have been numerous news reports and peer-reviewed research regarding the presence of per- and polyfluoroalkyl substances (PFAS) in the environment. The detected compounds include known PFAS (such as perfluorooctanoic acid [PFOA] and perfluorooctane sulfonate [PFOS]), and now there is emerging evidence regarding the environmental presence of novel PFAS (such as the hexafluoropropylene oxide dimer acid, HFPO-DA). Recently, novel PFAS have been identified using non-targeted analysis (NTA) approaches with liquid chromatography and high-resolution mass spectrometry (LC-HRMS). The greatest hindrance to confident identifications of novel PFAS by LC-HRMS is the accessibility of compound-specific analytical data, specifically mass spectral data, especially without the broad availability of analytical standards. Meanwhile, researchers across the world are producing quality mass spectral data for these novel PFAS from technical mixtures, synthesized compounds, and limited/expensive stocks of analytical standards. Often these produced data are used for internal mass spectral libraries that are not easily communicable between laboratories. To address this data need, researchers at NIST are designing a database structure that is specifically built to store, manage, and analyze mass spectral data regarding historically-known and novel PFAS. The database, based in an open-sourced SQL format, includes the management of mass spectra, their associated analytical metadata (such as instrument parameters), sample information, and annotated fragments for similarity searching. Included in this database will be a system for submitting data with a confidence level determination, and the statistical assessment of mass spectral uncertainty. The database is currently in a prototype format, but the functions and concepts will be presented. With the data in a publicly-accessible, open-sourced format, PFAS researchers across the world will be able to utilize the data for the identification of PFAS in environmental and other samples.

337 Characterizing Azobenzene Disperse Dye Occurrence in House Dust via Non Targeted Analysis


Disperse dyes are a class of substituted anthraquinone- or azobenzene-based dyes used to color synthetic fabrics such as polyester, nylon, and acrylic. Many of these dyes are chlorinated or brominated, and account for roughly 70% of the 9.9 million tons of industrial colorant used annually. Azobenzene dyes are well-characterized as electrophilic mutagens and contact allergens in clothing, but little is known about occurrence of these dyes in the indoor environment, nor their health implications following exposure. Furthermore, no comprehensive chemical database of disperse dyes exists. Here, we report tentative and confirmed identifications of numerous azobenzene disperse dyes in house dust samples collected from 190 homes in the Toddlers Exposure to SVOCs in Indoor Environments (TESIE) study in central North Carolina. House dust samples were collected in 2014-2016 by research investigators from homes with small children. We used a data-dependent, suspect-screening analytical strategy with HPLC-ESI-HRMS/MS analysis to annotate azobenzene-class disperse dyes in organic house dust extracts. A substructure search in CAS was used to assemble a suspect list of compounds containing p-aminoazobenzene as the core structure of disperse dyes. Extracted dust samples were then analyzed using an Orbitrap Lumos mass spectrometer in positive and negative modes with data-dependent MS/MS selection. Tentative identifications were assigned using a weight-of-evidence non-targeted analysis approach with multiple open-source, in silico fragmentation algorithms combined with curated data source, scientific reference, and patent information for each candidate compound. Based on our preliminary data, we have tentatively identified approximately 90 features in house dust as azobenzene compounds at environmentally relevant concentrations (area counts greater than or equal to 10^{5}); many of these compounds are halogenated. More than 30 of these tentative identifications appear to be significantly (p = 0.05) enriched in the homes of Hispanic and non-Hispanic black children relative to homes of non-Hispanic white children. We report the first comprehensive analysis of azobenzene compounds in house dust in the United States. Ongoing analysis will confirm tentative identifications with authentic reference standards, and will continue to investigate associations of tentatively identified azobenzene compounds with additional metadata available (e.g. age of home, square footage, etc.).

338 Towards Confident Identification of Organic Pollutants Without Authentic Standards

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One aim of nontargeted screening (NTS) is to identify new environmental pollutants prior to their emergence as global contaminants. Suspected pollutants are typically identified using the time-honoured approach of comparing their electron ionization (EI) mass spectra with those compiled in libraries or obtained from authentic standards. Nevertheless, such libraries are incomplete, and standards may be unavailable or too costly. This study evaluates the performance of competitive fragment modeling (CFM-ID) and quantum chemical electron ionization mass spectrometry (QCEIMS) for suspect screening and identification of unknowns. EI mass spectra of 35 compounds, including halogenated organics, brominated and organophosphorus flame retardants, and disinfection by-products were computed and compared with the NIST Library using standard matching algorithms. The computational results were also compared to collision-induced dissociation (CID) experiments with authentic standards as well as an indoor dust sample containing flame retardants and other pollutants. QCEIMS generally performed equivalently or better than CFM-ID. Average match factors were 628 vs. 542 for the halogenated organics, and on average 55% of CID products were accurately predicted by QCEIMS compared with 17% by CFM-ID. For the organophosphorus flame retardants, CFM-ID predicted 58% of CID products whereas QCEIMS predicted 48%. When applied to the indoor dust sample, QCEIMS performed comparably to routine combinatorial methods for suspect screening, identifying 19/20 target compounds. The challenge of identifying unknown pollutants presents a cyclic problem: by virtue of being unknown, these pollutants are not found in any database, and there are no authentic standards available for confirmation. Herein, two cases are presented of previously unreported pollutants. The close match between the experimental and QCEIMS predicted spectra raises the tantalizing possibility that an unknown pollutant can be confirmed in hours, as opposed to days or months required to obtain an authentic standard.

339 Nontarget Profiling of Organic Compounds in a Temporal Series of Hydraulic Fracturing Flowback and Produced Waters

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Horizontal drilling coupled with hydraulic fracturing (HF) is a widely-used technology to enhance the release of oil and natural gas from tight reservoirs. Large volumes of water are mixed with HF fluid additives and
propellant which is pumped into the wells at high pressure to fracture the target geologic formation. When HF pressures are released, a fraction of the injected water along with natural formation water return to the surface, which we refer to here as flyback and produced water (FPW). FPW is often brackish and contains a mixture of organic compounds originating from HF fluid additives, geogenic substances, and possibly transformation products. HF-FPW is toxic to aquatic life, but its chemical content is largely unknown, variable and complex. In this study, seven FPW samples were collected from a HF operation in the Duvernay Formation (Alberta, Canada) over 30 days of flyback and characterized by a nontarget workflow based on high performance liquid chromatography - high resolution mass spectrometry (HRMS). A modified Kendrick mass defect plot and MS/MS spectral interpretation revealed seven series of homologous compounds of ethylene oxide, among which a series of aldehydes was proposed as degradation products of polyethylene glycols, and two series of alkyl ethoxylate carboxylates could be proprietary HF additives. Many other ions were confidently assigned a formula by accurate mass measurement and were subsequently prioritized for identification by matching to records in ChemSpider and the USEPA's CompTox Chemistry Dashboard. Quaternary ammonium compounds, amine oxides, organophosphorous compounds, phthalate diesters and hydroxyquinoline were identified with high confidence by MS/MS spectra (Level 3), matching to reference spectra in MassBank (Level 2) or to authentic standards (Level 1). Temporal trends showed that most of the compounds declined in abundance over the first nine days of flyback, except for phthalate diesters and hydroxyquinoline that were still observed on Day 30 and had disappearance half-lives of 61 and 91 days, respectively. All the compounds followed first-order disappearance kinetics in flyback, except for polyoxygenated acids which followed second-order kinetics. This analysis and the workflow, based largely on public on-line databases, enabled profiling of complex organic compounds in HF-FPW, and will likely be useful for further understanding the toxicity and chemical fate of HF-FPW.

340 Using suspect screening to determine Hurricane Florence’s impact on chemicals of concern at a forested water reuse site

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The city of Jacksonville, North Carolina, currently utilizes a forested water reuse system to treat and repurpose its municipal wastewater. Forested water reuse systems provide an alternative means of wastewater discharge in which treated effluent is applied to forest soils via slow-rate irrigation. Although these systems have been utilized for decades in the US, they have only recently been investigated in terms of their roles as a source of emerging contaminants into the environment. The entire forested watershed at the Jacksonville site covers 7200 acres (2900 ha) for which 2000 acres (810 ha) are irrigated with wastewater. The irrigated area of the site contains multiple streams throughout its forest, is bordered by agricultural land use, and also receives leachate input from a nearby landfill. The site was impacted in September 2018 by Hurricane Florence, receiving approximately 760-990 mm rainfall over the entire month (whereas 2007-2017 September rainfall values range from 38-310 mm). The purpose of this study was to assess changes in organic chemical contaminants of concern related to the impact of the hurricane both on and directly off site. A previous study at this site examining a smaller scale storm event found that storm events send pulses of chemical contaminants into surface waters with high initial concentrations that are then rapidly diluted. Surface, ground-, and wastewater samples from the site collected prior to and after the hurricane’s impact were analyzed via a suspect screening approach to determine differences in numbers of chemical features and changes in chemical feature composition. We believe this will provide valuable information as to how tropical storm events impact emerging contaminants not only within such forested water reuse systems, but also the potential for their transport to surrounding areas.

341 Combining and multiplexing novel online sampling techniques to widen coverage of non-targeted analysis in water

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Water safety and quality are fundamental to human development and well-being. Yet, we are exposed to several thousand chemicals in our water daily. Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Environmental regulations throughout the world currently focus on monitoring a limited number of well-known compounds that are assumed to be responsible for significant ecological and human health related risks. However, the quantum of chemicals we are exposed to in the environment is significantly greater. Hence there is a growing interest to extend the well-defined fraction of anthropogenic chemicals, the priority pollutants declared by the regulations, to allow the surveillance screening for contaminants of emerging concern and thus provide comprehensive data on the chemical quality of drinking and surface waters. Contamination of environmental samples with harmful chemicals can be detected with high-resolution mass spectrometry (HRMS), which provides accurate mass data on the compounds found with broad range of physicochemical properties and allows retrospective analysis to look for known and newly identified contaminants in a single sample. Targeted analytical methods are increasingly complemented by untargeted acquisition methods using high resolution accurate mass (HRMS), which provides accurate mass data on the compounds found with broad range of physicochemical properties and allows retrospective analysis to look for known and newly identified contaminants in a single sample. Targeted analytical methods are increasingly complemented by untargeted acquisition methods using high resolution accurate mass Q-TOF LC/MS due to comprehensive screening requirements in current environmental regulations as well as increasing interest in the occurrence of contaminants of emerging concern. However, coverage of chemicals that can be accurately identified by HRMS is a function of the sample preparation technique and is often not investigated thoroughly. The determination of polar and semi-polar compounds in a single analytical run is difficult due to their inherently different physicochemical properties. It is challenging to analyze polar compound with conventional SPE setup as they rapidly pass through the SPE cartridge, but they have successfully been used for increasing the sensitivity of an LC/MS system due to the enrichment of semi-polar compounds on the cartridge. Issues with time, labor and reproducibility though led us to investigate a novel online SPE approach in the first phase that will be discussed. The aim of the current work was the development of a target and suspect screening LC/MS method using HRMS for the determination of contaminants of emerging concern with broad range of physicochemical properties in drinking water by leveraging a customized online SPE setup for polar and non-polar analytes in a single injection to ensure their high quality. This coupled with direct large column aqueous injection in the same analysis helps with recovery and identification of other compounds that would be lost on the SPE cartridge due to non-retention. This unique approach of using online SPE and direct injection simultaneously allows for broader range of analysis of chemicals present in the sample. This study will present data on less frequently considered issues with sample preparation that are not considered when looking into HRMS analysis too.

342 Toxic Contaminant Identification in Wastewater Effluent using Gas Chromatography High Resolution Mass Spectrometry

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In order to identify the source of toxicity in wastewater effluents a conventional targeted analysis approach may not always be sufficient, due to significant limitation of the scope and possibility of unknown chemicals causing the toxicity. A more comprehensive screening and/or non-targeted analysis is often be required. The use of liquid chromatography coupled with a high-resolution mass spectrometer has gained in popularity for these kinds of analysis in the last few years. Yet, many
Microplastics in the Environment: Transport, Fate and Ecological Effects - Part 2

343 Measuring Microbead and Microplastic Trends in Wastewater Treatment Plant Effluents Before and After Regulation

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Microplastics enter waters such as the Laurentian Great Lakes from a wide variety of sources and pathways, including wastewater treatment plant effluents. Microbeads, which have been used in personal care products such as exfoliating face and body washes, are one source of microplastics that received considerable attention, and were subsequently regulated in both Canada and the United States, banning their use in such products. Three wastewater treatment plants (WWTPs) from the Greater Toronto and Hamilton Area, with effluents that reach Lake Ontario, Canada, were sampled to characterize the types of microplastics present, the relative contributions of microbeads, and to track changes in microbead abundances following their removal from personal care products. Sampling began in 2014 at one WWTP and 2016 at the other two and continued into spring 2019, bracketing the dates bans took effect in Canada and the US. Two sampling strategies, net grabs and 24-hour composites, were employed and compared, ensuring a range of particle sizes were captured. Personal care products containing exfoliating materials were purchased from retail outlets in the Toronto, Ontario in 2015 prior to companies removing polyethylene microbeads and in 2018 after the ban in Canada. Microplastic particles were counted and categorized according to particle morphologies using a microscope to reflect source types, ensuring both irregularly-shaped and spherical microbeads could be appropriately measured and tracked. Microbead abundances declined over the sampling period reflecting removal from the marketplace. The abundance of spherical microbeads increased relative to irregular microbeads due to the continued use of multicolored spherical beads, which are typical composed of synthetic wax or cera microcrystalline as confirmed by FTIR spectroscopy. The composition of microplastics in the effluents varied among the WWTPs, with industrial-based sources representing a significant fraction of one plant, demonstrating the presence of other manageable microplastic sources that are not captured under initiatives to address litter and single-use plastics.

344 Assessing blue jeans as a major microfiber source to global aquatic systems

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United States consumers purchase ~450 million pairs of blue jeans per year, with global sales increasing annually. Approximately 75% of consumers strongly prefer denim produced using 100% cotton or cotton blends. Cotton is a natural fiber and is commonly considered more environmentally friendly than synthetics, however cellulose fibers (including cotton) are among the most common types of anthropogenic particles observed in the natural environment. Risks associated with processed cotton microfibers in the environment, including persistence and toxicity, are unknown. We analyzed samples for microplastics and microfibers (MFs) from several stages along the microfiber aquatic pathway, including in-home washing machines, waste water treatment plants (WWTPs), freshwater lakes of southern Ontario, aquatic organisms inhabiting Lake Ontario, and marine sediment from the Canadian Arctic Archipelago. Cellulose-based cotton fibers were identified using a combination of Raman spectroscopy and morphology. Further detection of a dye or chemical additive indicated anthropogenic origin. Cellulose fibers that did not contain a dye or additive were considered cellulose of ‘unknown origin’. However, there are no natural sources of cotton within >1000 km of our study sites. Microfibers, and among those, cellulose fibers, were the dominant particle type in all samples. WWTP final effluent analysis showed that 80% of particles discharged into Lake Ontario were MFs, and 11% of MFs were identified as anthropogenic cellulose. Lake Ontario and Lake Huron sediments also showed that 90% of particles were MFs, and ~50% of all MFs were identified as anthropogenic cellulose. Microparticles recovered from Rainbow smelt from the Great Lakes also indicated a dominance of MFs, at ~97%. Raman analysis is still to be conducted on a portion of these particles. Widening the geographic scope, our findings from sediment taken across the Canadian Arctic Archipelago were congruent with other ecosystems, as 90% of particles were MFs, and ~35% of all MFs were anthropogenic cellulose. Approximately 75% of anthropogenic cellulose fibers found across ecosystems contained blue indigo dye. The prevalence of anthropogenic cellulose fibers with indigo dye are consistent with the microfibers shed from washed blue jean denim. Our results show the extensive footprint of our current blue jean culture that extends throughout aquatic ecosystems.
345 Microplastics and contaminants: Field experiments to assess the role of microplastics as a vector for contaminants
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Microplastics (MP) are polymer particles with a diameter of less than 5 mm, originating from commercial use (primary MP) or degradation of larger plastic debris (secondary MP). The presence of large amounts of MP in the sea is a significant pollution issue. Besides the risk of physical damage to marine organisms that ingest MP, concern has been expressed about exposure to contaminants sorbed to MP from seawater. The sorption process is known from passive sampling studies using plastic polymers such as polyethylene (PE) to accumulate contaminants from seawater. The project PlastiCod has studied the contaminant sorption to MP in the sea and the subsequent uptake by Atlantic cod (Gadus morhua). In the field experiments, PE particles (0.3-0.6 mm) were deployed alongside sheets of polydimethylsiloxane (PDMS) and polyoxymethylene (POM), commonly used passive samplers. The polymers were placed in the sea at nine locations along the coast of Norway for about four months and subsequently analysed for polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCD), chlordane-related pesticides and toxaphene. The contaminant concentrations sorbed to PE were generally low, but higher than in the virgin PE. The ΣPCB concentrations (CB-28, -52, -101, -118, -138, -153, -180) ranged from 0.09 to 2.9 ng/g dry PE, with highest average concentrations for CB-52 and CB-101. Amongst the PBDEs, BDE-47, -49, -99, -100 and -209 were detectable in most samples, with highest concentrations for BDE-47 (0.007-0.06 ng/g PE) and BDE-209 (not detected-0.8 ng/g PE). The maximum ΣHBCD concentration was 0.09 ng/g PE. The PDMS concentrations ranged between 0.07-0.9, 0.04-0.2 and 0.003-0.05 ng/g for ΣPCB, ΣPBDE and ΣHBCD, respectively. Data for chlordane-related pesticides and toxaphene are still being processed for PE and PDMS, as well as data for all contaminants in POM. Comparisons between PDMS and PE indicate higher concentrations in PDMS for the most hydrophobic compounds and will be analysed further. Duplicate samples from the same location showed better agreement for PDMS than for PE. The highest concentrations were generally found in samples near the capital Oslo. However, elevated concentrations of specific compounds occurred in some locations, indicating local phenomena. The results can be compared with food-chain associated contaminant exposure and contribute to our understanding of the significance of MP as a vector for contaminants.

346 Microplastics in San Francisco Bay: Abundance, Transport, Fate, and Policy Recommendations
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The San Francisco Bay Microplastics Project has characterized microplastics and other microparticles in a variety of media to determine sources, pathways, and loadings to San Francisco Bay, a densely populated urban environment, as well as to the adjacent Cordell Bank, Greater Farallones and Monterey Bay National Marine Sanctuaries. Field staff collected samples of stormwater runoff, wastewater effluent, open Bay and Sanctuary surface waters, Bay sediment, and two species of prey fish. All samples were analyzed for microparticles using visual techniques; a subset of the particles was examined via Raman or FTIR spectroscopy to identify whether they were composed of plastic polymers or other materials. The concentrations observed were used to validate a process-based particle transport model for the Bay and Sanctuaries that can be used to predict the transport and fate of microplastics in the region. Findings further informed a collaborative, multi-stakeholder process to develop data-driven region-specific policy recommendations to reduce microplastic pollution.

347 Weathering impacts on the fate of plastic debris in the marine environment
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The marine environment is the final sink for a large fraction of the plastic waste that we generate on land. As soon as plastic is emitted to the environment, it is subject to factors influencing its yet poorly characterized weathering. This presentation will highlight some of the major research outcomes of the JPI Oceans-funded project WEATHER-MIC (www.jpi-oceans.eu/weather-mic, 2016-2019). The overall goal was to assess how weathering impacts the transport, fate and toxicity of plastic material in the marine environment. A major topic was to characterize the chemicals that are liberated from plastic into artificial seawater under strong UV light irradiation. Several breakdown products of the polymer backbone were identified, and the leachates were tested for mixture effects in cell-based, algal and daphnid bioassays. At the same time, changes in particle properties were characterized, and the weathered particles were tested along with their pristine counterparts in the algae and daphnid test systems. We also addressed the impact of weathering on the sinking rates of plastic particles and incorporated the outcomes into a mathematical model. Future work will also be presented, including a glimpse on the results of a scientific expedition on the German research vessel "SONNE," crossing the North Pacific Ocean between Vancouver (Canada) to Singapore in summer, 2019. During the cruise, we will both collect and generate field-weathered plastic in the Great Pacific Garbage Patch and along gradients to less polluted areas. Sampling will consider both plastic debris and the surrounding media (water and sediment) at the sea surface, in the water column and in the seabed, to determine if the plastic is a source or sink for organic environmental pollutants. The results are expected to contribute to our understanding of the transport and fate of plastic debris in the marine environment, and to help test the hypothesis that the majority of plastic debris emitted to the marine environment sinks to the seabed, where it is stored for an undetermined time.

348 Synthesis of metal doped nanoplantastic particles and microplastic fibers and their utility for investigating plastic fluxes in complex matrices
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Reports on the occurrence of particulate plastics (nano- and microplastic particles and fibers) in the environment emerge on a weekly basis, but quantitative data are still limited due to analytical difficulties and inconsistencies of the methods applied to detect particulate plastics in complex environmental matrices. While progress is still ongoing to develop analytical methods to measure particulate plastic in field studies, researchers who study the fate, transport and biological interactions and effects of nano- and microplastics in bench top or pilot scale studies can take advantage of an entirely different approach. In this work, we synthesized a variety of particulate plastics (nanoplastic particles, fibers) with an embedded inorganic fingerprint (Pd or In; approx. 0.5% metal/wt) which can be used to detect plastic by common analytical techniques
for metals analysis, such as ICP-MS. This allows us to more quickly and quantitatively assess plastic in complex matrices than is currently possible with other analytical techniques. To highlight the utility of this approach, here we used these materials to investigate the fate and transport of particulate plastic in a pilot-scale WWTP representing the activated sludge process. Triplicate samples were taken from the mixed liquor and effluent at least twice a week for the entire length of the experiment, which lasted five weeks. With a recovery rate of plastics over 90%, our findings show that in discrete grab samples 98% of plastics (both nanoplastic particles and microplastic fibers) were in the activated sludge, with a high correlation between TSS concentration and plastic concentration. However, when assessing the total mass balance (i.e. including respective volumetric flows of the sludge and effluent), only about 70% of the plastic is retained in the activated sludge. As our test system boundaries did not include the primary clarification stage of WWTP, a further reduction of plastic in full scale WWTP may be expected. Nevertheless, by using these metal-doped plastics, benchscale and pilot-scale studies can be used as a bridge to understand (particulate) plastic in complex matrices until analytical techniques to measure particulate plastic in solids, in trace concentrations, and in wastewater applications of UV-based AOPs for potable water reuse will be addressed. Prof. Dionysiou will elucidate the advantages and challenges for the treatment of emerging contaminants for water reuse.

350 Microplastics in biosolids and agricultural soils: A Canadian case study
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Here, we report on microplastics (MPs) detected in biosolids and in the soils to which they were applied in Ontario, Canada. MPs in biosolids from three waste water treatment plants, three agricultural fields receiving biosolid application and a fourth control field were examined. Composite samples were collected at three depths (0-5, 5-10 and 10-15 cm) over the course of a growing season. Approximately 10K MP particles were detected per kg biosolid (dry weight). Fragments and fibers were the most common form of MP, beads were a minor component of all biosolid samples and glitter was detected in one biosolid sample. Polyethylene, polypropylene, and polyester were the dominant polymer types across all biosolids samples. MPs concentrations in the top 15 cm of soils receiving biosolid amendments averaged 170 MP particles per kg soil (dry weight) versus 7 MP particles per kg soil (dry weight) in the control soil where no biosolids were applied. In contrast to the biosolid samples, fibers were the dominant MP type in all fields. MPs were detected in the deepest samples at all sites, in lowest concentrations in the control field. The three study sites demonstrate significant differences in microplastics transport behaviour over time, with evidence of vertical migration in some with lower permeability. There is no evidence that the MPs detected were associated with agricultural plastics (e.g. use of plastic mulches). These results are likely to be extremely useful for modelling studies of MP fate and transport and can support a stakeholder dialogue about the risks and benefits of biosolid application.

349 Characterizing Microplastics in Bottom Sediments from US Waterways
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The US Army Corps of Engineers uses dredging to excavate shoaled sediments from federal navigation channels to maintain safe and navigable waterways. Given the reported extent of microplastics in the aquatic environment, environmentally relevant exposure information is needed for bottom sediments targeted for dredging to lend context to the potential risk of the presence of these materials. Therefore, the objective of this research was to measure the occurrence and abundance of microplastics in sediments collected from waterways where dredging is performed and characterize exposure parameters (i.e., size, shape, composition) that are likely to influence ecological risks. Sample locations included sites dredged within the Great Lakes, Gulf of Mexico, Long Island Sound, Atlantic Ocean, and the Mississippi River (n=9) and both freshwater and marine reference sites (n=2) where no dredging occurred. The number of particles for all samples ranged from 162 to 6,110 particles/kg dry wt., with a mean of 1,636 particles/kg dry wt. Microplastic particle shapes observed in the sediments examined included fibers, films, foams, fragments, and spheres. Fragments occurred most frequently, present in all sample sites (100%, n=11), followed by fibers (81%), spheres (75%), foams (38%) and films (34%). Based on analyses of chemical composition of the particles using Fourier transform infrared spectroscopy (FTIR), polyethylene:propylene was the most common polymer type observed. Microplastics varied considerably among sites with respect to abundance and shape. The occurrence of microplastics at every sample site in this study (including freshwater and marine reference sites) was consistent with microplastic occurrence and abundance reported by investigators in other regions, and provides evidence that microplastic particles are abundant in both marine and freshwater bottom sediments and therefore should be anticipated in dredged sediments. These data provide additional insight and context to key parameters (e.g., particle concentration, shape, and chemical composition) necessary to inform ecological consequences of microplastic exposures during dredging operations.

351 Advanced technologies to remove contaminants of emerging concern for water reuse
D. Dionysiou, University of Cincinnati / Department of Biomedical, Chemical and Environmental Engineering (DBCEE)
With the increasing public attention to health risk associated with environmental pollution, introduction of newly synthesized chemicals into the environment, and the rapid development of analytical instruments, a wide variety of contaminants of emerging concern (CECs) were detected in recently years. Various treatment technologies are developed to remove these CECs from wastewater for water reuse applications, including filtration, membrane separation, reverse osmosis, activated carbon adsorption, ozonation, and advanced oxidation processes (AOPs). In this presentation, Prof. Dionysiou will elucidate the advantages and challenges for the treatment technologies for the removal of CECs. Work from his group on the applications of UV-based AOPs for potable water reuse will be addressed. Special attention will be given to the transformation products and cytotoxicity of treated CECs.

352 Using UV/chlorine as drinking water barrier in Harmful Algal Bloom events: Effects and concerns
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The widespread occurrence of harmful algal blooms (HABs) in drinking water sources poses great threat to the drinking water safety. During HABs, certain cyanobacteria could produce cyanotoxins which are potent hepatotoxins, and besides they could release algal organic matter, which as the primary source of dissolved organic nitrogen (DON) can serve as a nitrogenous disinfection byproduct (N-DBP) precursors.
UV/chlorine process has been evaluated as a potentially practical and effective process to degrade frequently detected cyanobacterial toxins in drinking water. Meanwhile the N-DBP formation need to be studied to fully evaluate the impact of UV/chlorine process on the quality of finished water. In this study, degradation of MC variants, including MC-LA, MC-RR, MC-YR, and MC-LR, by UV/chlorine process and chlorination and were evaluated. The combined UV and chlorine oxidation showed a significant synergistic effect on the degradation of all studied MCs. Rapid degradation of MCs was observed even at high pH 8-10, which indicated the UV/chlorine could be employed to treat water from several lakes contaminated with HABs after proper pre-treatment in engineered water treatment plants. The formation of nitrogenous disinfection byproducts (N-DBPs) from microcystin, arginine, or algal organic matters can be enhanced by UV/chlorine compared with chlorination only. The UV/chlorinated cyanotoxins also showed quantitatively less cytotoxicity than treated by chlorination.

353 Microbial Communities as Drivers of Non-Target Chemical Change and Contaminants of Emerging Concern Degradation

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Microbial communities in aquatic systems act as drivers of chemical change, including the degradation of contaminants of emerging concern (CECs). This study investigated the ability of microbial communities to alter the surrounding chemical environment, and to degrade a suite of 21 known CECs across time and space. A series of four streams and a wastewater treatment plant were sampled across three seasons. Microbial community composition was identified using 16S Illumina sequencing, non-target chemical analysis was performed using high resolution time-of-flight mass spectroscopy, and future work includes a target analysis of the 21 CECs. Using hierarchical clustering and multidimensional scaling, chemical and microbial communities have been grouped to find the most important variables. Microbial variables will be used to predict chemical signature changes over time. The key microbial species will be compared against CECs degradation to determine the core microbiome most important to CEC removal. Identification of such a core microbial community can be utilized to seed wastewater treatment plants such that CECs removal can be improved prior to wastewater discharge into surface water.

354 Evaluation of waterborne estrogenic activity at a land-based, water recirculation aquaculture facility using E-screen

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Land-based, closed-containment production of Atlantic salmon Salmo salar using recirculation aquaculture system (RAS) technologies could prove a viable avenue for aquaculture industry expansion, given the limited coastal locations worldwide that are suitable for raising this species in tradition sea cage systems. At present, certain hurdles remain regarding RAS Atlantic salmon production; these include early maturation, which can result in decreased product quality through reduction in normal flesh coloration. It is hypothesized that accumulating steroid hormones in RAS water can influence early maturation. We therefore sought to investigate waterborne estrogenic activity at a land-based RAS facility raising Atlantic salmon, utilizing the highly sensitive in vitro assay E-screen. Water samples were collected from replicated (n=3) RAS treatment with or without ozone, +O3 or - O3, as well as influent spring water and combined facility effluent water, over a 4-month sampling period. Samples were also collected from the facility spring pond, receiving both spring water and facility effluent, and a nearby duck pond (presumed positive control). E-screen results indicated that estrogenic activity of influent RAS water from +O3 or -O3 was never greater than 0.008 ng/L of estradiol equivalents (E2Eq), with 75% of intake samples either ≤ solvent method blanks or below the limits of quantitation. Concentrations of all water samples collected were 10-fold lower than the predicted No Effect Concentration for E2 in fish (2 ng/L). While culture tank water from +O3 RAS tended to be lower in E2Eq than those from -O3 RAS, there was some inconsistency across all RAS culture tanks. On one sampling date the ozonated culture tanks had higher E2Eqs than two of the non-ozonated RAS tanks. Liquid chromatography, tandem mass spectrometric (LC-MSMS) analysis of samples from this date confirmed the presence of estrone in all RAS tank samples, with quantitation valid only in the three RAS with higher E2Eqs. Estradiol glucuronide was present in the same three RAS, and in spring and duck pond samples. Estrone concentrations were ~ 3 times higher in the duck pond than in the RAS tank waters. The extremely low concentrations of E2Eqs in tank waters indicate there would be no threat to aquatic life by release of tank effluents to environmental surface waters. While estrogenic activity of water from ozonated RAS tanks tended to be lower, ozonation treatment had no significant effect on Atlantic salmon early maturation, which was high in both +O3 or - O3 RAS. Further investigation is therefore required to assess the role of accumulating steroid hormones in RAS, alone and in combination with other important environmental variables, on the development of early sexual maturation in Atlantic salmon.

355 Transcriptome response of Danio rerio and Promelas pimephales to complex pharmaceutical mixtures in a WWTP effluent-impacted stream

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Pharmaceuticals are an important class of contaminants that have been documented release into the environment by wastewater treatment plants (WWTPs). The incomplete removal of pharmaceuticals during treatment within WWTPs poses potential risk to aquatic organisms in streams receiving effluent, particularly during low-flow conditions that elevate concentrations of complex mixtures of pharmaceutic. Although the endocrine disrupting potential of select individual pharmaceuticals has been studied, less is known regarding mixtures of pharmaceutical compounds which are known to be present in WWTP effluent and receiving water bodies. To characterize the potential risks of adverse effects that pharmaceutical mixtures pose to aquatic organisms, Muddy Creek, a small (22.5 km2) stream receiving effluent from the North Liberty WWTP in Iowa, was selected as a field laboratory for study. Four sampling sites were chosen to capture the spatial and temporal variability of pharmaceutical mixtures: (1) 100 m above the WWTP outfall, (2) the WWTP outfall, (3) 100 m below the WWTP outfall, and (4) 5 km downstream of the WWTP outfall. From September 2017 to August 2018, monthly water samples were collected during low-flow conditions and analyzed by the U.S. Geological Survey for 110 pharmaceuticals and total estrogenicity. Corresponding monthly water samples were also sent to the University of Wisconsin-Milwaukee for zebrfish (Danio rerio) exposure and gene expression studies. Zebrfish embryos were exposed to all monthly water samples for 3- and 6-day durations. The expression of five genes along pathways in the hypothalamus-pituitary-gonadal (HPG) axis: Vitellogenin, CYP19a2, GnRH, and ER-alpha were analyzed using quantitative polymerase chain reaction (qPCR). Next generation sequencing and RNAseq were used to identify approximately 700 genes with significant differential expression (p< 0.05) in larval fish (6 days post-fertilization) exposed to water from the outfall and from the site 100 m below the outfall. The transcript-level impacts of exposure to complex mixtures of pharmaceuticals in wastewater effluent are also being investigated in laboratory-created pharmaceutical
mixture exposures with zebrafish and an in-stream exposure with juvenile fathead minnows (*P. pimephales*). Ultimately, the gene expression results from this study will inform a predictive model to correlate real-world mixtures of pharmaceuticals.

**356 Significant improvements to effluent discharged into the Grand River as a result of infrastructure upgrades at the major wastewater treatment plants**

N. Srikanthan, L. Bragg, E.K. McCann, H. Dhiyebi, P. Law, Region of Waterloo; M.R. Servos, University of Waterloo / Biology

Wastewater treatment plants (WWTPs) are traditionally designed to remove contaminants such as total suspended solids, phosphorous, and ammonia. Pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) are widely prevalent in wastewater but are not targets for removal in Canada, causing them to be discharged into surface waters. As a result, municipal wastewater is one of the largest contributors to surface water contamination. The Kitchener and Waterloo wastewater treatment plants (WWTPs) are the two largest WWTPs along the Grand River watershed in southern Ontario. The effluent discharged from both of these plants has been analyzed for various nutrients, PPCPs, and EDCs since 2010. Recently both plants underwent major infrastructure and treatment process upgrades. Effluent quality has been measured in pre, during, and post upgrade time periods, allowing for an evaluation of effluent quality as a result of upgrades. Grab samples were collected and extracted using solid phase extraction. The samples were analyzed using a biological assay (yeast estrogen screen) for total estrogenicity and chemical analyses for pharmaceuticals and specific hormone concentrations (LC-MS/MS) as well as nutrients. Results show a significant decrease in ammonia concentrations which is a major indicator of improved effluent quality (e.g. nitrification). Analysis of total estrogenicity and select hormones and pharmaceuticals (e.g. estrone, ibuprofen, and naproxen) also showed decreases corresponding to upgrades at both treatment plants despite these compounds not being specific targets of the upgrades. These compounds are removed through biodegradation and respond well to treatments with good nitrification and long solids retention times. However, many compounds remain detectable and some are recalcitrant to secondary treatment (e.g. venlafaxine, carbamazepine). Overall the upgrades implemented at these two plants have had a positive impact on the quality of the final effluent discharged. A corresponding improvement in indicators of exposure and health in fish populations downstream of the treatment plants have also been reported. This data will aid in developing relationships between contaminant exposure and secondary stressors, and validating predictive models linking contaminants to specific biological endpoints.

**357 Identification of Predominant Antibacterial Pollutants in Wastewater Treatment Plant (WWTP) Sludge by an Unbiased Chemical-Genetics Platform**

H. Barrett, University of Toronto / Chemistry; H. Peng, University of Toronto / Department of Chemistry

Antibiotic resistant bacteria (ARB) have been found in wastewater treatment plants (WWTPs), and recent studies have focused on their potential as hotspots for ARB development. It is necessary to identify the major chemicals in WWTPs that kill bacteria and lead to antibiotic resistance, but identification of the causative antibacterial chemicals remains elusive for current methods-- chromatographic and effects-directed analyses approaches have limitations in terms of specificity, recovery efficiency, and accuracy. We hypothesize that identifying the key protein(s) mediating the antibacterial potencies will enable us to apply pull-down untargeted chemical analysis (PUCA) to identify the causative chemicals. To achieve this goal, a hybrid workflow is applied wherein the key protein is first identified via chemical genetics screening. We have constructed His-tagged overexpression and SPA-tagged ‘knock-down’ libraries for all 300 essential genes in *E. coli*. This chemical genetics platform was tested for antibiotics with different modes of actions. His-tagged strains were effectively rescued in the presence of antibiotics targeting enzymes (e.g., trimethoprim-FolA, trimclosan-FabI) and membrane proteins (e.g. ampicillin-PbpG) but not larger ribosomal complexes (e.g. tetracycline-rpsA). To overcome this challenge, SPA-strains were tested and found to be susceptible to antibiotics targeting enzymes, membrane proteins, and ribosomal proteins while having increased sensitivity to antibiotic effects, making them ideal for real sample applications wherein antibiotics are present at low concentrations. Notably, a significant response was observed for a SPA-FabI strain at 4 µg/L of trimclosan, which is comparable to the sensitivity of mass spectrometry. The established platform was applied to identify the predominant antibacterial reagents in sludge samples from Ontario WWTPs. Initial screening has demonstrated that several SPA strains, such as SPA-FabI, are susceptible to sludge extracts which indicates that FabI may be the key protein mediating antibacterial potencies in WWTPs. PUCA methods established in our previous work were adopted to identify the exact chemicals physically targeting FabI proteins. This study is expected to establish an unbiased chemical genetics platform to identify antibacterial reagents in WWTPs, and the susceptible *E. coli* strains established in this study will provide a cost-effective method to bio-monitor antibacterial potencies in diverse environmental samples.

**358 The interactions of azole compounds with an anammox enrichment culture: Toxicity and biotransformation**

N. Lakhey, R. Sierra-Alvarez, J.A. Field, University of Arizona / Chemical and Environmental Engineering

Azole (five-membered heterocyclic aromatic compounds) are prominent emerging contaminants frequently detected in water and wastewater streams. This study investigates the effect of the presence of the azole compounds towards the anaerobic ammonium oxidation (anammox) process, which is an emerging and efficient biotechnology for nitrogen removal during wastewater treatment. The toxicity of eight widely used azole compounds, namely, 1H-benzotriazole, 5-methyl-1H-benzotriazole, 1H-benzotriazole-5-carboxylic acid, 3,5-dimethyl-pyrazole, 1-methyl-pyrazole, 1H-pyrazole, 1H,1,2,4-triazole and 1H-imidazole towards an anammox enrichment culture (AEC) was tested using batch bioassays. The key finding of the toxicity study was that the azole compounds were for the most part mildly toxic to the anammox process except for 1H-benzotriazole and 5-methyl-1H-benzotriazole. Amongst the azole compounds tested for their toxicity, 1H-pyrazole (PA) and 1H,1,2,4-triazole (TA) were found to be biotransformed when incubated with the AEC along with the usual anammox substrates, ammonium (NH4+) and nitrite (NO2-). Substrate scope experiments revealed that the presence of nitrate (NO3-) along with glucose significantly promoted the biotransformation process. Process optimization and kinetic studies were carried out. The AEC was found to bring about the biotransformation of PA and TA at a high rate of 0.22 mmol PA gVSS-1 d-1 and 0.24 mmol TA gVSS-1 d-1 respectively, under the optimal conditions. The uncultured heterotrophic microorganisms coexisting with the anammox bacteria in the AEC are hypothesized to be responsible for the biotransformation. Ongoing work includes characterization of the biotransformation products using LC-MS/MS techniques, and determination of the microbial diversity in the AEC. The results of the toxicity study provide a better understanding regarding the use of the anammox process in the treatment of both municipal and industrial wastewaters containing azole compounds. This study also highlights the ability of the AEC to biotransform and potentially degrade the azole compounds that were previously considered to be non-biodegradable.
Tuesday Platform Abstracts

Estimating Environmental Hazard and Risks from Exposure to Perfluorinated and Polyfluorinated Alkyl Substances (PFAS): Outcome of a Focused Topic Meeting

M.S. Johnson, US Army Public Health Center / Toxicology; I. Cousins, Stockholm University / Department of Environmental Science and Analytical Chemistry (ACES); R.C. Buck, The Chemours Company / Fluoroproducts; C. Weis, National Institutes of Health/NIEHS

Per- and polyfluorinated alkyl substances (PFAS) are largely surfactants and were historically used in multiple industrial applications, such as fire-fighting foams, anti-stain products for carpet and upholstery and heat-resistant, nonstick cookware and are increasingly found in biota and media within the environment. Together, these classes of compounds represent over 3,000 chemicals that can be persistent in the environment and in biota. A focused topic meeting/workshop was held in August 2019 to gather the latest science in chemistry, environmental fate, ecotoxicity, human health effects and risk characterization and to address how to best interpret these data and formulate a roadmap towards improving our understanding of risks. Specific charge questions were developed on this topic each set specific to one of the breakout session areas to include: analytical chemistry, exposure analysis, ecotoxicity, human health concerns, and risk characterization. The products of these breakout groups will be presented relative to the general trends discussed in these groups. Other outcomes will be summarized regarding trends in the available science and areas for further research for these unique substances.

359 Estimating Environmental Hazard and Risks from Perfluorinated and Polyfluorinated Alkyl Substances (PFAS): Outcome of a Focused Topic Meeting

360 Per- and Poly-Fluoro Alkyl Substances (PFAS): Environmental Sources, Chemistry, Fate and Transport - Report from the 2019 SETAC Focused Topic Meeting

M. Mills, US Environmental Protection Agency / National Risk Management Research Laboratory; S. Korzeniowski, BEC; J.L. Guelfo, Texas Tech University / Civil, Environmental, and Construction Engineering

The overall objectives of the SETAC focused topic meeting (FTM; August 2019) were two-fold: 1) to review new and emerging information on PFAS chemical classification and grouping, environmental chemistry, detection technology, fate and transport, exposure potential, human health toxicity, and ecological toxicity and 2) to harness the expertise of eminent scientists from around the globe with the goal of developing a risk assessment approach that considers mechanistic (including computational) approaches for extrapolating exposure and effects across different scenarios/species and compounds within environmental pathways for exposure. Our workgroup included 7 major presentations and a subsequent breakout group that identified fundamental aspects of the current state of the science, critical knowledge gaps, and future research needs. The seven major workstreams in our workgroup (sources, chemistry, fate & transport) were as follows: Key challenges and strategies for source-pathway evaluation and prioritization; Existing analytical techniques and areas of need for detecting and measuring PFAS; Identification of PFAS in the environment; Physical-chemical properties of PFAS, patterns that can be used to develop empirical models of environmental fate and transport, and application of physical-chemical properties towards defining source zones and source strength; Addressing long-term transformation of PFAS precursors in the environment; Current state of the science and advances in the systematic characterization and categorization of PFAS; Classification and grouping of PFAS for environmental risk assessment. This platform presentation will highlight workgroup outcomes and frame these findings within the broader scope and output of the PFAS FTM.

361 Research Needs for Better Understanding Pathways of Human and Ecological Exposures to Poly- and Perfluoroalkyl Substances (PFAS)


This presentation will provide a summary of presentations and discussions convened by the Exposure Assessment breakout group as part of the SETAC Focused Topic Meeting on environmental risk assessment of PFAS. Topics include current understanding of the global distribution of PFAS, exposures from drinking water and diet, the role of contaminated sites for elevated exposures, bioaccumulation in food webs, and toxicokinetics of PFAS in humans and wildlife. The focus of the presentation will be to highlight key gaps in knowledge identified in the breakout session that affect exposure and risk assessments for PFAS. We will also provide an overview of the state-of-the-science understanding in each topical area discussed.

362 Assessing the Ecological Effects of PFAS: Current Knowledge, Existing Uncertainties, and a Path Forward

G.T. Ankley, US Environmental Protection Agency / Mid-Continent Ecology Division; M. Houde, Environment and Climate Change Canada / Aquatic Contaminants Research Division; A. Kumar, CSIRO / Land and Water; Program- Environmental Contaminant Mitigation and Biotechnology; J.L. Newsted, Ramblel / Environmental and Health Sciences; R.P. Lanno, Ohio State University / Department of Evolution, Ecology, and Organismal Biology; C. Salice, Towson University / Biology; B.E. Sample, Ecological Risk, Inc.; M.S. Sepulveda, Purdue University / Department of Forestry and Natural Resources; S. Valsecchi, Water Research Institute - Italian National Research Council IRSA-CNR

This talk will provide an overview of the state-of-the-science and forward-thinking recommendations by an international group of experts tasked with considering assessment of the potential ecological effects of per- and polyfluoroalkyl substances (PFAS). While there have been hundreds of peer-reviewed publications examining different facets of the toxicity of PFAS in plant, invertebrate, and vertebrate species relevant to ecological risk assessment, most of this work has been conducted with only a small number of individual high-visibility PFAS and a few species. For example, a reasonable amount of data exist concerning the effects of perfluorooctane sulfonate (PFOS) on model aquatic invertebrate and fish species, but much less information is available concerning possible toxicological effects in plants, terrestrial invertebrates, and vertebrates such as amphibians, reptiles, birds and mammals. Also, there are little or no toxicity data for any species for most of the hundreds to thousands of PFAS that theoretically may enter and persist in the environment. Since testing resources are limited, there is a need to prioritize those PFAS of greatest concern in terms of possible ecological effects, and to identify/develop standardized, cost-effective approaches for testing when required. These approaches should employ, to the extent possible, a mechanistic understanding of biological pathways impacted by different PFAS so that likely susceptible species and endpoints are emphasized. A pathway-based understanding of toxicity would enhance the ability to extrapolate potential PFAS effects from tested to untested species and across different PFAS structures. Species-specific assay selection and experimental design also need to consider unique physico-chemical attributes of individual and PFAS mixtures that can be challenging in execution and interpretation. Similarly, there is a need for efficient analytical and biomonitoring tools to detect occurrence and possible effects of complex PFAS mixtures in the field. The contents of this talk do not reflect organizational policies of the coauthors.

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363 Human Health Effects from Exposure to Perfluorinated and Polyfluorinated Alkyl Substances (PFAS)

J. Smith, Navy and Marine Corps Public Health Center / Environmental Health; A. Boobis, Imperial College London / Centre for Pharmacology & Therapeutics; S. Roberts, University of Florida / Department of Environmental and Global Health

Per- and polyfluorinated alkyl substances (PFAS) are classes of compounds that have been used extensively in household products and in multiple industrial applications, such as fire-fighting foams, anti-stain products for carpet and upholstery and heat-resistant, nonstick cookware and are increasingly found in biota and media within the environment. Data from epidemiological studies are suggestive of many toxic endpoints; however, studies conducted in animals are varied and not consistently corroborated by the human data. This presentation will summarize the outcome of a focused topic meeting on this subject to include a synopsis of the outcome of specific charge questions involving the effects in humans from exposure to these substances. Additionally, uncertainties associated with the available database will be discussed to include areas of further research for these unique substances.

364 Characterizing the Risks from Exposure to Perfluorinated and Polyfluorinated Alkyl Substances (PFAS)

M. Dourson, Toxicology Excellence for Risk Assessment; A. Hinwood, EPA Victoria / Office of the Chief Environmental Scientist; T.I. Halldorsson, University of Iceland / Faculty of Food Science and Nutrition, School of Health Sciences

Characterizing the risk from exposure to per- and polyfluorinated alkyl substances (PFAS) has been varied between various jurisdictions. Data from epidemiological studies, studies conducted in experimental animals, and mechanistic data are varied and subject to different degree of uncertainty. As a result, interpretation of those data to safeguard public health and the environment is complex. Here we present the outcome of a SETAC Focused Topic Meeting and workshop on this subject and provide a summary of how various jurisdictions have interpreted the available experimental and observational data to develop health benchmarks. This presentation will also summarize the outcome of a breakout group session where experts in academia, government, and industry have worked together to address several target questions on moving forward towards the goal of consistently evaluating toxicity data for risk characterization. Additionally, uncertainties associated with characterizing risk from various lines of evidence and the relative importance of various exposure routes will be discussed.

365 Assessment of Potential Mercury Toxicity to Native Invertebrates in a High-Gradient Stream

J. Flanders, EHS Support, LLC; G. Long, EHS Support; B.J. Reese, AECOM / DHS Remediation; N.R. Grosso, Corteva / Environmental Remediation; W.H. Clements, Colorado State University / Fish, Wildlife and Conservation Biology; R.G. Stahl, DuPont (retired)

We recently presented the results of a study that evaluated the potential effects of mercury (Hg) on benthic macroinvertebrates in the South River, Virginia, USA (Flanders et al., 2019; IAM 15 (3): 374-384). This study, evaluated spatially and temporally matched sediment chemistry, population-level community metrics, and toxicity testing (Sediment Quality Triad), exposure and effect analysis in bulk and interstitial sediment and interstitial water, and critical body residue analysis. The results of this comprehensive evaluation of exposure and effects and illustrates the inadequacy of literature-derived screening benchmarks for sediment and body residue exposures. Ten-day Chironomus dilutus and Hyaletta azteca toxicity tests established site-specific no-effect concentrations (NOEC) at 18.9 mg/g total Hg (THg) and 102 ng/g methylmercury (MeHg). However, the benthic community at these locations was impaired, with lower mayfly and caddisfly composition. Few locations had concentrations of THg and MeHg that exceeded the NOEC in bulk or interstitial sediment. The THg concentrations in interstitial water were far below concentrations expected to reduce survival in benthic invertebrates, and only a low percentage of samples exceeded sublethal (growth) low-effect concentrations (LOEC) for THg or MeHg. The THg concentrations in invertebrate tissue did not exceed the NOEC or LOEC in the South River, and MeHg concentrations exceeded the LOEC at all locations, including those with no evidence of benthic impairment, illustrating the uncertainty associated with this line of evidence. Finally, statistical modeling that evaluated diversity of sensitive invertebrate species as a function of Hg exposure, geomorphological parameters, and physicochemical variables indicated that physicochemical and geomorphological parameters were most predictive of benthic community; where Hg was indicated, we were unable to distinguish between models with or without interstitial water Hg. Overall, the lines of evidence indicate that Hg, while clearly toxic to invertebrates at sufficiently high exposure concentrations, is not negatively impacting invertebrate communities in the South River. This study illustrates the difficulty of assessing risks to invertebrates using traditional tools of risk assessment and identifies critical gaps in knowledge that complicate the management of Hg risk.

366 Lines of evidence within risk characterization designed to evaluate the likelihood of adverse ecological effects

J.L. Peterson, Oregon Department of Environmental Quality / Northwest Region, Portland Harbor Section

Risk characterization is a critical but often underrepresented component of the ecological risk assessment process. Ecological risk assessment guidance proposed by the Oregon Department of Environmental Quality identifies qualitative and quantitative lines of evidence to evaluate the likelihood of adverse effects at cleanup sites. Lines of evidence focus on the adequacy of exposure and effects assessments to characterize those parameters that represent the greatest reducible uncertainty. The guidance identifies specific methodologies to ensure a clear presentation of the nature, magnitude, spatial distribution, and relevance of the risk estimates. These components are used to evaluate the likelihood of adverse effects in support of a risk determination, guide additional data collection to improve accuracy, or inform remedial decisions. Risk characterization lines of evidence will be presented along with real world examples.

367 Lessons Learned for Ecological Risk Assessment at a Legacy Chromalloy Plant


A baseline ecological risk assessment (BERA) was conducted for an 333-acre site which includes an abandoned ferrochromium alloy processing plant and legacy slag in the eastern US. The BERA for the site included upland, floodplain and in-stream aquatic habitat. COPCs include heavy metals, notably chromium. There are many lessons learned for this site, specifically regarding bioavailability of metals to ecological receptors and the way in which this site-specific information impacted the findings of the BERA. While there is a plethora of scientific research on lead and arsenic bioavailability for human health risk assessment since the passage of CERCLA in 1980, there is less attention paid to use of bioavailability to support ecological risk assessment. In vitro tests identify the bioaccessible fraction of a constituent which is the fraction that dissolves from its matrix (e.g., soil) in the gastrointestinal tract and is available for absorption. USEPA developed in vitro bioaccessibility methods for arsenic and lead exposure in humans. The Framework for Metals Risk Assessment (USEPA 2007), however, provides guidance for both human health and ecological risk assessment. In order to effectively evaluate exposure risk due to metals, the USEPA says: “risk assessors should adjust bulk metal concentrations by appropriate bioavailability factors to achieve comparable, actual uptake of metals by organisms.” That said, agencies often do not accept use of bioavailability for soil, sediment or prey items for ecological risk assessment because the analytical methods were developed
for humans, not ecological species, and this site was not an exception. Soil, sediment and invertebrate tissue were analyzed for 18 metals for bioaccessibility based on the USEPA Method 1340, with some modifications to reflect physiologic conditions of a bird and/or small mammal. The BERA was finalized to include the empirical bioaccessibility data in the upper trophic level receptor hazard indices, but also evaluated 100% bioaccessibility in the uncertainty section. Additional lines of evidence were generated including three biocriteria studies for the creek. The lines of evidence converged to indicate there was unlikely risk for receptor exposure to media at the site as well as Cross Creek.

368 Assessment approaches for data-poor substances: A walkthrough using examples from risk assessments under Canada’s Chemicals Management Plan

T. Francis, K.L. Potter, S. Gordon, Environment and Climate Change Canada

Under the Canadian Environmental Protection Act, 1999, Environment and Climate Change Canada and Health Canada assess and manage, where appropriate, risks of chemical substances to the environment and to human health. The Chemicals Management Plan (CMP) is a Government of Canada initiative to address approximately 4300 substances identified as priorities for assessment. This presentation will focus on risk assessment approaches used in the evaluation of substances that are lacking empirical data. Different assessment approaches that can be used to characterize physical-chemical properties, environmental distribution, bioaccumulation and ecotoxicity will be explored using specific examples from risk assessments currently being developed under the CMP. These examples may include substances such as naphthalene sulfonic acids, aliphatic amines, and benzothiazoles. Approaches discussed will include in silico, read-across and weight of evidence approaches.

369 Development of Ecological Risk-based Thresholds for Cs-137 Using Log-Linear Regression-based Bioaccumulation Models

R.E. Sample, Ecological Risk, Inc.; C. McCarthy, Jacoby; D. Wright, Jacobs Engineering Group, Inc.; S. Robinson, INTERA Incorporated / Toxicology Risk Assessment; A. Aly, INTERA Incorporated

Cs-137 is a radionuclide fission product from nuclear reactors and nuclear weapons. Nuclear fuel and weapons manufacturing, accidents, and above-ground weapons testing have resulted in elevated Cs-137 concentrations in some terrestrial environments. Risk from Cs-137 in soil to terrestrial biota is evaluated using models such as RESRAD-BIOTA. Bioaccumulation factors (BAFs) are a ratio of tissue-to-soil concentration used to estimate internal radionuclide concentrations. BAFs assume uptake is represented by a single, constant value over all soil concentrations. Analyses of metals and organics show non-linear uptake, with rates varying by concentration. Similar uptake relationships were expected for radionuclides. A dataset was developed from published measures of Cs-137 in terrestrial invertebrates, small mammals, shallow-rooted plants, and co-located surface soil. Regression analyses were performed on natural-log transformed tissue and soil data. Statistically significant regressions (with soil concentrations associated sensitivity analyses allow risk assessors to consider and predict effectiveness of remedial actions to reduce such risk. Even when model results are not documented in an ecological risk assessment, key areas of uncertainty on which to focus during the risk assessment. Additionally, population models often help explain why field observations of abundant wildlife populations seemingly differ from predicted adverse effects from laboratory toxicity studies. Examples of population modeling we conducted include evaluating lead shot ingestion effects on bird populations in Europe, dark-eyed junco exposure to mine-related copper, sora exposure to lead, and salmonid metapopulation exposure to selenium and total PCBs, passerine bird exposure to mine-related selenium and lead, and waterbird exposure to an oil spill. Through modeling, we found that population viability risk and magnitude of chemical effects differ depending on the (1) direction (increasing, decreasing, or stable) of the population trend; (2) level of suppression below carrying capacity by a chemical vs. natural stressor, (3) amount of natural environmental stochasticity, (4) frequency of catastrophic or bonanza (e.g., predation-release) events, (5) exposure area selected, (6) amount of compensatory mortality, and (7) rate of recovery once stressor is removed, which is strongly affected by density-dependent factors. Calibration of the baseline model to empirical data, often available in the literature, is key to increasing model accuracy. Accounting for habitat quality, the minimum viable population size, metapopulation dynamics, and overlap in mortality and reproductive effects are important to obtaining a realistic understanding of effects when the model is applied to the study site. Traditional risk assessments often ignore key endpoints or treat them in isolation, potentially leading to erroneous conclusions. Population modeling and associated sensitivity analyses allow risk assessors to consider and integrate all life stages and endpoints for a species and identify key factors driving risk. Once the primary risk-driving factors are determined, remediation can be optimally designed by addressing those factors.

370 Lessons Learned after 10 Years of Population Modeling for Ecological Risk Assessments

C.B. Meyer, A.B. Francisco, M. Buonanduci, ARCADIS US, Inc; E. Morrison, ARCADIS

Over the past 10 years, Arcadis has used population models to better understand risk to wildlife populations from exposure to toxic substances and predict effectiveness of remedial actions to reduce such risk. Even when model results are not documented in an ecological risk assessment, they are useful because they can cost-effectively provide guidance on key areas of uncertainty on which to focus during the risk assessment. Additionally, population models often help explain why field observations of abundant wildlife populations seemingly differ from predicted adverse effects from laboratory toxicity studies. Examples of population modeling we conducted include evaluating lead shot ingestion effects on bird populations in Europe, dark-eyed junco exposure to mine-related copper, sora exposure to lead, and salmonid metapopulation exposure to selenium and total PCBs, passerine bird exposure to mine-related selenium and lead, and waterbird exposure to an oil spill. Through modeling, we found that population viability risk and magnitude of chemical effects differ depending on the (1) direction (increasing, decreasing, or stable) of the population trend; (2) level of suppression below carrying capacity by a chemical vs. natural stressor, (3) amount of natural environmental stochasticity, (4) frequency of catastrophic or bonanza (e.g., predation-release) events, (5) exposure area selected, (6) amount of compensatory mortality, and (7) rate of recovery once stressor is removed, which is strongly affected by density-dependent factors. Calibration of the baseline model to empirical data, often available in the literature, is key to increasing model accuracy. Accounting for habitat quality, the minimum viable population size, metapopulation dynamics, and overlap in mortality and reproductive effects are important to obtaining a realistic understanding of effects when the model is applied to the study site. Traditional risk assessments often ignore key endpoints or treat them in isolation, potentially leading to erroneous conclusions. Population modeling and associated sensitivity analyses allow risk assessors to consider and integrate all life stages and endpoints for a species and identify key factors driving risk. Once the primary risk-driving factors are determined, remediation can be optimally designed by addressing those factors.

371 Risk-Informed Prioritization of Resources

F. Cooper, N.C. Garisto, ARCADIS Canada, Inc. / Risk and Radioactivity

A risk-informed approach can be used in deciding when to collect site-specific information rather than rely on literature-based values for an Ecological Risk Assessment (EcoRA). The proposed tool is a Sensitivity Analysis (SA): Step 1: Conduct Tier 1 EcoRA using parameter values from literature. Step 2: Perform a SA on key parameters. The SA can be carried out using a software add-on (i.e., Monte Carlo analysis) or simply by manually running the model multiple times (i.e., based on the upper and lower bounds of each parameter). Benefits of SA software include time saving, reduced error and the ability to assign a probability distribution function to each parameter. The SA will determine which parameters have more influence on the EcoRA results. For example, the SA may indicate that the EcoRA results are very sensitive to variations in toxicity reference values (TVRs) and in soil-plant transfer factors (TFs), and not as sensitive to water-fish TFs. Key parameters and their sensitivities will vary for different sites and receptors. Step 3: Informed by the SA results, design and implement a monitoring program. Field data can be used directly (such as pH) or in calculations to derive parameters such as site-specific TFs. Cost considerations can be applied, e.g., sampling food items, which is generally less expensive than sampling actual biota.
Step 4: Conduct Tier 2 EcoRA using site-specific parameter values where collected, and all other parameters from literature. This approach has been used successfully to refine EcoRA results using site-specific parameters derived from field campaigns. In one assessment, the SA determined that EcoRA results were heavily influenced by soil-water distribution coefficient \( K_d \); therefore, soil data were collected from the site and used to update the EcoRA. In another assessment, field results were used to confirm that the TRVs available from literature were conservative. In terms of prioritizing resources, there is also value in investing in biological field surveys at the outset of a project, specifically for the determination of presence/absence of Species At Risk. Because listed species are required to be assessed at an individual level rather than population level, site-specific information on the likely presence/absence of At-Risk Species will have a substantial impact on the EcoRA outcome.

372 Ecological Risk Assessment of heavy metals in sediment from three oil-producing regions in Ilaje Local Government Area of Ondo State, Nigeria

A.M. Olatunji-Ojo, D.O. Odedeyi, O. Olayinka-Olagunju, Adekunle Ajassin University / Department of Animal and Environmental Biology

Nigeria is one of the developing countries that depend largely on oil exploration as major source of revenue for economic development. More than 400,000 tons of oil has spilled into the creeks and soils of most oil producing communities in Nigeria, thereby, affecting the livelihood of host communities. The study aimed at evaluating the present health status of water bodies proximate to oil wells located in Ilaje communities using six pollution indices which comprises of three single pollution indices \{Contamination Factor (CF), Ecological Risk Factor (ER) and Index of Geo-accumulation (Igeo)\} and three Integrated pollution indices \{Pollution Load Indices (PLI), Potential Ecological Risk Index (RI) and Nemerow Pollution Index (Pnemerow)\} to quantify the extent or degree of heavy metal contamination in the sediment. Eight (8) heavy metals \{Cadmium (Cd), Iron (Fe), Copper (Cu), Lead (Pb), Nickel (Ni), Manganese (Mn), Chromium (Cr), Zinc (Zn)\} from sediment taken for five (5) months from three different regions of Ilaje (Ayetoro, Oreore and Aberoke) were analyzed using Atomic Absorption Spectrophotometer. Heavy metal concentrations range from: Cd (0.0607 - 0.1067ppm), Fe (152.5404 - 246.713ppm), Cu (0.5339 - 1.3073ppm), Pb (0.2612 - 0.5226ppm), Ni (0.1370 - 0.2339ppm), Mn (0.5643 - 0.7345ppm), Cr (0.1785 - 0.2423ppm), Zn (1.0753 - 1.7945ppm). All the pollution indices show the study sites are not polluted with low potential ecological risk. Result of Pnemerow also indicated the areas to be safety domains. Continuous monitoring of these areas using Bioindicators, especially when there is oil spillage, is therefore, recommended.

Relations Between the Bioaccumulation of Organic Chemicals in Aquatic and Air-Breathing Organisms

373 Reliable Methods for Predicting Octanol-Air Partition Coefficients for Use in Bioaccumulation Risk Assessment

S. Baskaran, University of Toronto, Scarborough / Chemistry; Y. Lei, University of Toronto / Physical and Environmental Sciences; F. Wania, University of Toronto, Scarborough / Department of Physical and Environmental Sciences

The potential for air-breathing organisms to efficiently eliminate relatively water-soluble compounds via urination can be assessed with the compound’s octanol-water equilibrium partition coefficient \( K_{OW} \). However, the elimination potential of a relatively volatile compound via respiration is dependent on its octanol-air partition coefficient \( K_{OA} \). Compounds with a log \( K_{OW} \) less than 2 or a log \( K_{OA} \) less than 5 are more readily eliminated. Numerous studies have measured and predicted the \( K_{OW} \) for thousands of structurally diverse organic compounds and values are often reported with a high degree of confidence along with associated uncertainties. This allows for the use of \( K_{OW} \) values in tier 1 chemical risk assessments. On the other hand, measured \( K_{OA} \) values exist for a little over 500 compounds, most of which are non-polar, halo-genated aromatics. In this work we present an overview of all measured \( K_{OA} \) values to date. Using this compilation of measured \( K_{OA} \) values, we assess the performance of multiple property estimation techniques based on poly-parameter linear free energy relationships (pplFERs), quantitative structure property relationships (QSPRs), and quantum-chemistry and statistical thermodynamics. In particular, we assess the prediction performance with respect to (i) temperature, (ii) a model’s applicability domain, (iii) a chemical’s functional groups and (iv) a measured value’s experimental technique. Of special interest is the uncertainty of log \( K_{OA} \) predictions close to the threshold for respiratory elimination of log \( K_{OA} \). \( K_{OA} \) values predicted with pplFERs using experimental solute descriptors agree best with values measured at 25°C; within the threshold region \((3 < \log K_{OA} < 7)\) the prediction uncertainty is ~0.3 log units and thus comparable to the measurement uncertainty.

374 Analysis of attenuating factors for terrestrial food web biomagnification of cyclic volatile methylsiloxanes

K. Plotzke, Dow Chemical Company / Consumer Solutions; D. McNett, The Dow Chemical Company / Toxicology Environmental Research and Consulting; J.A. Durham, Dow Corning Corporation / Toxicology and Environmental Research Consulting; K.B. Woodburn, The Dow Chemical Company / HES

The critical concern regarding bioaccumulation is the issue of biomagnification, specifically substances that accumulate via the food web to progressively higher concentrations that may toxicologically impact top predators and humans. The key question is how to best predict biomagnification, a complex ecosystem phenomenon that is difficult to model in the laboratory. A laboratory BCF from water uptake is often used as a surrogate for biomagnification. A BCF should only be considered a Tier 1, screening-level surrogate for biomagnification as it addresses only one level in the food chain and can be highly problematic in accurately characterizing dietary accumulation via the food chain. In this work, we examined the biomagnification of two volatile cyclic siloxanes, octamethylcyclotetrasiloxane (D4) and decamethylcyclopentasiloxane (D5), in aquatic food webs that terminated with terrestrial organisms and compared data to a recent terrestrial food web study. The toxicokinetics of volatile cyclic siloxanes D4 and D5 have been extensively studied in aquatic and terrestrial organisms up to and including humans. Studies assessing metabolism (in vitro and in vivo) and other important kinetic processes of D4 and D5 will be presented as attenuating factors as to why these materials do not demonstrate biomagnification (TMF>1) through analyzed aquatic/terrestrial food chains.

375 A Chemical-Activity-Based Approach for Assessing Bioaccumulation of Per- and Poly-fluoroalkyl Substances in Aquatic and Air-Breathing Organisms

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Per- and poly-fluoroalkyl substances (PFAS) are an important class of organic contaminants due to increasing evidence of environmental persistence, bioaccumulation potential and toxicity. This presentation will provide an overview of the current state of knowledge regarding PFAS bioaccumulation potential, including governing mechanisms and modeling approaches. We utilize a chemical activity-based modelling approach to further evaluate PFAS bioaccumulation in different food webs, with a particular focus on evaluating bioaccumulation behavior of PFAS in aquatic versus air-breathing organisms. Chemical activity \( (a, \text{unitless}) \) in a given medium is related to concentration \( (C, \text{mol/m}^3) \) by the corresponding solubility \( (S, \text{mol/m}^3), \text{(i.e.,} a = C/S) \). The available data show that bioaccumulation potential of perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkane sulfonic acids (PFASs) is highly related to perfluoroalkyl chain length. For example, bioconcentration factors (BCFs) are relatively
low for C8-C11 PFCAs (4.0-4.900 L/kg), whereas BCFs of longer-chain PFSAs (C12-C14 PFCAs) range between 18,000-40,000 L/kg. Field-based studies have shown trophic magnification factors (TMFs) of PFCAs and PFSAs in aquatic food webs are typically < 1, indicating no biomagnification. Conversely, TMFs in food webs containing birds and mammals generally exceed 1, indicating biomagnification in those air-breathing cations. Conversely, TMFs in food webs containing birds and mammals are elevated above those in environmental media and prey organisms, primarily due to efficient gastrointestinal uptake and negligible elimination via key depuration pathways (i.e., urinary, biliary, respiratory, biotransformation). Lastly, key uncertainties and knowledge gaps related to bioaccumulation behavior and exposure assessment of PFCAs, PFSAs, as well as other PFAS of emerging concern will be highlighted.

376 PCB metabolism by benthic organisms vs. otters in the Green-Duwamish River (Seattle)

L.A. Rodenburg, Rutgers University / Environmental Sciences

Fingerprinting of data from the Green-Duwamish River was used to determine polychlorinated biphenyl (PCB) sources to organisms including benthic (amphipods, clams), fish (six species), shellfish (three species) and otters (in scat). The data sets included 128 samples of tissue from benthic, fish, and shellfish species, and 73 samples of otter scat and were analyzed by Positive Matrix Factorization to identify PCB source fingerprints. One of the five fingerprints isolated from analysis of the tissue data resembled Aroclor 1260 but displayed characteristic evidence of cytochrome P450 metabolism. This fingerprint was present in all of the organisms tested, with the highest proportions in fish and lowest in benthic organisms. Analysis of the otter scat data yielded two fingerprints that were dominated by the unmetabolized coeluting congeners groups 83+99, 129+138+160+163, 153+168, and 180+193. One of these two otter scat fingerprints was higher in molecular weight (MW) with proportionately more 180+193. These two fingerprints explain 67% of PCBs found in otter scat and display variation by location, with samples from the Duwamish River near Seattle displaying the higher MW metabolized congener pattern, and samples from the more rural upstream areas of the Green River displaying more of the lower MW metabolized fingerprint. These results suggest that organisms at all trophic levels metabolize PCBs. Metabolism was most evident in fish tissue and otter scat. Benthic organisms displayed less, but still noticeable, metabolism.

377 A Macro Review on Bioaccumulation and Biotransformation of Many Organic Compounds in Birds

D. Kuo, City University of Hong Kong / Architecture and Civil Engineering

Birds constitute an important animal class with diverse habitats, trophic interactions, and ecological roles in the biosphere. To better grasp the knowledge gaps and research needs on bioaccumulation and biotransformation of organic chemicals in avian species, published experimental studies and reports were reviewed. Review efforts focus on the reporting of bioaccumulation metrics, toxicokinetics, pharmacokinetics, cytoxicological responses, metabolic pathway, taxonomy, and exposure condition. Approximately 15,000 data entries (~1,000,000 filled cells of information) were compiled following a critical review of over 300 primary bioaccumulation, biotransformation, and pharmacokinetic studies. The review so far covered some 400 organic contaminants on close to 300 wild avian species and domestic breeds. The overall bird bioaccumulation and biotransformation data/information space generally differs substantially with those associated with fishes or aquatic invertebrates. In bird studies, bioaccumulation and toxicokinetics are frequently quantified or depicted in terms or metrics different from the established modeling framework in ecotoxicology. Furthermore, field bird surveys often use tissue concentrations alone to indicate the bioaccumulation of target chemicals without reporting concentration or chemical activity of any reference exposure medium. The mobility and foraging behavior of birds also implies uncertainties associated with spatial/medium distribution of target chemicals and dietary makeup of the individual must be properly factored in the characterization of field bioaccumulation potential. Consequently, a number of alternative metrics have been proposed to characterize the bioaccumulation of chemical in birds under diverse experimental protocols. Biotransformation kinetics is generally less well characterized in birds than in fishes or invertebrates. While in vitro characterization based on targeted enzymatic activities are available, a significant portion of these measurements pertain to the baseline activities or responses. Much endeavor and cooperation is needed for advancing bioaccumulation and biotransformation science in birds, and plausible future directions are discussed.

378 Uptake, Deposition and Metabolism of the Flame Retardant and Plasticizer Triphenyl Phosphate in Eggs and Chicks of Japanese Quail

R.J. Letcher, Environment and Climate Change Canada / Ecotoxicology and Wildlife Health Division; S.C. Marteinson, Government of Canada / Environment and Climate Change Canada; M.F. Guigueno, McGill University / Department of Natural Resource Sciences; K.J. Fernie, Environment and Climate Change Canada; J. Head, McGill University / Natural Resource Sciences

Organophosphate esters (OPEs) are extensively used as flame retardants (FRs) and plasticizers in a variety of products including building materials, textiles, and electronic equipment. An important and current-use OPE is triphenyl phosphate (TPHP), and the production and use of TPHP has increased since the phase-out and regulation of polybrominated diphenyl ether (PBDE) FRs. Concentrations of OPEs in biota are generally considerably lower than for PBDEs, suggesting OPEs (including TPHP) may have comparatively low bioaccumulative potential. Understanding the toxicokinetics and metabolism of TPHP is essential to the exposure, fate and subsequently the risks posed to wildlife by this OPE. The objective of this study was to determine the in vivo uptake, deposition and metabolism of TPHP by Japanese quail (Cortunix japonica) embryos and chicks as well as the formation of a major metabolite diphenyl phosphate (DPHP). Quail were dosed with TPHP at low, medium and high concentrations by air cell egg injection followed by daily oral dosing and compared to vehicle-only exposed controls. Eggs were assessed for TPHP and DPHP at 2 days (prior to any hepatic development) or 10 days after (post-hepatic development) injection, and chicks were assessed at 6 days post-hatch. TPHP was measured in all eggs and chicks from the dosed groups, as well as in control samples albeit at low levels. DPHP was detected in all exposed eggs and chicks at concentrations that increased with the dose. Not all of the depleted TPHP was accounted for by DPHP formation in eggs although DPHP appears to be an important or dominant metabolite in the quail, making up 41-74% of all metabolites formed in eggs. TPHP was rapidly depleted and metabolized in Japanese quail where only 33% of the injected TPHP remained in eggs 2 days post injection, and 2% after 10 days with half-lives ranging from 1.1 - 1.8 days for the three exposed groups. In medium- and high-dose chicks, DPHP concentrations exceeded those of TPHP making up 67% and 76% of the total burden, respectively. The fact that DPHP was formed indicates Phase I CYP-mediated metabolism of TPHP in quail eggs and chicks. TPHP is rapidly metabolized in developing quail embryos, and TPHP concentrations may vary greatly with the age of the embryo and the stage of its development, and thus maternal exposure to TPHP itself may be difficult to elucidate in wild eggs.
379 In Vitro Demethylation of Environmentally Novel and Highly Brominated and Methoxylated Contaminants in Herring Gull Hepatic Microsomes

T.A. Smythe, Carleton University / Chemistry; R.J. Letcher, Environment and Climate Change Canada / Ecotoxicology and Wildlife Health Division

One trend for newer replacement organic brominated flame retardants (BFRs) appears to be towards higher molecular weight and highly brominated chemicals, such as oligomeric polyhalogenated polynucleic ethers (PHPEs), or polymer flame retardants (e.g. PolyFR). Despite their intrinsically low bioavailability and instability, it is increasingly evident that abiogenic and/or microbial degradation processes can substantially impact their environmental recalcitrance. We have shown that the bio- transformation of emerging BFRs in wildlife species (e.g. birds, fish and marine mammals) is very poorly understood. Since 2015, only one study has investigated the metabolism of BFR degradation by-products, i.e. the in vitro hydroxylation of the photolytic breakdown-products of the PHPE flame retardant tetraedecabromo-1,4-diphenoxynbenzene (TeDB-DiPhOBz) in herring gull (HG, Larus argentatus) liver microsomes. It was hypothesized that HGs were metabolically capable of producing methoxylated polybrominated diphenoxynbenzenes (MeO-PB-DiPhOBz); which are novel contaminants reported in Laurentian Great Lakes HG eggs and tissues; following the dietary accumulation of the TeDB-DiPhOBz photolytic breakdown-products and subsequent hydroxylation and methylation metabolic processes. Our recent measurements of MeO-PB-DiPhOBzs in HG regurgitant, as well as in the soil surrounding selected HG nest sites, suggests instead that MeO-PB-DiPhOBzs are bioavailable and bioaccumulative contaminants, and that HGs are exposed to them directly (e.g. via the diet). To assess the metabolic capacity of HGs for clearance/transformation of these contaminants, the objective of the present study was to utilize existing HG liver microsomal (LM) biotransformation assays for the structure-specific demethylation of 5x unique tetrabromo- and 5x pentabromo-MeO-PB-DiPhOBzs to their corresponding hydroxylated-(OH)-PB-DiPhOBz congeners. Assays were established in both rat (Wistar-Han) LMs and HG LMs using 6-MeO-BDE-47 as an active control across 8 concentrations (0.01 to 10 µM) and 9 time points up to 100 min. The Michaelis-Menten constant (Km) and maximal reaction rate (Vmax) for demethylation was determined for all MeO-PB-DiPhOBzs that exhibited significant depletion. These results suggest that HGs are metabolically competent in the demethylation of MeO-PB-DiPhOBzs, and may suggest a possible route of clearance of these contaminants by the HGs.

380 The case for simple bioaccumulation models for air- and water-breathing organisms

A. Celsie, Queens University; D. Mackay, J. Parnis, Trent University / Chemistry

A key criterion for identifying chemicals of concern is bioaccumulation, usually using bright-line criteria for bioconcentration based on the octanol-water partition ratio (KOW). Using these guidelines has recently led to misidentification of some chemicals drawing criticisms and recognition that it may be time to move beyond simple bright-line criteria. For example, the use of Kow can misidentify chemicals that bioconcentrate in air-breathing species or chemicals that are subject to slow uptake or biotransformation. We suggest that there is a need for simple, freely available and transparent bioaccumulation models for both water and air-breathing species including fish, birds, and mammals using illustrative organism properties. An attractive approach is to base the models on the fugacity concept, explore the dependence of steady-state organism fugacities and concentrations on the input fugacities for water, air and diet and identify conditions under which biouptake results in fugacity magnification (equivalent to biomagnification) from respired water, air or diet. Also interesting is the time required to achieve, or recover from, a steady state fugacity. Since fugacity is the basic driving force for bioconcentration, bioaccumulation, biomagnification, and trophic magnification it makes sense to employ it directly in biotake models as a step towards determining concentrations. Using a simple model available in spreadsheet format has two advantages. First, the model can be used for educational purposes and can readily demonstrate the fundamental causes of bioaccumulation and biomagnification, the relative contributions of diet, respiration and the mitigating roles of biotransformation, growth dilution, and reproductive losses. Second, the model can be used for preliminary evaluation of new chemicals to assess the potential of a particular chemical to cause high fugacity or concentration for a range of selected species. If such potential is identified it may justify the use of more detailed, complex, and rigorous models or tools (such as AQUAWEBC or BAT) that can provide a more in-depth analysis. In this presentation such simple models are described for fish, birds, terrestrial and marine mammals. References: 1. McLachlan, M. S. Environ. Sci. Process Impacts, 2018, 20, 32-37. Arnot, J. A.; Gobas, F. A. P. C., Environ Toxicol Chem 2004, 23(10), 2343-2355. Armitage, J. M.; Toose, L.; Embry, M.; Foster, K. L.; Hughes, L.; Arnot, J. A. The Bioaccumulation Assessment Tool (BAT) Version 1.0., Developed by ARC Arnot Research and Consulting Inc.: Toronto, ON, Canada, 2018.

Western Research Methods and Indigenous Knowledge: Collaborative Approaches Towards Environmental Quality and Integrity

381 Tribal/EPA Collaboration to advance chemical risk assessments in the US

D.C. Barton, Columbia River Inter-Tribal Fish Commission; F. Corey, Aroostook Band of Micmacs; L. Zender, Zender Environmental Health and Research Group

The National Tribal Toxics Council (NTTC), Tribal Pesticide Program Council (TPPC) and Tribal Science Council (TSC) collaborate with the United States Environmental Protection Agency (EPA) to address issues related to indigenous populations’ exposures to chemicals. The goal of this collaboration is to characterize how tribal exposures to chemicals may differ from that of the general population due to unique tribal customary, cultural, ceremonial and subsistence practices and to identify exposures that result in elevated risks to tribal members. This presentation will highlight key elements of this collaboration and demonstrate how indigenous knowledge can inform the science of exposure and risk assessment. Tribal lifeways are inclusive of, but not limited to, economic, cultural, ceremonial, recreational and subsistence practices. Tribal lifeways include the use of the local ecology for food, medicine, education, religion, occupation, income and all aspects of life. Tribal lifeways stem from tribal culture, which is not an optional lifestyle choice, but rather an essential part of a tribe’s identity. Culturally specific subsistence consumption of locally-harvested foods is particularly important in evaluating tribal exposures. Also, tribal exposures may be influenced by historical patterns of residential construction, unique regional transportation options, and the management of water and waste on tribal lands. While cultural and traditional practices may result in unique exposures for tribes, other factors are important. For example, tribal lands exist in a wide range of geographies and climates that may result in exposures that differ from those of the general population. A current focus of the effort is to ensure that the potential for elevated exposures and risks is considered under the new Toxic Substances Control Act (TSCA). Under TSCA’s risk evaluation process, the EPA is required to “determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator under the conditions of use.” Our collaborative efforts to develop tribal exposure scenarios as an initial case study will inform the evaluation of potentially exposed populations, including tribal populations, in TSCA risk evaluations.
Tuesday Platform Abstracts

382 Empowering Māori indigenous knowledge for better environmental quality and integrity outcomes for New Zealand
J.M. Ataria, Cawthron Institute; R. Tuia-Gordon, Te Kawerau-a-Maki; D. Whaanga, Te Ao Mārama, Inc.; L.A. Tremblay, Cawthron Institute; O. Pantos, ESR; G.L. Northcott, The New Zealand Institute for Plant & Food Research Limited; V. Baker, Institute of Environmental Science Research Limited

Aotearoa New Zealand is not immune to the unaltered anthropogenic environmental pressures affecting all terrestrial, freshwater, marine and atmospheric environments today. In the global rally to tackle increasingly complex wicked problems, there is growing recognition of the importance of indigenous ecocentric worldviews. Here in Aotearoa New Zealand, there is increasing commitment to employing the unique corpus of Māori knowledge alongside western science to address issues like environmental contamination. Further, there is an expectation that Māori, the indigenous people of Aotearoa New Zealand, should be integral involved in natural resource management and strategies to mitigate impact. Robust methodologies to support a meaningful interface and respectful knowledge sharing between indigenous and western science are still evolving, and despite the benefits that can be derived from good collaborations, the quality of engagement is not always satisfactory. Poor interpersonal relationships, inequity and undervaluing of Māori knowledge are just beginning points to consider in the work of supporting indigenous knowledge systems to help re-purpose global and western thinking for environmental sustainability principles and practice. By providing an appropriate historical context, this talk will consider the critical issues now facing Māori and their corpus of knowledge. This gives a lens to consider and identify fundamental requirements that will support international efforts to apply indigenous principles and knowledge within an ecotoxicological, research and natural resource management context.

383 Indigenous science, anti-colonial science, and community-based Western science on marine plastic pollution in Nunatsiavut
M. Libaion, Memorial University / Department of Geography; N. Healey, Memorial University

Settler colonialism is an ongoing structure that, through a diversity of interlocking techniques, maintains settler access to land for settler goals. As many Indigenous people well know, some of these techniques are exercised through research. After introducing the concept of research colonialism, this talk articulates the efforts of CLEAR, an Indigenous-led, marine plastic pollution laboratory that conducts research in Nunatsiavut, to do environmental science by creating and using Indigenous, anti-colonial, and community-based protocols affiliated in Western science. Differentiating between these different approaches is one of the aims of this presentation. Using cases of methodological protocols, we show how rather than integrating (or appropriating) Traditional Ecological Knowledge into Western science projects, CLEAR works to enact Metis and Inuit values of humility, reciprocity, balance, and respect at every stage of research, from how we design research instruments, to how and with whom we collect environmental samples, to how we “dispose” of samples after use. We will discuss some of our anti-colonial protocols and their politics, including community peer review, sampling techniques for food sovereignty, and animal respect protocols as they have been developed and used in plastic pollution research in Nunatsiavut.

384 Commission for Environmental Cooperation (CEC) Project 15: Proper Functioning Condition (PFC) Assessment Report
K. Charles, H. Charles, Chippewas of Georgina Island First Nation; R. Hall, USEPA; D. Mosley, Pyramid Lake Paiute Tribe / Fisheries Department

The Commission for Environmental Cooperation (CEC) facilitates collaboration and public participation to foster conservation, protection and enhancement of the North American environment for the benefit of present and future generations, in the context of increasing economic, trade, and social links among Canada, Mexico, and the United States. CEC supported projects have often focused on preventing degradation of natural resources (essential plant communities, water quality and quantity, etc.) by improving ecological function conditions; enhancing collaboration between North America countries’ natural resource and environmental agencies to address preservation and restoration of ecosystem resilience; and engaging local communities in order for watershed protection to be sustainable. In this context, preserving Traditional Ecological Knowledge (TEK) or Indigenous Knowledge (IK) has been an important objective. Ecosystems are defined as an interconnected community of vegetation, soils and landform, hydrology, and microorganisms linked by physical and chemical interactions. Ecosystems provide a sustainable flow of natural resources and ecological services required to meet the nutritional, cultural, societal and economic needs of indigenous populations. The hydrologic, physical and ecological alterations resulting from terrestrial activity can have a pronounced impact on the natural function of uplands, and stream and wetland riparian areas. This presentation will focus on CEC Project 15, done in collaboration with the Chippewas of Georgina Island, which sought to address the concepts of sustainable ecosystems and communities by using and identifying what role TEK/IK plays in indigenous communities’ approach to natural resource management. TEK/IK provides the foundation for integrated riparian management focused on riparian and upland ecological function relationships. The presentation will highlight the collaborative interactions, based in both TEK/IK and the science of proper functioning condition (PFC) to achieve the this first nation’s goal of restoring a natural stream on Georgina Island.

385 An assessment of the Efficacy of Utilizing Restored Anadromous Fisheries Resulting from Dam Removal in Support of Tribal Sustainability and Sustainability
M. Stover, USEPA Region 1; D.H. Kusnierz, Penobscot Nation / DNR; J. Lin, L. Melnyk, USEPA Cincinnati / National Exposure Research Laboratory; K. Pugh, ATSDR; G. Perelman, ATSDR; J.M. Lazorchak, US Environmental Protection Agency / ORD/NERL/Systems Exposure Division

American Indian tribes have unique traditional cultural practices that are often not adequately protected by classic regulatory approaches. The sustenance fishing practices and rights of the Penobscot Nation (Nation) are currently impacted due to unsafe levels of dioxins, furans, PCBs, and mercury found in the tissues of resident fish species from the Penobscot Reservation. However, recent river restoration efforts, including dam removals, have resulted in the abundant return of several anadromous fish species to waters where Penobscot tribal members fish for sustenance, where these species have been missing for over the past 100 years. Consumption of these species of returning fish will likely restore a major component of the tribal members’ traditional diet. However, information regarding contaminant levels in these fish is needed to guide the Nation with respect to safe consumption. EPA, in collaboration with the Nation and the Agency for Toxic Substances and Disease Registry (ATSDR), assessed the safety of human and wildlife consumption of six species of anadromous fish, Alewife, American Shad, Blueback Herring, Rainbow Smelt, Striped Bass, and Sea Lamprey plus one of roe from American Shad. Fish were collected and filleted in the field by the Nation’s DNR with assistance from EPA. Fillets were then analyzed by EPA in 2017 and 2018 for mercury, PCBs, dioxins and furans. A preliminary assessment of mercury levels in these fish was compared to reference doses as established in the US Integrated Risk Information System (IRIS) and wildlife values. The concentrations of mercury ranged from around 10 µg/kg in roe samples to around 650 µg/kg in sea lamprey. Current health advisories in the area are set at sufficient levels to protect tribal sustenance fishers from harmful consumption of the fish species, except for Sea Lamprey. Using a consumption wildlife value of 70 mg/kg for Mink and 100 mg/kg for Otters, the results indicate that Alewife, Striped Bass and Sea Lamprey pose a risk to Mink, while Rainbow Smelt, Striped Bass and Sea Lamprey pose a risk to Otters. The results of PCBs, dioxin and furans will also be presented in a one health approach included in a public health
assessment the influence of colonization on our approach to scientific inquiry and understanding of ecological health. It will shed light on the benefits of new approaches to environmental decision making that include other bodies of knowledge such as Indigenous Ecological Knowledge. This will be done through the review of two case studies both of which use varying approaches to weaving knowledge systems in order to arrive at a place where environmental decision making can be made. Case study 1 will explore a novel approach to a risk assessment of a contaminated harbour. Case study 2 examines the influence of mercury on traditional food sources and the importance of creating culturally appropriate safe food consumption guides. Through these case studies we will speak to the processes, challenges, and benefits that come with such collaborative approaches to tackling environmental issues.

Wildlife Ecotoxicology: Assessing Effects of Chemical Stressors at Multiple Scales

389 Wildlife Ecotoxicology: High Time for the Top-down Approach as the Essential Forensic Tool

L.V. Tannenbaum, US Army Public Health Center / Army Public Health Center

A fully plausible approach to understanding and assessing contaminant exposure concerns for wildlife, recognizes that contaminated environments have had all the chances they could have possibly needed to severely impact ecological receptors. This admittedly controversial approach argues that the time is well past for ‘bottom-up’ tasks such as engaging with assessing risks, or modeling how contaminants move through ecosystems in support of predictions of toxicological effects that might come to be expressed. The more appropriate approach is to directly assess the health of the actual receptor of concern in the field (in a ‘top-down’ fashion). This presentation will report on several such field-based assessment types. These include a) successes of applications of the ASTM certified Rodent Sperm Analysis method, which has effectively solved the chemical mixtures riddle, b) potential for wild rodent ovarian follicle counting (WROFC) to also demonstrate absent reproductive impacts in terrestrial mammals, and c) illustrate with GPS tracking data, that commonly assessed larger mammals are spatially irrelevant at conventional contaminated sites. Collectively, the information to be presented strongly suggests that a dramatic paradigm shift is in order for addressing wildlife ecotoxicology concerns.

390 Embryotoxicity of diluted bitumen applied to eggshells of wild double-crested cormorants and domestic chickens

M.D. King, Simon Fraser University / Biological Sciences; J.E. Elliott, Environment and Climate Change Canada / Science and Technology Branch Ecotoxicology and Wildlife Health Division; T. Williams, Simon Fraser University / Department of Biological Sciences

Breeding birds that become oilied may return to incubate their eggs, but even small quantities (>=1 ul) of conventional crude oils are embryotoxic when applied to the exterior of the eggshell. Therefore, we investigated whether an unconventional oil sands product, diluted bitumen (dibit), was toxic to embryos of two species, domestic chickens (Gallus gallus) and wild double-crested cormorants (Phalacrocorax auritus). We incubated embryos in artificial egg incubators and applied various doses of lightly weathered dibit ranging from 1 to 20 mg to the eggshells during early or late development. In both species, eggshell oiling with dibit caused no significant decrease in embryo survival at sampling (85% development). Furthermore, in chicken embryos exposed during late development, we found no significant difference in growth, haematoctict, haemoglobin, or heart rate. We present additional preliminary growth and heart rate data in double-crested cormorants, as well as more sensitive gene expression analysis data. We discuss briefly how the chemical composition of dibit, including polycyclic aromatic hydrocarbon profile, physical properties of dibit, and the weathering process may contribute to the apparent lack of effect on survival, growth, or aerobic capacity in these species compared to similar studies with conventional crude oils. This study indicates that
391 Arctic seabirds: Do contaminants influence their ability to respond to climate change?

K.J. Fernie, Environment and Climate Change Canada; R.J. Letcher, B.M. Braune, Environment and Climate Change Canada / Ecotoxicology and Wildlife Health Division; J. Head, K. Elliott, McGill University / Department of Natural Resource Sciences

In the Arctic, wildlife encounter multiple environmental stressors, including climate-related changes, ice availability, and chemical pollutants. Because the endocrine system has a critical role in allowing animals to respond to environmental stress (e.g., changing ice patterns), endocrine disruption could influence the ability of wildlife to respond to climate change. We investigated whether contaminants compounded the impact of climate change on Arctic seabirds by limiting their ability to respond to changes in ice availability. During our study, thick-billed murres (Uria lomvia) experienced significant dietary changes, the earliest (2017) and latest (2018) ice conditions and hatch dates in 40 years, as well as average ice and breeding conditions (2016). Nearly 170 thick-billed murres were sampled, including foraging behaviors, circulating hormones and mercury (Hg), and in a subset of birds, per-/polyfluoroalkyl substances (PFASs), and brominated flame retardants (BFRs). The presence of ice determined the birds’ foraging locations that varied annually, as did the composition of their diet, both reflected in dietary proxies (stable isotopes). Dietary proxies explained much of the annual variation in high Hg levels, but not in PFCArs, PFASs, or BFRs that were low and unrelated to hormones or behaviour. During the medium-ice year (2016, positive relationship) and low-ice year (2017, negative relationship), high Hg levels were related to circulating T3, and in turn, T3 was related to time spent diving for prey, directly in contrast to the high-ice year (2018, no relationships). Based on our findings, we tentatively conclude that Hg may be influencing the ability of thick-billed murres to adjust to variation in ice cover, but only in years when ice leaves unusually early.

392 A tail of two birds: Contrasting diet mediated contaminant burdens in herring gulls and double crested cormorants

S. de Solla, Environment and Climate Change Canada / Wildlife Landscape and Science Directorate; K. Hughes, Broadening Biological Consulting; G. Barrett, Environment and Climate Change Canada / Wildlife and Landscape Science Directorate; C.E. Hebert, Environment and Climate Change Canada

Diet is an important factor for determining exposure of bioaccumulative persistent organic pollutants to high trophic level vertebrates, such as colonial waterbirds. The Great Lakes Herring Gull Monitoring Program has proved valuable in contributing to our understanding of food web dynamics and the importance of understanding diet in interpreting contaminant and related data. We assessed relationships between diet, as assessed using stable isotopes (δN, δC) and essential fatty acids, with contaminants burdens in eggs of herring gulls (HERGs) from 2015 to 2018 and from 15 colonies in the Great Lakes. Eggs of double crested cormorants (DCCO) from some of the same colonies were also collected and analyzed for the same suite of contaminants providing a unique ability to compare similarities and differences in contaminant burdens between a generalist for the same suite of contaminants. DCCOs clearly had a greater aquatic diet than HERGs, intercolony variability in diet had more profound effects on egg burdens in HERGs than DCCOs and both enrichment in δN and ω3:ω6 influenced contaminant burdens in eggs of HERG more than DCCOs. Despite their similarities, cormorants and gulls provide complimentary information about both the food web and contaminant exposure in the Great Lakes.

393 Pesticide exposures in hummingbirds and honey bees in Blueberry agriculture in British Columbia, Canada

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Globally over 300 species of hummingbirds contribute substantially to both the biodiversity and ecosystem services as pollinators. Recently however studies in Canada determined for the first time that hummingbirds are exposed to pesticides and they are detectable in their urine and feces. Imidacloprid is most commonly detected but also clothianidin and thiamethoxam and, in 2018, we also detected flupyradifurone in hummingbird urine. Furthermore, pesticide synergists used to enhance pyrethroid toxicity are also detected in hummingbird feces and in sediments from irrigation ditches near blueberry crops. In 2017, we sampled hummingbirds throughout Vancouver Island, and the dry interior of BC, and in parks within Saskatchewan. Neonicotinoid detections in hummingbirds were associated with sites near agricultural areas primarily fruit growing areas and highest concentrations were found in the Fraser Valley sites near blueberry fields. In 2018, measurements of pesticides in hummingbird food sources such as flowers, and flower nectar in honey bee hives within our study sites, and water and sediment samples near to berry crops/our study sites in British Columbia, Canada traced hummingbird exposure to sites on and near to the sprayed fields. Concentrations of neonicotinoids found in honey bee nectar are 1-10 µg/kg which literature reports indicate are associated with chronic sublethal effects in honey bees.

394 Intraspecific Variation in Metal Tolerance Across the Landscape Provides Insight into Evolutionary Responses

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Wetland ecosystems experience widespread contamination from human activities. The conditions in these environments are often novel and beyond the range that organisms have adapted to. When faced with novel stressors, populations may go locally extinct if fitness is severely reduced. Alternatively, populations can be rescued by phenotypic plasticity and/or local adaptation. Amphibians are particularly tied to wetland habitats and are highly sensitive to contaminants. However, we know little about the evolutionary responses of amphibian populations to metal contamination. In this study, we leverage nine years of data on patterns of metal tolerance in southern toads, Anaxyrus terrestris, across the Savannah River Site (SRS). The SRS provides a landscape with hundreds of wetlands and heterogeneous patterns of contamination, including constructed wetlands of varying ages and well documented metal mixtures. We used a combination of microcosm, mesocosm, reciprocal transplants, quantitative genetics, and elemental analyses to investigate among population tolerance to metal contamination. Our data demonstrate that populations newly exposed to copper contamination may initially experience reduced fitness, but that local adaptation can occur within 10 generations. In addition, we found evidence that populations can locally adapt within 20 generations to partially ameliorate the fitness reductions associated with metal mixtures from coal combustion wastes. Elemental analyses suggest that the mechanism for adaptation may involve maintaining ionic balance in the presence of osmotic stress induced by metal exposure. Surprisingly,
individuals from populations adapted to coal combustion wastes do not have elevated tolerance to copper, indicating that adaptation does not yield cross-tolerance. Local adaptation appears to come with multiple costs; offspring of parents from a contaminated site can experience reduced larval performance in other environments and juveniles display lower survival and performance. Ultimately the persistence of populations in contaminated environments may depend not only on the potential for local adaptation, but also the costs of tolerance and the spatial and temporal variation in the presence of contaminants.

395 Chronic effects of sewage effluent, EE2 and fluoxetine as well as depuration rates of perfluorooctane sulfonate on male hatching Snapping Turtles

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Pharmaceuticals, personal care products (PPCPs) and Perfluorinated Alkyl Acids (PFAAs) are widespread environmental contaminants frequently detected in the aquatic environment. The persistence and environmental effects of these compounds is not fully understood leading to a heightened research interest evaluating their impact on taxa. Some PPCPs are incompletely removed or degraded to bioactive metabolites during processing at municipal wastewater facilities. Similarly, the use of PFAAs in aqueous film forming foam (AFFF) has been linked to substantial environmental contamination, following its use as a fire retardant for fuel-based fires at airports. Snapping turtles (Chelydra serpentina), being quite tolerant of organic enrichment, are commonly found below Municipal Waste Water Effluent (MWWE) discharges leading to exposure to PPCPs. Previous studies have measured high concentrations (>1 ppm wet weight) of the PFAA, perfluorooctane sulfonate (PFOS), in the plasma of snapping turtles collected near international airports. Male hatching snapping turtles, collected as eggs from a relatively pristine location (Algonquin Park, northern Ontario, Canada) were reared in a laboratory setting and exposed to MWWE (concentrations up to 90%), synthetic estrogens (EE2; 0.1 µg/L) and fluoxetine (0.32, 32 and 320 µg/L) for 82 days. In a separate dietary, depuration, study, turtles were exposed to PFOS (1, 10, 100, 1,000 and 10,000 ng/g wet wt) for 1 month and depuration rates were determined. MWWE displayed reduced liversomatic indices (LSI) and somatic growth commensurate with an observed decrease in appetite. Oxidative stress was induced by EE2 and reduced by fluoxetine. However, no changes were observed in brain citrate synthase, lactate dehydrogenase or acetylcholinesterase activity indicating metabolic rate was not significantly altered in this organ. Overall, these results suggest that chronic exposure to MWWE, EE2 and fluoxetine affected growth and LSI of hatching snapping turtles but had limited effect on metabolism. Depuration rates of PFOS increase our understanding of the effects of spills on aquatic organisms.

396 Hindered phenols and treated effluent: Effects on a native Canadian amphibian

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Municipal wastewater treatment plants (WWTPs) are used to treat sewage in order to reduce suspended solids, total chlorine, and ammonia before releasing as treated effluent. Most WWTPs are required to report carbonaceous biochemical oxygen demand (CBOD) in treated effluent, a measurement used to give an indication of organic contaminants removal through microbial activity. However, WWTPs have been shown to be a vector of many contaminants into aquatic ecosystems via effluent discharge. To understand the implications of the release of this chemical mixture into the aquatic environment, we exposed a native Canadian amphibian, the northern leopard frog (Lithobates pipiens; formerly Rana pipiens) to a dilution series of effluent from Hamilton, Ontario, Canada. In a comparison study, leopard frogs, were exposed to a single compound, 2, 4-di-tert butylphenol (2,4-DTBP; CAS: 96-76-4), an antioxidant (trade name: Prodox 146) for applications including fuels, rubber, and plastics. 2,4-DTBP and other alkylated phenolic antioxidants are of concern due to potential endocrine disruption. Both experiments employed water-borne exposure to tadpoles for up to 30 days and were monitored for survival, growth, and development. Additionally, liver tissue metabolomic profiles were examined as potential biomarkers of toxicity. Lipid metabolites (i.e., acylcarnitines and glycerophospholipids) were elevated with exposure to 2, 4-DTBP compared to controls, putatively through alterations in fat metabolism and excretion. However, survival, growth and development were not affected. Effluent exposures are underway. Continued monitoring of and assessment of the toxicity to effluent released by WWTPs is required to understand the effects on species inhabiting receiving environments. This research is therefore crucial in providing the essential information for the continued improvement of WWTPs. Lastly, this study highlights the need for testing ecotoxicity using complex mixtures that are representative of our ambient environment.
397 Sub-lethal embryonic cardiotoxicity is associated with increased mortality of overwintering juveniles in Pacific herring (C. pallasi)

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In 1989, the Exxon Valdez oil tanker ran aground and emptied 11 million gallons of oil into Prince William Sound. The spill overlapped in time and region with the spawning of Pacific herring, an important forage fish. Several years later when the spawn of 1989 would have returned to breed, the population crashed and has yet to recover. Since then, it has been established that larval herring are extremely sensitive to polycyclic aromatic hydrocarbons (PAHs), a complex mixture of organic compounds in crude oil. The developing heart in particular is the primary target of crude oil toxicity and a strong hypothetical starting point for a cascade of events leading to reduced recruitment at the population level. The goal of this work was to determine latent functional effects and potential sources of delayed mortality during the first year. Herring embryos were exposed to 0 to 3.4 ppt PAHs via a dispersion generator from 24 hours post fertilization to 10 days and subsequently reared in clean sea water. Cardiac morphology, primarily contractility and ventricular ballooning, was assessed during larval and juvenile stages via video microscopy and histology. An overwinter fasting trial was conducted during juvenile stages (100 fish/tank) for oiled/unooled and fed/unfed treatments until 50% mortality. Condition factor and lipid composition were also tracked throughout starvation. We found that oiled herring had reduced ventricular ballooning that persisted well into larval development which can lead to altered morphology and function at juvenile stages. During a simulated overwinter fasting, oiled herring experienced mortality 15-20% sooner than control indicating that early oil exposure may impact the ability of juveniles to survive their first winter if food is scarce. More work is needed to determine the relationship between latent effects on cardiovascular morphology and overwinter survival after embryonic exposure to oil.

398 Acute and latent effects on the teleost kidney following early life-stage exposure to Deepwater Horizon crude oil

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Much has been learned with respect to the developmental toxicity of crude oil exposure to teleost fish in the years following the Deepwater Horizon oil spill. Among the key findings are several lines of evidence that specific crude oil constituents, namely polycyclic aromatic hydrocarbons (PAHs), impair the function and proper development of the teleost heart. The resulting reduction in cardiac output is believed to elicit a characteristic suite of downstream effects (e.g., pericardial and yolk sac edema) and likely impairs the proper development of other organs, such as the kidney, which is a crucial osmoregulatory organ. While there is some evidence that exposure to individual PAHs impairs development of the early stage kidney (i.e., pronephros), little is known regarding the effects on the pronephros following exposure to complex crude oil mixtures at environmentally relevant concentrations. Furthermore, it is unknown whether early life stage (ELS) effects arising from short-term exposures result in long-term or latent effects on kidney function and, consequently, osmoregulation. To address these knowledge gaps, time-course and dose-response exposures to embryos/larvae of zebrafish (Danio rerio) and red drum (Sciaenops ocellatus) were performed using high energy water-accommodated fractions (HEWAFs) of DHW slick oil. Transcriptional changes in genes with various structural, functional and signaling roles specific to different regions of the developing pronephros (e.g., glomerulus, pronephric tubule and pronephric duct) were assessed by QPCR and whole mount in situ hybridizations. Morphological changes in the pronephros were determined by immunohistochemistry using an antibody raised against Na/K ATPase (NKA). Additionally, latent effects of ELS crude oil exposure on kidney function and overall osmoregulation were assessed by subjecting red drum to an acute salinity transfer challenge. Results demonstrate transcriptional changes in key genes involved in early kidney development and function, and that early stage impairment of normal kidney development might translate into long-term impairment of teleost kidney function. This research was made possible by a grant from The Gulf of Mexico Research Initiative.

399 Developmental Thyroid Disruption Impairs Reproduction: Uncovering Mechanisms Using a Transcriptomic Approach

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Thyroid disrupting compounds (TDCs) are known to interfere with normal thyroid hormone (TH) signaling. During embryonic and juvenile development, thyroid hormones modulate a variety of biological processes such as neurogenesis and the growth of the skeletal and muscular systems. Therefore, the majority of research on early life-stage (ELS) thyroid disruption has focused on its effects on growth and development. However, recent research has shown that ELS TDC exposure can also have adverse effects on reproduction later in life. Specifically, fathead minnows exposed to propylthiouracil (PTU), an anti-thyroid drug known to inhibit the synthesis of thyroxine (T4), during early development (from hatch through 42 days post hatch) experienced a 50% reduction in fecundity relative to controls. Data suggested that the observed reductions in fecundity may have resulted from changes in male reproductive behavior and/or female ovarian development. To investigate the potential for and mechanism underlying PTU-induced alterations in ovarian development and male behavior, brains and ovaries of PTU-exposed and control males and females, respectively, were collected immediately after exposure for transcriptomic analysis. Of the genes that were found to be differentially expressed between the brains of PTU-exposed and control males, many were associated with neurogenesis, various aspects of brain development, and steroid hormone signaling. Given the known role of steroid hormone signaling in sexual differentiation of the male brain, these results provide evidence supporting the hypothesis that ELS chemically-induced hypothyroidism leads to altered brain development and subsequent alterations in behavior. Alterations in the expression of genes within ovaries suggest that PTU exposure may affect ovarian development potentially impairing reproductive output in adulthood. Overall, the results of this study may help link transcriptomic alterations in the ovary and male brain to alterations in behavior and reproductive success, which have important population-level consequences.

400 Perchlorate induces non-alcoholic fatty liver disease in developing fish

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Perchlorate is a pervasive, water-soluble contaminant that competitively inhibits the sodium/iodide symporter, reducing the available iodide for thyroid hormone synthesis. Insufficient iodide uptake can lead to hypothyroidism and metabolic syndromes. Because metabolism, obesity and non-alcoholic fatty liver disease (NAFLD) are tightly linked, we hypothesized that perchlorate would act as an obesogen and cause NAFLD via accumulation of lipids in liver of developing threespine stickleback (Gasterosteus aculeatus). We performed an upshift/
downshift exposure regime (clean water to perchlorate treated water or perchlorate treated water to clean water) on stickleback embryos at two concentrations (30 mg/L and 100 mg/L) plus the control (0 mg/L) over the course of 305 days. Adult stickleback were euthanized, H&E stained and analyzed for liver morphology. We counted the number of lipid droplets, and measured the area of each droplet and the total lipid area of a representative section of liver. We found that perchlorate treated fish had more and larger lipid droplets, and a larger percentage of lipid in their liver than control fish. These data indicate that perchlorate causes NAFLD and hepatic steatosis in stickleback at concentrations commonly found at contaminated sites. These data also indicate the potential of perchlorate to act as an obesogen. We tested this by exposing developing zebrafish (Danio rerio) to perchlorate-contaminated water (0.01, 10, 30 and 100 mg/L) or control water; we euthanized fish at 133 days and stained with oil red O for lipids. Here we report on the obesogenic capacity of perchlorate by examining organ specific lipid accumulation and whether perchlorate induces these effects at concentrations commonly found in drinking water. Future work is needed to determine the mechanisms by which perchlorate induces lipid accumulation, and the relevance for the on-going obesity pandemic in humans.

401 Laboratory and mesocosm investigations of the ecotoxicological effects of metformin on fish

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Environmental research has recognized the occurrence and fate of pharmaceuticals in the aquatic environment as an emerging issue in aquatic toxicology. Currently, one of the most prevalent contaminants is the type-2 diabetic drug, metformin. Metformin has been measured in the ng-μg/L concentration range in surface waters and wastewater effluent. Our recent laboratory research shows that Japanese medaka (Oryzias latipes) exposed to a range of metformin concentrations (3.2, 10, 32, and 100 μg/L) from embryo through 28-days post hatch have a significant decrease in length and wet weight when compared to control fish. Metabolomic analysis performed on fish exposed to 3.2 μg/L metformin showed changes in the metabolome of the larval medaka, indicating significant dysregulation in fatty acid and lipid metabolism including metabolites associated with cellular energetics. Interestingly, a separate laboratory study performed by our research group, found no effects of metformin on growth in medaka exposed from embryo through adulthood, and despite significant effects on hepatic steroid hormones, metformin did not affect the reproductive output of breeding medaka, differing from results in the literature. The significant effects seen on larval growth and metabolome, and the shift in hepatic sex steroids seen in adult medaka, raised concern regarding metformin’s effects on wild fish. Thus, an 8-week mesocosm study was conducted at the International Institute of Sustainable Development Experimental Lakes Area (IISD-ELA) to investigate the effects of metformin on the overall and reproductive health of wild caught fathead minnows (Pimephales promelas). Specifically, four replicate mesocosms (2 meters in diameter by 1 meter deep, ~3,140 L) were dosed with one of three treatments, 0, 4, and 40 μg/L metformin. Each mesocosm contained 10 fathead minnows (4 males, and 5 females) for the full 8-week study. At study termination the growth (length, weight, condition factor, gonadosomatic and hepatosomatic indices) metrics and reproductive endpoints (egg production, egg fertilization, embryo hatch success, gonad histology, and sex steroid production were assessed).

402 Assessing the Effects of Environmentally Relevant Concentrations of Metformin to Fathead Minnows Exposed over a Full Life Cycle

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Metformin is a commonly used glucose-lowering drug that has been detected in municipal wastewater effluents at mid μg/L concentrations. We exposed fathead minnow (Pimephales promelas) over a full lifecycle to three concentrations of metformin: 4, 40, and 400 μg/L. The low concentration is similar to metformin concentrations in rivers, and the mid concentration similar to metformin concentrations in MWWEs. Mean measured concentrations of metformin were 3.0, 31, and 322 μg/L. During the life-cycle exposure, no significant changes were observed in survival of fathead minnows. Growth and maturation of the fathead minnows was unaffected by metformin exposure. There were no significant differences in condition factor, gonadosomatic index, or liver-somatic index in the metformin-exposed fish. Mean time to first breeding was significantly delayed by 10 days in 31 μg/L metformin treatment (and was delayed, but not significantly, in the 322 μg/L treatment). Overall, the metformin-exposed fathead minnows produced similar numbers of eggs as control fish. Egg quality was very good and was unaffected by metformin, with % fertilization 92-96 %, and 70-77 % hatching success in F1 fry. Eggs hatched in 5 days, severe deformities in fry were low (2-4 %), and there were no effects on survival or growth of F1 larvae at 9 and 16 days post-hatch from any metformin treatment compared to controls. Exposure to the metformin at environmentally relevant concentrations (i.e. 4 and 40 μg/L metformin) over a full life-cycle caused no adverse effects in fathead minnows.

403 Impact of agricultural pesticides on the endangered copper redhorse: transcriptomic and organismal level responses at an early life stage

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The copper redhorse (Moxostoma hubbsi) (CR) is an endangered fish that exists only in the St. Lawrence River and its main tributaries in southern Quebec, Canada. The closely related river redhorse (Moxostoma carinatum) (RR) and the CR share the same habitat and spawning grounds, however, the RR population is faring better (special concern). A myriad of anthropogenic factors may be leading to the poor natural recruitment of the CR, including contamination of their only known spawning grounds and nursery habitats within the Richelieu River with agricultural pesticides (e.g., atrazine, clothianidin, glyphosate, metolachlor). Our efforts focused on measuring the effects of these pesticides on early life stages of fish. CR and RR embryos (1000 per species) were obtained from the provincial government’s artificial breeding program during the summer of 2018. Half the embryos were exposed to Richelieu River water in an in situ flow-through system while the other half were exposed to laboratory water used as control. Embryos exposed to river water hatched
prematurely, with a median hatch time that was 19 hours earlier than the control group. River-water treated embryos also had a lower survival rate (73% vs. 93%). A similar trend was seen with RR in hatching time but the scale of the effects was much smaller, possibly suggesting a difference in species sensitivity. RNA sequencing was performed on 9 pools of 5 larvae per treatment and 137 genes were differentially expressed. Numerous genes involved in anatomical structure development, cell differentiation/proliferation growth were dysregulated following incubation in river water. Differences in the transcription patterns of growth-related genes may be due to differences in hatching time leading to varying developmental stages at termination. However, the opposite may also be true: river water may alter gene expression related to growth and development and may explain earlier hatching. Genes involved in stress, inflammatory and immune responses were also dysregulated. To pinpoint possible causes of the effects we observed, a series of exposures will be performed using chemicals previously identified in the river water. This study will provide valuable data on the effects of agricultural contaminants present in the Richelieu River and increase our knowledge on the individual and mixture effects they have on an endangered fish.

404 Pesticide Detoxification and Handling in Two Life Stages of Lake Sturgeon
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Two lampricides, TFN and niclosamide, are applied to Great Lakes tributaries infested with larval sea lamprey (Petromyzon marinus) to control populations of this invasive fish in the Great Lakes. While the lampricides specifically target the larval lamprey, which have a low detoxification capacity, non-target fishes are more vulnerable, as they are able to detoxify the pesticides via Phase II detoxification pathways, such as glucuronidation. However, some non-target fishes are vulnerable, including young of the year (YOY) lake sturgeon (Acipenser fulvescens), which are an economically and ecologically significant species, which is currently considered at risk in the Great Lakes basin. We hypothesized the sensitivity of YOY sturgeon to lampricides was due to a lower detoxification capacity, compared to older, more tolerant sturgeon. To test this hypothesis, lake sturgeon (YOY and 1+ year) and larval lampreys were exposed to TFN and niclosamide, alone and in combination. Compared to 1+ sturgeon, YOY and lampreys accumulated greater amounts of both parent lampricides. In sturgeon, however, the levels of glucuronidated and sulfated metabolites, the two main products of lampricide detoxification, were comparable in the two age groups. Therefore, we suggest that the greater sensitivity of the YOY to the lampricides may be due to their higher accumulation of the parent compound compared to the 1+ fish, rather than to differences in detoxification capacity between the age groups. We conclude that delaying lampricide treatments until sturgeon are older could mitigate potential adverse effects on this at risk species. Notably, the sulfated and the glucuronidated metabolites of the lampricides were also detected in larval sea lamprey, suggesting that they may be able to evolve resistance to lampricides by increasing their detoxification capacity.

Freshwater Salinization: Causes, Effects and Working Towards Solutions

405 Chloride water quality guidelines are too high for aquatic life in softwater Boreal Shield Lakes
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Chloride concentrations have been increasing in many lakes in Ontario due to the application of road salts to de-ice paved surfaces in winter. Softwater lakes in the Boreal Shield may be more sensitive than hard water lakes to chloride. We conducted 21d static with 48 h renewal bioassays with 10 clonal lines of Daphnia pulicaria, and 6 other species of Daphnia, all widespread species in the Boreal Shield lakes of Ontario, Canada. The Cladocera were collected from softwater lakes in the region, fed 1 mg Carbon/L/day and the bioassays conducted with < 24 h old neonates at 20°C and 16:8h light:darkness in FLAMES medium. The daphnids were examined daily for survival and reproduction. LC50s were calculated for each clonal line and each species under 7 chloride treatments, ranging from 0.39 to 150 mg/L in FLAMES medium, using reagent quality NaCl. The LC50s were lower than the current water quality guidelines for chloride. Our research found that the softwater clonal lines and species tested are at risk when comparing the determined LC50s with the current chloride guideline for the protection of freshwater life. These results are supported by paleoecological data that provide evidence that other Cladocera species have been affected by chloride increases associated with road salt application. Together these results suggest that water quality guidelines for chloride should be reconsidered for softwater lakes on the Boreal Shield.

406 Effects of Seasonal Temporal Variability of Salt Disturbance on Chironomus dilutus survival, emergence, and fecundity
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Toxicity of road de-icing salts to freshwater aquatic invertebrates is well documented within the scientific literature. Exploration of various aspects of de-icing salt toxicity demonstrate an overall concern for freshwater salinization through runoff of salts during spring snowmelt. This is a confounding issue as salts must be used in northern climates to clear snow and ice from roadways to protect human safety, but such applications risk the integrity of natural systems. Many of the experiments evaluating de-icing salt toxicity, however, utilize static toxicity tests, which fail to encompass the nuances of salt exposure, especially in lotic ecosystems. During winter months, salts entering streams and rivers demonstrate pulsed increases in salinity, as snowmelt brings salt into the system. Conversely, during summer months, pulses of freshwater from rain events cause declines in salinity followed by steady increases as water is lost through evaporation. As such, exposed organisms in these systems must deal with a constant fluctuation in osmoregulatory costs, possibly leading to adverse, chronic effects. Therefore, evaluating toxicity of de-icing salts to freshwater invertebrates inhabiting lotic systems requires a modified approach. The objective of the current study was to evaluate the effects of pulsed exposures of de-icing salt, mimicking exposure during summer months with biweekly pulses of freshwater to exposure chambers, to two generations of Chironomus dilutus. Second instar C. dilutus were exposed to one of three salt treatments based on environmental monitoring data, with biweekly decreases in salt concentration through pulses with freshwater. Endpoints, including survival, emergence success, male to female ratio, and fecundity were evaluated, with offspring of the first test generation serving as test organisms for a repeated experiment using the same experimental design. No significant effects were observed in either the first or second test generation due to the pulsed salt exposure, suggesting environmental exposure patterns observed in local streams may not be harmful to native invertebrates. With novel experimental design and test protocols, more realistic evaluations of the threat caused by freshwater salinization to natural systems can be realized, allowing for development of more effective and credible solutions to the problems of road de-icing salts.
407 Broad-scale assessment of long-term stream chloride trends across Ontario, Canada
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Increasing chloride concentrations in streams due to urbanization is a growing concern today, with numerous detrimental effects on freshwater ecosystems, drinking water resources, and overall watershed health. Several studies have associated chloride with urban road salting practices, while others have reported possible long-term retention of chloride in both urban and rural watersheds. As chloride can follow complex pathways from source to stream, there is a need to assess the roles of different landscape characteristics and anthropogenic activities as drivers of these pathways. The goal of this study is to document long-term changes in stream chloride concentrations in watersheds that span latitudinal, physiographic and land cover gradients, in order to support future research on legacy impacts of chloride as well as inform management decisions that balance winter road safety and reduce salt inputs. Long-term chloride concentration trends assessed using the seasonal Mann-Kendall show both increasing and decreasing trends in provincially monitored sites in multiple regions across Ontario, Canada. These trends and their seasonal variations will be further explored to investigate potential landscape and anthropogenic drivers such as land use/land cover, roads and lane length density, soil type, and population.

408 Transepithelial Potential as a Predictor of Major Ion Toxicity in Fish
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One of the stressors faced by freshwater ecosystems is salinization, for which there are no guidelines that rigorously address the contributions of different ions and their potential interactive effects, including sodium (Na+), potassium (K+), calcium (Ca2+), magnesium (Mg2+) cations paired with chloride (Cl⁻), sulphate (SO42⁻), and bicarbonate (HCO3-) or CO3-2 anions. These major ions elevated concentrations may, to different extents and in interactions, alter the balance of blood ions, acid-base status, and internal fluid volume regulation in freshwater animals in complex ways. To address this complexity, an ongoing modelling approach relates major ion toxicity to the predicted depolarization of transepithelial potential (TEP) across the gills, utilizing the Goldman-Hodgkin Katz (GHK) equation and assumed permeability ratios and internal concentrations to estimate TEP. However, at present there is a critical lack of data relating actual TEP changes to changes in major waterborne ion concentrations, to blood ions, and to mortality. Our research addresses this gap, and so estimate TEP. However, at present there is a critical lack of data relating actual TEP changes to changes in major waterborne ion concentrations, to blood ions, and to mortality. Our research addresses this gap.

409 The acute and subchronic toxicity of major geochemical ions to fathead minnow: Ion interactions and interspecies comparisons
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Adverse effects from increased concentrations of major geochemical ions (Na+, K+, Ca2+, Mg2+, Cl-, SO4²-, HCO3-/ CO3-2) to aquatic communities are evident in various locations. Experimental work has shown that the toxicity of ion mixtures to aquatic organisms is dependent on the specific mixture of ions present and on the receptor organism. Based on extensive testing of the acute toxicity of single salts and binary salt mixtures in various dilution waters to fathead minnow fry, the relationships of this toxicity to ion composition will be presented and contrasted with relationships for Ceriodaphnia dubia. For both species, key elements of these relationships include the importance of considering chemical speciation and activity, the existence of multiple mechanisms entailing both additive and independent interactions among ions, and effects of non-toxic levels of Ca on the toxicity of other ions. Differences between the species include a sulfate-dependent toxicity for minnows not evident for C. dubia, a better correlation of the toxicity of Na-dominated mixtures to Na activity for fathead minnow versus to total ions for C. dubia, and different interactions between Na and K. Ion toxicity to fathead minnow in early-life-stage and embryo-larval tests will be discussed and contrasted with the acute toxicity to fry. Consideration also will be given to the applicability of single salt toxicity tests to the more complex mixtures typical of major ion enrichment in surface waters. This abstract does not necessarily reflect U.S.EPA policy.

410 Integrating Laboratory Data on Major Ion Toxicity for Multiple Species into a Broader Assessment Approach
D.R. Mount, R.J. Erickson, B. Forsman, R. Hockett, C.T. Jenson, T.J. Norberg-King, US Environmental Protection Agency / ORD/NHEERL / Mid-Continent Ecology Division

We have completed extensive acute toxicity testing of major ion toxicity to several freshwater organisms, along with more limited chronic toxicity testing. Comparison of analyses across species has shown both similarities and differences. For example, all species evaluated have shown additive toxicity among sodium salts, but for some species exposure response relationships are best represented by solution osmolarity, while for others sodium activity appears to better explain toxicity. For most species, ion mixtures whose cation composition is dominated by magnesium and/or calcium appear to show toxicity via a different mechanism than for those dominated by sodium, though the relative potency of these two mechanisms varies. With minor exceptions, responses are mostly independent of anion composition, except to the extent that anion composition influences the chemical activity of the cations and contributes to overall osmolarity. In all cases, chemical activity better explains toxicity than mass concentration, though less robust mass concentration-based models may be sufficient for most environmental assessments. We review these findings to identify key issues and potential paths forward for developing a broadly applicable assessment approach. This abstract does not necessarily reflect USEPA policy.

411 Conductivity dynamics in green stormwater infrastructure (GSI)
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Bioswales are a common infiltration-based stormwater management practices (SMPs), and are touted as one the most highly recommended green stormwater infrastructure (GSI) approaches to manage both water
quantity and quality. Salinization effects are investigated through variety of approaches including total dissolved solids, conductivity, and elemental concentrations (i.e., Na and Cl) in a variety of media including runoff, porewater, underlying groundwater, and plant tissue. Field monitoring results show that runoff, and to a lesser extent porous media porewater, exhibits a flashy saline response which is attributed to deicer salt application. However, soil conductivity values remain elevated farther into the spring indicated that some constituents (e.g., Na) are retained in the soil and may potentially impact plant growth. Sodium uptake and translocation into the plant is also demonstrates.

412 Habitat remediation strategies for mitigating salinity inputs to freshwater systems

K.R. Palmquist, Exponent / Ecological and Biological Sciences Practice; T. Sparacio, Exponent / Environmental & Earth Sciences Practice; W.L. Goodfellow, Exponent / Ecological and Biological Services Practice

Freshwater salinization of large watersheds may greatly affect the system's value for agricultural, water supply, industrial use, and recreational activities. The Colorado River Basin Salinity Control Forum was formed in 1974 to develop and implement salinity reduction projects throughout the basin, to provide agricultural improvements and rangeland projects, and to better manage industrial and wastewater contributions of salinity to the watershed. Habitat remediation strategies to mitigate salinity inputs can help resource managers improve irrigation and land-use protection and evaluate potential projects to understand cumulative benefits. Using case examples, this presentation will explore mitigation options, such as irrigation upgrades, ecosystem restoration, erosion control, and invasive species removal, which can be used for on-site or off-site projects. Remediation strategies incorporate a series of factors such as the determination of benefits and assessing the overall value of the identified mitigation projects, quantification of cumulative benefits, and comparison of normalized cost estimates across a suite of habitat remediation strategies.

Alternative Approaches to Animal Testing for Ecotoxicity Assessments: Exploring New And Novel Approaches - Part 1

413 High Losses and Crossover of Semi-Volatile and Hydrophobic Test Chemicals in In Vitro Assays Conducted in 96 Well Plates

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In vitro assays are normally conducted in plastic multi-well plates open to exchange with the ambient air. The concentration of test substances freely available to cells is often not known, can change over time, and is difficult to measure in the small volumes in microplates. However, even a well-characterized toxicological response is of limited value if it cannot be linked to a well-defined exposure level. The aim of this study was to develop and apply an approach for determining time resolved freely dissolved concentrations of semi-volatile and hydrophobic organic chemicals (SVHCs) in in vitro assays: (1) free fractions were measured by a new medium dilution method, and (2) time-resolved loss curves were obtained by measurements of total concentrations in 96-well plates during incubations at 37°C. Headspace solid-phase microextraction was used as an analytical technique for 24 model chemicals spanning 6 chemical groups and 4-5 orders of magnitude in Kow and Kaw. Free fractions were above 30% for chemicals with log Kow < 3.5 and then decreased with increasing log Kow. Medium concentrations declined significantly (>50%) within 24 hours of incubation for all 20 chemicals having log Kow > 4 or log Kaw > -3.5 in serum free medium. Losses of chemicals were lower for medium containing 10% fetal bovine serum, most significantly for chemicals with log Kow > 4. High crossover to neighboring wells was observed also below log Kow of 4 and log Kaw of -3.5. Sealing the well plates had limited effect on the losses, but clearly reduced crossover. The high losses and crossover of most tested chemicals question the suitability of multiwell plates for in vitro testing of SVHCs, and call for (1) test systems that minimize losses, (2) methods to control in vitro exposure, (3) analytical confirmation of exposure and (4) exposure control and confirmation being included in good in vitro reporting standards.

414 Advancing In Vitro Fish Cell Line Culturing Techniques for Routine Regulatory Ecotoxicity Testing

J. Scott, SLR Consulting / Integrative Biology; M. Minghetti, Oklahoma State University / Integrative Biology

In both regulatory whole effluent toxicity (WET) testing and chemical registration, in vivo fish assays compromise a large volume of species tested to measure and identify harmful environmental impacts. In vitro alternatives are an improvement from in vivo methods by allowing identification of a toxicant's mode of action, granting a high throughput approach with reduced test duration and costs, and importantly eliminating the need for live animals. Previous studies have shown that the fish gill cell line RTgill-W1 cultured as a monolayer respond to broad range of chemicals dissolved in water similarly to fish. However, this in vitro system presents some limitations such as the need to manipulate the exposure medium due to low osmotic stress tolerance, which can reduce bioavailability and toxicity of dissolved chemicals. To overcome this limitation RTgill-W1 cells can be cultured on transwells tolerating direct exposure to water samples, thus increasing chemical bioavailability for effluent and chemical toxicity testing. Culturing of RTgill-W1 on transwells facilitates the formation of a polarized epithelium which allows the measurement of key physiological processes such as epithelium permeability, trans-epithelial electrical resistance, and tight junction proteins. This study aims to characterize the responses of selected common and emerging chemicals of concern (metal, metalloid, nanomaterial, persistent organic pollutant, biocide, endocrine disruptor, pharmaceutical and personal care product) to cells cultured on transwells using a multiple viability endpoint analysis. Cells will then be exposed to non-toxic and toxic (EC20) doses of the selected chemicals and mRNA levels of Metallothionein, Vitellogenin, and Cytochrome P-450 1A gene expression will be measured. Additionally, selected real effluent samples will be exposed side by side using cells as a monolayer, and a polarized epithelium to compare sensitivity of the systems. Concluding we will confirm analytical analysis of the effluent sample (e.g. ICP-OES, GC-MS, and LC-MS) and evaluate if the cellular and molecular endpoint measured on RTgill-W1 can identify the toxic chemical in solution. Results from this study will determine if direct sample exposure to RTgill-W1 cells as a polarized epithelium is able to predict and identify toxicity of chemicals and effluents.

415 Liver dethroned!? The caudal fin as a non-lethal alternative to transcriptomics-based evaluation of oil spill effects in Pacific salmon

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Rapid and sensitive tools for assessing environmental toxicity can be crucial to monitoring oil spill impacts and remediation efforts. Transcriptomic biomonitoring of sentinel animals can be a powerful method for tracking and evaluating the impact of environmental toxicants, however, current methods require animal sacrifice. We have previously demonstrated that the salmonid caudal fin, which can be rapidly sampled non-lethally, is a viable alternative to conventional liver tissue sampling. Our previous work using targeted qPCR revealed that cyp1a, a “classic"
hepatic indicator of polyaromatic hydrocarbon exposure, was significantly increased in the caudal fin after exposure to marine diesel demonstrating that this tissue is very sensitive to oil exposure. The purpose of the present work is to create a more comprehensive view of the transcriptome response in comparison to the liver and to identify additional biomarker candidates. Using RNA-Seq analysis, we show that the caudal fin more consistently responds to marine diesel exposure in a sex-dependent manner in comparison to the liver. We performed RNA-Seq on paired caudal fin and liver tissue from 20 genotypically-sexed male or female juvenile coho salmon following a 96 h exposure to either 1000 mg/L marine diesel seawater accommodated fraction (WAF) or seawater control. In the male and female caudal fin, marine diesel WAF exposure induced the differential expression of 620 and 501 transcripts respectively, consistently enriching cellular adhesion and morphogenesis pathways. Cell signaling pathways were uniquely enriched in males and metabolic, apoptotic, and embryonic pathways in females. Of the 176 and 352 transcripts differentially expressed in the male and female livers, some protein folding pathways were commonly enriched, with cellular localization and transport largely enriched in females and cellular metabolism in males. In the caudal fin, 36 marine diesel responsive transcripts were common in males and females, whereas, only 12 transcripts were common in the liver. These results show that the caudal fin exhibited a more consistent response between sexes than the liver tissue. Furthermore, the results indicate that the caudal fin is more sensitive to marine diesel WAF exposure than the conventional liver tissue. Taken together, sampling and transcript analysis of the caudal fin presents an exciting non-lethal alternative for assessing and monitoring oil spill effects.

416 Toward an AOP-based tiered testing strategy for thyroid hormone disruption

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Assessment of thyroid hormone disrupting chemicals (THDCs) is considered a major gap in current approaches for the testing of endocrine disrupting chemicals. The need to advance screening and testing strategies for THDCs includes the development of in silico and in vitro methods that anchor chemicals acting through a thyroid mechanism to adverse responses. The Adverse Outcome Pathway (AOP) framework is therefore particularly helpful for the identification of relevant assays and endpoints. Here, we demonstrate the use of in chemico assays targeting specific key events of an established AOP network to predict higher biological endpoints in fish early-life stages. Specifically, an AOP network linking thyroid hormone disruption to impaired swim bladder inflation was used to select assays measuring thyroperoxidase and deiodinase inhibition, key enzymes in the thyroid hormone metabolism. A set of 51 compounds was screened using these assays, and data were used to predict acute and chronic effects on swim bladder inflation. Predictions were validated using FET and FELS in vivo experiments in zebrafish and fathead minnow. A tiered testing strategy for the identification of THDCs was proposed based on these data. Our thyroid hormone disruption AOP network is part of the OECD AOP development programme workplan (project 1.35), and the associated assays align with the thyroid-related assays that are listed in the OECD Conceptual Framework for Testing and Assessment of Endocrine Disrupting Chemicals (revised 2018) as assays for which no formal guidance has been written at present. As part of their endocrine disruptor screening program, the USEPA included this work while assembling a conceptual thyroid hormone disruption AOP network spanning different taxonomic groups (fish, amphibians, mammals) to assist high throughput assay development. The ongoing JRC EURV ECVAM validation effort of in vitro assays for THDC screening is making use of this project’s data to ensure synergies and overlap. The AOP network is currently being used as one of the building blocks of a larger cross-species AOP network within the context of the H2020 ERGO project (“Breaking down the wall between human health and environmental testing of endocrine disrupters”), which aims to improve hazard assessment of endocrine disrupting compounds by demonstrating that it is feasible to extrapolate effects of EDCs across vertebrate classes, from fish and amphibians to humans.

417 Critical evaluation of the “gold standard” fish acute toxicity assay

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Regulatory environmental toxicology relies on experimental results from a handful of standardized toxicity tests including the fish acute toxicity assay (e.g., OECD 203, EPA OPPTS 850.1075). Several alternative (AA) assays are currently being developed to replace the acute fish toxicity (AFT) assay including the fish embryo toxicity (FET) test, fish cell line test (FCT), as well as computational approaches. AA assays must be easily-transferred to new labs, statistically robust, reproducible, reliable, and “accurate.” That is, the replacement assay must produce the same result as the AFT (e.g., LC50). Implicit in this comparison is the assumption that the AFT is robust, reliable, and reproducible. Notably, the AFT has never undergone a rigorous validation process. The reliability and reproducibility of the AFT are largely unknown, and widely taken for granted during AA-validation exercises. In this presentation, we will summarize the barriers to regulatory acceptance of AA assays. The rigor of AA approaches will be contrasted to the AFT. We will also explore how the AFT as an assay would be interpreted, if evaluated using todays criteria for a regulatory-appropriate assay.

418 Quantifying Conservatism in ecoTTCs and Chemical Toxicity Distributions: Case Study of Chemicals with Regulatory Water Quality Values

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Ecological Thresholds for Toxicological Concern TTC (eco-TTCs) summarize a large array of species-level toxicity data as a probabilistic distribution of Predicted No-Observed Effect Concentrations (PNECs). These probability distributions enable the prediction of untested chemicals based on grouping via a structural attribute, mode of action, or functional use. The approach may be useful for assessing chemicals at early tiers of the risk assessment process, providing hazard perspective on chemicals that lack QSARs, guiding product development discussions, and assisting read across or category justifications. Because PNECs can be regionally based in their development, and apply different Application Factors (AFs), PNEC distributions are expected to vary by region. There may be situations where a researcher or assessor is interested in the toxicity distributions, without the added conservatism introduced by the assessment factors or the regional overtones of their application. A chemical toxicity distribution (CTD) can be used to perform this type of analysis. The purpose of this presentation is to share initial findings of a case study assessing conservatism in eco-TTC and CTD approaches. Aquatic toxicity-based water quality standards (e.g., Water Quality Criteria and Standards; Environmental Quality Standards) provide benchmarks for assessing the conservatism in ecoTTC and CTD approaches. Eco-TTC and CTD estimates were compared to existing criteria and screening benchmark values from regulatory jurisdictions for several groups of chemicals. Groupings were based on: 1) availability of aquatic criteria values from more than
one regulatory jurisdiction; 2) sufficient data to develop eco-TTC and CTD estimates; and 3) identified and articulated grouping criteria (e.g., common mode of action, chemical functional classes, and presence on priority lists). This presentation will provide an overview of the case studies, the approaches utilized, rationale for group selection, and a quantitative comparison of the degree of conservatism in ecolTC and CTD approaches. Guidance will be provided to new users of this tool to explore case studies and applications to chemical evaluation strategies.

419 Revisiting and Updating Chemical Categorizations with High-Throughput Screening Data

The views expressed in this abstract are solely those of the authors and do not represent the policies of the USEPA. Mention of trade names or commercial products should not be interpreted as an endorsement by the EPA. Chemical categorization, or grouping, is routinely employed by academia, industry and government agencies to capture and report salient chemistry and toxicity correlations as well as to identify analogs for chemicals that have limited empirical information. However, there is a continual need to modify chemical categories as new information on chemical hazards becomes available. This study incorporated new approach methodologies (NAMs) to evaluate whether potential refinements could be made to the 56 New Chemical Categories (NCC), as defined under the Toxic Substances Control Act (TSCA) and implemented in the OECD Quantitative Structure-Activity Relationship (QSAR) Toolbox profiler. Specifically, ToxCast and Tox21 high-throughput screening data and chemoinformatic techniques were used to evaluate potential refinements to the chemical categories. Chemical inventories from regulatory agencies of the United States and Canada were grouped into existing NCC and were found to have similar category coverage compared to the ToxCast and Tox21 inventories, suggesting biological information gleaned from these data may inform the current NCC classifications. Examination of the biological activities of the NAM data suggests some refinement of NCC may be needed, including derivation of phenolic ester and phenolic aliphatic amine classes that are currently grouped as multicategories within the NCC definition. This approach also identified data gaps in the NAM inventory and potential analogs for chemicals that may fit the suggested new categories, such as octyl gallate (phenolic ester). Further, hierarchical clustering of ToxPrint chemotypes present in chemicals within the neutral organic NCC category also provided data to support potential subcategorization and class refinement.

420 Toxicity by Descent: A Modern Chemical Hazard Assessment Framework
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Predicting both human health and ecological hazards for industrial chemicals is extremely challenging, in part because investigations on how chemicals perturb biological processes producing harm historically relies on different animals on which toxicity can be most conveniently studied. This dilemma regrettably has created an unnatural divide in the scientific pursuit at understanding the exposure limits of humans, and the permissible levels of contaminants in the environment, for many thousands of synthetic compounds. This division has been manifested by a reliance on mice and rats as human surrogates (by virtue of our shared mammalian biology) and by a reliance on a fish, a cladoceran zooplankton and an algal species (an aquatic food chain) as sentinels for setting regulatory limits to protect human or environmental health. Yet discoveries made within the past 15 years in studies of animal genomes point to a significant number of conserved genes and their functional associations for growth, maintenance and reproduction. Here, evidence is given on the feasibility of classifying chemicals in the near future for their harmful effects on people, based on gene expression monitoring using distantly related and environmentally relevant model test species. This method aligns human- and eco-toxicology towards a more general understanding of how exposure to pollutants disrupts biological processes that otherwise ensure animal (including human) health. We conclude with a method that determines the likelihood that existing biomarkers that are specific to human pathways are indicative of exposure-related health outcomes using distantly related test species with examples using the waterflea Daphnia.

Fate, Effects, Mitigation and Monitoring of Oil and Oilfield Wastewater Spills in Freshwater Ecosystems - Part 1

421 The impact of photo-oxidation on the chemistry of hydraulic fracturing flowback and produced water
X. Wang, L. Hounjet, R. Gieleciak, C. Lay, Natural Resources Canada

Hydraulic fracturing is a technique where water is pumped into wells under high pressure to increase oil and gas production by fracturing low permeability geologic formations, such as shale, tight sands, coal-beds, and other gas or oil-bearing strata. The fracturing fluids consist primarily of water (90%) mixed with some sand (9.5%) and a small proportion of other chemicals (0.5%). Information provided to the “FracFocus” website (https://fracfocus.org/) by hydraulic fracturing operators has increased public awareness of the chemicals used for hydraulic fracturing. If accidentally spilled, these chemicals could migrate from well pads to groundwater or surface water. In addition, it is possible that chemicals could leak into an aquifer if a wellbore is breached, even given the many layers of protective casing. Furthermore, temporary in-ground storage near the well pads could also increase the risk for chemical leak due to potential lining failure. All the above processes are potential pathways for chemicals used by hydraulic fracturing to enter the environment. In order to predict the environmental fate of hydraulic fracturing chemicals, environmental studies and modeling have to be conducted. In addition, potential treatment strategies have to be screened to target hydraulic fracturing chemicals. In Alberta, the current practice for recycling hydraulic fracturing flowback and produced water is to inject the water after temporary in-ground storage. If or when the water chemistry is such that the water can no longer be used for recycle, it is transported for disposal downhole in deep wells. During the temporary on-site storage process, the water chemistry may change due to photo-degradation or biodegradation, which may affect the water use for extraction and production. In addition, the degradation by-products may be more toxic than the original compounds and become a new source of potential environmental contaminants. In this study, the photo-degradation of chemicals contained within hydraulic fracturing flowback and produced waters is examined. Results of detailed chemical analyses of water samples before and after irradiation are compared. These results shed light on the dynamics of hydraulic fracturing flowback water and produced water chemistry during its temporary on-site storage.
Although A. Weinrauch, E. Folkerts, T. Blewett, G. Goss, University of Alberta / produced water over time following exposure to hydraulic fracturing flowback and of evaluating multiple exposure regimes, but perhaps more importantly driver in chronic toxicity. The findings of this study show the importance acute results. Causality in acute and chronic bioassays differed as acute a significant amount of latent mortality occurring when compared to the chronic toxicity of FPW in this species was more pronounced with acute toxicity was significant at low dilutions of FPW (48h LC50: 4-5%). FPW exposures. Bioassays and pulse toxicity were evaluated to better understand the implications of FPW releases. Bioassays used FPW acquired from a local well in Alberta. Although L. variegatus have a high tolerance to aquatic contamination, acute toxicity was significant at low dilutions of FPW (48h LC50: 4-5%). Chronic toxicity of FPW in this species was more pronounced with LC50s (survival/reproduction) and EC50s (total mass) as low as 0.53% FPW. Investigations evaluating pulse toxicity (6h and 48h) also showed a significant amount of latent mortality occurring when compared to the acute results. Causality in acute and chronic bioassays differed as acute toxicity appeared to be driven mainly by salinity but was not the sole driver in chronic toxicity. The findings of this study show the importance of evaluating multiple exposure regimes, but perhaps more importantly the complexity of FPW.

423 Rainbow trout hepatocyte metabolism is differentially altered over time following exposure to hydraulic fracturing flowback and produced water

A. Weinrauch, E. Folkerts, T. Blewett, G. Goss, University of Alberta / Biological Sciences

Hydraulic fracturing is a widespread practice utilized in North America to extract oil and natural gas from shale reserves. The wastewater produced as a result of this practice is termed flowback and produced water (FPW). The aim of this study was to determine if acute FPW exposure impacts the hepatic metabolism of rainbow trout at either 48 h or 3 weeks following exposure. We hypothesized that FPW exposure would alter nutrient metabolism as the liver would be performing the metabolically demanding role of detoxification. Using isolated hepatocytes, the uptake properties of radiolabeled glucose and alanine were assessed following exposure to 2.5% and 7.5% FPW, with concurrent salt-matched controls also performed. Exposure to FPW led to step-wise increases in hepatic glucose uptake, but had no effect on alanine acquisition. The activity of key enzymes involved in glucose and amino acid metabolism were also assessed following exposure. Amino acid metabolism decreased 48 hours following exposure and was further reduced after 3 weeks. Although FPW exposure did not always elicit immediate effects on glucose metabolism, by 3 weeks there is an overall trend of reducing glycolysis and promoting hepatic glucose mobilization. Overall, these results indicate sustained impacts on hepatic metabolism following acute FPW exposure.

424 Alkylated Polycyclic Aromatic Hydrocarbons Understanding Fate and Persistence in Aquatic Systems following a Condensate Release - a Case Study

L. Mooney, Millennium EMS Solutions, Ltd.

As hydrocarbon mixtures weather, alkylated homologs of parent polycyclic aromatic hydrocarbons (PAH) comprise a greater proportion of the mixture. Little toxicology information for many of these homologs is available. Adverse effects from alkylated forms are documented for aquatic receptors; however, within mixtures the specific contribution of alkylated forms to noted adverse effects is uncertain and the ability of risk assessors to appropriately evaluate risk from these compounds is limited. This case study presents multi-year sediment data following a condensate release into a creek system in northern Alberta. Alkylated homologs persist relative to parent compounds and are mobile, aggregating in depositional areas. Invertebrate tissue analysis reveals a biocumulation of alkylated homologs, when parent PAH are not significantly higher than reference. Despite this, the density and composition of the invertebrate community in exposed erosional areas is not statistically different from reference areas. Fish are documented to transform and eliminate alkylated PAH and one of the documented toxicity endpoints from prolonged exposure is tumor development. Applied endpoints in an ecological risk assessment generally include population-level effects, and tumor development is not generally considered. Risk assessors are then left applying toxicity surrogates and relying on sediment chemistry trending for management decisions related to alkylated-PAH.

425 Chemical and toxicological assessment of water quality downstream of oil and gas produced water discharge

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Produced water (PW) is the largest waste stream associated with oil and gas extraction. This fluid contains hydrocarbons, salts, metals, radioactive materials and any remaining chemical additives. In the United States, west of the 98th meridian, the National Pollutant Discharge Elimination System exemption allows for release of PW to surface waters for agricultural beneficial reuse. Due to the complex and variable composition of PW, the downstream impacts of these releases are not fully understood. In this study, a detailed chemical and toxicological analysis was conducted on a PW stream released for agricultural beneficial reuse. Acute toxicity, mutagenicity and developmental toxicity were analyzed using daphnia magna, yeast and zebrafish, respectively. Over 50 geogenic and anthropogenic organic chemicals that were not specified in the effluent limits were detected at the discharge including 1,2-dichloroethane (0.5 µL/L), naphthalene (8-13 µL/L), and nonylphenol ethoxylates (~8-12 µL/L). Most organic chemicals were removed within 15 km of the discharge due to volatilization, biodegradation, and sorption. Inorganics measured at the discharge were all within regulatory effluent limits, though some, such as barium, exceeded chronic water quality criteria. While some inorganics decreased with distance (barium, strontium and radium), the majority increased in concentration downstream (chloride, sulfate, etc.), likely due to evaporation. This resulted in some, including lead, exceeding regulatory limits downstream. The yeast strain used in this study was engineered to measure four types of mutation including copy number variation (CNV) duplication, CNV deletion, forward point mutation and reverse point mutation. In all four assays, higher mutation rates were observed at the discharge and decreased with distance downstream. This was most prominent for CNV duplications. A similar trend was observed for carcinogens detected in the stream (e.g., benzene, naphthalene, radium). Increased rates of CNV deletion, forward point mutation and reverse point mutation were attributed to salts and carcinogenic organic compounds. Acute toxicity was minimal, and no developmental toxicity was observed. Regulatory health thresholds for most chemical species detected at the discharge do not exist. This study showed that chemical analysis alone is insufficient for analysis of PW releases and that an assessment of chronic toxicity is necessary to fully assess PW for beneficial reuse.

426 Environmental influences on phenanthrene accumulation and toxicity from hydraulic flowback and produced water in rainbow trout

T. Blewett, G. Goss, University of Alberta / Biological Sciences

Spills of hydraulic flowback and produced water (HFPW) can be devastating to the freshwater environment. These effluents are extremely complex mixtures, high in salts (Na, Ca, Cl, K, Mg), metals (e.g. nickel, lead) and organics (e.g. polycyclic aromatic hydrocarbons; PAHs). Environmental
influences such as temperature can greatly alter the bioaccumulation and toxicity of organics in HFPW, and subsequently, toxicity. Using a radiotracer-based approach, we examined the effect of temperature (4, 13 and 17°C) and salinity on the uptake kinetics of 14C-phenanthrene as a model HFPW PAH in the freshwater rainbow trout. Total phenanthrene accumulation was temperature-dependent, with 4-fold greater accumulation in 17°C temperatures. However, when co-exposed with HFPW, phenanthrene accumulation dropped from 2.0 (mg/g wet wt. - to 0.2ng/g wet wt). Regardless of temperature, the lowest accumulation always occurred in the HFFPW mixtures. Indicating that the presence of HFPW altered the bioavailability of these complex chemical mixtures. Temperature also altered the tissue-specific distribution of phenanthrenes (highest accumulation in the liver), while changes in uptake patterns with salinity were also noted and attributed to altered gill function (reduced oxidative stress capacity) and morphology (e.g. osmotic stress - histology showed a 6-fold reduction in gill area compared to control fish). Our data suggest that the impacts of HFPW will depend on prevailing environmental conditions at spill sites which will affect the fate of these chemicals, but that these impacts may be able to be predicted through models that account for salinity and temperature.

427 Determination of pathways and potential effects of oil and gas activities on ecological receptors


The U.S. Geological Survey has an integrated team studying historic and current oil and gas (OG) activities on landscapes. Our interdisciplinary team works with organizations inside and outside of government to distinguish perceived vs. actual risks from OG development to organisms. We are focused on three interdisciplinary science objectives: 1) Source mobility and toxicity risks; 2) Exposure pathways and risks to receptors; and 3) Resilience/restoration of environment. To address these objectives, we have conducted numerous laboratory and field studies across the United States, including in North Dakota (ND) where extensive historic and current OG activities provide opportunities to study potential effects from legacy spills and recent releases of wastewater. Studies in ND include determinations of chemical constituent pathways and effects on biota following a 2014 release of OG wastewater to Blacktail Creek, ND. A barium and strontium signal associated with OG wastewater persisted at an experimental site downstream from the spill where an in situ fish bioassay demonstrated increased mortalities 6 months following the reported spill. Toxicity was not observed in later years and the barium and strontium signals, though still existing, were diminished. Additional investigations of ammonia levels in the stream suggested the variable nature of river flow in this watershed contributes to the variability of continued OG wastewater influence on the surface water quality. Laboratory bioassays with reconstituted waters mimicking the ionic composition of a site 1 month after the spill indicated that elevated major ions alone could adversely affect fish and aquatic invertebrates. Investigations of legacy spills included mapping of potentially contaminated sites; toxicity bioassays with aquatic plant, invertebrate, and amphibian; and amphibian surveys. Laboratory studies documented reduced amphibian survival in sediments with elevated salt content, and surveys identified invertebrate diversity and amphibian abundance were sensitive responses to elevated salt content. Changes to wastewater disposal practices instituted after 1982 had a positive influence on water quality and amphibian abundance. OG wastewater plume studies indicate decades to centuries are needed for attenuation of salts affecting wetland systems. These studies highlight how interdisciplinary science provides information about source mobility, pathways, and potential effects of OG wastewater.

428 Can the toxicity of oil sands process-affected water be mitigated by a green photocatalytic method?

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Naphthenic acids (NAs) are common toxic components of oil sands process affected water (OSPW) that reach concentrations in tailings ponds known to be lethal to aquatic animals. The mitigation of NA toxicity is imperative to OSPW management, but storage in interim tailings ponds pose risk of release into the environment and existing detoxification treatment options are limited. Here we examined the ability of a novel advanced oxidative method, UV photocatalysis over titanium dioxide- (TiO2) coated buoyant microparticles, to reduce the toxicity of NA-fraction components (NAFCs) from OSPW to developing fathead minnows (FHM). Experiments were performed using dilutions of NAFCs extracted from OSPW to assess the toxicity of water solutions treated with this method to developing and larval FHM in a controlled laboratory experiment and an outdoor, semi-natural setting. Increased treatment intensity (i.e., duration of photocatalysis) resulted in the greater removal of acid-extractable organic (AEO) compounds in exposure waters. Treatment to 50% AEO degraded (< 20 mg/L) reduced mortality, but the frequency of cardiovascular abnormalities remained elevated in treatments with more than 90% AEO degraded (3 mg/L). Incomplete degradation of AEOs (e.g., 25% AEO degraded, 20-25 mg/L) increased malformation frequency in fish in a manner typically associated with chronic toxicity during development. This study provides the novel assessment of green technology to address a large-scale environmental and ecotoxicological problem in Canada’s oil sands region.

Fate and Effects of Metals: Mechanistic Knowledge of Metal Interactions With Aquatic Biota - Part 1

429 Rare Earth Element Solubility and Speciation: Impacts on Bioavailability

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In recent years there has been an increased interest in mining of Rare Earth Elements (REEs) in Northern Canada. As the result of this potential development, the release of these metals into the environment poses a potential threat to the health of aquatic ecosystems. However, the speciation information needed for the development of toxicity prediction models for these metals is limited. The main purpose of this project is to understand REE solubility and interactions with dissolved organic matter (DOM). To this end solubility and DOM binding tests were conducted with both a representative light REE (samarium) and a heavy REE.
The solubility of these elements in clean water solutions of variable carbonate concentrations (atmospheric, 1 mM and 10 mM) and pH (6, 7, 8, 9) was monitored for 120 hours. It was found that for the most insoluble systems (i.e., high pH, high carbonate and high total metal) agreed well with equilibrium model predictions (PHREEQC), but for more neutral pH and lower metal concentration, the observed solubility was up to a factor of 4 higher than predicted by the equilibrium model. Fluorescence quenching and REE ion-selective electrodes were used to measurements metal-DOM binding constants and quantify binding sites on DOM. These binding assays demonstrate that existing databases for REE binding actually overpredict complexation at low, environmentally relevant, levels of metal and revisions are required. A conditional solubility/binding model for short exposure times will be presented, and existing toxicity data reinterpreted in context with this model. DOM is known to be a toxicity modifying factor for lanthanides and a detailed understanding of lanthanide speciation in the presence of DOM will eventually facilitate the development of quantitative bioavailability-based models to help manage the impacts of potential lanthanide mining operations in Northern Canada.

430 The issue of REE solubility in determining toxicity thresholds
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In recent years, a steady, reliable, and secure supply of critical metals has become increasingly important to major industrialized economies that seek to sustain their industrial base and develop advanced technologies, such as clean energy. In light of this, Canada, with its significant critical metal reserves, has an opportunity to supply some of the global demand for critical metals. However, the present knowledge of potential eco-toxicological effects of REEs is limited, specifically chronic toxicity data are under-represented, which poses a challenge to risk assessors and regulators when trying to understand the potential environmental effects of REEs in freshwater systems. For the past four years, NRCan has developed and funded research to understand the chronic toxicity of four priority lanthanides: Lanthanum (La), Cerium (Ce), Neodymium (Nd) and Yttrium (Y). Species tested include various fish species as well as numerous invertebrate organisms. However, one of the main issues identified during these tests has been the rapid decrease in solubility of the four REEs, ranging in a loss of 30-90% over the course of a 24hr period. To this end, it has posed a challenge to determine an accurate toxicity measure (i.e. EC50, IC10) due to the uncertainty over the rapidly changing exposure concentrations. This presentation will discuss the various factors that could be contributing to this change in solubility and offer a comparison of methods that could be used in determining a relevant toxicity value (i.e. IC10, EC50) with the hopes of providing regulators and risk assessors with approaches to better estimate the toxicity of these REEs.

431 Integrated ecotoxicological assessment of Rare Earth mixtures in freshwater bivalve
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Rare Earth Elements (REE) are essential in high-technology products including technology for the transition to sustainable energy and numerous industrial, medical, military applications. Consequently, REE are considered technological critical elements subject to geopolitical issues. For about twenty years, their increasing extraction, processing and use led to their release in the environment including aquatic systems. However, nowadays, little is known about the ecotoxicology of REE particularly in complex natural systems. Moreover, most of the available data concerning REE toxicity is focused on single elements, whereas they are commonly found as a group in nature. REEs are expected to have cumulative toxic effects on organisms, owing to their similar physicochemical properties, but studies on their mixture toxicity, more representative of realistic scenarios, are necessary to uphold this assumption. In this context, the ECOTREE international research program aims to understand better the fate, behaviour and the potential biological effects of REEs on freshwater ecosystems and, particularly in this presentation, on Asian clam, Corbicula fluminea. The bivalves were exposed during one week to 3 REEs representative of the lanthanide series: neodymium, gadolinium and ytterbium alone and in mixture in absence and presence of Dissolved Organic Matter (DOM: 8 mg/L of dissolved organic carbon including 6.8 mg/L of fulvic acid) to assess the influence of DOM on REE toxicity. Main physicochemical properties of the exposure media were characterized in order to study further REE speciation, bioavailability using chemical equilibrium models including ion-binding models for OM. Both, total REE bioaccumulation and subcellular compartmentalization were measured by ICP-MS in gills and digestive glands. Additionally, toxicity responses of bivalves were evaluated using a multi-marker approach at different levels of the biological organization. For the physiological assessment, 12 biomarkers of general stress or metal-specific, involved in antioxidant (i.e. superoxide dismutase, catalase) and antioxidant (acid phosphatase) functions, metal (metallothioneins, hemolymphatic calcium) and energetic metabolisms (i.e. triglycerides) or cell damages (i.e. lipid peroxidation, apoptosis) were measured by automated spectrophotometer and polarography and expressed with multivariate analysis. Exposure experiments were conducted on May 2019 and related analysis are still in progress.

432 Bioavailability of Technology Critical Elements to Aquatic Biota in Freshwater
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The growing use of rare earth elements and other technology critical element such as In, Ge and Ga in personal electronic devices, green technologies and medical applications results in a developing concern for impacts in aquatic environments. However, there are no water quality guidelines/criteria for TCEs and few studies available. The objective of this research is to contribute data towards the establishment of assessment tools for the effects of TCEs. We have studied the toxicity of Ce, Sm, Dy, Tm, In, Ge and Ga to sensitive invertebrates (Hyalella azteca and Daphnia). The toxicity modifying influences of cationic competition (Ca, Mg and Na) and dissolved organic matter (DOM) were assessed. With some exceptions, for example Ge, Ca and DOM provide protection against toxicity. The protection that DOM provided for Ge toxicity was minimal. In chronic Dy toxicity studies with Hyalella both Ca addition and DOM addition provided protection and EC50 values for growth over 28 d increased from 1.0 uM (95% CI of 0.83-1.35) in moderately hard culture medium to 2.7 uM (2.4-2.9) with the addition of 1.5 mM Ca uM and to 5.6 uM (5.1-6.0) when 6 mg DOC/L was added to test solutions. These effects were linked to significant accumulation of Dy but there was no correlation between impacts and accumulation. In chronic tests with Tm DOM provided protection against Tm and stimulated growth at low Tm concentrations. A 3 fold increase in Ca levels did not offer protection against Tm but reducing Ca by 50% (to 0.25 mM) resulted in higher toxicity. This may be due to the physiological stress of low Ca on the Hyalella rather than an effect related to competition. Incorporation of effects into toxicity prediction models was inhibited by a lack of understanding of solution geochemistry. Funded by NSERC and Environment Canada via a Strategic Grant.
Lanthanides (LNs) have become an essential commodity in many high-and green-technology applications such as smartphones, computers, wind turbines, electric vehicles. Their increasing economical importance has drawn attention to the limited knowledge about their ecotoxicology. As ecotoxicological studies become available, difficulties in properly appreciating effects of LNs using standardized procedures have emerged, including challenges in maintaining stable exposure concentrations in standardized laboratory conditions and in relating laboratory findings to actual field situations. In the present study, the ecotoxicity of the whole lanthanide series to *Daphnia magna* was tested along with a characterization of the stability of exposure concentrations obtained by measurements of total ($t=0$ and 48h) and total filterable ($<0.45\mu m$) concentrations. For selected elements (Nd, Gd and Yb), exposures were performed in absence and presence of dissolved organic matter (DOM ; 8 mg L-1 including 6.8 mg L-1 of fulvic acid) to assess the effect of this important environmental variable on both the ecotoxicity to daphnids and the stability of exposure concentrations in the test medium. In the absence of organic matter, the decrease in filterable LNs concentrations ranged from 10% to > 95% over 48 hours and showed an inverse relationship with atomic mass suggesting that, as a minimum, EC50 must be corrected to take into account such decrease. The addition of organic matter decreased the ecotoxicity of Nd and Gd, probably by formation of non-bioavailable complexes. On the contrary, addition of organic matter did not significantly affect the effects of Yb.

Due to their distinct physicochemical properties, rare earth elements (REEs) are critical to high-tech and clean energy industries. In nature, they are likely to occur as mixtures and thus most exposures will be for multiple REE simultaneously. Furthermore, since most of the REEs occur as trivalent cations, it is reasonable to hypothesize that they will not be taken up via the same membrane transport proteins as the mono- and divalent metals. Thus, it is not clear to what extent the presence of hardness metals (Ca, Mg) or other REE will affect metal bioavailability or effects. In this paper, we have carefully examined the bioavailability of several REEs for the freshwater alga, *Chlamydomonas reinhardtii*. Biouptake experiments generally showed strictly competitive interactions, i.e., a predictable reduction of the bioaccumulation of a first metal when in the presence of a second metal. Furthermore, these experiments suggested that the REE used a similar uptake pathway, with fairly similar affinity constants. In contrast, following the exposure of *C. reinhardtii* to REEs of interest, we performed on *C. reinhardtii* and *N. palea*. Results show that the role of the silica frustule surrounding the cell membrane will be investigated as a potential explanation for the difference in HA impact on PGEs uptake and toxicity compared to green algae. These results appear to be in conflict with the biotic ligand model, demonstrating the importance to continue such studies in order to better predict bioavailability of metals in presence of complex ligands such as NOM. Also it raises the issue of the impact of platinum on microalgae in realistic environmental conditions (with ubiquitous NOM), primary producers being of great ecological importance.
Concentrations and Thresholds for Effects of Current Use Pesticides in Aquatic and Terrestrial Ecosystems - Part 1

437 An ecological assessment of the effects of fipronil and degradates on US streams


The U.S. Geological Survey performed chemical and ecological surveys at 442 wadable streams in regions of the U.S. during 2013-17. Field sampling included as many as 14 weekly water samples for analysis of 225 pesticide compounds, followed by a survey of ecological communities. The insecticide fipronil and its degradates were detected in 19% of water samples nationally but in 53% of samples in the Southeast region. To refine ecologically relevant benchmarks for fipronil compounds used in risk assessments, we conducted a 30-day mesocosm experiment. Natural stream invertebrate communities were transplanted into 36 experimental streams under laboratory control. Treatments included 6 controls and 6 un-replicated concentrations of each fipronil compound: fipronil, fipronil amide, desulfinylfipronil, fipronil sulfone, and fipronil sulfide. Nominal exposure concentrations were 3-1563 ng/L (fipronil and amide) and 1-31,256 ng/L (desulfinyl, sulfone, and sulfide). Effect concentrations eliciting a 50% response (decline in abundance, EC50) were developed for as many as 15 taxa response signatures for each compound. The EC50s were combined with aquatic toxicity values from the EPA ECOTOX database to develop Species Sensitivity Distributions. Hazard concentrations for the 5th percentile of adverse effects on stream organisms (HC5) were derived for each compound using maximum likelihood methods and a parametric bootstrap technique. Resulting HC5s were: 1.7 ng/L for sulfone, 4.5 for sulfide, 5.1 for fipronil. No HC5 was calculated for the fipronil amide, which caused little toxicity to insect larvae in the mesocosm experiment. Values of HC5 were used to normalize fipronil compound concentrations in field samples to toxic units (TU), and the median TU was calculated for each site. The median TU was >0.1 in 30% of streams and >1.0 in 17% of streams. Based on a regionally specific measure of invertebrate ecological condition (invertebrate multi-metric index [MMI]), 168 streams were rated to have “Poor” ecological condition (38% of all streams sampled); 40% of these Poor streams also had a TU >= 1.0 for fipronil compounds. The highest number of streams with Poor ecological condition were in the Southeast region. These results suggest that fipronil compounds could be degrading the ecological integrity of streams throughout the U.S., and effects are heightened in the Southeast region where fipronil compound use is higher than in other regions.

438 The facts about fungicides: exposure, effects and risk using monitoring data from around the globe

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Fungicides are increasingly used in conventional agriculture to ensure global food security and their use is forecasted to intensify under changing climatic conditions and the proliferation of invasive fungi. The intensity of fungicide use varies both regionally and with the target crop. Fungicides can reach aquatic ecosystems and can occur in surface waters in agricultural catchments throughout the entire growing season due to their frequent, prophylactic application. Despite the intensive use of fungicides and the potential ecotoxicological risks to aquatic organisms, the exposure, fate and effects of fungicides have received less attention compared to herbicides and insecticides. To document the extent of exposure, the direct and indirect effects of a variety of fungicides and the potential risks to aquatic organisms, we conducted a detailed literature review of monitoring data from 5 continents. Our analysis showed that fungicides occur widely in aquatic systems, that the accuracy of predicted environmental concentrations is debatable, and that fungicide exposure can be effectively mitigated. We additionally demonstrated that fungicides can be highly toxic to a broad range of organisms not typically prioritized in current risk assessments of herbicides and insecticides. Finally, we outlined central research gaps that challenge our ability to predict fungicide exposure and effects, promising research avenues, and shortcomings of the current environmental risk assessment for fungicides.

439 Large-scale evaluations of pesticide concentrations in surface waters

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Pesticides are regularly detected in surface waters worldwide. Despite numerous local monitoring studies, our cumulative knowledge on both exposure in large parts of global agriculture and factors driving aquatic pesticide concentrations is still sparse. Transient exposure profiles at low, yet environmentally-relevant concentrations, for instance for some insecticides, provide additional challenges in obtaining data suitable for thorough assessments. Studies evaluating pesticide data at larger spatial or temporal scales only appeared over the last few years. Comparisons of field concentrations with regulatory threshold levels provide ample opportunity to evaluate pesticide monitoring data. Meta-analytical approaches can help to contextualise findings e.g. with type of pesticide, use-data, sampling procedures, site characteristics, and environmental regulations. Those few studies focusing on global or continental data e.g. from Europe or the U.S. will be synthesized. Results show that detected pesticide concentrations often exceed regulatory threshold levels suggesting that pesticide regulations often fail to protect agricultural surface waters. Amongst others, shortcomings in predictive modeling applied during regulatory exposure assessment contribute to these failures. Provided that surface waters are facing the strongest biodiversity declines, and water security threats are a global phenomenon, we need to rethink the use and management of pesticides in agriculture.
440 Meta-Analysis of insecticide risks and their drivers for surface waters in the United States

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Pesticide contamination of nontarget aquatic ecosystems via agricultural nonpoint sources is an issue globally, as well as in the United States. Especially insecticides, due to their high toxicity, can adversely affect surface water integrity, thus, comprehensive assessments of their potential ecological implications are necessary on large spatial scales. To address this challenge and to provide an additional line of evidence for risk managers, a literature synthesis and meta-analysis (1962 - 2017) of 259 peer-reviewed publications was conducted, detailing the occurrence and associated risks of insecticides and their degradates (n = 38) in United States surface waters. Measured insecticide concentrations (MIC) obtained via this procedure (n = 5830) were compared to regulatory threshold levels (RTL) to investigate, (i), overall and substance-specific risks in combination with potential future use trends, and (ii), spatio-temporal factors driving these risks, which were subsequently used for a national risk model. MICs were found to regularly exceed their RTL in both the water and sediment phase (48%, n = 5830) and more frequently thresholds, above which adverse effects for regional biodiversity can occur, questioning if current pesticide risk assessment and application schemes can be considered environmentally benign. Pyrethroids showed highest exceedance rates of all insecticide classes, which may be most concerning given that some of these products have seen rapid adoption by agricultural producers in recent years. Several significant risk determining factors were identified, e.g., toxicity-normalized use was found to be the most important predictor describing local risks, moreover sampling intervals affected risk characterizations by up to one order of magnitude. Also, in smaller watersheds (< 100 km²), MICs were found to pose significantly higher risks. Lower order streams, which rarely are the focus of monitoring programs, are hence most vulnerable to adverse insecticide contamination, threatening biodiversity and their function. Finally, spatio-temporal factors, such as rainfall erosivity and irrigation practices, affected insecticide risks significantly. Relevant predictors were used to model potential insecticide risks in U.S. surface waters for 2017.

441 Assessing agrochemical pollution in shallow well waters and chronic kidney disease in endemic Sri Lankan villages

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Agriculture has become a major industry in Sri Lanka since the Green Revolution. Subsequent increase in use of agrochemicals and the resulting burden of drinking waters by these chemicals has become suspect as a cause of the increase in chronic kidney disease of unknown etiology (CKDu) in lowland agricultural communities over the last two decades. This work provides the first data on select agrochemical compounds observed in Sri Lankan well and groundwaters and relates this data to the occurrence and progression of the disease in a cohort of 300 participants identified as having CKDu through a national screening. Results show strong indications that consumption of well water correlates with initial estimated glomerular filtration rates (eGFR) and that agrochemical concentrations in these wells often exceed US Environmental Protection Agency and World Health Organization guidelines for drinking water.

442 Mitigating Pesticide and Nutrient Contamination of Agricultural Wetlands in Canada’s Prairie Pothole Region

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Wetlands in the Prairie Pothole Region of North America are a valuable resource to humans and the environment alike. However, intensive agriculture has led to the loss and degradation of wetlands in this region which are frequently contaminated by pesticides and excess nutrients. Therefore, this project investigates the potential effects of pesticides and eutrophication on Prairie Pothole wetland invertebrate communities and the efficacy of vegetated buffers in mitigating contamination. Over the summers of 2018 and 2019, 71 Saskatchewan wetlands in cereal and canola fields were sampled for aquatic invertebrates using the Canadian Aquatic Biomonitoring Network (CABIN) protocol for wetlands and pesticide and nutrient concentrations. Over 160 common use pesticides were measured in water samples as well as major nutrients such as ammonia and orthophosphate. Pesticide concentrations were converted to Toxic Units based on species sensitivity distributions and are being modeled with wetland vegetated buffer zone (VBZ) characteristics and nutrient measures for their potential effects on aquatic invertebrate species abundances. All 32 wetlands sampled in 2018 were contaminated with one or more pesticides, some wetlands containing as many as nine. The most commonly detected pesticides were the neonicotinoid clothianidin and the herbicide 2,4-Dichlorophenoxyacetic acid. We are currently examining the efficacy of different configurations and amounts of producer implemented VBZ plantings to assess their ability to improve wetland condition. Identifying what VBZ implementation strategies are most effective will allow land owners and conservation organizations to design and prioritize incentive programs that best protect our wetland resources in working agricultural landscapes.

443 Neonicotinoid insecticides in wetlands of Western Canada: Putting monitoring data into the context of risk for aquatic invertebrates

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Water monitoring was conducted in 2018 to determine weekly concentrations and dissipation of thiamethoxam, clothianidin and imidacloprid in 56 wetlands located within thiamethoxam seed-treated fields across the agricultural areas of Saskatchewan, Canada. Detection limits for thiamethoxam (0.0006 µg/L), clothianidin (0.002 µg/L) and imidacloprid (0.0006 µg/L) allowed for high resolution of these analytes in the wetland water; thiamethoxam and clothianidin were detected in 64% and 31%, respectively, of samples collected. Overall mean concentrations of thiamethoxam ranged from 0.0007 µg/L to 0.1406 µg/L per wetland; clothianidin mean concentrations ranged from 0.001 µg/L to 0.018 µg/L. Imidacloprid was detected in five samples from a single wetland over the study duration. The greatest thiamethoxam concentration recorded in the current study was 1.9 µg/L, which is below the acute HC5 value (9 µg/L) for freshwater aquatic invertebrates. The majority of wetlands (44 of 56) exhibited 21-day rolling average thiamethoxam exposure levels < 0.025 µg/L. Wetlands with chronic exposures exceeding 0.025 µg/L had maximum 21-day average concentrations ranging from 0.029 µg/L to 0.54 µg/L. Thiamethoxam aquatic mesocosm NOEC values of 0.3 µg/L was exceeded 4 times (< 1% of 21-day averages), in a single wetland, from Week 6 to 12, but this result was driven by a single peak on Week 9. For clothianidin, the greatest concentration recorded in the current study was 0.12 µg/L, which was below the aquatic invertebrate HC5 value of 1.5 µg/L for acute exposure. The maximum 21-day average concentrations of clothianidin in sampled wetlands ranged from 0.001 µg/L to 0.038 µg/L. With regard to chronic toxicity, all calculated 21-day
average concentrations were below the clothianidin aquatic mesocosm NOEC value of 0.281 µg/L. The current study expands upon the suite of neonicotinoids typically analyzed for and provides a robust chronic dataset, contributing to our understanding of the presence of neonicotinoids in prairie wetlands. Detection and concentration patterns were consistent with usage patterns and precipitation events, as has been observed in previous studies. The likelihood of exceeding acute and chronic effects thresholds was low under the current conditions in these wetlands.

444 Neonicotinoid Concentrations in Canadian Prairie Surface Waters - Evaluation of Potential Chronic Concentrations

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The presence of neonicotinoids in surface waters of aquatic ecosystems of North America has been documented in several publications, but these data tend to lack sufficient sampling frequency to evaluate the potential dissipation of residues in these waters. Neonicotinoids are known to dissipate in water through photolytic processes, but this is often not considered when evaluating concentrations from such studies. Therefore, maximum (acute) concentrations are often compared to chronic toxicity endpoints. The temporal aspects of aquatic concentrations are critical to understanding potential effects on aquatic organisms, specifically aquatic invertebrates in the case of neonicotinoids. Results from previous and ongoing, neonicotinoid-targeted, field-scale monitoring studies in Canadian prairie wetlands will be described, along with an evaluation of the temporal and spatial aspects of the observed water concentrations.

Advances in Passive Sampling Across Environmental Compartments - Part 1

445 Assessment of the potential biological relevance of chemicals sampled in tributaries of the Great Lakes using passive sampling and ToxCast


The Great Lakes Basin and associated tributaries include a highly diverse set of land uses ranging from watersheds that consist of relatively pristine forests and wetlands to agricultural areas, industrial centers, and urban environments. Sources within each of these land uses can contribute a suite of chemical contaminants to streams, posing a potential threat to aquatic biota and other wildlife. Determination of exactly which contaminants are of concern, requires integration of both biological and chemical data. The ToxCast program provides a method to screen sample results for potential biological effects using information from hundreds of high-throughput assays that characterize a range of cell responses and approximately 300 signalling pathways for more than 9000 chemicals. Passive samplers can provide data on the time-weighted average (TWA) concentration of select chemicals in the water which can be a reasonable estimate of an organism's exposure to dissolved chemicals. This study describes the combination of these two techniques to determine the potential biological impact of chemicals in surface waters. In 2010 and 2014, a combined total of 67 sites along tributaries of the Great Lakes were sampled using semipermeable membrane devices (SPMDs) and polar organic chemical integrative samplers (POCIS). Extracts from these samples were analyzed for 189 chemicals including organochlorine pesticides, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs), pharmaceuticals, current-use pesticides, plasticizers, flame retardants, fragrances, and other chemicals related to wastewater effluents. Resulting TWA water concentrations were evaluated for pathway-based bioactivity using exposure-activity ratios (EAR = measured concentration/ToxCast activity concentration) Of the 145 chemicals with at least one detection, 90 were listed in the ToxCast database, allowing for determination of EARs. A comparison of EAR values from each site indicated that several tributaries of Lake Michigan and Lake Erie had a considerably higher level of contamination and potential bioactivity compared to other sites. The largest EARs were a result of the presence of several pesticides, PAHs, fire retardants, and detergent metabolites.

446 Legacy contaminant concentrations in porewaters and well waters measured using novel passive sampling methods on a remote Northwestern Hawaiian Island

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Historic federal operations on some islands in the Northwestern Hawaiian Island chain have led to environmental contamination including elevated concentrations of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in specific areas. Some of these islands are now marine protected areas and home to several threatened/endangered species and exposure to these contaminants has the potential to negatively impact the wildlife and the marine ecosystem. The objective of this study is to assess the level of contamination and the potential for the bioavailable contaminants to move to the nearshore environment and the potential ecological risk to threatened/endangered species on this remote island location accessible only by boat. To this end, low-density polyethylene passive samplers (PEPS) in addition to sediment samples were used to measure both freely-dissolved and sediment contaminant concentrations, respectively. A series of 20 upland stainless-steel (SS) wells associated with previously measured contamination and associated with expected reference levels were installed. PEPS were deployed in nearshore sediments adjacent to the wells using SS frames. The concentration gradients between the inland wells and nearshore areas will be evaluated to assess the potential for contaminants to migrate from the island. Performance reference compounds for PCBs and PAHs were used with a first-order model to correct for disequilibrium. Preliminary measurements show freely-dissolved PCBs in well- and pore-water (NOAA 18 congener sum) ranged from non-detect to a high of 24 ng/L. Freely dissolved PAHs in well- and pore-water (USEPA priority pollutant 16 PAH sum) ranged from 0.2 ng/L to a high of 190 ng/L. The highest levels (PCBs and PAHs) were measured in well-water samples in and near to a historic dump site. Near-shore sites located closest to the dump site also exhibited the highest PCB and PAH porewater concentrations. Sediment bioaccumulation tests conducted with marine polychaetes showed similar trends. Overall, both PEPS deployment systems (coils and frames) were demonstrated to be effective in this remote location despite significant weather and sediment movement events. PEPS-measured dissolved concentrations were directly correlated with sediment measurements and suggest that contaminants in the historic dump are migrating to the near-shore porewaters. This work will be important to assess potential ecological risks to the island ecosystem.

447 Mechanistic modeling for aquatic integrative passive samplers: How can we realize linear uptake?

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Aquatic integrative passive samplers such as Chemcatcher and the Polar Organic Chemical Integrative Sampler (POCIS) have received increasing...
attention in environmental analytical chemists, primarily because this type of passive samplers has the potential to measure time-weighted average (TWA) concentrations in relatively simple, inexpensive, and sensitive manner. Many field applications have been reported, and the performance of passive samplers depends on the devices, the chemicals, and the environments. Particularly, it is not always the case that the uptake behavior shows linearity against time, which is necessary for an accurate calculation of TWA concentrations. In this work, we introduced a mechanistically based, diffusion-sorption model into characterization of the uptake of chemicals by Chemcatcher. The model was verified with data from laboratory channel and tank experiments for ca 20 various polar pesticides and pharmaceuticals. The model reproduced varying uptake profiles such as occurrences of lag-times, curvilinearity, and equilibrating behavior. From model simulations we came up with three general suggestions that help achieve linear uptake for diverse chemicals. (1) The diffusion-limiting membrane filter should not significantly sorb the chemicals; (2) the receiving phase (sorbent) should be “very” strong; (3) a thick aqueous boundary layer and/or a thick (non-sorbing) membrane filter helps extend the linear uptake period.

448 Differential Influences of Decentralized and Centralized WWTP across Four Bayous following Hurricane Harvey in the Houston Area using Passive Sampling

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The greater Houston metropolitan area is the most populated and fastest growing places in US with a high concentration of industry. The Texas Gulf coast was highly impacted by Hurricane Harvey in August 2017. Subsequently, we applied a battery of passive samplers to investigate possible organic compound pollution after the hurricane in four different small bayous in this area. The bayous were selected to test hypothesis that more extreme flooding impacted more recipients with prevailing decentralized sources of communal pollution (e.g., septic tanks) than those with centralized wastewater treatment. We used polar organic compound integrative samplers (POCIS pest configuration) and silicon rubber sheets for nonpolar pollutants. Three sampling sites were selected in each catchment and passive samplers were deployed for 10 days in March 2018. We performed targeted and nontargeted analysis of wide range of organic compounds in all passive sampler extracts using state of art techniques including LC and GC MS/MS and HRMS. The list of polar compounds includes 69 pharmaceuticals and metabolites, 105 pesticides and metabolites, 28 PFCs, 14 bisphenols, 4 linear alkylbenzenesulphonates, 6 sunscreens and UV stabilizers, 9 organophosphorous flame retardants. Principal component analysis of this data set showed significant differences in contamination patterns among bayous. While sites that were not severely flooded were grouped, more extremely flooded sites with onsite septic tanks were had a distinct contamination pattern from those with central wastewater treatment. However, explanation of principal component with corresponding variables (determined compounds) is not straightforward and needs more detailed data on population and agricultural activities in sampled bayous. Almost the same grouping we obtained when PCA was applied on HRMS nontarget data. Within HRMS data processing we obtained very promising results identifying a number of xenobiotics compounds in different basins. We can conclude that passive sampling combined with robust analytical exploitation of the samples can be used as prospective tool for unraveling complex contamination in aquatic ecosystems. In addition, HRMS data can be used for long term monitoring of changes in basins with possibility of retrospective analysis.

449 Comparison of Chemical Contaminant Measures Using CLAM, POCIS, and PED Samplers in Estuarine Mesocosms


Sampling chemical contaminants in the water column using discrete grab samples can present multiple problems. For example, the ephemeral nature of constituent concentrations in marine environment (i.e. changing with tides, currents, precipitation, etc.) means that a discrete water sample only represents a “snapshot” that may not be temporally representative of the system. Additionally for some analytes, large volumes of water may be required in order to detect the chemicals; this may not be logistically feasible, especially at remote field locations. To address this issue, both passive and active sampling devices have been engineered. Passive and active samplers have been in field studies, where the contaminant loading is unknown. The objective of this study is to assess the performance of three samplers compared to grab samples in estuarine mesocosm systems with known quantities of chemical contaminants. To this end, three different types of systems were compared: two passive samplers [POCIS (Polar Organic Chemical Integrative Sampler) and PED (polyethylene devices)] and one active sampler [CLAM (Continuous Low-Level Aquatic Monitoring)]. The CLAM and the CLAM utilize semi-permeable membranes, whereas the PED is a polyethylene sheet that directly adsorbs contaminants on its surface. This experiment utilized 9 estuarine mesocosms containing saltwater, sediment, and marsh vegetation to test the response of passive and active sampling technologies in comparison with traditional grab sampling methodologies. The systems received doses of representative contaminants from three different contaminant classes (a hydrocarbon, a pesticide, and an antimicrobial). The test was a stacked design whereby the systems received a low dose of contaminants for 30 days. After that, the systems received doses of the same contaminants at higher levels for an additional 30 days. The passive (POCIS & PED) samplers remained in the systems continuously for each 30-day period. Active (CLAM) sampler deployments occurred once each week for no more than a 24-hour period. Grab samples for traditional lab-based extraction methods were collected weekly to coincide with the deployment of the CLAM samplers. All samples (POCIS, PED, CLAMs, and grab samples) were extracted, eluted, and analyzed via established quantitative analysis methods. Results from these comparative trials will be reported.

450 Evaluation of Equilibrium Passive Sampling Polymers for Monitoring Munition Constituents in Aquatic Systems

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Military munition constituents (MMCs) are persistent environmental pollutants identified in water bodies surrounding historically deposited unexploded ordnance. In general, concentrations of MMCs in waters and sediments are very low and widely distributed. Therefore, fast detection and identification of trace levels of explosives is of great importance for monitoring and assessing of remedial implementation and effectiveness. In turn, passive and sensitive monitoring techniques provide a better understanding of the bioavailability and potential long-term bioaccumulation and toxicity of MMCs in different aquatic environments. This study explores the use of commercially available nonpolar polymers including polydimethylsiloxane (PDMS), low density polyethylene (LDPE) and polyoxyethylene (POM) as equilibrium passive samplers for measuring freel (free) concentrations of munition constituents. The potential of fabricated polymer sheets and polymer blends including ethylene vinyl acetate (EVA), a PDMS and Ambersorb mix, and more polar resins such as Isolute Env+, Oasis HLB and Porapak incorporated into Agarose gel is
also explored. Commercial and fabricated polymers were exposed in batch water systems spiked with the munition constituents 4-amino-2,6-dinitrotoluene (4-A), 2-amino-4,6-dinitrotoluene (2A), pentachlorothiol tetranitrate (PETN), 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane (HMX), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), picric acid (PA), and 1-nitroguanidin (Ngua). The uptake and change of explosive compounds was monitored in polymer and water phases over time with LC-MS/MS operated in electro-spray ionization mode (Sciex Qtrap 4500). Mass transfer coefficients ($K_L$) and partitioning constants ($K_{PW}$) were obtained from the kinetic and equilibrium portions of the datasets using a two compartment model. Results suggest that POM, EPA, PDMs, and Agarose-HLB are the most promising passive samplers for MCMs. It appears that $K_{PW}$ is also a master variable for describing the partitioning behavior of compounds with low hydrophobicity (< log 4). The two-compartment model provides excellent agreement between measured and predicted $K_{PW}$ values for different polymers and $K_c$ values, which can then be used with polymers exposed in the laboratory or field. The presentation provides information both on the uptake and release of explosive compounds to a variety of polymeric materials and discusses their potential for application in equilibrium passive sampling.

451 Advantages of Passive Sampling as a Decision Making Tool
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Passive sampling devices (PSDs) present numerous advantages over conventional sample collection methods for quantifying hydrophobic organic compound (HOC) availability in sediment, soil, surface water and storm water. PSDs can provide superior convenience, cost and data quality compared to conventional grab or mechanically extracted samples. A major advantage of PSDs is their property of quantifying only the freely dissolved, bioavailable fraction while not measuring the sorbed or non-bioavailable fraction. Measuring only bioavailable contaminants with PSDs provides a better measure of actual toxicity and mobility for environmental receptors and a lower tendency towards toxicity overestimation than conventional sampling methods. This presentation will highlight examples where PSDs have been used in the laboratory and in the field for decision making in site investigation and remediation, including techniques and advancements that simplify and improve ease of sampling, increase data quality and lower costs. We will demonstrate how a combination of an in situ application of peelers as PSD to analyze sediment porewater mobility of heavy metals and ex situ testing with polyethylene PSDs for polychlorinated biphenyl (PCB) and organochlorine pesticide (OCP) porewater concentrations was applied to site investigation. A second -in situ application will highlight the use of polyethylene-based PSDs to evaluate depth profiles of PCB porewater concentrations in sediment up to two feet below the sediment surface. A third laboratory case study will highlight the use of PSDs to evaluate the effectiveness of different levels of activated carbon to immobilize PCBs. The study reduced the remedial budget significantly by avoiding the addition of excess activated carbon amendment. The application of PSDs for in situ field monitoring pre- and post-remedy at the site were then used to evaluate remedy performance in the field.

Chemistry and Exposure in the Indoor Environment - Part 1

452 Indoor exposure to per- and polyfluoroalkyl substances (PFAS): Presence of PFAS in U.S. childcares
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PFAS, with their varied uses including as surface treatments for carpets, rugs, and upholstery as well as in waxes and cleaners, are potential contaminants of the U.S. childcare environment. To obtain a preliminary assessment of children's exposure in this environment, floor and surface dust samples as well as samples of nap mats were collected from eight childcares in Washington State and Indiana and analyzed for 42 ionic and neutral PFAS. Samples of mats and dust were analyzed for 42 PFAS as follow, including 31 ionic and 11 neutral PFAS. Ionic PFAS were analyzed on a UPLC-QQQ MS (Agilent 1290 Infinity II UPLC - 6470 QQQ-MS) with negative electrospray ionization (ESI-). Neutral PFAS were analyzed on an Agilent 7890 gas chromatograph (GC) coupled to an Agilent 5975C mass spectrometer (MS) in the electron capture positive ionization (PCI) mode. In the 20 samples analyzed, neutral PFAS including 6.2 FTOH (median level 125 ng/g), 10.2 FTOH (40.3 ng/g), and 8.2 FTOH (19.5 ng/g) were present in the highest concentrations. Precursor compounds EtFOSE and MeFOSE were also detected at relatively high concentrations (median 15.1 and 10.8 ng/g, respectively). Among the ionic PFAS, the fluorotelomer sulfonate compounds 6.2 FTS and 8.2 FTS were detected at the highest levels (median 11.9 and 5.8 ng/g, respectively). None of the childcares had carpeting, but sources of these compounds may include treated upholstery, rugs, and cleaners/waxes used on flooring. The surprisingly high concentrations of the fluorotelomer sulfonates may result from their use as fluorosurfactants in indoor cleaners, waxes, and polishes. In foam and polyester batting from nap mats in use at the childcares, ionic PFAS levels were consistent, ranging from < LOD to 11.2 ng/g, with PFHxDA present in the highest concentrations in most samples. Analysis of the mat samples found ?Neutral PFAS ranged from < LOD to 192.6, with a profile similar to that of dust, with the foam in the mats possibly serving as a passive sampler. These results indicate PFAS-containing products are likely used in childcares, with the result of exposing young children for a large portion of their day.

453 Human Exposure to Semi-Volatile Organic Compounds (SVOCs) in Social Housing Apartments
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When compared to outdoors, the indoor environment often has higher concentrations of some SVOCs, such as brominated flame retardants (BFRs) and phthalates that are used as additive flame retardants and plasticizers from consumer products and building materials. Some outdoor SVOCs such as polycyclic aromatic hydrocarbons (PAHs) can be transported into indoor environments which increase indoor exposure to these compounds. Most indoor sampling studies have focused on homes from mid-to-high-socio-economic status (SES) occupants. Residents of low-income social housing are vulnerable to health effects from exposure to indoor air pollution and yet have received much less attention. This study documented concentrations of FRs, phthalates and PAHs in indoor air with the goal of assessing indoor exposure in lower income social housing. Silicone rubber (polydimethylsiloxane or PDMS) passive air samplers were deployed for one week in 71 units in 7 multi-unit social housing buildings located in Toronto, Canada, during the summer and winter of 2017. Seventy-one PDMS samplers deployed were recovered for analysis on a GC-MS in EI and CI modes. Chemical mass collected by the samplers was converted to air concentrations. Tris(1,3-dichloro-2-propyl) phosphate (TDCPP) and Diethyl phthalate (DEP) were the dominate flame retardant and phthalate in indoor air in both summer and winter with median concentrations of 2160 pg/m³, 748 pg/m³ and 2070 ng/m³, respectively. The most abundant PAH was phenanthrene in summer with a median concentration of 82.8 ng/m³, whereas naphthalene was the most abundant PAH in winter with a median concentration of 81.7 ng/m³. No seasonal difference was observed among most of the SVOCs except for Di-n-octyl phthalate (DnOP), Dibutylphthalate (DBP), Acenaphthylene and BDE-49 which had relatively higher concentrations in winter than summer, and TDCPP which had a higher concentration in summer. In general, residents in social housing units experienced 2 to 19 times higher air concentrations of FRs and phthalates than those of predominantly detached and semi-detached houses in Toronto measured using the same passive samplers, presumably occupied by occupants with higher SES and with lower occupant densities, suggesting the potential for exposure disparity.
454 Associations of exposures to flame retardants and thyroid hormones in adults living in central Appalachia
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Health disparities still exist in rural Appalachian coal mining communities and environmental pollution from activities of the mining industry can contribute to population health inequities. Indoors environment is recognized to be intensively contaminated with flame retardants (FRs). The quality of indoor air has an important impact on health as people normally spend 80 - 90% of their time indoors. Our objectives were to evaluate exposure to FRs and to explore the relationships between chemicals exposures and health effects. We used passive air samplers with polyurethane foam (PAS-PUFs) to investigate the levels of polybrominated diphenyl ethers (PBDEs), novel brominated flame retardants (nBFRs), and organophosphate flame retardants (OPFRs) in indoor air and silicone wristbands to examine personal exposures to these chemicals in 8 communities in central Appalachia. PAS-PUFs were deployed indoors for 30 days in 101 residential homes during March 2017 - July 2018. One resident in each home wore a silicone wristband for 7 days. Whole blood was also collected from each participant by finger prick (blood spots) for thyroid hormone analysis. Relationships between PBDE, OPFR, and nBFR levels in wristbands and thyroid hormones including free thyroxine (FT4), triiodothyronine (FT3), and thyroid stimulating hormone (TSH), were assessed using multiple linear regression. The median total concentration for OPFRs, PBDEs, and nBFRs were 25,018, 206, and 69 pg/m³ in indoor PUFs, and 671, 49, and 114 ng/g wristband in wristbands. The most abundant chemicals in both air and wristbands were tris(2R)-1-chloro-2-propyl phosphate (TICIPP) among OPFRs, BDE-47 and -99 among PBDEs, and 2-ethylhexyl 2,3,4,5-tetrabromobenzocate (EHTBB) and bis(2-ethylhexyl) tetrabromophthalate (BEHTBP) among nBFRs. When controlling for age and smoke, positive and significant associations were observed between 2-Ethylhexyl diphenyl phosphate (EHPD), BDE-197, -100 and FT4, between tri-ethyl phosphate (TEP), pentabromobenzene (PBBZ) and FT3, and between tris(3,5-dimethylphenyl) phosphate (TMDPP), BDE-28, pentabromoethyl benzene (PBBE), anti-DP and TSH. These results indicate that wristbands are a good matrix for evaluating human exposures to FRs and possibly to other compounds as well.

455 Human Exposure to Phthalates via Indoor Dust Ingestion at Urban and Rural Homes in Eastern Slovakia
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Phthalates are used as plasticizing agents in polyvinyl chloride (PVC), food packages, toys, and many other products. They are easily released from the products to the indoor environment and partition to dust particles due to their hydrophobicity. Dust can be an important exposure route, especially for children. Health effects of phthalates have been identified as reproductive system dysfunction, endocrine disruption, allergy and asthma in children and obesity. Despite being restricted and regulated in many countries, the release from polymer products and human exposure may continue for decades since the products containing phthalates remain in use and even on the market. Therefore, it is crucial to identify concentrations and human exposure to phthalates in indoor environments. The current study investigated the phthalate concentrations in homes in Eastern Slovakia. In 60 homes one dust sample was collected from a child’s bedroom. Samples were solvent extracted with sonication. The extracts were fractionated and analyzed by GC–Orbitrap in full-scan (70-1000 amu) in EI with 30 m column. Blank subtraction was employed for final quantification. The median phthalate concentrations ranged between 0.01 μg/g for dipentyl phthalate to 327.8 μg/g for bis(2-ethylhexyl) phthalate (DEHP). DEHP constituted 83.3% of the total ten phthalates, followed by di-n-butyl phthalate (7.45%). DEHP concentrations in Slovakian homes were comparable to those in France, Denmark, USA, a few regions of China, and Qatar, but were lower than that in Germany, Sweden, Kuwait, China and Japan. Mann-Whitney U-tests revealed a statistically significant difference for butylbenzyl phthalate and dimethyl phthalate concentrations in urban and rural homes (p < 0.05). However, no significant difference was found between the homes with and without PVC flooring, suggesting that other indoor phthalate sources are influencing the concentrations in these homes. The estimated DEHP exposure via dust ingestion was 216 ng/kg/day for children and 98 ng/kg/day for an adult female. Our previous study identified phenanthrene as the compound having the highest estimated total intake among the semivolatile organic compounds identified in the same homes. In the current study, DEHP exposure was nearly 50-60 times higher than that of phenanthrene.

456 Occurrence and Human Exposure Assessment of Phthalates in Indoor Environment of Residential Buildings in Guangzhou, South China
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Phthalates are environmental endocrine disruptors that might have adverse effects on human health. In the present study, one hundred families were randomly selected, and indoor air, dust and urine of family member were collected to analyze phthalates or their metabolites in 2018, Guangzhou, South China. We aimed to evaluate the contribution of phthalates in indoor environment to total human exposure by comparing their external and internal exposure. Our results indicated that concentration of total phthalates in the indoor air was in the range of 279-5080 ng/m³, with a median value of 1920 ng/m³. Among all targets, Di-n-butyl phthalate (DBP), Di-isobutyl phthalate (DIIBP) and Di-(2-ethylhexyl) phthalate (DEHP) were the main pollutants, accounting for 52.3%, 28.1% and 10.0% of total amount, respectively. For the indoor dust, the concentration of total phthalates was 48.7-2850 μg/g, and DEHP, DBP and DIIBP were also the three main pollutants, accounting for 80%, 17% and 2%, respectively. For urine samples, concentration of metabolites was 10.7-2840 ng/mL. The concentration of Σ4 DEHP (sum of 4 metabolites of DEHP) ranged from 2.68 to 180 ng/mL. The total daily exposure of phthalates based on urinary phthalate metabolites was 10.8-62.4 μg/kg/day for all families. The exposure dose was significantly different among various age groups, with the sequences as infants (< 1 year old, 62.4 μg/kg/day) > toddlers (1-3 years old, 16.4 μg/kg/day) > teenagers (11-18 years old, 15.2 μg/kg/day) > adults (> 19 years old, 12.8 μg/kg/day) > Children (4-10 years old, 10.8 μg/kg/day). The daily exposure of DEHP for infants had exceeded the reference dose (RFD) given by the U.S. Environmental Protection Agency. In addition, the external exposure assessment showed that the daily intake of phthalates via dust ingestion and air inhalation was 0.166-2.54 and 0.297-1.54 μg/kg/day, respectively. The main exposure way of phthalates changed from dust ingestion to air inhalation with age increased. By compared with the total exposure, the contribution of phthalates exposure via indoor dust ingestion and air inhalation was less than 13.3%. The present study demonstrated that phthalate pollution in the indoor environment of residential buildings in Guangzhou was relatively serious. The total exposure levels for the family members were lower than the reference dose, but relative higher for infants. Indoor dust and air were non-negligible sources for human exposure to phthalates.

457 Sources of Isocyanic Acid (HNCO) Indoors: A Focus on Cigarette Smoke
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The sources and sinks of isocyanic acid (HNCO), a toxic gas, are largely uncharacterized in indoor environments. In particular, cigarette smoke has...
been identified to be a significant source of HNCO and possible precursor compounds. Identification of indoor sources and conditions that lead to elevated HNCO are necessary to understand the health risk for occupants. In this study, controlled smoking of tobacco cigarettes was investigated both in a residence in Toronto, Canada and in an environmental chamber using online chemical ionization mass spectrometry. Fast measurements, inside and outside of the Toronto residence, allowed for the determination of the emission rates of HNCO from cigarette smoke, the background conditions in the house, and comparison to outdoor concentrations. Chamber measurements explored possible indoor-relevant reactions - oxidation by ozone, hydroxyl radical (OH), and photo-reaction under indoor fluorescent light - that could lead to secondary production of HNCO from cigarette smoke precursors. The HNCO emission ratio from side-stream cigarette smoke was determined, from both the residence and chamber studies, to be in a similar range to emission ratios from previously reported biomass burning smoke sources. Side-stream smoke from a single cigarette introduced a large pulse of HNCO to the indoor environment, increasing the HNCO mixing ratio by up to a factor of ten above background conditions of 0.15 ppb. Even in the absence of smoking, the indoor HNCO mixing ratio in the Toronto residence was elevated compared to concurrent outdoor measurements by approximately a factor of two. Oxidation of the cigarette smoke by OH was the only investigated process to produce secondary HNCO. After 30 minutes of oxidation by OH (1.1 x 10^7 molecules per cm^3), the HNCO mixing ratio was observed to double and continued to increase with further oxidation. Loss of HNCO by partitioning or reaction at indoor surfaces was identified to be significant, in addition to mixing within the house and ventilation to outdoors.

458 The influence of bleach cleaning emissions on indoor chemistry: Formation of secondary gases and particles
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Application of chlorine bleach solution (major component sodium hypochlorite, NaOCl) in indoor environments emits gaseous hypochlorous acid (HOCl) and chlorine (Cl2), both of which are strong oxidants. HOCl and Cl2 may react with unsaturated organic compounds on indoor surfaces and in indoor air but their impact on indoor air quality has not been well characterized. In this study, we studied the reaction of limonene, one of the most common indoor volatile organic compounds (VOCs) arising from use of cleaning products, fragrance, air fresheners, with HOCl and Cl2 in an environmental chamber. A dark reaction was observed between limonene and HOCl/Cl2 leading to gas-phase reaction products investigated using on-line mass spectrometry. With subsequent exposure to indoor fluorescent lights or diffuse sunlight through a nearby window, a significant mass loading of secondary particles formed. Mass spectrometry measurements of the aerosols indicate a large contribution of particulate chlorine species and formation of high molecular weight products. This is the first study of the oxidation of limonene with HOCl and Cl2, and it illustrates the potential for particle formation to occur with indoor lighting during the use of common cleaning products. Formation of secondary products and particles may lead to health effects for indoor occupants.

459 Hydrogen Peroxide Emission and Fate After Cleaning Events
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Low oxidant levels and rapid exchange of air between indoor and outdoor environments often makes chemical transformations of gas-phase species unimportant indoors. However, perturbations to these environments such as cooking and cleaning can dramatically increase indoor oxidant levels, leading to rapid chemical transformations that can affect human health. While a number of studies have reported the effects of cooking on various markers of indoor air quality (such as oxidant levels and particulate matter formation), few studies have reported the effects of cleaning on indoor chemistry. High levels of gas-phase reactive chlorine species and hydrochloric acid (HCl) have been reported after washing surfaces with bleach, and hydroxyl radical (OH) levels were reported to increase greatly after cleaning surfaces with a limonene-based cleaner. In this work, we report time-resolved measurements of gas-phase hydrogen peroxide (H2O2) during and after cleaning floors with a peroxide-based cleaner. Peak H2O2 levels after cleaning were more than 1000 times higher than background levels. We used the INdoor air Detailed Chemical box Model (INDCM) to investigate the effects of H2O2 photolysis (initiated by room lights or sunlight attenuated through a window in the chamber wall) on air composition and radical formation in the chamber.

Micro- and Nano-Plastic Methods Research: Harmonizing Methods and Addressing Challenges - Part 1

460 A Methodology for Making Standardized Microplastics: Effect of Particle Size on Surface Area of “Weathered” Particles
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It is known that organisms ingest microplastics and that they may cause deleterious effects, but it is unclear how large a role microplastics play as a particle versus as an exposure route to organic pollutants. Many studies have tried to address this issue; however there has been much criticism for environmentally irrelevant conditions. Additionally, ecologically relevant experiments have not used standardized microplastic particles and have shown mixed results. The heterogeneity of methods makes comparing studies challenging, if not impossible. There is a clear need for the development of standardized methodology for testing the toxicity of microplastics and sorbed pollutants. An integral part of this process will be the creation of “weathered” microplastics of consistent surface area, as this attribute is important for sorption. In order to address this problem, the objective of this study was to develop a methodology to fabricate pitted and irregularly shaped (“weathered”) microplastics with standardized surface area on a mass basis. Rods of high-density polyethylene and polypropylene were cooled in liquid nitrogen and shaved with a stainless-steel wood file. The particles were sieved through nine different pore sizes and cleaned with solvent. Surface area was measured using Brunauer-Emmett-Teller theory with krypton gas. Results presented will show how surface area and surface morphology changes with particle diameter, including a study with the antimicrobial triclocarban to demonstrate the effects of surface area on sorption. Having standardized microplastics will enable the design of more realistic and comparable experiments, and will be a step closer to creating ecotoxicity tests for microplastics and organic pollutants.

461 Introducing New Application-Based and Spectral Libraries of Microplastics (SLoPP & SLoPP-E) for Raman Spectroscopy
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As smaller microplastic particles are increasingly included in research, it is critical to chemically characterize microparticles to identify whether they are indeed microplastics. To increase the accessibility of methods for characterizing microparticles via Raman spectroscopy, we created an application-based library of Raman spectroscopy parameters specific to microplastic particles based on color, morphology and size. We also created two spectral libraries that are representative of microplastics found in environmental samples. Here, we present SLoPP, a Spectral Library of Plastic Particles consisting of 148 reference spectra, including a diversity
of polymer types, colors and morphologies. To account for the effects of aging on microplastics and associated changes to Raman spectra, we present a Spectral Library of Plastic Particles aged in the Environment (SLoPP-E). SLoPP-E includes 125 spectra, including a diversity of polymer types, colors and morphologies. The microplastics used to make SLoPP-E spectra were sourced from environmental samples across a range of matrices, geographies and time points. Like many environmental samples, many of the particles included in SLoPP-E have undergone some form of chemical treatment or digestion (e.g., KOH digestion or density separation via CaCl2). Both libraries increase the likelihood of spectral matching for a broad range of microplastics, likely because our library includes plastics with a range of additives and pigments, and that have been exposed to the environment, characteristics that are not generally included in commercial libraries. When SLoPP and SLoPP-E are tested in combination with commercial libraries of over 24,000 spectra, they account for 69% of the top 5 matches across all particles tested (product and environmental). Furthermore, 80% of the top matches (first match) are from SLoPP and SLoPP-E. These tools were developed to improve the accessibility of microplastics research in response to a growing and multidisciplinary field, as well as enhance data quality and consistency. The development of accessible microplastics libraries are also intended to facilitate higher throughput and faster automation of polymer identification for Raman spectroscopy.

462 Method development for the isolation and analysis of micro- and nano-plastics using a potassium hydroxide digestion and particle pattern observations

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The global presence of micro- and nanoparticles (M/NPs) prompts concerns about the negative effects they may have on the environment and wildlife. To understand the potential effects of M/NPs, one must first understand exposure -- which involves isolating particles in a sample and determining how much is present. There are currently no standard methods for isolating and analyzing M/NPs. A common isolation procedure for environmental samples uses a potassium hydroxide (KOH) solution to digest organic matter. While this method has demonstrated that plastics ≥ 10 μm are not significantly degraded by the KOH, it is unknown whether plastics smaller than this size are affected. Once isolated, Raman spectroscopy is a common analysis method, but can be time-consuming. Automation has been proposed to make Raman analysis more efficient, but an appropriate subsampling strategy should first be determined. We present two related projects on the method development of M/NPs isolation and analysis. First, we aim to determine whether plastic particles contamination. Blank correction of samples was carried out as per common chemical analyses, including reporting concentrations based on limit of detection (LOD) and limit of quantification (LOQ), in order to reduce the possibility of reporting false positives. Further, given the possibility that not all particles would be recovered with the techniques used, spiked recoveries were essential to account for any losses during the processing. While we used two dense polymers (nylon and PVC), spiked recovery using a range of polymers and particle sizes, extracted using the same techniques as the environmental samples, is essential to gain an understanding of how recovery may vary based on particle type, shape and size. We employed state-of-the-art analytical techniques (linear array FTIR combined with MP Hunter software for data analysis). Such techniques require substantial sample processing, including digestion of organic material, to produce a ‘clean’ sample for analysis. As such we optimised wet peroxide oxidation (Fenton’s reagent) and enzymatic digestion (cellulase and trypsin). For complex inorganic matrices such as sediments and sludge, a flotation step is also essential. This presentation will detail the challenges faced in implementing such controls, and highlight the critical need for such standards, especially when communicating levels of microplastic contamination and risk to governments, industry and the public. Our results highlight the critical need to account for blank contamination: many studies to date would have reported far lower concentrations if carrying out such rigorous quality controls as implemented here.

464 Method optimization of microplastic extraction from marine sediments

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The distribution and fate of microplastics (MPs) (plastic particles < 1 mm in size) in marine environments are largely unknown. There are over 100 peer reviewed extraction methods for the isolation of microplastics from marine sediments; however, major procedural differences prevent meaningful comparisons among methods. Prior to this study, we conducted a method comparison analysis to assess the applicability of five popular methods to recover microplastics of different polymers, sizes, and shapes from two sediment types. Results from the method comparison analysis suggested that isolation of different MPs is strongly dependent upon MP properties, isolation method, and sediment characteristics. These prior results were used to develop a new method to extract microplastics (45-1000 μm) from amended environmental sediments which varied in sediment composition and percent organic carbon. Plastics tested included polypropylene (PP), low density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET), and polystyrene (PVC). Results indicated that this new method generally extracts over 70% of tested MPs from both sandy and silty sediments. The results presented include quantification of the performance of this hybridized method, as well as initial recommendations for routine microplastic monitoring in marine sediments.

465 Chemical compatibility of microplastic polymers with commonly used and novel biological preservation and digestion methods

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Plastic pollution is abundantly present in diverse marine habitats of Hawaii, including the nearshore habitat of planktonic larval fish that are economically and ecologically important. We have documented, using labor-intensive micro-dissection and Raman microscopy methods, that larval fish in this habitat are ingesting microfibers. Like other labs we are on a quest for higher throughput and automated methods to monitor the quantities and identities of microplastic debris in environmental samples.
Instead of micro-dissection, we considered five categories of previously published methods for digesting biological tissues away from ingested microplastics: acid, base, hydrogen peroxide, enzyme and ultrasonication. The first three methods use chemicals that are poorly compatible with some plastic polymers. Certain polymers anticipated in our samples are expected to dissolve in the chemical treatments (e.g., nylon in acid, base or hydrogen peroxide), leading to significantly underestimated quantities. Chemical compatibility with typical sample preservation methods is also a concern. The goal of this study is to test the compatibility of 14 polymers from several commonly used and novel preservation and digestion techniques, in triplicate and in the absence of biological tissue. Polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), low density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), cellulose acetate, nylon, polymer containing a high proportion of phthalates, polyurethane, as well as cotton and polyester fibers (1-2 mm particle sizes) will be used as representatives of the most common polymers found in Hawaiian marine debris and understudied fibers used in textiles. We will also test the stability of each polymer in two common preservatives, 95% ethanol and formalin, for 1, 7, 30, 60, 120 days and beyond. Recovery of each polymer will also be measured from treatments replicated from five published digestion methods and a novel method using bleach. Changes in particle count, mass, shape, surface texture, and spectra from attenuated total reflectance Fourier transform infrared spectroscopy will be measured. The data will be used to demonstrate the extent of possible underestimation of polymer quantities in previous studies that analyzed biological samples and to select optimal methods for future analysis of a large repository of preserved larval fish sampled from nearshore Hawaii.

466 “One Pot” Method for Collection and Preparation of Water and Sediment Samples for Detection and Characterization of Microplastics

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In microplastic analyses, one of the most commonly encountered challenges is avoiding sample contamination and minimizing losses during sample preparation steps. This contamination can be addressed through a combination of vigilant laboratory cleanliness and conscious decisions on materials used and worn during analysis, and losses can be minimized by decreasing transfer steps. However, there still exists a very real chance of contamination, carry-over, or loss events which can limit conclusions drawn. Here, we describe a “One-Pot” method (this includes sample preservation, storage, digestion, density separation, and dye-staining steps) which minimizes sample contamination and avoids transfer losses and carry-over events by keeping a sample in the same jar it was collected in until the sample is placed on a filter for analysis. Furthermore, this method uses relatively inexpensive and easily purchased or assembled materials such as canning jars and wire screens. Insight from the use of this method on samples collected from the Mississippi River is also detailed. In summary, the “One-Pot” improves the reliability of microplastic analyses, particularly for the smaller size fraction (less than about 0.5 mm) which are more prone to contamination and transfer losses.

467 Development of Evidence-Based Standards: Optimization of Raman Microscopy Methods for 1 um Particles of Five Different Plastics

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Raman microscopy is a non-destructive method for definitive identification of microplastic particles from environmental samples and is useful for evaluating microplastics in the 1-20 um size range. Integration of imaging software and automation with Raman analysis provides the opportunity for more efficient and comprehensive evaluations of microplastics. However, analytical settings and target particle characteristics such as laser power, integration time, particle size, and the type of plastic being analyzed can all affect the quality of spectra produced. This can significantly impact results especially for samples containing particles of different sizes or composition. Evaluation and optimization of these parameters is necessary to ensure results are accurate and reliable. This study evaluated the effect of laser power and integration time settings on target particle integrity and spectral quality for 1 um particles of five different plastics commonly found in environmental samples. Particles were filtered onto aluminum-coated polycarbonate filters and analyzed using Raman confocal microspectroscopy with a 532 nm wavelength laser using different combinations of laser power and acquisition times. Following analysis, particle integrity was visually evaluated and the quality of each resulting spectrum was determined by measurement of signal to noise ratios and comparison to an in-house reference. This data was used to determine optimized Raman analysis parameters for the five plastic types evaluated. The results of this study are a step forward towards the goal of validation and optimization of Raman microspectroscopy for application to environmental microplastics samples, which is necessary for establishing evidence-based methodology standards for this important analytical technique.

Incorporating New Approach Methodologies to Improve Ecological Risk Assessment - Part 1

468 Transcriptomic Dose-Response Modeling Provides Points of Departure that are Highly Correlated to Apical Measures of Aquatic Toxicity

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Transcriptomic dose-response modeling (TDRM) is a promising quantitative approach to derive protective estimates of points of departure (POD) for chemical risk assessment. To date, this method has primarily been applied in rodent and human models. Few studies have evaluated its application to environmental species. Here, we used publicly available toxicogenomics datasets to demonstrate that TDRM can produce protective POD estimates for various aquatic species (fish, daphnia, frog) exposed for short (<7 days) or long (>14 days) periods to different classes of chemicals (endocrine disruptors, flame retardants, herbicides and a metal). Toxicogenomics datasets (n=12) from aquatic organism exposure experiments with a minimum of four dose groups were downloaded from the gene expression omnibus (GEO). For each experimental dataset, transcriptomic points of departure (tPODs) were determined using the benchmark dose (BMD) method. Briefly, the tPOD was identified as the first mode or tenth percentile (whichever was lowest) of the distribution of the BMDs of all significantly differentially expressed transcripts. Most of the chemicals tested demonstrated a multimodal distribution of transcript BMDs, indicating a dose-specific co-ordination in the expression of large groups of genes. In most instances, the tenth percentile BMD was lower than the first mode BMD, and was used as the tPOD. tPODs were then compared to lowest observable effect concentrations (LOECs) for traditional apical measures of chronic toxicity (e.g. reproductive toxicity, lethality) determined in the same species as the transcriptomic datasets. LOECs for each chemical/species combination tested were identified from risk assessment documents from various regulatory jurisdictions. Overall, we found a very strong correlation between tPOD and the apical LOEC (R2=0.88). All of the tPODs were within one order of magnitude of the LOEC. Greater than 90% of tPODs were protective (i.e. equal or lower than the LOEC). These results provide compelling evidence that TDRM can be used to generate a POD that is protective of chronic toxicity for various aquatic species, chemicals and exposure durations.
469 Development of a zebrafish minimal set of sufficient key events (minSSKE) PCR array to screen chemicals for the potential to cause cancer

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Determining the potential of a chemical or mixture of chemicals to cause cancer can be a costly and lengthy process. Many of the mechanisms underlying tumor formation and cancer are conserved among vertebrates suggesting that Key Events underlying Adverse Outcome Pathways (AOPs) for tumor formation could be used to screen chemicals in animal alternative models such as zebrafish embryos. To explore this, we first developed a liver cancer (AOP) network based on mammalian literature. We then identified a set of 6 genes where individual AOPs converge and whose activation or inactivation is sufficient to predict activation of a Key Event within the AOP network. The minimal Set of Sufficient Key Event (minSSKE) genes included vegfa (angiogenesis), rbl (regenerative proliferation), foxm1 (regenerative proliferation), cdkn1a (regenerative stasis), and pcna (translesion synthesis). The genes were validated using analysis of microarray data for rats exposed to several known carcinogens in the Open TG-GATES data set. A PCR array for zebrafish embryos was designed from the minSSKE and was used to assess the carcinogenic potential of extracts from passive sampling devices exposed for one month to rivers near the Great Lakes and in complex mixtures of known chemicals. Exposure to PAHs from passive sampler extracts resulted in upregulation of rbl, cdkn1a and pcna while acs1a was downregulated indicating the potential for the chemical mixtures in the river water to cause tumor formation. We also examined the carcinogenic potential of mixtures of 20 known chemicals on zebrafish embryos using the PCR array. While the full mix of 20 chemicals caused upregulation of vegfa and foxm1, withholding Individual chemicals or classes of chemicals from the mixture resulted in no change of gene expression or upregulation of rbl and/or vegfa. This analysis indicates that a PCR panel based on the Liver Cancer minSSKE can be used to assess tumorigenic effects of chemicals. This approach has the advantage that each gene examined can be mechanistically linked to an adverse outcome of regulatory concern. Being able to directly connect chemical exposure to adverse effects by examining gene expression of sufficient Key Event components should facilitate prioritization activities in addition to hazard and risk assessment activities.

470 Linking molecular to bioenergetic responses: Metabolomic and lipidomic data inform changes in energy budgets of freshwater alga exposed to copper

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Comprehensive and efficient Ecological Risk Assessment depend on our ability to quantitatively extrapolate the effects of stressors, including toxic chemicals, under various environmental conditions, across levels of biological organization, and among species. The utility of bioenergetics models, such as Dynamic Energy Budget (DEB), has been demonstrated with many species to extrapolate from individual- to ecological-level effects of multiple stressors. However, DEB’s use of abstract variables obscures mechanistic connections to suborganismal biology, which complicates the use of “omics” data (OMICs: transcriptomic, metabolomic, lipidomic, etc) to predict impacts of contaminants on individuals. It would significantly strengthen DEB’s predictive power to be able to utilize the vast amounts of suborganismal data made available by advances in molecular and computational approaches. The ability to connect suborganismal (e.g. OMIC) data to bioenergetic impacts could allow the extrapolation of contaminants effects across levels of biological organization. We collected data on the molecular and individual-level response of the model freshwater green alga, Chlamydomonas reinhardtii, to copper (Cu, as CuCl₂). We generated metabolomics and lipidomics data from algae exposed to 4 concentrations of Cu over 7 time points (0-145h). The design of the experiment was guided by requirements of both DEB modeling and OMICs data analysis. We identified metabolites and lipids that varied significantly across time, concentration, and their interaction. Analysis of the metabolomic and lipidomic data sets have identified potentially impacted pathways that may further inform a DEB model of the algal response, similar to the identification of cascading impacts that lead to adverse outcomes in the Adverse Outcome Pathway (AOP) framework. In parallel, we developed a DEB model to describe Cu’s impact on the algae. We developed a toxicokinetic model of Cu uptake by the alga, and the internal concentration of Cu impacts algal bioenergetics. Cu’s mode of action within the model is both informed by the OMICs data analysis and also by identifying the mode of action yields the best fit of the DEB model to the algal and extracellular phosphorus data (similar to traditional “DEBtox” methods). In this way, we can test our framework of connecting OMICs data to a DEB model by comparing its result to the more traditional “DEBtox” method of identifying the mode of action of a toxicant.

471 New approach methodologies to elucidate smoke dyes adverse effects

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The field of (eco)toxicology keeps evolving towards the development of New Approach Methodologies (NAMs) not only as alternatives to animal models but also as faster and more accurate approaches to predict adverse effects on different species. Here, we explore the use of a set of biological and computational approaches to elucidate the potential adverse effects of six smoke dyes. Smoke dyes are specialty colorants designed specifically for pyrotechnic colored smokes, which have several uses including distress signals, smoke locators, or pyrotechnical devices among other. Some of those dyes can be used as food colorant as well. We used the zebrafish embryo to understand the potential adverse effects of six smoke dyes by analyzing morphological and behavioral effects as well as changes at the transcriptional level. The tested dyes were anasol red, anasol violet, anasol yellow, anasol green, anasol blue, and anasorpe red. All dyes except for anasol green had some morphological effects. Three of the dyes also presented behavioral effects. In order to understand if the behavioral effects were due to the ability of the dyes to cross the blood brain barrier (BBB), we used the in vitro PAMPA permeability assay. Four of the dyes showed some permeability to cross the BBB. In order to develop a transcriptional point of departure leading to predict hazard, we performed RNAsq on five different concentrations of each dye. The transcriptional data together with the apical effects is being used to develop a better understanding of smoke dyes hazard following an Adverse Outcome Pathway framework approach.

472 Swimming in circles: Improving detection of altered fish larval behavior after exposure to environmental chemicals

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Fish swimming behavior is often measured in aquatic ecotoxicology because it is a sensitive endpoint that can indicate neurological impairments after chemical exposure. Recent advancements in animal
movement models that contain components of discrete-time random walks suggest an improved approach to detecting altered behavior. Our application of this approach uses swimming behavior assessed at every recorded time point instead of summarized over time or over groups of fish, as is done often. We propose that the construction of hierarchical movement models that use individual fish frame rate movements will incorporate the multiple levels of variability and sensitivity recorded in these assays so that subtle behavioral responses, essential to fish survival and growth, can be detected. We applied this approach to analyze swimming behavior assays on fish larvae after exposure to sublethal levels of polychlorinated biphenyl congener 126 and methylmercury, two known neurotoxins that are common in the Great Lakes ecosystem. Over a set amount of time, the x-y coordinates of each individual fish were recorded at every video frame and the mean step length and turning angle were calculated. Using these parameters and animal movement models, we determined the characteristics of slow and fast swimming states, the probability of changing between states, and how they were altered under different chemical doses. The results from the movement models will be used to simulate individual non-random larval movement rates in population models and predict how altered swimming patterns might impact simulated growth or survival due to chemical exposures.

473 Towards risk assessment of data-poor species - from life history to physiological models through phylogenetic inference


Practical ecological risk assessment is a world apart from standardized ecotoxicological studies: it deals with time-varying exposure, non-lethal endpoints, and a multitude of species. This calls for physiological models that translate exposure to chemicals to relevant organismal endpoints, and for methods that extrapolate physiological and life history information across species, especially to those with limited data. The value of physiological models in risk assessment is widely recognized, as evidenced by mention of Dynamic Energy Budget (DEB) models in ISO and OECD guidance and EFSA scientific opinion. These models offer process-based descriptions of growth, reproduction and survival, readily adapted for effects of toxicants. However, DEB models can be difficult to parametrize, which is an obstacle to their wider adoption. This is especially challenging for species listed under the Endangered Species Act (ESA): as these are subject to regulatory limitations on data collection, we usually know little about them beyond taxonomic classification and a few life history statistics (e.g., maximum size, lifespan, fecundity). Here, we show how new physiological models can be built by combining a database of existing DEB models (over 1700 species in the Add-my-Pet database) with information on the taxonomy and life history of the species of interest. Our method produces an ensemble of DEB parameter sets, characterizing the most likely model and associated uncertainties (https://deb.bolding-bruggeman.com). Using a new compilation of traits of freshwater bivalves listed under the ESA, we demonstrate how a carefully picked set of life history statistics suffices to produce well-constrained DEB models, ready for further integration into population models for use in risk assessment.

474 Assessing risk to imperiled species: Modeling freshwater mussel populations

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Freshwater mussels are a highly diverse and imperiled faunal group; of 296 species currently identified in the US more than 70% are considered threatened or endangered (“listed”), or of special concern. Due to restrictions on testing endangered species and the difficulty of working with freshwater mussels in the laboratory, it is essential that predictive methods be developed to better assess the risks posed to listed freshwater mussels by a multitude of aquatic contaminants and other stressors. Dynamic Energy Budget (DEB) theory describes allocation rules of energy to metabolic processes and can be applied to quantify physiological responses (described as changes in growth, survival, and reproduction) of an individual to stressors in its environment. A major advantage of DEB models is the generic nature of the underlying theory which allows for broad applicability across species due to similarities in model structure. In this project we develop a trait-based modeling approach for freshwater mussels with the aim of assessing potential risks to listed species from exposure to various stressors. First we performed a life-history analysis in order to group mussel species into life-history categories for modeling and to identify appropriate and well-described representative species. Using these life-history categories, we then developed a generic DEB model framework for the representative species, allowing for comparison of parameters between species with different life-history traits. The DEB modeling framework we develop for the life-history types will be an integral component of individual-based models which simulate population properties from local individual behaviors. Ultimately the aim of this project is to provide improved population modeling approaches for assessing risks posed by various stressors for data-sparse listed species.
Advocating Science: Practical Approaches to Presenting Information and Results Without Advocating Policy or Preference

476 Practical Examples to Effectively Presenting Science Information and Results Without Advocating Policy or Preference

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Currently presenting technical information and one’s position is seemingly under increasing pressure to make sweeping claims, maximize impacts or simply enhance being noticed. Environmental management and policy is only as good as the science that informs the discussions and ultimate decisions. Without a sound understanding of how environmental systems work and how stressors on these systems can affect ecosystems, programs intended to manage these systems will continually be off target and policies developed to protect and enhance these systems may be inadequate due to this overall lack of scientific understanding by decision makers and the general public. An important aspect of the science that forms the foundational information needed to make correct decisions for managing these systems and developing policy is that the science and how it was obtained have to be transparent, well documented and impartial to the potential regulatory decisions that are under consideration. This talk will set the stage for the session “Advocating Science: Practical Approaches to Presenting Science Information and Results without Advocating Policy or Preference” by providing examples and experiences of the authors. Using case examples, the authors will explore issues related to proper science integrity and how the general misuse of science is most particularly in ecotoxicology and chemistry applications can be related to proper science integrity and how the general misuse of science at the core business is directed by policy and regulatory requirements, research provides an opportunity to perform and present scientific information in a pure form with clear research questions, methods, results, and conclusions. The key to disseminating unbiased scientific information within our organization is tied directly to our research and development program philosophy and the research design applied within the program. Each year, our small CRO sets aside research funds based on a percentage of the prior year’s profit which provides an opportunity to conduct research and offers financial incentives through tax dollar savings. Within this program, applied research which has no agendas, only solid research questions are performed. The research design that follows the initial work, including eventual connection with outside funding sources, is key to conducting and eventually presenting unbiased scientific information. Ultimately, this philosophy bleeds into all aspects of study work yielding higher quality science and less bias in the dissemination of the information. A case study from within this research program examining the neurological and behavioral mechanisms of BMAA (beta methylamino-L-alanine) toxicity in zebrafish will be presented. BMAA a ubiquitous algal toxin thought to cause CNS effects higher animals, including in humans. The discussion will demonstrate how this work has emerged from our program to be of interest in the private sector and how we maintain a non-agenda driven focus for this program while furthering the work including securing outside funding.

479 As science advances, so should its implementation in environmental policy and management

V. Forbes, University of Minnesota / Ecology, Evolution & Behavior

My premise is that environmental management decisions and policies informed by robust science are likely to be more effective than those that are not. As academic scientists, we view our role as advancing scientific understanding of natural systems and the impacts of human activities on them in ways that can be helpful to decision makers. Challenges in doing this include that natural systems are often extremely complex and characterized by non-linearities and emergent properties that make predictions difficult to achieve with confidence. This can result in one of two tendencies: to ignore the complexity and default to simplistic, presumably worst-case assumptions; or to over-complicate matters by focusing on the complexities without offering pragmatic solutions. Neither strategy appropriately balances the costs and benefits of management decisions to ensure that the things people care about are being protected. Despite substantial advances in the science, there are strong tendencies to retain traditional, simplistic approaches for using science in management and policy due to the time and effort needed to learn and implement new methodologies, various legal constraints, and basic resistance to change. Improving the scientific underpinnings of management and policy means replacing outdated approaches with better ones; not continuing to add new methods on top of existing ones. Such changes in how and which science is used will be most effective if debated with some distance from ongoing decisions and if doing so involves a partnership among all affected stakeholders to minimize bias and conflicts of interest and to ensure transparency and buy-in.

480 SETAC International Programs Committee (IPC) as a Vehicle for Promoting Objective Scientific Dialogue

K. Thomas, Global Silicone Council

Encouraging non-biased scientific dialogue that addresses advancements, and weaknesses, in the science associated with environmental toxicology and chemistry benefits practitioners from industry, government, and the academic community. For government experts, this dialogue informs the development of risk evaluations that ultimately impact regulatory decision-making. For industry, it provides useful insights that provide direction for product research, development, and stewardship, and for the academic community it helps to identify critical data and information gaps that drive priorities for basic research. The SETAC International Programs Committee (IPC) has been actively engaged in fostering scientific dialogue in way that is mutually beneficial to SETAC’s
core constituency in government, academia, and industry. The IPC has hosted symposia and workshops on a variety of topics including national and regional chemicals management approaches and methodologies for conducting ecological risk evaluations. The IPC has also engaged the global scientific community by hosting side events with international organizations such as the Stockholm Convention Persistent Organic Review Committee (POPRC) and the Conference of the Parties (COP). This dialogue has taken place across a variety of geographic regions including North America, South America, Europe, and Asia. These sessions have brought scientists together in a collaborative manner with a primary goal of leveraging SETAC’s strengths to advance the science. This presentation will summarize the work that the IPC has done to advance the scientific dialogue and highlight work that is planned for the future.

481 A Logical and Applied Ethics Analysis of Scientific Integrity and Perceived Conflicts of Interest in Environmental Toxicology

L. Burgoyne, US Army Engineer Research and Development Center / Environmental Laboratory

The primary objective of science is to obtain knowledge and identify the truth. Some advocacy groups, and some national and international agencies that identify chemical hazards and risks, refuse to use guidelines and studies funded by industry interests. Instead, these groups prefer to rely upon only those studies that have been published in peer-reviewed journals, or in some rare cases, guideline studies that they have paid to be peer-reviewed by an independent panel. In addition, some organizations and prominent scientists have argued that the public must be suspect of scientific studies in the peer-reviewed literature paid for by industry interests. In this presentation, I will discuss the logical fallacy that underpins these arguments, and perform a logical analysis that demonstrates how these arguments centered on sources of funding and conflicts of interest actually lead to the logical conclusion that all of the scientific literature, regardless of funding source and potential conflicts of interest, are false and untrustworthy. I will also examine this situation under an applied ethics lens, and illustrate the unethical behavior associated with discounting of science not based on how the study was performed, but rather on labels of who paid for the study. I will then discuss ways out of this conundrum, ways to defeat/avoid the logical fallacy, highlight the importance of critical thinking, and methods to ensure the soundness of science through Bayesian statistical approaches. The US Army Chief of Engineers has approved this paper for release. The views presented in this article do not necessarily reflect current or future opinion or policy of the U.S. Army Corps of Engineers.

482 The roles for and constraints derived from method standardization in international chemical environmental risk assessment

S.E. Belanger, Procter & Gamble Company / Global Product Stewardship

A recent Pellston workshop, “Improving the Usability of Ecotoxicology in Regulatory Decision-Making,” held in 2015, addressed the role of ecotoxicity testing in risk assessment. Many facets of data development and utilization were discussed resulting in a series of published manuscripts on reliability assessment, relevance assessment, weight of evidence formulation, and the philosophies to improve testing. A good balance of private sector, academia, and government scientists from across the globe worked through many aspects that also intersect with science advocacy. In this talk, I discuss how methods standardization at the international level is essential to the remove some features of bias, but at the same time is limiting as science advances. Non-standard and novel approaches fill the scientific gap between old “tried and true” methods and scientific progress on their way to become accepted and standard approaches themselves. Use of non-standard approaches therefore become integral to weight of evidence formulation and can become key cogs in the evaluation of new and existing chemical technologies in global management of chemicals. Openness to adapting and adopting the new science becomes a difficult challenge for prescriptive regulatory environments and requires a dispassionate evaluation of reliability, relevance, and repeatability of the generated information.

483 Agenda-Driven Normative Science, White-Hat Bias and Censorship: Why Peer-Review Needs an Overhaul

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In applied sciences, “normative” is defined as “a type of information developed, presented, or interpreted according to an assumed but usually unstated preference for a particular policy or class of policies. By example, public health, and ecosystem health, are often presumed to be desired outcomes and are promoted as explicit policies, while health risks are to be avoided. The enaction of these policy preferences constitutes advocacy. “White Hat Bias” is a phrase coined by public health researchers David Allison and Mark Cope to describe a “bias leading to the distortion of information in the service of what is perceived to be righteous ends,” often involving cherry-picking of evidence and publication bias. Righteous zeal and indignation toward certain aspects of western industry are used to construct a white-hat veneer. “Righteous ends” as described by Allison and Cope, serve well the objectives of normative science. Normative science and white-hat bias work together to distort public perceptions of science and its place within society and politics and ultimately, to justify a type of censorship defined as “-suppressing scientific reports by delaying their release or failing to make them available to the public” and/or “-removing otherwise qualified scientists from important positions by virtue of their disagreement with the current politics ... or because their research yielded results that did not favor the administration’s policy.” This presentation details a case study, the scientific underpinnings of which were published as companion articles in Environmental Toxicology and Chemistry in 2007. These publications debunked a body of literature promoted as evidence of endocrine disruptive effects on gender determination in endangered reptilian species. Despite scientific discreditation, that body of literature continues to be promoted as normative science to promote policy objectives regarding chemical regulation in the European Union. Fueled by the perception of righteous ends, these policy objectives have led to white-hat bias and scientific censorship within at least one prominent scientific society. This situation is not unique; collectively it erodes the epistemological basis of scientific inquiry, evidence, and progress. Only a drastic revision of the peer-review process and a tidal change within science can rectify this revolutionary trend and effectively correct societal and political misperceptions of science.

Ecosystem Services for Improved Decision-Making

484 Linking ecosystem services to health, economics and wellbeing through classification systems and achieving 18 benefits

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Recent studies show that ecosystem services analysis can have greater impact, be more accurate, and be more interoperable with the use of formal classification systems. These systems embody approaches such as: focusing on direct benefits to people, or “final” ecosystem services; clearly defining ecological endpoints and published in ERA or LCA; and using consistent, inclusive, and mutually exclusive hierarchies for defining ecosystem services. The Common International Classification of ecosystem services (CICES v 5.1) and the National Ecosystem Services Classification System Plus (NESCS Plus) are exemplary ecosystem services classification systems. These ES-CS were proposed by the European Environment Agency and USEPA, respectively, to improve communication among ecologists, economists, policy makers, and stakeholders. Effectively, they link ecological conditions, processes, and functions to economies and communities. This presentation will review the development of ES-CS and the 18 benefits that their use can provide. Case examples will be provided from real and desk applications of these ES-CS possibly including in ESA and LCA fields.
486 Integrating Aquatic Designated Use Protection and Restoration Strategies Using an Ecosystem Goods and Services Framework

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Water quality standards programs in the United States and other countries are based on designated uses (DUs), which are linked to criteria specifying maximum pollutant levels and other characteristics that are thresholds for waterbody compliance with regulatory goals. Most DUs are similar to certain provisioning ecosystem goods and services (EGS), such as drinking water supply and recreation (e.g., boating, fishing). Absent in the DU concept is supporting or regulating services, which results in disjointed and often ineffective aquatic ecosystem protection and restoration strategies. The focus on discrete sets of water quality parameters in the DU concept can often result in the appearance of conflicting DUs, resulting in poor provisioning of certain DUs. We present a framework that uses EGS to provide a more holistic assessment of DUs and help inform best management practices that could result in fuller attainment of DUs while providing greater provisioning of desired goods and services. Two case studies are discussed demonstrating some of the issues with the DU concept, how it is implemented in the U.S., and how the EGS framework can provide a crosswalk between the DU paradigm and stakeholder goals for a watershed. A process is presented that could help regulatory agencies and stakeholders make better use of the EGS framework in DU decisions, including watershed protection and restoration. The EGS framework presented here, coupled with a watershed stakeholder process focused on developing an integrative management strategy based on the framework, could help achieve multiple beneficial uses in an aquatic system.

487 EPA's EcoService Models Library (ESML): Applied Use Cases for a New Tool for Quantifying and Valuing Ecosystem Services


Ecosystems provide a variety of goods and services. For example, they regulate the quality of our air and water, provide protection from storms and floods, produce foods and other essential materials, and provide opportunities for recreation. Recognizing ecosystem services (ES) and understanding how society’s decisions affect them, is critical to sustaining human well-being. Computational models describing the processes underlying ES are useful for protecting, enhancing, and creating ES and thereby increasing human well-being. However, discovering and selecting those models is difficult because information about them is scattered throughout journals, websites and government reports. Information describing these models also is not uniform and can be difficult to assess via typical bibliographic searches. The EcoService Models Library (ESML) has been developed as a repository for ecological models. ESML is a publicly available website and database for finding, examining and comparing over 160 EMs for estimating ES. This presentation will demonstrate how ESML was used to find ecological models for identifying and characterizing ES socioeconomic benefits for three environmental scenarios: 1) adding constructed wetlands to agricultural landscapes to manage nutrient pollution; 2) during the ecological risk assessment process at hazardous waste sites; and 3) applying best technology available (BTA) to minimize adverse environmental impacts from impingement and entainment of fish and invertebrates at facilities operating cooling water intake structures.

488 Joining ecosystem services with ecological risk assessment to better articulate ecosystem protection importance for hazardous waste site cleanups

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In the United States, federal hazardous waste site cleanups are conducted under the Environmental Protection Agency (EPA) Superfund and Resource Conservation and Recovery Programs. The statutory mission of these two cleanup programs is remediation rather than rehabilitation; however, untapped opportunities exist to conduct remediation in more ecologically beneficial ways. We propose a logic train of: better understanding to increased appreciation to greater attention/action during cleanup planning and implementation; however, greater action needs to be fed with ways ecosystems can be supported within the cleanup statutory framework. We provide some suggestions of ways ecosystem classification systems and ecosystem goods and services (EGS) models and other tools could be employed to bolster the use of ecological risk assessment (ERA) findings in the hazardous waste site cleanup decision-making process. We propose that better articulation of the benefits to human well-being and health in local communities from healthy, functioning ecosystems ultimately will help lead to greater consideration of ecosystems during cleanups. To this end, we consulted the EPA EcoService Models Library (ESML) as well as EPA guides and publications on ERA and EGS to identify opportunities for better articulating the significant benefits provided to human communities by ecosystems. In addition to increasing general recognition ecosystem benefits, the other part of the challenge is to incorporate EGS and EGS tools into hazardous waste site cleanup process, especially ERA through roadmaps more clearly linking ecosystems, ecorisk, remediation, and ecological protection and rehabilitation. We have organized EGS models according to their topic and parameter foci to facilitate their application in ERA. Similarly, we have organized EGS concepts, tools, and approaches. In doing so, we have initiated the development of roadmaps to clarify the importance of ecosystem protection and provide insight regarding ways that considerations and modifications during hazardous waste site cleanups can lead to increased benefits for local communities. We suggest EGS models and other tools to facilitate their use in helping to clarify and strengthen ERA findings at hazardous waste sites. We are working toward applying these approaches and roadmaps to specific hazardous waste site cleanups.

489 The Integration of Ecosystem Services Into Human Health and Ecological Risk Assessment to Foster Better Risk Communication

M.W. Kierski, C. Menzie, Exponent / Ecological and Biological Services Practice

The U.S. Environmental Protection Agency (EPA) defines ecosystem services as the outputs of ecological processes that contribute to social welfare or have the potential to do so in the future. An example of an ecosystem service would be the food that a healthy fish population in a river provides to recreational anglers, the key being that ecosystem services provide tangible human benefits to ecological protection that occurs within a properly functioning ecosystem. In this presentation, we will explore the concept of ecosystem services and show how integrating ecosystem services into ecological risks assessments can provide a clearer way to communicate results to decision makers and other stakeholders including the public. While integrating ecosystem services into ecological risk assessment has begun to gain favor with EPA, it has not gained traction within the general practice of ecological risk assessment. We will explore possible reasons why and provide examples of how ecosystem services can be easily integrated into ecological risk assessments. In addition, we believe that the concept of ecosystem services allows a risk assessor to integrate both the human health and ecological risk assessment components of baseline risk assessments together in ways that are not possible without it. We will also explore examples of how this integration...
can be accomplished and improve risk communication. We will use an example of a baseline risk assessment performed under the Superfund program to compare and contrast the look and feel of the risk assessment results using the standard risk assessment approach and the integrated ecosystem-service-based approach. We believe that with this integration it is possible to more clearly communicate the ways that fostering a healthy ecosystem can lead to a healthy life, which will provide stronger and clearer arguments for when and why remedial action is required to solve an environmental problem.

490 An Exploration of Economic Valuation of Phosphorus in the Environment and its Implications in Decision Making
M. Sena, M. Rodriguez, University of Wisconsin, Madison / Civil and Environmental Engineering; M. Seth, Madison Metropolitan Sewerage District; A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering

In decision making processes today it is typically economic considerations that are the focus and that dictate what choices are made. However, this approach neglects or minimizes significant potential impacts these decisions can have, namely impacts to the environment and on our ecosystems. One way in which environmental considerations can be incorporated better into current decision making processes is through monetary valuation of ecosystem services or environmental damages. This work surveys environmental economics literature on monetary valuation of nutrients and nutrient pollution focusing specifically on phosphorus (P), and applies monetary valuation of P to a case study of nutrient recovery in wastewater treatment. The literature assessment highlights how widespread nutrient pollution issues are, and demonstrates the range in potential economic consequences from nutrient pollution related issues. Additionally, the literature survey shows a discrepancy between what the public has said they are willing to pay for P removal or reduction versus actual costs to remove P once it has entered the environment, and alludes to a lack in understanding by the public of the potential economic impacts nutrient pollution can have. Furthermore, the wastewater treatment nutrient recovery case study demonstrates how monetary valuation of environmental damages or ecosystem services can be applied in a realistic decision making scenario, and highlights how variability in monetary valuation methods and results can affect decision making.

491 Applying the National Ecosystem Services Classification System Plus (NESCS Plus) to ecosystem services analysis, revealing benefits
C. Rhodes, TDB Economics

The National Ecosystem Services Classification System Plus (NESCS Plus) is a robust, scalable, and flexible system for linking ecological changes to specific uses of ecosystem services by people. These include uses by communities, governments, and businesses that impact human health and wellbeing, as well as the economy. NESCS Plus, compared to all ecosystem services classification system (ES-CS), most embodies best practices in classification systems design. As a result, it is arguably the most effective ES-CS for delineating elements of ecosystem services that help to select appropriate metrics for analysis or accounting of ecosystem services. This presentation will provide an overview for applying NESCS Plus, building any introductions made during previous presentations in this session. Then, the definitions of ecosystem services--and their metrics--used in studies described in previous presentations will be reviewed with NESCS Plus. Case examples from other studies may also be used. Effectively, opportunities to improve the robustness, utility, and interoperability of the previous presentation will be highlighted. A discussion of the implications of the NESCS Plus follows. This discussion is relevant to all ecosystem services practitioners. The USEPA is very likely to release NESCS Plus before the SETAC North America 40th Annual Meeting. Moreover, even if not fully applying NESCS Plus, ecosystem services practitioners can easily benefit from using some of the definitions and methods associated with NESCS Plus.

Plants in Environmental Risk Assessment: Assessing and Predicting the Effects of Chemicals on Plant Communities

492 Glyphosate Effects and Accumulation in Invasive and Native Wetland Macrophytes
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Invasive aquatic plants can disrupt native wetland communities, with considerable ecological and economic impacts. Glyphosate-based herbicides can control invasive plants, thereby potentially restoring native plant biodiversity, but glyphosate is toxic to all plants. Land managers therefore must weigh the benefits of using glyphosate to manage invasive plants against the potential harm to nearby non-target plants. A balanced decision requires an understanding of the individual sensitivities of target and non-target plants, and the persistence of glyphosate in plant tissues post-exposure. We performed an experimental outdoor microcosm concentration-response study, in which we sprayed a range of glyphosate concentrations (0.1 - 8% solutions of the formulated product, corresponding to 0.5 - 43.2 g/L glyphosate) representing ‘real-world’ applications on two emergent plants that have invaded North American wetlands, Phragmites australis (Common Reed) and Typha x glauca (Hybrid Cattail), and a native co-occurring plant, Typha latifolia (Broadleaf Cattail). At 27 days post-exposure we compared sensitivity and accumulation of glyphosate, AMPA (one degradation product) and alcohol ethoxylate surfactant (from formulation) among the three taxa. Phragmites australis exhibited higher glyphosate sensitivity than both Typha taxa and accumulated more glyphosate and AMPA in above-ground tissues. We observed a qualitative trend of lower sensitivity and lower glyphosate and AMPA accumulation in T. x glauca compared to T. latifolia. Accumulation of surfactant residues was similar among taxa. This is the first evidence of inter- and intra-generic differences in glyphosate sensitivity and accumulation in emergent macrophytes. Our data show that responses of emergent macrophytes to glyphosate cannot be generalized among taxa. Understanding this variation can improve accuracy of predicted responses of invasive and native emergent wetland plants to glyphosate. These predictions can inform environmental risk assessments of glyphosate spray applications in wetlands, and can contribute to implementing effective and sustainable wetland management plans. Our detected glyphosate retention in treated plant tissues calls for further research on its fate in macrophytes.

493 Modeling phytoextraction of Ni-elevated soils using Alyssum species, Port Colborne, Ontario
S. Dehghani, K. Zupfer, L. Vasiluk, University of Guelph / School of Environmental Sciences; M.D. Dutton, hpa, Ltd.; M. Bellantino-Perco, Vale Canada, Ltd.; B.A. Hale, University of Guelph / SES

Abstract- Alyssum spp. as well-known hyperaccumulators of nickel (Ni) are of interest for phytoextraction of Ni-elevated soils such as those resulting from past Ni refining in Port Colborne, Ontario. A greenhouse study using Alyssum spp. planted in three main types of Ni-polluted soil in Port Colborne (heavy clay, organic muck, and sand) investigated the feasibility of using Alyssum spp. for soil-Ni mass transfer. These soils have different physicochemical parameters; irrigation and fertilization treatments were imposed on the three soils. The observed Ni mass distribution between soil and above ground vegetation was used in Stella modeling software to predict hypothetical timelines for the target reduction in soil Ni concentration. In addition, hypothetical Alyssum Ni extraction in several improved phytoremediation systems resulting from manipulation of effective soil physico-chemical properties, were modeled. Nickel concentration in organic, sand and clay soils was 914 mg/kg, 6180 mg/kg, and 4431 mg/kg, respectively. Clay and organic soils demonstrated
494 Evaluating mercury concentrations in edible plant and fungi species of Iqaluit, Nunavut and the surrounding area

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Environmental mercury (Hg) concentrations in the Canadian Arctic is a current area of concern. While efforts are being made to reduce mercury releases into the environment, Hg levels continue to increase within flora and fauna. To date, while there are numerous published articles on the impacts of mercury in Arctic wildlife species, literature on the accumulation in edible plant and mushroom species of the Canadian Arctic is very limited. Therefore, the main objectives of this study were to evaluate the mercury content in edible plant and fungal species of the Canadian Arctic and estimate the potential risk of mercury by consumers. This study was conducted during the summer of 2018 to determine the total mercury concentrations in 47 samples from 18 plant and four lichen species, and 74 samples from five fungal (mushroom) species growing in Iqaluit, Nunavut and the surrounding area. Samples were assessed using cold vapor atomic absorption spectrophotometry and mean mercury concentrations ranged from a high of 3.52 ± 2.0 ppm dw and 2.22 ± 1.59 ppm dw in Lycopodium perlatum and Calvatia cretacea (both puffballs), respectively to a low of 0.008 ppm Hg dw in Eriophorum scheuchzeri (Arctic cotton grass). There were significant differences in mercury concentrations across plant species as well as mushroom species. Work is currently underway to: i) determine if the mercury is from sources in the soil or atmosphere, ii) investigate the potential for mercury to bioaccumulate within consumers, and iii) assess the possible health effects associated with this consumption.

495 Role of duckweed - microbe interactions in the elimination of benzotriazole from salt-contaminated water

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Benzotriazole is a corrosion inhibitor that is environmentally persistent and potentially carcinogenic. Due to its limited removal in conventional wastewater treatment plants, complementary treatment strategies are being explored, such as constructed wetlands. In this study, we investigated the role of duckweed that grows naturally on the water surface of constructed wetlands. Specifically, we evaluated several factors that might influence the transfer and transformation of benzotriazole, including the concentrations of benzotriazole and salt in water, duckweed genotypes, and genotype-associated microbes using three duckweed genotypes collected from ponds located in Ontario, Canada. The reduction in benzotriazole concentration was investigated with and without the presence of microbes, as well as salt at typical stormwater runoff concentrations. Without salt and microbes, the reduction in concentration ranged from 26 to 69% for the duckweed genotypes and initial benzotriazole concentrations tested. In the absence of salt, the decline in concentration was comparable whether microbes were inoculated or not: with microbes, the reduction ranged from 28 to 68%. Without microbial inoculation, the presence of salt at 10 g/L decreased the reduction in benzotriazole concentration to a range of 1.0 to 32%. When both salt and microbes were present, the effect of salt was reduced, and the reduction in benzotriazole concentration ranged from 7.1 to 50%, which is greater than the case where microbes were absent. With the experimental setup, adsorption and phototransformation of benzotriazole were likely negligible. It is therefore expected that the biotransformation of benzotriazole carried out by duckweed and microbes was the primary pathway. Selected samples were further analyzed for benzotriazole transformation products using high-resolution mass spectrometry, and the results suggest the formation of both phototransformation and microbial transformation products. Taken together, these results suggest that duckweed has the potential to remove benzotriazole via biotransformation. Microbes associated with duckweed might further improve water quality, either by directly transforming benzotriazole or by altering plant transformation capacity. Further experiments will be conducted to study the performance of additional duckweed genotypes and the associated microbes, and to determine the depth of the water column that is impacted by duckweed for water treatment.

496 Toxicity of novel fire suppression gels to plant germination and emergence

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Previous research has shown that fire suppression additives containing perfluorinated compounds negatively affect the environment through persistent contamination and bioaccumulation. Manufacturers have introduced ‘environmentally-friendly’ alternatives, but limited studies on their fate and effect in the environment have been completed. A study was completed to investigate the toxicity of six fire suppression gels: Eco-Gel(TM), Thermo Gel 200L(TM), Fire Aid 2000(TM), Solberg Fire Foam(TM), Novacoal Foam(TM), and F-500(TM). Through direct aerial application of fire suppression gels, soil contamination can occur. Toxicity to three plant species was investigated through a root elongation assay and a seedling emergence test. The crop species Fagopyrum esculentum (buckwheat) and Raphanus sativus (radish), were tested in addition to the flowering plant species, Rudbeckia hirta, as it is commonly found within the boreal forest where fire suppression gels may be used to control wildfires. Emergence, growth and/or germination were documented after each test, and the concentration-response relationship determined, allowing the EC50 to be estimated. It was found that there was a large variation in toxicity between the fire suppression gels tested, and that some would pose a hazard to plants when released into the environment. With the knowledge gained from this study, a better understanding of the potential effects of fire suppression gels on terrestrial ecosystems can be developed.

497 Analysis of Non-Target Terrestrial Plant Studies

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Two types of Non-target terrestrial plant (NTTP) studies are required for registration of crop protection chemicals. Unlike many aquatic studies, it is not uncommon to test 8 to 10 treatment groups (application rates) or even as many as 12 to 14, in addition to one or two negative controls, with 4 to 10 replicates per application rate. There are three primary response: shoot height, dry weight and survival. Requirements include NOEC determination and ECx estimation, x=50 in Europe and x=25 in the US. There has been recent interest in the US of requiring estimation of ECx for much smaller values of x, such as x=10 or even x=5, at least for the growth responses. Issues of both statistical and regulatory importance for the survival response include how to account for (1) background (or control) mortality and (2) replicate variability, including treatment of the overdispersion that is sometimes observed. Issues of importance for the growth responses include how to (1) model hormesis or low-dose stimulation, which is not uncommon, (2) how to assess the quality of ECx estimates.
for all responses, and (3) to determine what size effects can be estimated reliably from the data resulting from these studies. Another issue is whether the experimental design should be changed, either to improve the quality of the statistical analysis or to reduce the cost of these studies without sacrificing the quality of statistical conclusions. These issues are explored through real data examples and extensive computer modeling. Some common errors are demonstrated that can seriously bias results. Simple, practical recommendations are made to eliminate these errors and improve the quality of results.

498 A Field Spray Drift Study to Determine Downwind Effects to Non-target Plants

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A spray drift and associated vegetative vigor study was performed to determine the off-field drift deposition and potential toxicity of a herbicide to sensitive non-target plants at various distances downwind from the treated area. Each treatment consisted of four 100 foot wide spray swaths that ran perpendicular to the target wind direction. There were three trials and each was performed on a 515 foot x 334 foot area that included the upwind control plants, treated area, and downwind plants. One trial had vegetation (approximately 12” tall mowed grass; typical scenario) in the downwind deposition area and two trials had bare ground deposition areas (worst-case scenario). Drift collectors placed 5, 30, 50, 75, and 100 feet downwind of the application area were analyzed for herbicide residues. Pots of lettuce and navy bean plants (2-4 leaf stage), two species known to be sensitive to the herbicide, were placed 5, 30, 50, and 100 feet downwind of the application areas. There were 25 replicate pots/species at each downwind distance and 5 replicate pots/species for the corresponding upwind controls. Each pot had 2 plants and plant height was determined prior to application for use as a covariate in the statistical analyses. The lettuce and navy bean plants were subsequently grown out in a greenhouse for 28 and 21 days, respectively. Plant survival, growth stage, phytotoxicity, and height were assessed at 7, 14 and 21 days after treatment (DAT) for all plants and at 28 DAT for lettuce. Dry weight was determined at test termination. No effects occurred to either test species placed in downwind vegetation at any distance. No statistical differences from controls were observed in navy bean or lettuce shoot height or dry weight at downwind distances of 30 feet or further from the edge of the application area for plants placed on bare ground. The field study results contrasted sharply with the high/larger predicted effects and effect zones that can result from using modeled spray drift curves and greenhouse bioassays with direct overspray exposure. This study confirms that comparing spray drift modeled exposure estimates to the greenhouse bioassay results can seriously over predict effects to downwind non-target plants.

499 Experimental studies to provide long-term data sets for testing population models for Lemna sp. and Myriophyllum spicatum

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TK-TD (toxicokinetic-toxicodynamic) models are considered a promising tool in higher tier risk assessments for the analysis and prediction of the effects of diverse, dynamic and complex exposure profiles on aquatic organisms. TK-TD models can be linked to population models to assess effects of these realistic exposure profiles on seasonal population dynamics. With respect to aquatic macrophytes, the EFSA PPR panel (2018) considered the Lemma model by Schmitt et al. (2013) ready to use, however a Myriophyllum spicatum model was reviewed with the conclusion that it needs further elaboration and testing. The TK-TD part of the models can be calibrated and validated by means of lower-tier laboratory test data. However, there is a lack of data on long-term seasonal dynamics of these species to test the model predictions of typical population dynamics in the field. In order to generate such data, a long-term study was set up in outdoor experimental systems from 2017 to 2019. The growth of Myriophyllum spicatum was monitored in baskets installed in an experimental ditch, while the growth of Lemna sp. populations was studied in outdoor microcosms. The monitoring of biomass (fresh, dry weight) and shoot length or frond numbers was carried out weekly to monthly, depending on the season. Apart from the standing crop, seasonal dynamics of short-term growth rates for shoots or fronds in baskets respectively microcosms were assessed for Myriophyllum and Lemna. In addition, relevant environmental parameters and weather data were collected. The results showed an increasing variability over time but a clear seasonal pattern. Both species displayed only slight declines of frond number respectively shoot length and biomass during the last two, relatively warm winters. Despite starting conditions as similar as possible, developments of replicates were partly highly variable. For Lemna, filamentous algae could have inhibited growth and caused variability between microcosms. For Myriophyllum, intraspecific competition might have played a role. For Lemna, dry weight per frond number increased in the winter season as plants increased weight during autumn as a result of storage of starch and the reduction of air spaces. Periodical growth rates highly correlated with temperature, while correlations with light conditions were less pronounced. The data will be published open access to allow testing of different models.

Contaminant Mixtures in Food: How Did They Get There and Should We Be Concerned?

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The field of environmental health science has undergone a marked transformation from the era of research and policies pertaining to single-chemical exposures, to broad recognition that chemicals co-occur in mixtures that must be studied in aggregate to accurately reflect human and wildlife exposures and associated health impacts. The complexity of these mixtures has necessitated the development of new analytical and statistical methods, strengthened our understanding of adverse health effects caused by contaminants across a wider range of environmentally-relevant concentrations, and identified novel and understudied exposure scenarios. The food we eat represents the ultimate complex mixture. We chose to leverage data from the US Food and Drug Administration’s TOTAL Diet Study, USDA’s Pesticide Data Program data, US Environmental Protection fish contaminant data and data from the primary literature to begin to answer the question: if “everything” is contaminated, what can we eat? For example, seafood contains omega-3 fatty acids, which are beneficial to neurodevelopment and cardiovascular health. Fish are also an important source of protein globally. However, they can contain harmful concentrations of mercury, polychlorinated biphenyls (PCBs), dioxins and perfluoroalkyl substances (PFASs). Similarly, dark-green, leafy vegetables contain many nutritionally-important characteristics, including high levels of vitamins, antioxidants and essential nutrients, which collectively support healthy function of a wide range of organ systems and protect against the development of cancer. However, these vegetables may also contain pesticide residues, heavy metals and PFASs. The complexity of weighing nutritional benefits with health risks of the food we eat poses difficult questions to scientist.
regulators and the public. In this study, we sought to answer the question of “Which foods should I eat?” by synthesizing data for major pathways of food contamination, health benefits and risks associated with staple foods in the United States and throughout the world. We then used a semi-quantitative approach to compare health risks and benefits in support of a tool that can be used by consumers to guide selection of the healthiest foods for themselves and their family, while also providing a research framework for addressing the scientific uncertainties.

501 Environmental contaminants in backyard chicken eggs from wildfire affected communities of California

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Wildfires are becoming increasingly common in California, more destructive, and more costly. In the fall and winter of 2017, several large wildfires broke out in northern and southern California causing 320,000 people to be evacuated, 185 hospitalized, 46 deaths and over 8,000 structures burned. The major concerns surrounding these semi-urban fires is the combustion, release, and volatilization of compounds such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs) from the burning of household hazardous waste, building materials, furniture, electronic equipment, and capacitor and transformer fluids. The emissions of these chemicals can result in contamination of land, soil, water, and urban agricultural products including chicken eggs. Urban agricultural products can concentrate pollutants up to five orders of magnitude more than those produced in rural areas and this risk may be exacerbated post-fire. The aims of this study are to determine the extent of PCB, PBDE, and PAH contamination in backyard chicken eggs collected from fire affected communities in northern and southern California, and to determine if proximity to wildfires affects contaminant load. Preliminary results suggest that backyard eggs from fire affected communities contain higher concentrations of these chemicals compared with eggs purchased from a local supermarket. Ongoing analysis will determine the effect of proximity to fire on contaminant concentrations. Characterizing toxic chemicals in urban agricultural products after fire events will help guide the development of food safety guidelines and intervention strategies to be used after future catastrophic fire activities.

502 How safe is the rice in our homes? Human health risk assessment of some potentially toxic elements in commonly consumed rice brands in Lagos, Nigeria

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Rice is a major staple food and a good source of nutrition for the world population particularly in Africa. In recent times, the Federal government of Nigeria has embarked upon a strategy to overcome food shortage and improve self-sufficiency drive for both local consumption and export of rice. However, rice may accumulate potentially toxic elements from groundwater and soil and this may cause serious health issues to consumers. Apart from the rice grown in Nigeria, there are several brands of rice imported from different countries to cater for the 200 million Nigerian populace. Despite the large consumption of rice, there are no comprehensive investigations of potentially toxic elements levels in Nigerian grown rice varieties and imported brands sold in Nigerian markets. No published report is available for the bioaccessibility of PTE in rice varieties sold in Nigeria. To this end, a total of 21 rice samples were collected from mills, markets in Lagos and International Institute for Tropical Agriculture in Ibadan, Nigeria. These samples were acid digested and analysed for As, Cd, Cr, Ni, Pb and Zn by Microwave Plasma Atomic Emission Spectrometry (MP-AES). The mean concentrations for the elements analysed were 0.03, 0.75, 0.22, 0.55, 0.35, and 2.46 for As, Cd, Cr, Cu, Pb and Zn respectively. The average concentrations of the elements investigated were below the permissible threshold limit set by WHO/FAO with the exception of Cd and Pb. Human health risk assessment performed on the concentration results revealed individual hazard quotient calculations for the rice samples did not exceed the safe limit of 1 but the summation of the hazard quotients in all elements analysed which yielded the value for hazard index (HI) exceeded the safe limit of 1 in about 40% of the rice samples studied, suggesting risks to consumers. Results also revealed As and Cd as the largest contributors to non-carcinogenic risks to humans. Also, the results revealed no carcinogenic risks from As and Pb concentrations in the rice samples but the 10-4 threshold was exceeded for Cd and Cr.

503 Carrageenan as a source of arsenic, lead and cadmium to infant foods

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Carrageenan is an FDA-approved seaweed-derived ingredient in nearly 6% of foods in the USDA Food Composition Database, including organic, vegan and vegetarian foods. It is used to thicken, set, or stabilize processed foods. Because the seaweed from which carrageenan is derived is grown in seawater, it can accumulate significant concentrations of arsenic (As), cadmium (Cd), and lead (Pb); raising concerns that consumption of foods containing carrageenan will increase population exposures to toxic metals. Exposure to As, Cd, and Pb from consumption of carrageenan-containing foods has not been studied. Carrageenan is used extensively in the US as an emulsifier in ready-to-eat infant formula (not powder-based formula). The European Union (EU) prohibits carrageenan in infant formulas, citing the increased permeability of the infant gut and the potential for immunological effects, although direct evidence of harm has never been shown. Carrageenan has been associated with various gastrointestinal disorders in adults, particularly ulcerations and general inflammation, which has called its use into question. Links between these effects and the toxic metals in carrageenan have never been explored. Despite this, carrageenan remains approved for use in the EU in follow-on formulas aimed at infants > 4 months of age. Arsenic, Cd, and Pb are developmental toxicants. Early-life chronic, low-level exposures to these metals can have tangible impacts on cognitive development. For As and Pb at least, the existence of a safe exposure level, even for adults, is still actively debated. Given the critical windows of vulnerability in the first year of life, exposure to these toxic metals from consumption of ready-to-eat infant formulas and follow-on formulas made with carrageenan may have serious consequences for infant neurodevelopment. We hypothesize that the use of carrageenan in infant and follow-on formula results in significant elevations of concentrations of As, Cd, and Pb compared to formula without carrageenan or breastmilk. We are conducting an international market-basket study of infant formula foods (powder-based, and ready-to-eat) for analysis of As species, Cd, and Pb and will use these measurements alongside complementary measurements of these metals in breast milk to 2) conduct a comparative dietary toxic metals exposure analysis across the various types of infant foods. Preliminary findings are presented.

504 Dispersant-crude oil mixtures and seafood safety testing and consumption after the Deepwater Horizon oil spill

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Communities dependent on fisheries in the Gulf of Mexico faced a number of challenges during and following the British Petroleum Deepwater Horizon explosion, oil spill and cleanup (DWH). Re-opening of federal waters to fisheries by the National Oceanic and Atmospheric Administration and Food and Drug Administration followed a protocol developed after the Exxon Valdez oil spill based on analysis of 13 polycyclic aromatic hydrocarbons (PAHs) in seafood tissue; however numerous groups, including members of Congress, non-governmental organizations, scientists, local fisherman, processors, and chefs, raised concerns over the adequacy of the protocol for ensuring the safety of seafood, particularly due to the large amount of dispersants (Corexit 9500A and Corexit 9527) applied on the water surface and subsurface to alter the fate...
and transport of the oil. Fisherman-led sampling and testing was combined with government-led results to geospatially evaluate PAH levels and potential pyrogenic versus petrogenic sources from a variety of seafood. Additional government-led protocol development and seafood testing for the Corexit 9500A component dioctyl sodium sulfosuccinate (DOSS) suggested direct exposure via seafood consumption and hence toxicity was expected to be minimal; however there is uncertainty regarding the potential for alterations of exposure and toxicity of chemically dispersed oil when compared to non-dispersed oil. Other research suggests oil spills may alter bioavailability of heavy metals. This talk will provide an overview of the current methodology for ensuring seafood safety after oil spills, seafood tissue analysis results after DWH, quantification of seafood consumption patterns before and after DWH, and how properties of dispersant-oil mixtures can be used to improve future human health risk estimates.

505 Implications of Polycyclic Aromatic Hydrocarbon (PAH) Mixtures Found in Food Using In Vitro Metabolism, Computational Modeling, and Human Microdosing

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Cereals, vegetables, and smoked foods, especially traditionally smoked fish, contain complex mixtures of polycyclic aromatic hydrocarbons (PAHs). Once absorbed, various cytochrome P450 enzymes (e.g. CYP1A1, CYP1B1, etc.), glutathione transferases, and other enzymes metabolize PAHs resulting in competing rates of bioactivation to procarcinogens and detoxification via clearance. Since multiple PAHs can be substrates for various enzymes, we hypothesize that exposure to PAH mixtures may cause metabolic competition, inhibiting PAH metabolism, and affecting PAH clearance, detoxification, bioactivation, and toxicity. We used in vitro metabolism assays, computational modeling, and human microdosing studies to test the implications of human exposure to PAH mixtures using benz[a]pyrene (BaP), dibenzo[def,fp]chrysene (DBC), and a mixture of the top 10 most abundant PAHs found at the Portland Harbor Superfund Site (Supermix10) as model compounds. We observed competitive in vitro metabolism when co-incubating various combinations of PAH substrates in hepatic microsomes of mice, rats, and humans. In general, DBC was the most potent inhibitor tested. We calculated and incorporated inhibition coefficients into a physiologically based pharmacokinetic (PBPK) model to simulate internal dosimetry and metabolic interactions between BaP and DBC. To assess impact of co-administration of food with high levels of a complex PAH mixture, humans were orally dosed with 46 ng of [14C]-BaP neat, with smoked salmon (Confederated Tribes of the Umatilla Indian Reservation) or with commercial canned salmon. Levels of BaP were measured in plasma and urine using ultra performance liquid chromatography and accelerator mass spectrometry. Co-administration of smoked salmon and canned salmon reduced and delayed BaP absorption, suggesting a food matrix effect rather than a PAH mixture effect. The PBPK model was able to accurately simulate these observations in humans, and extrapolate these findings to other doses, exposure scenarios, and internal organ concentrations. These simulations suggest that competitive PAH metabolism is not expected to significantly alter BaP pharmacokinetics at environmental exposure levels. Funded by NIEHS Grant P42 ES016465, NIH Grant R01ES028600, and NIH Grant P41GM103483.

506 Prenatal Co-Exposure to Methylmercury and Inorganic Arsenic

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Background: Prenatal co-exposure to inorganic arsenic and methylmercury may adversely impact offspring development, and these impacts may be synergistic. Mercury may also impact the metabolism and excretion of arsenic. In the human body, arsenite is accumulated in cells through aquaporins, while mercury may act as an aquaporin inhibitor. In Oregon, there are statewide fish consumption advisories for methylmercury, due to historic mercury mining from the 1890s-1960s. Groundwater arsenic levels are also elevated. In Oregon, it is important to investigate prenatal co-exposure to both methylmercury and arsenic, because of their health impacts to the developing fetus, and their unique association with aquaporins. Methods: We are currently enrolling pregnant mothers (< 21 weeks gestation) in a pilot study at two hospitals in Oregon. After providing written informed consent, biomarkers are collected (blood, urine and hair samples). Total mercury and/or methylmercury are analyzed in all three biomarkers, while arsenic species are analyzed in urine [inorganic arsenic, dimethylarsinic acid (DMA), and monomethylarsonic acid (MMA)]. Mothers complete a questionnaire concerning demographics and fish/rice consumption, and a tap water sample is brought from home for analysis of arsenic. Preliminary Results: To date, 32 mothers were enrolled. All tap water arsenic concentrations were below the detection level (< 2 ppb, n=13); however urine sum of arsenic species (= inorganic As + DMA + MMA) averaged 2.8 ppm (median: 3.2 ppb, inter-quartile range: 0.31-4.4 ppm, unadjusted for specific gravity, n=13). These values were comparable to other cohorts of pregnant mothers in the U.S. and Europe, where drinking water arsenic levels were low. Maternal hair total mercury averaged 0.27 ppm (median: 0.17 ppm, range: 0.02-1.0 ppm, n=27). Hair total mercury not strongly correlated with urine sum of arsenic species, urine DMA, urine MMA, or urine DMA/MMA (Spearman’s rho range: -0.03, 0.19, p=0.54-0.92, n=13); however the number of paired samples was small. Enrollment and lab analyses are ongoing, including analyses of arsenic species, total mercury, methylmercury, and aquaporins.

507 Modeling chemical mixture effects on health using Bayesian kernel machine regression

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Recent progress in understanding how chemical mixtures affect health is largely attributed to collaboration between scientific fields, innovation of statistical methods, and prioritization from funding agencies. Metals are an important class of chemicals to examine mixture effects because they are ubiquitous in the environment, commonly co-occur and have interactive potential. Bayesian Kernel Machine Regression (BKMR), a statistical approach developed to assess environmental mixtures, allows for the evaluation of the joint, nonlinear and interactive associations of chemicals on health. This presentation will describe the application of BKMR using our recently completed study, which used BKMR to evaluate the association of manganese (Mn), copper (Cu), lead (Pb) and chromium (Cr) measured in multiple biomatrices and children’s cognition. We measured Mn, Pb, Cu, and Cr in hair, blood, urine, nails, and saliva collected from 635 Italian adolescents ages 10-14 years. Full-scale, Verbal and Performance IQ (FSIQ, VIQ, PIQ) scores were measured using the Wechsler Intelligence Scale for Children (WISC-III). BKMR was used to estimate associations of IQ with the metal mixture. In secondary analyses we used BKMR’s hierarchical variable selection option to inform biomarker selection for Mn, Cu and Cr. Median biomarker concentrations in primary analyses were: hair Mn, 0.08 μg/g; hair Cu, 9.6 μg/g; hair Cr, 0.05 μg/g; blood Pb, 1.3 μg/dL. Adjusting for sex, age, home score, hemoglobin and socioeconomic status, we observed an inverted u-shaped association between hair Cu and VIQ, consistent with Cu as an essential nutrient that is neurotoxic in excess. When Cu was set at its 10th percentile, the mixture of Mn, Pb and Cr set at their respective 90th percentiles was associated with a 2.9 (95% CI: -5.2, -0.5) point decrease in
VIQ score, compared to their median concentrations. There was suggestive evidence of interaction between Mn and Cu. In secondary analyses, biomarkers associated most strongly with VIQ score were saliva Mn, hair Cu and saliva Cr. This metal mixture was negatively associated with IQ, especially at low Cu levels. Our work supports further investigation into the nonlinearity of Cu and the joint and interactive associations of Mn, Cu and Pb with neurobehavior.

Life Stage-Specific and Multi-Generational Effects of Environmental Stressors in Fish - Part 2

**508 Intersex development in adult fish. Are estrogenic compounds the main culprit?**

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Impacts on fish exposed to municipal wastewater treatment plant (WWTP) effluent is a concern globally. One of the most documented cases is in the Grand River of southern Ontario, where male rainbow darter (Etheostoma caeruleum) caught below the Kitchener and Waterloo WWTPs have exhibited feminization characteristics. These impacts are thought to be due to estrogenic compounds (natural and/or synthetic) present in WWTP effluents. Intersex, along with other impacts, have reduced to reference-level conditions after the Kitchener WWTP had upgraded its facility, further supporting the association of these impacts with WWTPs. Although a strong link has been established between WWTP effluent and impacts in rainbow darter, the following questions are still not well understood: i) are estrogenic compounds present in WWTP effluents responsible for the impacts observed in male rainbow darter and ii) are these impacts related to the exposure during a critical window? To address these questions, wild sexually mature male rainbow darter from a reference site were brought into the laboratory and exposed to 17α-ethinylestradiol (EE2) at nominal concentrations of 0, 1, or 10 ng/L in a flow-through system. Rainbow darter were exposed for 23 weeks (May to October), which covers the major period of recrudescence (germ cell proliferation) and is hypothesized to be a window of exposure when fish are more sensitive to EDcs. After the exposure, rainbow darter were assessed for liver vitellogenin expression, in vitro androgen production, intersex, and behavioural endpoints. Intersex was induced, with significant increases in incidence from 18% in controls to 70% in the higher dose (10 ng/L EE2). In vitro androgen production significantly decreased from 60 pg/mg tissue (in controls) to 10 pg/mg tissue at 10 ng/L EE2. The results observed in this exposure are consistent with impacts previously identified in male rainbow darter downstream of WWTPs in the Grand River providing evidence that responses observed in the field are likely due to estrogenic constituent(s) present in WWTP effluents. In addition, recrudescence may be a critical window of sensitivity; this is being further investigated. Answering these questions concerning critical constituents present in WWTP effluent and identifying sensitive windows of exposure, may help to better manage the treatment and release of WWTP effluents into aquatic receiving environments.

**509 Maternal Preconception Exposures to PFOS and PFBS Impact Zebrafish Fatty Acid Profiles and Development**

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Perfluorobutane sulfonate, PFBS, is a perfluoralkylated substance and a shortened (4 carbon chain) alternative to PFOS, perfluorooctane sulfonate (8 carbon chain). Using the zebrafish model (Danio rerio), this study aims to compare the effects of a maternal, preconception exposure to PFBS and PFOS on reproductive and developmental endpoints. Four adult female fish, Tg(insulin:GFP) were stripped to remove existing eggs and exposed to waterborne concentrations of 0.08, 0.14, or 0.25 μg/mL PFBS or PFOS, or 0.01% DMSO. Exposures continued for 1 week for a complete cycle of oocyte maturation. Following exposures, females were bred daily with unexposed males until 5 successful embryo collections occurred. These embryos were imaged daily through 120 hours post fertilization, hpf, via live brightfield and fluorescence microscopy, and growth, yolk sac area, and pancreatic beta cell area were measured. Few significant changes in these developmental endpoints were observed in embryos from the first collection. However, in the 5th collection, significant reductions in length, yolk sac area, swim bladder inflation, and pancreatic beta cell area were measured in embryos collected from the 0.25 μg/mL PFBS treatment group. Analytical chemistry revealed that PFBS detection in freshly fertilized embryos changed over time. PFBS was measured at 120 pg PFBS/embryo in the 1st collection of 0.08 μg/mL PFBS. However, PFBS was not measured in the embryos by the 5th collection in any treatment group, nor was PFBS measured in maternal tissues. In contrast, PFOS was detected in concentrations of 4000 pg PFOS/embryo in the 1st collection. Detection persisted into the 5th collection, and PFOS was detected in maternal liver and ovary samples. Fatty acid profiles were examined in freshly fertilized embryos. In both PFOS and PFBS embryos, there was a significant decrease in the proportion of oleic acid, and significant increase in docosahexaenoic acid (DHA) in PFBS samples. PFAS exposures in female fish may impact the nutrients loaded into the egg during this process, which is evident in the effects on fatty acids and yolk sac area in the early developmental stages. This nutritional deficit, possibly coupled with loading of toxicant into the eggs, may explain the persistence of effects at 120 hpf. Together this suggests that there may be alterations in oocyte maturation and metabolic homeostasis in larvae associated with maternal, preconception exposure to PFBS and PFOS.

**510 Fathers matter: The effects of paternal exposure to pharmaceuticals on offspring reproductive health in zebrafish**

S. Fraz, McMaster University / Biology; J.Y. Wilson, McMaster University / Department of Biology

Chronic, low concentration chemical exposures may have both direct health outcomes on adults and indirect effects on their offspring. Using zebrafish, we have examined the impacts of two common environmental pharmaceutical compounds, carbamazepine and gemfibrozil, on reproductive output and a suite of male reproductive endpoints (aggression, courtship behaviour, 11-ketotestosterone levels, sperm morphology, sperm motility). Fish were exposed for 6 weeks to 10 μg/L of carbamazepine or gemfibrozil prior to assessment of reproductive endpoints. Our studies have examined the direct effects of the pharmaceuticals on the parental fish and found decreased reproductive output, lower 11-ketotestosterone levels, altered behaviour, and sperm morphology with both pharmaceuticals. The reproductive effects of these pharmaceuticals on the parental generation have been consistent and repeatable across several experimental exposures. Offspring were generated in four different lines from crosses with both parents unexposed, both parents exposed, or with only one parent exposed to distinguish between maternal and paternal effects on offspring reproductive endpoints. The impacts were the result
of parental exposure because the offspring were reared to the F_2 generation in clean water; F_2 embryos could only have been exposed via maternal deposition into the yolk. For both compounds, paternal exposure was most important for offspring reproductive health; offspring from crossing exposed mothers and unexposed fathers did not show significant effects. This rules out maternal deposition as an important exposure scenario for the F_1 embryos. Yet, reproductive output was lower in crosses with an exposed father, supporting the notion that paternal exposure was impacting offspring health. The effects of paternal gemfibrozil exposure were largely limited to the F_1 generation while the effects of paternal carbamazepine were evident into the F_2 generation, suggesting transgenerational effects. Considering that carbamazepine is a histone deacetylase inhibitor in mammals, the effects of carbamazepine are likely via an epigenetic mechanism. Recent studies in zebrafish support the role of the sperm epigenome in early development stages and major reprogramming events. Collectively, our data suggest that paternal exposures are strongly relevant to offspring reproduction and male reproductive health in fish.

511 Impacts of Embryonic Exposure to Cannabidiol or Δ9-Tetrahydrocannabinol on Zebrafish (Danio rerio) Reproduction and Behavior in F0 and F1 Generations
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Cannabinoids including Δ9-tetrahydrocannabinol (THC) and cannabidiol (CBD) are being increasingly consumed for therapeutic purposes. Yet the potential adverse outcomes following exposure to cannabinoids during critical developmental periods such as embryogenesis is currently lacking. Zebrafish present a distinct advantage when studying the multigenerational effects following developmental exposure to canna-binoid compounds due to their conserved endocannabinoid system with mammals, well-characterized morphology and behavioral phenotypes, and high fecundity. The objective of this study was to assess acute, morphological, and behavioral effects following a 96-hour developmental exposure to THC or CBD and assess persistent impacts in adult fish and their offspring. Zebrafish were exposed from 6 to 96 hours post fertilization (hpf) to nominal concentrations of a solvent control (0.05% DMSO), THC (0.024 - 0.6 mg/L; 0.08 - 2 uM) or CBD (0.006 - 0.15 mg/L; 0.02 - 0.5 uM). Two and a half years following the initial larval exposure, aged F_0 (developmentally exposed) and F_1 (parents were exposed) fish were assessed for aging phenotypes such as brain and liver expression of genes involved in: neurodevelopment (bdnf), proliferation (p53), cell cycle arrest (p16, p21), and immune markers (tnfα, Il-6, Il-1b). A significant reduction in Fulton’s Condition Factor was observed for adult F_0 ZF (LOEC 39 µg/L) starting at 4 h post-fertilization (hpf) to 5 dpf post-fertilization (dpf). Neurobehavioral and molecular assays were conducted for F_0 ZF at larval, 21 dpf larvae, juvenile, adult stages as well as the subsequent larval F_1 generation. Global DNA Methylation measurements were analyzed for 5 dpf F_0 larvae, 21 dpf F_1 larvae, and 5 dpf F_1 larvae. Behavior assays assessing swimming behavior (distance traveled and velocity) of the exposed F_0 generation and F_1 larvae, and 5 dpf F_1 larvae. Behavior assays assessing swimming behavior (distance traveled and velocity) of the exposed F_0 parents or are inherited by larval F_1 progeny. Embryos were exposed to chlorpyrifos-oxon at 0.01 and 50 µg/L starting at 4 h post-fertilization (hpf) to 5 dpf post-fertilization (dpf). Neurobehavioral and molecular assays were conducted for F_0 ZF at larval, 21 dpf larvae, juvenile, adult stages as well as the subsequent larval F_1 generation. Global DNA Methylation measurements were analyzed for 5 dpf F_0 larvae, 21 dpf F_1 larvae, and 5 dpf F_1 larvae. Behavior assays assessing swimming behavior (distance traveled and velocity) of the exposed F_0 generation are conducted at 5 dpf and 21 dpf. F_0 embryos were raised to adulthood under standardized laboratory procedures in triplicates per treatment to account for differences in tank effect. Additional behavioral analyses were conducted at 11 weeks to assess juvenile shoaling interactions and adult novel tank diving. Significant decreases in swimming activity (both distance traveled and velocity) was observed for 5 dpf F_0 ZF exposed to the 50 µg/L treatment (p < 0.0001). No behavioral changes were observed for F_0 ZF at 21 dpf swimming behavior or shoaling at 11 weeks. Increased anxiety-associated behavior was observed during novel tank diving analyses for F_0 female ZF at 50 µg/L CPO exposure. Meanwhile, significant increase in Fulton’s Condition Factor was observed for adult F_0 ZF males at 50 µg/L exposure as compared to control, indicating changes in

512 Evaluation of multigenerational effects of 2-ethylhexyl 4-hydroxy-benzoate, bisphenol A, and dibutyl phthalate in Japanese medaka
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Three chemicals, 2-ethylhexyl 4-hydroxybenzoate (2-EHHB), bisphenol A (BPA), and dibutyl phthalate (DBP), were evaluated for multigenerational endocrine-mediated effects using a modified Japanese medaka (Oryzias latipes) extended one-generation reproduction test (MEOGRT) (OCSPG TEG 890.2200). Fish were exposed to five test concentrations, a water control and for DBP, triethylene glycol (solvent control), under flow-through conditions starting with adults (F_0) through the end of the second generation (F_2). Exposure to 2-EHHB significantly decreased fecundity, fertility, and growth (Lowest Observed Effect Concentration (LOEC) 5.3 µg/L) in F_0, F_1, and F_2 adults. Liver vitellogenin (vtg) mRNA increased in F_1 and F_2 subadult males (LOEC 101 µg/L) and the number of anal fin papillae were significantly decreased (LOEC 49 µg/L). Significant testicular degeneration (LOEC 5.3 µg/L) was also observed in F_1 and F_2 male adults. Findings suggest that 2-EHHB may have estrogenic effects. Results for BPA indicated that there were significant reductions in fecundity and fertility in F_0 (LOEC 2600 µg/L) and F_1 (LOEC 390 µg/L) generation adults. In F_1 subadult males, there was significant gonadal feminization (LOEC 480 µg/L), reduction in anal fin papillae (LOEC 150 µg/L), and increased liver vtg (LOEC 390 µg/L). Results may indicate an anti-androgenic and/or estrogenic mode of action leading to diminished fertility and fecundity as well as feminization of male medaka. Exposure to DBP did not significantly affect F_0 adult survival, growth or fertility, but F_1 adult fertility and fecundity was significantly decreased at the highest test concentration (LOEC 305 µg/L). Male and female growth was significantly reduced in F_1 and F_2 subadults and adults with males (LOEC 16 µg/L) being more sensitive to DBP than females (LOEC 39 µg/L). Embryo hatchability (F1 and F2) was significantly reduced (LOECs: F1 16 µg/L; F2 39 µg/L) as was the number of male anal fin papillae (F1 subadult LOEC 39 µg/L). Collectively, findings did not suggest a specific mode of action. Data from the MEOGRT can be used in a weight-of-evidence evaluation to establish dose-response relationships and potential connections to endocrine modes of action and effects. Disclaimer: The views expressed in this presentation abstract are those of the authors and should not be construed to represent any Agency determination or policy.

513 Transgenerational effects of developmental exposure to chlorpyrifos-oxon in zebrafish (Danio rerio)
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Chlorpyrifos (CPF) is a broad-spectrum organophosphate pesticide widely used in agricultural applications in the United States, which has been attributed to a number of neurodevelopmental disorders. It is unclear if the adverse effects associated with developmental exposure to the active CPF metabolite, chlorpyrifos-oxon (CPO), persist into F_0 adulthood and future generations. The parent CPF is bio-transformed into the highly bioactive toxic CPO metabolite and travels through the body of a pregnant female to the womb. Furthermore, limited data exists on the persistent noncholinergic and DNA methylation effects of embryo-larval zebrafish (ZF) post developmental exposure to CPO. The goal of this study was to investigate if changes in ZF behavior were manifest throughout the life of the exposed F_0 parents or are inherited by larval F_1 progeny. Embryos were exposed to chlorpyrifos-oxon at 0.01 and 50 µg/L starting at 4 h post-fertilization (hpf) to 5 dpf post-fertilization (dpf). Neurobehavioral and molecular assays were conducted for F_0 ZF at larval, 21 dpf larvae, juvenile, adult stages as well as the subsequent larval F_1 generation. Global DNA Methylation measurements were analyzed for 5 dpf F_0 larvae, 21 dpf F_1 larvae, and 5 dpf F_1 larvae. Behavior assays assessing swimming behavior (distance traveled and velocity) of the exposed F_0 generation are conducted at 5 dpf and 21 dpf. F_0 embryos were raised to adulthood under standardized laboratory procedures in triplicates per treatment to account for differences in tank effect. Additional behavioral analyses were conducted at 11 weeks to assess juvenile shoaling interactions and adult novel tank diving. Significant decreases in swimming activity (both distance traveled and velocity) was observed for 5 dpf F_0 ZF exposed to the 50 µg/L treatment (p < 0.0001). No behavioral changes were observed for F_0 ZF at 21 dpf swimming behavior or shoaling at 11 weeks. Increased anxiety-associated behavior was observed during novel tank diving analyses for F_0 female ZF at 50 µg/L CPO exposure. Meanwhile, significant increase in Fulton’s Condition Factor was observed for adult F_0 ZF males at 50 µg/L exposure as compared to control, indicating changes in
growth between treatments. Separate samples were collected at 5 dpf for molecular and global DNA methylation analyses to assess long-term and generational changes due to developmental CPO exposure as compared to control. The maximum velocity observed from startle response (tapping) was significantly decreased in 5 dpf F1 ZF for the 0.01 µg/L treatment. All samples collected from F0 and F1 were analyzed to assess genetic regulation of cholinergic (AChE), dopaminergic (TH1, DAT), neurodevelompental (C-FOS, GRIN-1B, LINGO-1B), and de novo methylation genes (DNMT-3AA, DNMT-3AB, DNMT3BA). No change in AChE was observed at any treatment. Down-regulation of C-FOS, GRIN-1B, and DNMT3AA was observed in 5 dpf F0 ZF exposed to 50 µg/L chlorypyrifos-oxon. GRIN-1B (0.49 fold) and DNMT-3AB were down-regulated in 21 dpf F0 ZF at 50 µg/L exposure. However, up-regulation of GRIN-1B was observed in 21 dpf F0 ZF at 0.01 µg/L exposure. Up-regulation of DNMT3AB was the singular gene change observed for 5 dpf F1 ZF. Global DNA methylation decreased for 21 dpf F0 ZF 50 µg/L and 5 dpf F1 0.01 µg/L treatments as compared to the control ZF. No differences in TH1, DAT, or DNMT3BA were observed in any age or generation of ZF. Identification of potential noncholinergic behavioral, molecular, and epigenetic outcomes informs future investigative efforts and regulatory efforts into the persistent effects of developmental CPO insecticide exposure in ZF.

515 Multigenerational effects of endocrine disrupting compounds: Understanding population level implications using modeling approaches
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Emerging research demonstrates that endocrine disrupting compounds (EDCs), which agonize, antagonize, and/or synergize the effects of endogenous hormones, can cause deleterious effects as a result of early-life exposure, as well as effects across generations. As such, we explored the effects of a suite of EDCs (ethinylestradiol, bifenthrin, levonorgestrel, and trenbolone) at low ng/L concentrations on the euryhaline model fish *Menidia beryllina*. Fish were exposed from fertilization until 21 dph, then reared through three generations in clean water. Early life exposure led to changes in sex ratio, phenotypic deformities, and differential gene expression and methylation across generations. Taken together, early life EDC exposure caused functionally relevant changes in the epigenome, transcriptome, and reproductive and immune phenotypes in directly (P0), indirectly (F1), and unexposed individuals (F2). To examine the consequences of these individual-level effects on overall population dynamics, we used these data to parameterize a size-and-age-structured integral projection model (IPM). This approach represented empirically-determined effects on growth, survival, and fecundity. Additionally, we tracked the distribution of multi- and transgenerational effects in the model. We then quantified the effects of both single and chronic exposures to a range of EDCs at environmentally relevant concentrations, both for population persistence and population variability. Accounting for multi- and transgenerational responses led to model predictions that a) single EDC exposures have longer-term effects on population variability (i.e., oscillations in abundance), and b) chronic EDC exposures were more likely to lead to population collapse. These projected effects demonstrate that EDC exposures can have far-reaching effects on unexposed generations, highlighting the need for these types of cross-generational effects to be considered in risk assessment.

Fate and Effects of Chemicals from Stormwater Runoff

516 Potentially toxic elements (PTEs) transport and accumulation in green stormwater infrastructure (GSI)
E. McKenzie, A. Behbahani, R.E. Ryan, Temple University / Civil and Environmental Engineering

Biowales are a common infiltration-based stormwater management practices (SMPs), and are touted as one the most highly recommended green stormwater infrastructure (GSI) approaches to manage both water quantity and quality. However, potentially toxic elements (PTEs) do not degrade, therefore the elevated concentrations that are observed in the runoff can accumulate in the soil and can be transported to the underlying groundwater. This study combines field data from Interstate-95 sites in Philadelphia, including highway runoff and SMP pore water concentrations, with 1-D transport modeling to understand the long term accumulation and transport of nine PTEs within the SMP media. PTE breakthrough in the soil media was observed to exhibit the following trend: Cl, Cr, Cd, As, Cu, Pb, Fe. Soil associated concentrations in the top media layer (0 - 5 cm) were compared against relevant soil screening values, and it was determined that Cl, Cr, an As would exceed the soil screening values after 20 years of SMP use. To evaluate potential risk associated with contaminating the underlying groundwater, media porewater concentrations at a depth of 5 m were compared to drinking water or aquatic life criteria; after 20 years of simulated use, only Cl concentrations exceeded regulatory values. The interactions between SMP loading ratio (i.e., the ratio between the contributing surface area and the SMP infiltration area) and SMP media solid-water distribution coefficient (Kd) were evaluated and confirmed that increased transport was associated with elevated loading ratio values and with decreased Kd values, but that the risk of PTE contamination of soil and groundwater, compared to relevant criteria, was generally fairly consistent.

517 Mitigation of stormwater toxicity with permeable pavement
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Permeable concrete and asphalt are engineered to allow stormwater infiltration while maintaining structural resilience under heavy vehicle loads. Adding carbon fiber to the matrix of permeable pavements increases their tensile strength. Multiple studies have focused on evaluating the engineered design performance of these permeable materials. However, it is unclear whether these materials provide chemical treatment of surface stormwater runoff and whether they contribute toxic chemicals to effluent water. We evaluated permeable concrete and asphalt cores six inches in diameter and depth with and without the addition of carbon fiber. Control water and stormwater runoff from a busy arterial road were pumped at a low flow rate (1 L/hr) through each core. The use of control water is representative of rain water while the stormwater treatment shows how these pavements may perform when exposed to diverted runoff from impermeable surfaces. After four hours of treatment influents and effluents were analyzed for water quality and chemistry (pH, dissolved oxygen, PAHs, fecal coliform bacteria, total suspended solids, dissolved organic carbon, and dissolved metals) and for toxicity on the crustacean *Ceriodaphnia dubia* and zebrafish (*Danio rerio*). Results will show (a) how permeable pavements alter clean and polluted influents; (b) whether carbon fiber alters the water quality of permeable there is a difference in treatment between permeable concrete and asphalt with and without carbon fiber additions; and (c) what effect aging over three treatments has on performance.
518 Testing Novel Bioretention Soil Media for Removal of Polycyclic Aromatic Hydrocarbons and Escherichia coli in Urban Stormwater Runoff

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Current stormwater permitting regulations in the state of Washington do not include performance goals for the treatment of pollutants like certain organic contaminants (Polycyclic Aromatic Hydrocarbons - PAHs) and bacteria (total and fecal coliforms, enterococci, Escherichia coli). As a first step in determining Best Management Practices (BMPs) for the treatment of these contaminants from stormwater runoff, a bench scale study has been conducted to assess the contaminant removal efficiencies of several emerging bioretention soil media (BSM) amendments. The following treatments have been compared in a bench scale stormwater filtration experiment: 1) sand (control), 2&3) sand amended with two different high temperature pyrolysis biochars, and 4) sand amended with alum (i.e., aluminum sulfate). These treatments have been chosen for their adsorptive properties, availability, and ability to enhance desirable hydraulic properties in stormwater bioretention systems. In a series of three dosing experiments, small bioretention columns have been dosed with 1) clean fish rearing water (to condition columns and leach potential toxicants) 2) PAH-spiked stormwater (made with used motor oil mechanically dispersed in water), and 3) E. coli spiked synthetic stormwater. Influent and effluent from the columns have been analyzed for standard parent PAH compounds and E. coli concentrations. Danio rerio (zebrafish) morphometric bioassays have been conducted to assess potential toxicity of media leachates to determine whether these novel media leach toxicants. Similar bioassays have also been conducted on the effluents from the treated PAH spike to evaluate the ability of the media to attenuate PAHs. Results indicate that the sand and alum treatments leached a mean of 0.12 and 0.14 µg/L of TPAHs respectively compared with the biochars which leached 0.079 and 0.016 µg/L. In the PAH spike experiment the sand, biochar 1, biochar 2, and alum treatments achieved mean TPAH removal rates of 32%, 99.8%, 99.8%, and 29% respectively. The D. rerio assay and E. coli spike data are not yet available, but currently available results suggest that biochar is a promising bioretention amendment for improving removal of organic contaminants, such as PAHs, from stormwater.


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Urban landscapes are often contaminated by a complex mixture of contaminants of emerging concern (CECs). These landscapes are defined by an abundance of impermeable surfaces that act as conduits during precipitation events moving contaminants into aquatic ecosystems. Prior research on the introduction of CECs into surface waters have focused on municipal wastewater treatment plants and agricultural runoff. This study investigates the effects of urban stormwater runoff on larval fathead minnows. In addition, we examined the mitigating potential of detention ponds and iron-enhanced sand filtration (IESF) as best management practices. We collected inflow and outflow water samples following 3 cm precipitation events during snow melt, spring flush, and summer rains from seven stormwater ponds across the greater metropolitan area of Minneapolis and St. Paul, MN, USA. CECs were commonly detected in stormwater runoff with greater concentrations in inflows when compared to pond outflows. In some instances, CEC concentrations raveled those reported for treated wastewater effluent. Endpoints measured include fathead minnow hatch success, survival, growth, development, predator avoidance performance, and foraging efficiency. Our results indicate that stormwater was most detrimental to larval fathead minnows during snow melt (declining survival and foraging efficiency). For snowmelt, foraging efficiency for treated runoff was greater than untreated runoff (p=0.04). However, that effect was seasonal with summer runoff showing untreated runoff having a greater reduction in foraging efficiency than IESF treated runoff (p=0.04). Stormwater treatment performance varied by season with best management practices having the greatest impact during summer rain events. This study suggests that best management practices provide some benefit in reducing CEC presence in urban stormwater although the biological benefits are seasonally limited.

520 Concentrations of Microplastics in Urban Stormwater Runoff from the City of Calgary, Canada

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In urban environments, impervious surfaces, such as rooftops and roadways, prevent precipitation from soaking into the ground. This runoff flows into storm sewers and is eventually discharged into surface waters, often without treatment. Urban stormwater runoff is a source of pollutants and sediments to surface waters and is thought to be an important vector for the introduction of microplastics into the aquatic environment. However, there is a paucity of data available on the prevalence of microplastics in urban runoff, limiting assessment of its role in transporting microplastics and preventing any form of risk assessment or mitigation strategies to be implemented. This study investigates the concentration and characteristics of microplastics in urban stormwater runoff from the City of Calgary, Canada. Samples (n=75) were collected throughout the summer of 2017 from 15 sampling locations representing a range of catchment sizes and land use types. Samples were collected under both baseflow and rain event conditions using a combination of autosamplers and grab sampling. Suspected microplastics were visually characterized by microscopy and, for selected samples, further identified using Raman microspectrophotometry. Total concentrations of suspected microplastics ranged from 9 to 230 pieces/L (mean=52.9 pieces/L), with microplastics < 125 µm being the dominant size class. The predominant category of microplastics found in samples across all conditions was fibers, followed by fragments, consistent with other studies of microplastics in freshwater that have found fibers and fragments to be the dominate category of microplastic present. We also found relationships with land use and concentration, microplastic size, and morphology. This work represents one of the first studies on the occurrence of microplastics in stormwater runoff and will provide a baseline for future monitoring and mitigation studies.

521 Development of robust chemical indicators of urban runoff and sewage contamination in urban streams and an estuary in Sydney, Australia

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Many organic micropollutants have been identified as indicators of specific types of pollution particularly from sewage, roads and general urban areas. There is often an assumption made that the chemical is a good indicator of a specific pollution source without evaluating whether there are other sources. If this chemical indicator is not source specific then erroneous conclusions can be made about the source of contaminants present in waters. A study was conducted on two urban creeks and in an urban estuary in Sydney, Australia to illustrate how robust indicators can be determined. To increase the range of organic micropolllutants that could be detected, two passive samplers (ChemCatches and Polar Organic Chemical Integrative Samplers) were used and compared. The
two passive samplers, along with compositd water samples from auto-
samplers were analysed by multi-residue GC-MSMS and LC-QTOF-MS 
database methods to investigate 1,393 organic chemicals, including pharma-
caceuticals and personal care products (PPCPs), pesticides, PCBs, PAHs, 
flame retardants, antioxidants and sterols such as coprostanol (a fecal indicator). A total of 255 chemicals were detected from the three urban sites surveyed: 187 using GC-MSMS and 75 using LC-QTOF-MS. Raw sewage samples were collected from sewers in the vicinity of these three urban sites to confirm what chemicals were present in sewage. Overall, 111 chemicals were detected in sewage using GC-MSMS with 73 of these 
chemicals detected at all three sites. Similarly, 73 chemicals were detected 
using LC-QTOF-MS with 59 of these samples detected at all three sites. Those chemicals that were commonly present in sewage and absent in the 
three urban sites were deemed to be potentially good indicators of sewage. Those chemicals absent in the sewage and commonly detected at 
the urban sites were deemed to be good indicators of non-sewage contami-
nated urban runoff. Many chemicals, including caffeine, were commonly 
detected in sewage and at urban sites and are poor indicators of any spec-
cific pollution source. Many chemicals, particularly pharmaceuticals have 
specific uses and can clearly be associated with sewage. However, uses 
of the remaining potentially good indicators were also were examined in 
the literature to help confirm whether they are good sources of sewage 
or urban runoff.

522 Enrichment and Attenuation of Organic Contaminants in an 
Urban Creek During a Rainfall Event 
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Urbanization is a global phenomenon characterized by changes in land 
use. With increased urban landcover comes the creation of more impervi-
sous surfaces, which in turn results in increased runoff generation after 
a precipitation event. Watershed urbanization provides a mechanism 
for the transport of contaminants to surface waters. Mimico Creek 
watershed is a highly urbanized watershed in Toronto, Canada, which 
drains into Lake Ontario. In this work, we monitored the concentra-
tions of four groups of organic contaminants - Polycyclic Aromatic 
Hydrocarbons (PAHs), Substituted Polycyclic Aromatic Hydrocarbons 
(SPAHs), Organophosphate Flame Retardants (OPFRs) and Benzotriazole 
Ultraviolet Stabilizers (BT-UVs) in Mimico Creek. These concentra-
tions were monitored before, during and after a major rainfall event in the 
summer of 2018. The aim of this was to explore the significance of stormwater as a source of contaminants to the river. In addition to stormwater, we 
also explore the influence of unregulated wastewater discharge. Results 
indicate that the contaminants behave differently as stormflow increases and decreases over time. Some contaminants show a sudden spike in 
concentrations, which coincides with the beginning of stormflow, while 
others show a dilution pattern. Our results suggest that during precipita-
tion events, stormwater plays a major role in the enrichment of highly 
water-soluble contaminants, while hydrophobic contaminants, which are 
more abundant in the particle phase, are mostly diluted.

523 Assessing sediment recontamination and bioaccumulation of 
metals from stormwater runoff 
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Effective means of evaluating the significance of the stormwater inputs 
are important when evaluating the long-term effectiveness of sediment 
remedial efforts. Here we present improved tools to assess the impact 
of stormwater runoff on metal sediment contamination, bioaccumula-
tion, and bioavailability in Paleta Creek, the San Diego Naval Base 
in California, USA. Intensive stormwater sampling was coupled with 
receiving water sediment sampling, including sediment traps and surficial 
sediment collections, ex situ bioassays, using the clam Macoma nasuta, 
and porewater sampling via DGTs during the wet and dry season. The 
effects of stormwater on receiving water were evaluated by examining 
the statistical differences by location (near stormwater discharges to far) and 
period (dry vs wet season) of concentrations in sediment cores, sediment 
traps, tissue bioaccumulation and sediment porewater. Non-parametric 
statistics using R showed strong coupling between location and period 
for Cd, THg, Ni, Pb and Zn, with concentrations of these metals increasing 
toward the stormwater discharge and during the wet season. Cu and 
As, however showed no significant increases during the wet season and 
increasing toward locations further from the stormwater, suggesting that 
other sources were important. Sediment traps were useful to confirm 
these results while reflecting only sediment depositing during a single wet 
season, whereas sediment samples inherently reflect historical discharges 
as well. Despite the significant increases in sediment concentration 
in many metals, bioassay tissues showed that concentrations of all metals 
showed significant decreases during the wet season, suggesting that 
stormwater contaminants were associated with less bioavailable forms. 
Deposition and reduction in the sediment column would normally be 
expected to lead to further reductions in bioavailability over time sugges-
ting that stormwater in this watershed is not a significant contributor to 
benthic organism impacts despite recontamination as measured by 
the bulk sediment concentration. Moreover, porewater concentration 
measurements also showed significant decreases over the wet season for 
all metals, consistent with the reductions in bioaccumulation and further 
suggesting reduced bioavailability of stormwater metals.

Alternative Approaches to Animal Testing for 
Ecotoxicity Assessments: Exploring New And Novel 
Approaches - Part 2

524 Identifying methods for the assessment of toxicant-induced 
alterations in neurological function in larval fathead minnows 
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Alterations in neurological development and/or vision have been noted 
after exposures to a variety of environmental contaminants, includ-
ing heavy metals, pesticides, pharmaceuticals, and estrogens. Despite 
the growing interest in assessing the neurotoxicity of toxicants, routine 
toxicity testing methods-such as the recently developed fish embryo toxic-
ity (FET) test-do not currently include endpoints capable of predicting
adverse impacts on neurological development. Previous studies have identified embryonic eye size as a potential FET test endpoint, and while there is limited evidence suggesting that these alterations are indicative of altered neurological development, studies validating the link between eye size and organism fitness are needed. The overarching goal of this project is to investigate whether reduced embryonic eye size at the conclusion of the FET test is predictive of altered neurological function and/or vision in larval fathead minnows. The inclusion of such an endpoint would greatly expand the utility of the FET test by allowing for the assessment of neurological teratogens. But first, assays capable of identifying toxicant-induced alterations in neurological function and/or vision in larval fathead minnows must be validated. Therefore, the objective of the present study was to validate methods to assess vision/neurological function in larval fathead minnows using a known neurotoxicant, chlorpyrifos, and the established positive control for the FET test, 3,4-dichloroaniline. Minnows were exposed for 5 or 12 d, starting at <2 hours post fertilization, then neurological function was assessed via three assays: the optomotor response assay, a feeding assay, and the e-start assay to determine which assays were sensitive to chemical exposure. The results of this project will be utilized in future studies investigating whether reductions in embryonic eye size are predictive of sublethal adverse effects.

525 Expanding the chemical footprint of the pp-LFER Target-Lipid Model (pp-LFER TLM) using Quantum-chemically estimated Abraham Parameters (QCAP)

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The target lipid model (TLM) has been well-established for predicting the acute and chronic toxicity of neutral organic polar and non-polar narcotic chemicals. Additionally, the TLM-derived threshold values for ecological protection (HCS) have been demonstrated to be sufficiently protective for this suite of chemicals. However, further adaptation and extension of the TLM to complex chemistries (i.e., surfactants and other ionizable chemicals) has been slow, likely in part to difficulties in obtaining reliable estimates of the octanol-water partition coefficient (Kow), which controls the relative potency (and threshold values) of the narcotic chemicals. For some classes of compounds, empirical class corrections have improved predictions, however, many classes remain data poor and consequently poorly-predicted. The development of a molecular-descriptor-based pp-LFER TLM removed the need for chemical class corrections and improved predictions for complex classes of chemistries. However, classes like surfactants are still poorly characterized with respect to their molecular descriptors, and for ionic species, only recently have methods been developed to compute these parameters. The aim of this work is two-fold: (1) to provide a standardized approach and re-calibration of the pp-TLM framework using quantum-chemically calculated Abraham descriptors; and (2) to include novel classes of chemicals - including neutral and ionic surfactants and expand the predictive domain of the TLM as a chemical hazard and risk assessment tool. Predictions for a training and calibration set of compounds (including the expanded 2018 TLM data set) are compared using (a) the traditional Kow-based TLM, (b) the pp-LFER TLM (Absolv descriptors), and the pp-LFER TLM (quantum chemical descriptors).

526 Effects of atrazine on life parameters, oxidative stress, and ecdysteroid biosynthetic pathway in the marine copepod Tigriopus japonicus

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Atrazine is a widely used pesticide that is also known as endocrine disrupting chemical (EDC) for animal. The aim of this study was to investigate adverse effects of atrazine on life parameters, oxidative stress, and ecdysteroid biosynthetic pathway in the marine copepod Tigriopus japonicus. In T. japonicus, no mortality was shown in response to atrazine up to concentration 20 mg/L in acute toxicity assessment. In nauplii, retardation in the growth and prolonged molting and metamorphosis resulted under chronic exposure of atrazine at 20 mg/L. In addition, body sizes were significantly decreased (P< 0.05) in 20 mg/L atrazine-exposed T. japonicus nauplii with the generation of reactive oxygen species. Also, significant increase in the enzymatic activity of glutathione-S-transferase in adult T. japonicus was observed at low concentration of atrazine. To understand effects of atrazine on ecdysteroid biosynthetic pathway-involved genes (e.g., neverland, CYP307E1, CYP306A1, CYP302A1, CYP3022A1 [CYP355A1], CYP304A1, and CYP18D1) was examined with mRNA expressions of ecdysone receptor (EcR) and ultraspriacle (USP) in response to 20 mg/L atrazine in nauplii and adults. These genes were significantly downregulated (P< 0.05) in response to atrazine, compared to the control but not for adult T. japonicus. These results suggest that atrazine can interfere in vivo life parameters by oxidative stress-induced retrogression and ecdysteroid biosynthetic pathway in this species.

527 Toxicogenomic study using genome-wide identified glutathione S-transferases in the copepods Tigriopus japonicus and Paracyclopinula nana

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The glutathione S-transferases (GSTs) are crucial group of enzymes in living organisms which detoxify both endogenous and exogenous compounds such as pharmaceuticals and environmental pollutants. In addition, it is also widely accepted as one of the predominant antioxidant enzyme family against reactive oxygen species (ROS) and oxidative stress by catalyzing the conjugation of glutathione (GSH) to electrophilic compounds to render them water-soluble. The genome-wide identification of GST genes in T. japonicus and P. nana resulted in 32 and 20 GSTs in total, respectively. To validate the detoxification function of the identified GSTs, both copepods were exposed to copper (Cu2+) and the reactive oxygen species (ROS) level and GST activity were measured. This study covers full identification of GST classes in two marine copepod species and their important role in marine environmental ecotoxicology. This is the first study characterizing the whole GST gene family in the copepod T. japonicus and P. nana with in-depth detailed information on the synteny analysis, which could be applied to other genetically complex organisms without currently available whole genome sequences.

528 Predictive Molecular Level Toxicity Signatures Based on Non-Targeted Analysis and QSAR modeling: A Case Study of the Lubbock Canyon Lake System

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Current aquatic toxicity assessment strategies are heavily focused on targeted analysis and in vitro/in vivo toxicity data to understand the impact on aquatic organisms upon exposure to complex mixtures such as effluent. However, based on this approach alone, it is difficult to explain observed toxicity symptoms and the hidden impact on biological pathways that were not accounted during an effect analysis. The recent advances in analytical instruments (e.g., high-resolution mass spectrometry) could help us to understand chemical fingerprints of complex mixtures and this information could be integrated with the QSAR (quantitative structural activity relationships) model to understand toxicity signatures of complex mixtures in aquatic organisms. The goal of this study was to understand...
toxicity signatures in the Lubbock Canyon Lake System (LCLS) which, is an effluent dominated stream, using integrated analysis of data from non-targeted analysis of water samples and a QSAR model. Four water samples were collected from the LCLS including upstream, effluent outfall, and two downstream locations. These water samples were analyzed with non-targeted analysis and targeted analysis to understand the level of contamination in the LCLS. Furthermore, potential interactions of identified chemicals was predicted using the Similarity Ensemble Approach (SEA), which is based on the QSAR modeling concept, and a literature search (Comparative Toxicogenomic Database, CTD). Gene Ontology was used to map the predicted chemical interactions to biological pathways, and then ranked based on the number of interactions. The predicted molecular level toxicity signatures were confirmed by measuring molecular biomarkers in larval zebrafish exposed to water samples for 5 days. Based on predictions, the top pathways that could be impacted with 1-4 sites were the serotonin receptor signaling pathway, the adrenergic receptor signaling pathway, gonadotropin receptor releasing hormone pathway, and the in aquatic organisms. There was 80% agreement between the predicted toxicity signatures and the measured molecular toxicity signatures at the effluent discharge and downstream sites. Results from this study will allow researchers to choose chemical fingerprint guided biological pathways to assess adverse impacts on aquatic organisms upon exposure to complex mixtures.

529 In vitro Screening of Bisphenol A Replacement Compounds: Cytotoxicity and mRNA Expression in Chicken Embryonic Hepatocytes
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A market for bisphenol A (BPA) replacement compounds has emerged due to restrictions on the use and production of BPA. Some of these structural analogs have been detected in the environment, yet little is known about their toxicological properties relative to BPA. In the present study, an avian in vitro toxicogenomic model was used to compare the biological activity of five replacement compounds to BPA. Cell viability and mRNA expression were compared in primary chicken (Gallus gallus domesticus) embryo hepatocytes (CEH) exposed to BPA, bisphenol F (BPF), bis(3-allyl-4-hydroxyphenyl)sulfone (TGSIIH), 1,7-bis(4-hydroxyphenyl)-3,5-dioxahexane (DD-70), bisphenol AF (BPAF) or 4-hydroxyphenyl 4-isopropoxysulfone (BPSIP). Transcriptomic effects were determined using two PCR arrays: 1) the ToxChip, which measures the expression of several toxicologically-relevant genes; and 2) the AestroChip, which measures estrogen-responsive genes. DD-70 (LC50=32.9±7.3) and BPAF (LC50=43.1) were more cytotoxic to the embryos compared to BPA (LC50=61.7±43.1). Both BPA and the 5 replacement compounds altered the expression of genes related to xenobiotic metabolism, DNA repair, and the thyroid hormone pathway. The BPA alternative, TGSIIH, elicited the most changes in gene expression, affecting all of the pathways represented on the ToxChip array. The rank order of gene dysregulation based on the ToxChip array was TGSIIH > BPF > DD-70 > BPAF > BPSIP. All of the replacement compounds and BPA altered at least one gene on the Aestrochip array. BPA upregulated the expression of two genes, apovitellenin (3-fold) and carnitine palmitoyltransferase (2-fold). The expression of apovitellenin was also changed by two of the replacement compounds, BPSIP (3-fold) and BPF (42-fold). BPSIP altered the most estrogen-responsive genes (7/10). The rank order of Aestrochip gene dysregulation was BPSIP > BPF > BPAF > BPA > DD-70 > TGSIIH. Overall, the results suggest that certain BPA replacement compounds elicit comparable or even greater toxicity than BPA and may act via different mechanisms.

530 Metabolomic analysis reveals dysregulation of amino acid and lipid metabolism in human liver cells exposed to environmental obesogens
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Obesity is considered a global pandemic affecting people of all ages and backgrounds. Environmental chemicals classified as obesogens may contribute to the promotion of obesity by altering lipid metabolism. While these obesogens are abundantly used in a wide variety of consumer products, from food packaging to fungicides, there is limited information available regarding the mechanism by which environmental exposure can contribute to the onset of obesity. In this study, potential alterations in the levels of 40 metabolites and 360 lipids in the human HepaRG liver cell line, a validated model for cellular steatosis, exposed to different concentrations of seven potential environmental obesogens were evaluated. These compounds included the pharmaceuticals rosiglitazone (ROS) and fenofibrate (FEN), the perfluorinated compounds perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), the plasticizers bisphenol-A (BPA) and di-2-ethylhexyl phthalate (DEHP), and the fungicide tributyltin (TBT). Additionally, LC50's were calculated for each compound, and immunofluorescence microscopy for cellular bioaccumulation of neutral lipids was conducted. Environmental levels of PFOS, DEHP, and TBT showed significant lipid bioaccumulation in the immunofluorescence assay. This was associated with increased levels of most of the evaluated lipids and a reduction on some amino acids. Overall, this integrated omics analysis provides mechanistic insights into the potential of these environmental pollutants to cause non-alcoholic fatty liver disease (NAFLD). Furthermore, this study actively contributes to the development of molecular signatures of toxic effects of chemicals causing fatty liver diseases and to the development of alternatives to in vivo experimentation.

531 Cell-based Lipidomics for Assessing Ecological Impacts of Environmental Surface Waters
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Chemicals released into surface waters by waste water treatment plants (WWTPs) and industrial and agricultural operations often produce adverse outcomes in both humans and wildlife. Traditional methods using live animals for conventional risk assessments are both resource- and time-intensive, and thus not sustainable in the long term. Cell-based assays have been widely used to gain information on impacted cellular pathways and relevant biomarkers of environmental exposure. In the current study, we applied a zebrafish liver (ZFL) cell-based lipidomics approach to assess the potential ecotoxicological impacts of complex contaminant mixtures in eight stream waters collected across the United States and Puerto Rico. ZFL cells were exposed to media prepared with the surface water samples for 48h. Intracellular lipophilic metabolites were detected using liquid chromatography high-resolution mass spectrometry (LC- HR MS). Untargeted lipid profiling revealed significant cellular stress resulting from exposure to several of the sites, including peroxisomal-mediated oxidative stress, endoplasmic reticulum stress, lysosomal disruption, and mitochondrial dysfunction. The results demonstrate the utility of cell-based lipidomics for environmental monitoring and risk assessments of surface waters. Detailed methods and results will be reported.
Fate, Effects, Mitigation and Monitoring of Oil and Oilfield Wastewater Spills in Freshwater Ecosystems - Part 2

532 The physical and chemical fate of diluted bitumen following experimental spills into freshwater limnocorals

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Diluted bitumen (dilbit) is increasingly transported by pipeline in Canada to global markets, raising the likelihood of accidental spills. A recent report by the Royal Society of Canada concluded that more research is needed on the weathering; fate; behaviour; and environmental effects of dilbit in aquatic systems to better inform spill response countermeasures. To address this research need, the BOREAL project (Boreal-lake Oil Release Experiments by Additions to Limnocorals) was commissioned to carry out large-scale field simulations of a dilbit spills into a freshwater lake. Nine limnocorals (10 m diameter, >100 m³) were installed in Lake 260 of the International Institute for Sustainable Development’s - Experimental Lakes Area (IISD-ELA) near Kenora, Ontario. Experimental spills were carried out at oil volumes ranging from 1.5 to 179.8 L, resulting in oil:water ratios ranging from 1:100,000 to 1:1000. This presentation will report on the physical and chemical characteristics; fate; and behaviour of dilbit following its addition to water, paying special attention to major processes including evaporation, spreading, dissolution, emulsification biodegradation and submergence. Following dilbit application to water, rapid evaporation of the volatile fractions present in the dilbit was observed during the first 4 days of the study, coinciding with increases in density (0.922 g/mL to > 1 g/mL) and viscosity (181 to > 1 000 000 mPaS) of the spilled material. Dilbit’s water content rapidly increased from 0.18 to 24% during the first 8 days of the study, characteristic of the formation of a water entrained sate. The onset of submergence across all treatments progressed from low to high, with the lowest treatment beginning to sink on day 12, and the highest treatment beginning to sink on day 31. The submergence observed can be mainly attributed to increases in density of the dilbit following extensive weathering. This work provides baseline data on the environmental fate and behaviour of dilbit in a realistic freshwater environment. In particular, we are the first to demonstrate the propensity for dilbit to sink under ambient environmental conditions in fresh waters typical of many boreal lakes across the Canadian Shield.

533 Dilbit for dinner: Using stable isotope analysis to trace carbon from a diluted bitumen spill into the aquatic food web

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Bitumen extracted from the Canadian Oil Sands is viscous to such a degree that it must be diluted with light gas condensates to flow through pipelines, yielding diluted bitumen (dilbit). Dilbit is transported across Canada in large volumes through an intricate network of pipelines, which in the event of a rupture, can put the surrounding ecosystems at risk. We conducted a limnocorral experiment at the International Institute of Sustainable Development-Experimental Lakes Area in Northwestern Ontario, Canada. This study involved simulating a dilbit spill in 9 10-m diameter limnocorals (~100 m³) installed in the littoral zone of a boreal lake. Different volumes of dilbit were added to the limnocorals, simulating a range of environmentally realistic spill volumes. Our research involved investigating the incorporation of dilbit derived carbon into the aquatic food web by analyzing stable isotopes in periphyton and phytoplankton for 80 days. Periphyton exhibited a linear 13C depletion as a function of dilbit volume added (p=0.034). Additionally, we exposed freshwater mussels Pyganodon grandis to oil-contaminated water and analyzed their muscle tissue. By the 25th day, the limnocorals treated with 42 L and 82 L showed a 13C depletion (-36.69 ± 2.91 ‰, and -36.47 ± 1.68 ‰) statistically different from control (-33.28 ± 0.5 %) (p=0.008, and p=0.048, respectively). Stable isotopic analysis of carbon was used to track the Deepwater Horizon oil spill in marine systems, but to date, stable isotopes have not been used as a tool to track the fate of dilbit in freshwater ecosystems. Our research demonstrates the utility and power of applying isotope analysis at the site of future freshwater oil spills.

534 The stimulation of freshwater phytoplankton communities following experimental diluted bitumen spills in boreal lake limnocorals

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Following highly publicized oil spills, the public has grown increasingly wary of the threat oil spills pose to aquatic ecosystems, yet the impacts of diluted bitumen in freshwater remain unclear. To address this gap, the BOREAL (Boreal lake Oil Release Experiment by Additions to Limnocorals) project seeks to give a comprehensive picture of effects for a complete ecological risk assessment of diluted bitumen by using a temperate oligotrophic lake with a natural food web for exposure. At the IISD-Experimental Lake Area in 2018, we simulated seven diluted bitumen spills—over a range of environmentally realistic spill volumes—in 10 m diameter, in-lake limnocorals, containing >100 m³ of water and natural lake sediment. We assessed diluted bitumen’s effects on the structure and function of phytoplankton communities for 80 days post-spill. Employing multiple lines of evidence, we assessed algal responses through analysis of chlorophyll-a, traditional taxonomy by light microscopy, flow cytometry, FlowCAM imaging cytometry, Pulse-Amplitude-Modulation (PAM), and genomic methods. Although there were species-specific responses, both chlorophyll-a, and photosynthetic ability increased with diluted bitumen dose by two weeks post-spill. Our preliminary interpretation is that phytoplankton may have been stimulated by diluted bitumen providing accessible carbon for growth or through a decline in grazers while also responding to reduced light under oil slicks. This research contributes to our understanding of the effects of diluted bitumen spills in freshwater ecosystems and will provide algal bioindicators of oil pollution for use after accidental spills and to monitor recovery.
535 The BOREAL Project: Changes to Freshwater Invertebrate Communities Following Simulated Diluted Bitumen Additions to Boreal Limnocorals
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To bring bitumen from Canada’s Oil Sands to market requires transportation over sensitive boreal environments via rail, truck, and pipeline. With proposed expansion of pipeline infrastructure in Canada, there is a clear need for whole-ecosystem based research evaluating fate, toxicity, and remediation of oil spills specific to freshwater environments. The Boreal Lake Oil Release Experiment by Additions to Limnocorals (BOREAL) aimed to specifically address the fate, behaviour, and toxicity of dilbit spills. The BOREAL study was conducted in an oligotrophic lake (Lake 260) at the IISD-Experimental Lakes Area in Summer 2018. A total of nine 10-metre diameter, ~100-m³, limnocorals were deployed. Seven limnocorals were treated with different volumes of a diluted bitumen product in a regression design accompanied by two reference limnocorals (far-field and near-field). Dilbit volumes ranged from 1.5 L to 180 L, which is representative of historical oil:water ratios for pipeline spills in North America between the 50th and 99th centile (2008-2018). The zooplankton, benthic invertebrate, and emerging insect communities were monitored for 14 days post-addition and 76 days post-addition for abundance and community composition. 48 hours following dilbit addition, zooplankton abundance had decreased in all enclosures, except for our near-field control and did not recover over the study duration to pre-treatment values. Rotifer communities became the dominant phylum within the limnocorals, while copepod communities substantially declined in all treatment limnocorals and the far-field control. No discernable or consistent impact on zooplankton community diversity (functional diversity) was observed between pre-addition and end-of-study samples. There was no clear impact observed to resident benthic invertebrate communities relative to control limnocorals and reference sites; however, a concentration-response decline was observed in total insect emergence, which was not specific to any particular insect family. Overall, invertebrate communities saw sustained declines post-addition. Sheen presence within high-treatment enclosures limited insect emergence, indicating a possible physical impact following oil exposure rather than direct toxicity to insect communities.

536 Fish embryotoxicity associated to weathered Cold Lake Blend diluted bitumen
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For several years now, CanmetENERGY’s Devon Research Centre has been performing experiments in a 1200-L wave tank examining the physical and chemical behaviour of various crude oil/water mixtures under varying temperature regimes. Our research group at INRS has undertaken a long-term collaboration with CanmetENERGY seeking to add biological impact assessments to their physical and chemical behaviour studies. A test initiated in September of 2018 used the diluted bitumen (dilbit) Cold Lake Blend (CLB) with air and water temperatures of 15 °C. Water samples were taken from the wave tank 5 times during the 35-day experiment (times 1, 6, 14, 28, & 35) and were used to perform early life stage exposures using fathead minnows (Pimephales promelas). For each sampling time, newly fertilized embryos were exposed to a serial dilution of the original tank water samples, to non-contaminated river water (used in the tank), and to a reconstituted water control. Embryos were raised until hatching. Embryonic and larval mortality were noted as were hatching time and the incidence and type of malformations, number of heart beats/min, and in vivo EROD activity. Surviving larvae were flash frozen for subsequent gene expression analysis. Preliminary results showed that CLB exposure yielded significant negative impacts on embryonic fish, including increased rate of mortality and malformations, and alterations of the heart beat frequency and EROD activity. The highest mortality rate was found at times 1 and 6, while malformation incidence, heart beat count, and EROD activity were much more affected in the highest CLB concentrations tested for each of the time-points. Real-time RT-PCR analysis of a series of genes related to xenobiotic detoxification and oxidative stress are ongoing. This research project demonstrates the importance of testing inherent toxicity associated with more natural oil weathering conditions as fish embryotoxicity changes with changing oil chemical profiling.

537 The transcriptional responses of Japanese medaka eleutheromembryos to sublethal dibiit exposure
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Diluted bitumen (dibit) produced in Canada’s oil sands region is currently being transported across North America in close proximity to important watersheds and is destined to expand as demand for petroleum products to overseas markets grows. However, only limited characterization of the potential risks to aquatic ecosystems has been performed, despite increases in current volume and frequency of transcontinental movement of dibit. We expand upon our earlier dibit toxicity studies to survey the transcriptomic responses of newly-hatched Japanese medaka (Oryzias latipes) following embryonic exposure to dibit-derived water accommodated fractions at environmentally relevant levels. The central aims of this work were: 1) to pinpoint novel biomarkers of developing fish subjected to sublethal concentrations of dibit and 2) to identify gene networks altered prior to the onset of developmental malformations; including species-specific responses, e.g., abnormal swim bladder inflation. Using a custom-made microarray for medaka, we contrasted the transcriptomic profiles of control-, dispersant- (Corexit®9500A), and dibit- (Cold Lake Blend and Access Western Blend)-exposed medaka. Then, we surveyed mRNA targets demonstrating exposure-related responses with the corresponding developmental malformations observed at hatch. Of these, cytochrome P450 transcripts (e.g., cyp1) in fish from all dibit treatments (malformed, or not) ranked within the top differentially expressed genes as the superlative individual gene biomarker of exposure and toxicity; others included: fibroblast growth factor (fgf7), aryl hydrocarbon receptor (ahr), and AHDR repressor (ahrr), as well as heat shock protein 70kDa (hsp70). Gene set analysis of expression data enriched during the response to dibit exposure included: cell process-, immunological-, and metabolic pathways, lipid metabolism, steroid biosynthesis, and effects on a number of critical growth receptor signaling pathways. Differences were also noted in the response of fish exposed to combined dibit and dispersant treatments from those in the dispersant-only group. Both dibit and dispersant exposure at the embryonic stage appeared to have individual and combinative effects on the transcripts of newly hatched medaka. This is the first study to assess the mRNA responses of developing fish, including species-specific effects, to sublethal dibit exposure in order to establish dibit toxicity profiles derived from transcriptomic responses prior to the manifestation of visible signs of chronic toxicity.
538 Evaluation of the toxicity of diluted bitumen on two Canadian salmonids during their development

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Canada’s crude oil production is growing and requires an increase of transport capacity. Pipeline construction projects are being developed to transport diluted bitumen (dilbit) from Alberta, Canada to the coasts. Dilbits are a mix of bitumen and natural gas condensate, which facilitates transport by reducing bitumen’s viscosity. However, limited information is available on the toxicity of dilbits in freshwater ecosystems. This project aims to evaluate the impact and toxicity of dilbits in two salmonids found in Canadian freshwater ecosystems. Chronic exposures were performed on rainbow trout (Oncorhynchus mykiss) and Atlantic salmon (Salmo salar) at different developmental stages. One dilbit (Clearwater McMurray) and one conventional crude oil (Lloydminster) were tested. Oils were mechanically dispersed to assess the toxicity of their water accommodated fraction (WAF). The toxic components of the oils were analyzed in WAF dilutions (PAHs, VOCs, and BTEX). At exposure completion, mortality, growth, and malformations were assessed. CYP1A activity, an indicator of the detoxification capacity, was quantified along with the expression of its gene. In addition, the quantity of oxidative damage on cellular lipids (malondialdehyde) and the expression of other targeted genes (cat, sod, gst, p53, and XRC) were measured. Preliminary data suggest Clearwater McMurray dilbit to be the most toxic oil to both salmonid species as it yielded higher mortality rates than the conventional oil. CYP1A activity and cyp1a mRNA levels increased in rainbow trout larvae following an exposure from the fertilized egg stage to hatching (exposure duration of approx. 30 days), but CYP1A activity decreased once these exposed fish were returned to clean water until yolk sac resorption (deparation duration of approx. 20 days). Noteworthily, CYP1A activity was not significantly induced when the exposures started after the eyed stage. When comparing salmonid species responses to the dilbit treatment, mortality rates of the two oils were similar for both species, even if chemistry analysis demonstrated a higher level of TPAHs in the WAFs used for the salmon exposure. This research project will help understanding of the impact and toxicity of conventional and unconventional oils on the early life stages of economically important freshwater fish species for Canada.

539 The Freshwater Oil Spill Remediation Study (FOReS): Evaluation of oil spill-related toxicity using an in situ amphibian metamorphosis assay

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There is a major knowledge gap regarding effective remediation strategies for oil spills into freshwater environments. As one component of an oil spill remediation project on the IISD-Experimental Lakes Areas (ELA), we studied the development of local Wood frog (Lithobates sylvaticus) larvae (tadpoles). For the pilot study, experimental oil spills of 1.25 L of weathered diluted bitumen and conventional heavy crude, were applied to shoreline plots (enclosures) (2.5m x 15m) in Lake #260 at the IISD-ELA, resulting in a 0.1cm coating on the water. This was followed by standard clean-up (skimming, slushing, sorbent pads) and natural attenuation. Wood frog egg masses were collected from local wetlands and hatched in the laboratory. At Gosner stage 21-22, the tadpoles were placed into the experimental enclosures. The pilot study included 20 animals per cage, 4 cages (replicates)/enclosure, 4 enclosures (1 dilbit, 1 conventional crude, 2 controls). In year 2, the full study entailed 40 animals per cage, 3 cages (replicates)/enclosure X 18 enclosures. Tadpoles are fed, monitored every other day, and euthanized when >50% reached their metamorphic climax. Gross anatomical examinations are conducted, and samples collected for relevant biochemical, endocrinological and contaminant analyses. In year 1, tadpoles were introduced into enclosures before controlled spills of diluted bitumen or crude oil, which were then treated with physical, chemical and/or biological clean-up methods. Control replicates were carried out in the same lake and shoreline habitats, but had no exposure to the oils treatments. In year two, the acclimated tadpoles are being reintroduced into the enclosures after the controlled oil spills and experimental clean-up methods have been conducted. The pilot study confirmed that tadpoles could survive the oil applications of diluted bitumen and crude oil, continuing to develop through metamorphosis. Major endpoints that will be discussed and compared are: 1) survival, 2) size at- and time to-metamorphosis, 3) body condition (body mass: length), 4) behavioural responses, 5) thyroid hormones levels (biomarkers of endocrine disruptors) 6) triglyceride levels (indicate body energy stores), and 7) tissue metal levels. Developmental and toxicological responses in the frogs allow comparisons that will distinguish the clean-up strategies that best support the restoration of ecosystem function.

Fate and Effects of Metals: Mechanistic Knowledge of Metal Interactions With Aquatic Biota - Part 2

540 Unraveling local pH and metal speciation surrounding single phytoplankton cells: Implication for metal bioavailability

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Over the last 40 years, a general consensus has developed that uptake of trace metals by phytoplankton can be well predicted by metal speciation in ambient bulk water. However, an important but untested assumption of the current paradigm is that local chemical conditions such as pH and metal speciation in the boundary layer surrounding single phytoplankton cells are not distinguished from those in bulk water. A lack of knowledge on local pH and metal speciation in the micro- or nano-space (i.e., phycosphere) represents an impediment to accurately predicting metal bioavailability. Here, a novel zwitterionic label-free pH nanoprobe was developed by crosslinking glucose oxidase and polylysine at the tip of a nanopipette. This pH nanoprobe has a sensitivity greater than 0.01 pH units in the pH range from 6.0 to 9.0, a fast ~2 ms response time, a 50 nm spatial resolution, and a linear pH response in solutions up to 0.7 M ionic strength. The measured local pH in the proximity of single cells of several model phytoplankton species of cell diameter ranging from 5 to 150 um were significantly different from bulk water pH; local pH values were influenced by light intensity, ambient concentration of bicarbonate, and the distance to the cell. With this in mind, we calculated the potential influence of the local pH conditions on the speciation of dissolved essential (Co, Cu, Fe, Mn, Ni and Zn) and non-essential metals (Al, Cd, Hg, Pb, Sc and Sm) within this microenvironment in both marine and fresh waters. We propose that many of the ‘previously unexpected metal uptake’ data purely based upon metal speciation in bulk water can be successfully explained when considering local pH and metal speciation changes in the phycosphere.
541 Effects of sublethal Cd, Zn, and Cd/Zn mixtures on antioxidant defense and oxidative stress in early life stages of the purple sea urchin

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There is growing interest in the toxicity of metal mixtures, but very little information on how individual metals interact mechanistically in causing pathologies at a physiological level. Oxidative stress is now emerging as an important mechanism of metal toxicity, so we examined diagnostic indicators of ROS effects during the first 72 h of embryonic development of a marine model organism, the purple sea urchin Strongylocentrotus purpuratus. Earlier, classical EC50 testing had demonstrated that the toxicities of Cd and Zn were less than additive (i.e. antagonistic) in this system. Embryos were continuously exposed to control conditions, to Cd alone (29 μg/L), to Zn alone (9 μg/L) or to a Cd (29 μg/L) plus Zn (9 μg/L) mixture. These sublethal concentrations represent ~10% of the acute EC50 for each metal. Bioaccumulation, antioxidant capacity against peroxyl radicals (ACAP), total glutathione (GSH), glutathione-S-transferase (GST), glucose-6-phosphate dehydrogenase (G6PDH) superoxide dismutase (SOD) and lipid peroxidation (LPO) were analyzed at 24 h (blastula), 48 h (gastula), and 72 h (pluteus) stages of development. There were no changes in the whole body concentration of Zn (an essential nutrient metal) during the exposures, whereas Zn tended to reduce the marked bioaccumulation of Cd. In control animals, ACAP progressively declined from 24 h to 72 h, while LPO reciprocally increased, but other parameters did not change. Cd alone was more potent than Zn alone as a pro-oxidant, with the major effects being decreases in SOD and parallel increases in LPO throughout development; GST also increased at 24 h. Zn alone caused only biphasic disturbances of ACAP. In all cases, the simultaneous presence of the other metal prevented the effects, and there was no instance where the oxidative stress response in the presence of the Cd/Zn mixture was greater than in the presence of either Cd or Zn alone. Therefore the sublethal effects of joint exposures were always less than additive or even protective, in agreement with classical toxicity data. Furthermore, our results indicate that SOD and Zn can play important roles in protecting sea urchin embryos against Cd-induced lipid peroxidation (IDRC, International Canada Research Chairs Program).

542 Understanding Mechanisms of Bioavailability of Metal Mixture Exposures

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Risk assessments for metal-elevated waters typically use environmental quality standards derived from studies of single metal toxicity thresholds. However, geologic co-occurrence in the feedstocks means that most metal-elevated sites are a mixture of metals at concentrations which individually could cause toxicity. Extensive research into the mechanisms of interactions of trace metals with water chemistry factors (pH, major cations) has contributed to the development of the Biotic Ligand Model (BLM), however little knowledge of interactions amongst co-existing trace metals exists. Here, we aim to gain mechanistic insights into the impact of mixtures on metal-BL binding in aquatic plant, Lemna minor, under alkaline conditions (pH 8.3). Metal accumulation in single metal versus ternary mixture exposures were assessed using saturation binding principles derived from enzyme kinetics. The basis is that a fixed number of BL binding sites exist, which become saturated and can be fitted to a Michaelis-Menten saturation curve. Previous studies have exploited saturation binding to explore metal-BL binding, however, none of these studies consider plants; hence the importance of the present work for ecotoxicological risk assessment of mixtures. Results show that Ni-Cu-Cd compete for uptake into organism, but once inside, their interactions are smaller. Overall, Free Ion Activity Model or BLM alone will not model bioavailability, as the organism plays a role in determining what it is exposed to.

543 Examining the relationship between metal exposure (Cd and Hg), subcellular accumulation, and physiology of juvenile Crassostrea virginica

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Bivalves living in urbanized environments are subjected to a variety of pollutants, including non-essential trace metals [i.e., cadmium (Cd) and mercury (Hg)]. Accumulation of these metals in sensitive subcellular components, such as organelles and enzymes, may impact physiology at the whole-body and subcellular levels. In order to explore the their individual toxicity and associate subcellular partitioning, juvenile eastern oysters, Crassostrea virginica, were exposed to Cd or Hg [Control, Low (1x) and High (4x)] in the laboratory. Physiological endpoints were overall condition, protein content, and aerobic potential (via electron transport system assay). Subcellular fractions included an insoluble fraction (which would contain metal-rich granules), heat-stable proteins (including metallothionein-like proteins), organelles and heat-denatured proteins (including enzymes). Despite the 4-fold increase in metal concentrations, oysters from the High-Cd treatment (2.4μM Cd) attained a body burden that was only 2.4-fold greater than that of the Low-Cd treatment (0.6 μM Cd), while oysters from the High-Hg treatment (0.056μM Hg) accumulated 8.9-fold more Hg than those from the Low-Hg treatment (0.014μM Hg). The fold difference in total Cd burdens was, in general, mirrored at the subcellular level, though binding to heat-denatured proteins in the High-Cd treatment was depressed (only 1.6-fold higher than the Low-Cd treatment). Hg did not appear to appreciably partition to the subcellular fractions examined in this study, with the fold-difference in accumulation between the Low- and High-Hg treatments ranging from 1.5-fold (heat-stable proteins) to 4.6-fold (organelles). Assessment of toxicological endpoints showed that oysters exposed to High-Cd (2.4 mM) had significantly lower condition indices, proteins, and a depressed ETS activity as compared with Control and Low-Cd. Oysters exposed to Hg [Low-Hg or High-Hg] appeared to be unresponsive in terms of condition index, protein content and ETS activity. Differences in how oysters internalized and partitioned these metals, and not overall body burdens, may account for observed differences in toxicity. Additionally, environmentally realistic concentrations, mimicked by the Low-Cd (0.6 mM Cd) and Low-Hg (0.014 mM Hg) treatments, are unlikely to be hamper efforts to restore this ecosystem engineer in urbanized ecosystems (i.e., Hudson Raritan Estuary).

544 Influence of water quality on the acute toxicity of cadmium to the Florida apple snail, Pomacea paludosa

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Cadmium (Cd) is a toxic metal and present in many aquatic ecosystems due to anthropogenic activities. While water quality influence metal toxicity and environmental quality guidelines have taken the influence of water quality, specially dissolved organic carbon (DOC) and pH into account for a number of metals, such as Cu, Zn, Ni, the current guidelines for Cd only consider the effect hardness as a modification factor. This study determines the influence of water quality on the bioavailability and acute toxicity of cadmium to the Florida apple snail (Pomacea paludosa) in support of development of water quality guidelines for tropical environment. 96-h acute toxicity tests were conducted with P. paludosa in waters at various hardness, DOC, and pH. Survival of snails was measured to determine lethal effect concentrations (e.g., NOEC, LOEC, LC5, LC50). Results of the present study show that the toxicity of Cd was strongly
influenced by water quality. The toxicity significantly decreased when water hardness, DOC, and pH were increased. For example, the 96-h LC50 increased from 53 to 108 µg/L Cd when hardness was increased from 45 to 277 mg/L as CaCO3 or the LC50 increased from 35 to 119 µg/L Cd when DOC concentration was increased from 5 to 20 mg/L. The decrease in Cd toxicity with increasing hardness is attributed to the competitive binding between hardness ions (i.e., Ca2+, Mg2+) and Cd2+ to the biotic ligand. The change in toxicity of Cd with DOC was explained well by the results of chemical speciation analysis for Cd in the exposure water. The percentage of Cd that bound to DOC (Cd-DOC), which is believed to be non-bioavailable Cd species increased from 8.2% to 24% while free Cd (toxic species, Cd3+) decreased from 84% to 70% when DOC concentration increased from 5 to 20 mg/L. Results of the present study are useful for development of water quality guidelines for Cd that takes the influence of water quality guidelines into account, especially for tropical aquatic ecosystems, such as the Florida Everglades.

545 Effects of waterborne chromate (Cr6+) on mRNA expression patterns in Lake Trout (Salvelinus namaycush)

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In anticipation of the development of chromite mining in the Ring of Fire in Northern Ontario, we assessed the effects of Cr6+ on the liver transcriptome of Lake Trout which is native to that area. Juvenile lake Trout were exposed in the laboratory to waterborne Cr6+ (0.2 ppb and 3 ppm) for 21-days (n = 6 flow-through tanks of 3 fish per tank); laboratory water was used for the control treatments. The high treatment was for 7-days due to mortality beyond 10-days in a pilot experiment. The liver transcriptomes of 2 fish per tanks were sequenced via a TruSeq/NextSeq workflow and assembled de novo via Trinity. At a false discovery rate (FDR) of 0.01 about 4,600 mRNA transcripts were differentially expressed (DE). The largest response was seen in fish from the 3 ppm Cr6+ treatment: ~2,200 transcripts were DE relative to the control and low dose treatments. In the 0.2 ppb Cr6+ treatment ~1,200 transcripts were DE relative to the control and high dose treatments. In the control treatment ~1,000 transcripts were DE relative to the high and low dose treatments. The DE transcripts were identified, curated, and functionally analyzed by means of Ingenuity Pathway Analysis (IPA). In IPA, we contrasted each Cr6+ treatment against the control fish and against one another. We also contrasted the control fish against DE transcripts that were common to both the low and high concentration treatments. Our results suggest that Cr6+ caused molecular level responses in Lake Trout at an environmentally realistic concentration of 0.2 ppb. Liver Hyperplasia/Hyperproliferation with 908 DE transcripts was significantly enriched in the 0.2 ppb dataset relative to the control fish. The most enriched molecular and cellular functions were Cell Death & Survival and Protein Synthesis with 535 and 245 DE transcripts respectively. We shall also highlight some significant effects on upstream regulators and mechanistic networks to gain insight into the effects of Cr6+ exposure on juvenile Lake Trout.

546 Sub-lethal effects and accumulation of thallium following chronic exposure to model organisms Daphnia magna and rainbow trout

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Thallium (Tl) is a trace element associated with base mining effluents. In Canada, water quality guidelines for Tl exist, but are based on only a few data, most of which are acute in nature. In the current study, chronic waterborne exposures of Tl were conducted using two freshwater model species, the water flea (Daphnia magna) and rainbow trout (Oncorhynchus mykiss). Ecologically-relevant endpoints such as reproduction, growth and survival, were combined with assays examining sub-lethal mechanisms of effect on ionoregulatory enzyme activity and tissue burden, following 21 and 28 day exposures, for Daphnia and rainbow trout, respectively. Whole animal or tissue Tl burdens were also measured to establish relationships between exposure concentration, bioavailability and toxicity. Exposure of Daphnia to Tl (8ug L−1) resulted in inhibited growth, impaired reproduction and delayed time to first brood. In rainbow trout, Tl (170ug L−1) inhibited ionoregulatory enzyme activity, possibly a consequence of Tl mimicry of monovalent cations such as potassium. These effects were correlated with Tl tissue burden. Our findings show that chronic exposure to Tl can cause impairments to ecologically-relevant endpoints, albeit at concentrations at the high end of the environmental range.

547 Tissue Metal Concentrations and Anti-oxidant Enzyme Activity in Sharks

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Metals occur naturally in the environment; however, anthropogenic practices have resulted in increased metal concentrations in coastal ecosystems. Sharks are important species, ecologically, recreationally and commercially. Reference levels of metal contaminants in the tissues of sharks, particularly, great whites, is lacking. In this study, concentrations of copper (Cu), cadmium (Cd), nickel (Ni), lead (Pb), selenium (Se), silver (Ag), and zinc (Zn) were measured in the muscle tissue of various shark species including Atlantic sharpnose shark collected from 12 sites along the coast of the southeastern United States, and in great white and tiger sharks, in collaboration with OCEARCH. Metal exposure in various species has been correlated with oxidative stress. Therefore, activities of antioxidant enzymes (superoxide dismutase, catalase, and glutathione peroxidase) were also examined in the shark muscle tissue with the objective of identifying a nonlethal bioindicator of metal pollution. This study provides reference levels of metal contaminants in the muscle tissue of several shark species and provides insight into oxidative stress defenses in these top-level carnivores.

Behavioral Ecotoxicology in the Lab and Beyond: Incorporating Environmental Complexity and Relevance

548 Chronic Exposure to Dietary Selenomethionine Disrupts Social Learning and Serotonergic Neurotransmission in Zebrafish

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Selenium (Se) is an essential element that has vital physiological functions as well as toxicological properties at elevated concentrations. Although the adverse neuro-behavioural effects of Se have been previously investigated in fish, very little is known about its effects on social learning behaviour in fish. In this study, we investigated the effects of environmentally relevant concentrations of Se on social learning and serotonergic neurotransmission in zebrafish. To this end, we examined whether exposure to different concentrations of dietary selenomethionine (control, 3.2, 12.6, 34.5 µg Se/g dry weight) for 90 days affected the ability of the individual observer fish to follow the demonstrator (experienced) fish escaping an oncoming trawl. Training of naive fish in this social learning paradigm occurred for 5 consecutive days in the presence of experienced demonstrator fish. Subsequently, during probing, the social learning performance of test fish was assessed in the absence of the demonstrator fish. Our results indicated that while 90% of the fish in the control and lower Se-exposure groups (3.2 and 12.6 µg/g) demonstrated a faster escape response by choosing the trained (correct) route, fish in the
highest Se-exposure group (34.5 µg/g) displayed a significantly slower escape response and only 60% of them used the trained route. In order to understand the potential mechanisms underlying these behavioural effects, oxidative stress, a key driver of Se neurotoxicity, was evaluated by measuring the lipid peroxidation (LPO) and the expression of several antioxidant enzymes genes in the zebrafish brain. In addition, since the serotoninergic neurotransmission system is known to be a key regulator of social behaviour in fish, we also evaluated the brain serotonin levels and the expression of several serotoninergic genes. Our results suggested that exposure to Se (34.5 µg/g) caused a higher LPO level and upregulation of antioxidant genes in the zebrafish brain. Moreover, high Se exposure was also found to disrupt the gene expression of serotonin receptors (htr1a, htr1b, and htr1ab), transporter (slc6a4a), synthesis (tryptophan hydroxylase-2), and degradation (monoamine oxidase) in the zebrafish brain. Overall, our study suggests that chronic Se exposure disrupts social learning in zebrafish, likely via the disruption of serotoninergic neurotransmission in the brain.

549 Hidden in the sand: Modification of burying behaviour in shore crabs and cuttlefish by antidepressant exposure

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Pharmaceuticals, such as antidepressants are constantly released into the aquatic environment. Consequently, fluoxetine (FLX) and venlafaxine (VEN), the active molecules of Prozac(C) and Effexor(C), are detected up to several ng/L in freshwater and marine coastal waters. Both compounds act on the serotoninergic system, which may result in behavioural impairment, especially of juvenile animals presumed to be more susceptible to low concentrations. The objective of this study was to determine if environmental concentrations of FLX alone or combined with VEN could have any effect on innate burying behaviour in two juvenile marine invertebrates, i.e., Sepia officinalis and Carcinus maenas. Juvenile cuttlefish were exposed from hatching to 30 days post hatch to either FLX alone (i.e. 5 ng/L) or in mixture with VEN (i.e. 2.5 ng/L as well as 5 ng/L of each antidepressant). Juvenile crabs (< 2 cm carapace width) were exposed for a period of 34 days to 5 ng/L of FLX and a mixture of 5 ng/L of FLX and VEN each. Several parameters of sand digging behaviour were assessed weekly in both species. The occurrence of sand digging behaviour decreased in cuttlefish exposed to a mixture of FLX and VEN at the lowest concentration (2.5 ng/L each). At the mixture of 5 ng/L VEN and FLX each, a better body covering in juvenile crabs was observed. In both species, innate behaviour was modified under exposure to mixtures of FLX and VEN at environmentally realistic concentrations. These alterations were observed at an early developmental stage, when animals are particularly prone to predation. Hence, the modification of behavioural traits by exposure to pseudo-persistant antidepressants may decrease the survival of these two species in the long term.

550 Summer vs. Winter: How do fish respond physiologically and behaviourally to wastewater exposure under two seasonal regimes?

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Municipal wastewater treatment plant (WWTP) effluents are one of the largest (by volume) anthropogenic sources of aquatic pollution in Canada. Conventional WWTPs are not capable of fully removing particular water-borne contaminants, such as many pharmaceuticals and personal care products. As a result, WWTP outfalls often become major point sources of contaminants into effluent-receiving watersheds. Wastewater can impact fish and other aquatic organisms on multiple levels of biological organization, including but not limited to endocrine disruption, metabolic and behavioural dysfunction, as well as population- and community-level disturbances. However, much of the research conducted to date has not considered the effects of seasonal variation on fishes’ responses to wastewater contamination despite how relevant and overwhelming its effects can be. Our research aimed to address this issue by conducting a laboratory-based experiment, where fathead minnow (Pimephales promelas) were chronically exposed for 21 days to 0%, 25%, and 50% concentrations of wastewater under two thermal regimes (summer: 20°C; winter: 4°C). Various fitness-linked behavioural traits were examined following the exposures, including boldness, locomotor activity, sociability, foraging, and predator responses. We also assessed various whole-organism physiological traits that are strongly linked to our behavioural markers such as resting and maximal metabolic rates, aerobic scope, and critical thermal maximum. We examined behavioural and physiological impacts of wastewater exposure in tandem to gain a more holistic and ecologically-relevant understanding of how aquatic organisms respond to anthropogenically-induced stressors across different seasons. Our research will be able to further bridge the gap between controlled lab experiments and highly dynamic real-world field-based studies.

551 Behavioral consequences of per- and poly-fluorinated alkyl substances (PFAS) for crayfish species located at contaminated field sites

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The necessity for bioindicator species to aid in the assessment of impacts on aquatic ecosystems is currently rising due to the continued anthropogenic degradation of environments. Several characteristics of crayfish make them suitable candidates for use as bioindicators: global distribution, high population densities, low migratory rate, sensitive physiology and behaviors, and easy maintenance within laboratory environments. The demonstrated sensitivity of crayfish as an established bioindicator for an array of anthropogenic toxicants, raises interest in the sensitivity of crayfish to use as a bioindicator for emerging contaminants. The emergent contaminant family, per- and poly-fluorinated alkyl substances (PFAS) such as perfluorooctyl sulfonate (PFOS) and perfluorooctanoic acid (PFOA), have gained particular research attention due their widespread detection and stability within the environment. Previous research has demonstrated exposure to PFAS causes negative effects on the reproductive, endocrine, immune and nervous systems of experimental organisms, however, behavioral effects have not been well documented. The aim of this study was to investigate the behavioral consequences of PFAS exposure on crayfish species and the utility of these organisms as a bioindicator model for PFAS contamination. Differences in the escape response of crayfish from the predatory odor of Micropterus salmoides and in plant consumption were compared between animals collected from various polluted locations in Northern Michigan. Water chemistry sampling in Northern Michigan environments performed by Tip of Mitt Watershed Council (Petoskey, Michigan) and University Michigan Biological Station Analytical Laboratory (Pellston, Michigan) provided verification of PFAS concentrations at crayfish sampling sites to determine the relationship between behavioral deficits and toxicant concentration. Behavioral responses were analyzed and resulted in differences in two ecologically relevant bioassays. Due to the prevalence and known uptake of perfluorinated compounds by aquatic organisms, a suitable bioindicator species and further study on important fitness related behaviors that may be affected by PFAS are critical.

552 Altered reproductive behaviour by male fathead minnows during a whole ecosystem EDC exposure study

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Male fathead minnows (Pimephales promelas) provide extensive parental care, and have become a model species for understanding the impacts of estrogentic compounds. Reduced nesting aggression is a common
behavioural expression of estrogen exposure for male fish in laboratory studies. However, the existence and potential repercussions of altered reproductive behaviour in the wild are unknown. We quantified the reproductive behaviour of male fathead minnows from in-lake video recordings taken before, during and after a synthetic estrogen used in birth control pills (ethynylestradiol, EE2) was added to Lake 260 at the Experimental Lakes Area. Male fatheads exposed to EE2 showed marked reductions in secondary sexual characteristics compared to males from reference lakes. Exposed males reduced time spent tending to eggs as a direct result of increasing frequency of aggressive encounters in response to greater numbers of fish surrounding the nests. These nest intruders were likely feminized male fathead minnows. Thus, the few fathead males that were able to breed during the exposure period faced increasing nest threats from conspecifics that reduced their ability to defend egg clutches and resulted in significantly fewer eggs per nest compared to pre-exposure. Observations of heightened aggression by EE2-exposed spawning male fish run counter to many previous studies. Our study highlights the complex ecological and behavioural interactions that occur in natural systems and further demonstrates the need for studies conducted at the scale of a whole ecosystem.

553 Effects of contaminants across ecosystem boundaries: a conceptual note
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It is common knowledge that freshwater ecosystems are under substantial anthropogenic pressure. Contamination by organic and inorganic substances of anthropogenic origin via point and non-point sources is one of the most important factors worldwide. This fact has attracted substantial attention by researchers that are interested in the impact of chemicals at different levels of biological organization - from biomarkers to populations and even ecosystems. However, relatively little information is available on how the chemical contamination of aquatic ecosystems impacts their subsidy of adjacent terrestrial (riparian) food webs, which might either be bottom-up or top-down directed. The scarcity of data might mainly be driven by the complexity of experimental designs required to test for related hypotheses. This presentation will discuss experimental designs that support the development of this emerging field of research. We argue that experimental systems that are specifically designed (i.e., contain both an aquatic and a terrestrial model ecosystem) to assess for the aquatic subsidy of terrestrial systems will be fundamental to advance knowledge. Moreover, in addition to assessing the quantitative impact of contamination on the subsidy also qualitative measures need to be involved. In this context, stable isotope analysis and methods describing the energetic and nutritious conditions of prey and predators from aquatic and riparian systems, respectively, are imperative. The complexity of aspects associated with the stress-induced implication on the subsidy of terrestrial systems by aquatic resources opens doors for interdisciplinary collaborations of ecology and ecotoxicology.

554 Behavioural and ecological responses to chemical pollution
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Humans have brought about unprecedented changes to environments worldwide. For many species, behavioural adjustments represent the first response to altered conditions. Such behavioural modifications can potentially improve an organism’s prospects of surviving and reproducing in a rapidly changing world. However, not all behavioural responses are beneficial. Human-altered conditions, including the discharge of anthropogenic chemicals into the environment, can undermine the reliability of sexual signals used by animals to assess potential suitors. Environmental pollutants can also impair sensory systems or interfere with physiological processes needed to mount an appropriate behavioural response. An understanding of behaviour could therefore be important in helping to explain why some species are able to survive, or even flourish, under human altered conditions, while others flounder.

Concentrations and Thresholds for Effects of Current Use Pesticides in Aquatic and Terrestrial Ecosystems - Part 2

555 An Integrative Analysis of the Effects of Neonicotinoids on the Ruby-throated Hummingbird, Archilochus colubris
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Neonicotinoids are the most widely used class of insecticides globally, due to their high efficacy and apparent target specificity. Although exposure is known to occur in a variety of non-target organisms, effects on these systems are largely unquantified. This is especially concerning for hummingbirds, which experience exposure through the floral nectar that supports their extreme metabolisms. To respond to this concern, we measured the sublethal cellular, physiological, and behavioral effects of imidacloprid, a common neonicotinoid, on ruby-throated hummingbirds (Archilochus colubris). Birds were exposed to one of three field-realistic dosing conditions (control, 0.172 mg/kg, and 2.5 mg/kg) once per day for three days prior to terminal sampling. Cholinesterase activity assays showed significant dose-dependent neurotoxic effects of imidacloprid exposure in hummingbirds. Similarly, birds’ metabolic rates (VO2) showed significant dose-dependent decreases within 2 hours after dosage. Metabolic rates did not differ between control and dosed birds 24 hours after exposure demonstrating an acute effect on activity immediately after exposure. Measurements of thermal and metabolic responses provided insight into how imidacloprid exposure affects daily energy budgets. No emergent trends arose between torpor propensity and exposure to the pesticide from preliminary data analyses, though body mass did show a significant decreasing trend in both dosage conditions. Oxidative damage biomarkers were quantified to elucidate the non-specific effects of detoxification in liver and muscle tissues. The stress-induced suppression of the humoral immune response to imidacloprid was determined through relative heterophile to lymphocyte ratios. Additionally, feeder tracking ability was tested after dosage, while hovering, preening, and feeding behaviours were indexed to evaluate how toxic effects may be expressed on a whole-organism level. This novel integrative study highlights the deleterious off-target effects of one of the most widely used agrochemical in Canada. Researching these effects is critical in the prevention and remediation of the consequences that arise from anthropogenic activities on ecosystems near and within agriculture.

556 Toxicity of agrochemicals detected on wildflowers to larval Painted Lady Butterflies (Vanessa cardui)
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Beef cattle feed yards and row crop agriculture are the predominant sources of agrochemical usage in the Southern High Plains (SHP) of the United States. Beef cattle feed yards use large quantities of insecticides to control insect pests, and veterinary pharmaceuticals to promote cattle growth and health. To increase yields, row crop-based agriculture relies heavily upon herbicides, fungicides, and insecticides. Previous studies have documented occurrence of agrochemicals and agrichemical mixtures beyond feed yard and row crop agriculture boundaries in uncultivated, marginal areas, raising concern that migratory pollinators and pollinators...
indigenous to the SHP may become exposed to toxic agrochemicals. Painted lady butterfly (Vanessa cardui) larvae were used to investigate potential toxicity of agrochemicals quantified on wildflowers among pollinators. Moxidectin, an anti-parasiticide used on beef cattle feed yards, was determined to be extremely toxic to V. cardui larvae, with a lethal dose at which 50% of larvae died (LD₅₀) of 2.1 ± 0.1 ng/g. Additional agrochemicals, more commonly used in row crop agriculture (pyraclostrobin, clothianidin, and permethrin) delayed V. cardui development from larvae to butterfly. However, moxidectin was the only chemical that produced significant toxic effects at environmentally relevant concentrations. These results indicate that agrochemicals originating from feed yards have the potential to adversely impact development of pollinator larvae occurring in the SHP.

557 Effects of bifenthrin on the dopaminergic pathway in juvenile steelhead (Oncorhynchus mykiss)

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An increase in urban application of pyrethroids in the San Francisco Bay Estuary and Sacramento San Joaquin Delta have raised concern for salmonid populations, as several species have been classified as threatened. Bifenthrin, a type I pyrethroid, is one of the most predominant pyrethroids measured in the Bay-Delta watershed. Previous studies have shown that bifenthrin disrupts the hypothalamic-pituitary-gonadal (HPG) axis, inhibiting gonadal development and inducing estrogenic effects in juvenile salmonid species, such as steelhead. To further understand the mechanism of bifenthrin-induced toxicity to the dopaminergic system, juvenile steelhead were exposed to environmentally relevant concentrations of bifenthrin found before and after major rainfall events (60 and 120 ng/L, respectively) and assessed for the dysregulation of genes involved in the regulation of dopamine levels in the brain, catechol O-methyltransferase (COMT) and monoamine oxidase (MAO). We found that COMT and MAO expression were significantly upregulated in bifenthrin-exposed fish. Metabolomic analyses were conducted on fish brains to further understand the underlying mechanisms of toxicity to the dopaminergic system. The goal of the present study is to better understand the toxicity of bifenthrin to the dopaminergic system in fish. This research was made possible by a Proposition 1 grant from the California Department of Fish and Wildlife.

558 An investigation of the effects of Dicamba exposure on zebrafish (Danio rerio) and rainbow trout (Oncorhynchus mykiss)

J.G. Miller, University of Lethbridge / Biology; E. Vandenberg, University of Lethbridge / Biological Sciences; S. Wiseman, University of Lethbridge / Biology

Dicamba (3,6-dichloro-2-methoxybenzoic acid) is an herbicide used in industrial, domestic, and municipal applications to control woody plants and broadleaf weeds. Currently, dicamba is the second most used benzoic acid herbicide in Canadian agriculture. Because of its widespread use, dicamba is frequently detected in surface waters. In Alberta, dicamba has been found at concentrations of 0.3µg/L in irrigation canals and 2.6µg/L in storm water ponds. However, little is known regarding the effects of dicamba on freshwater aquatic vertebrates. To this end, the toxicological effects of environmental and supra-environmental concentrations of dicamba were investigated in primary cultures of rainbow trout (Oncorhynchus mykiss) hepatocytes and in early-life stages of zebrafish (Danio rerio). Hepatocytes were exposed for 48h to 22.0, 2.20, or 0.22 µg/L dicamba and zebrafish were exposed < 1h post-fertilization until hatch to 50.0, 5.0, or 0.50 µg/L dicamba. The mRNA abundances of biomarkers related to the cellular response to oxidative stress (catalase, superoxide dismutase, glutathione-s-transferase, and glutathione peroxidase) were quantified. Exposure to dicamba did not alter the mRNA abundance of biomarkers of the cellular response to oxidative stress in either species. Also, dicamba did not cause lethality or developmental malformations (edema, spinal curvature) in embryos of zebrafish. However, exposure to Dicamba did elicit an increase in concentrations of s-adenosyl methionine (SAM) in both rainbow trout hepatocytes and zebrafish larvae at 2.20 and 5.0 µg/L, respectively. S-adenosyl methionine is a critical regulator of the cellular methyl pool, and contributes methyl groups important for methylation of DNA, biotransformation of exogenous and endogenous chemicals, and the response to oxidative stress. Neither DNA methylation or expression of DNA methyltransferase enzymes were impacted in zebrafish embryos exposed to dicamba. The role of SAM in the adaptive or maladaptive responses to dicamba are being further investigated in zebrafish. Our data suggests that current environmental concentrations of dicamba do not pose a risk to freshwater fish.

559 Exposure and risk characterization of micropollutants in small streams: agricultural pesticides versus wastewater compounds

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Both agricultural pesticide use and wastewater inputs might contribute to the micropolllutants burden of small and medium-sized streams in rural catchments. Several studies have shown that pesticide exposure is particularly high during discharge events. We present results from a nationwide survey for the monitoring of small streams (KgM, https://www.ufz.de/kgm/index.php?en=44480). At 69 sites from all over Germany, grab water samples were taken at base flow conditions in regular intervals and heavy rain-event triggered composite samples were collected using an automated sampler. In all samples, 385 compounds representative for agricultural use and municipal wastewater were analysed by direct injection LC-HRMS for a wide-scope target screening and quantified using a semi-automated software processing. Currently, the spectrum of analysed compounds is expanded towards 1000 potentially relevant chemicals from agricultural and urban sources. Overall, the samples showed a high spatial and temporal variation of micropollutant concentrations. More than 300 out of the 385 compounds were found in at least one sample. In the majority of the grab samples less than 25 compounds were detected, in contrast to more than 50 in two thirds of the event samples. Agricultural pesticides (majorly herbicides such as metamitron and ethofumesate) and wastewater derived compounds (such as caffeine, artificial sweeteners or the pharmaceutical metformin) were found in high concentration in both types of samples. The maximum concentrations in event samples were in general higher (up to three orders of magnitude) than in grab samples for both pesticides and wastewater-derived compounds. Current investigations aim to assess the acute toxic risk for benthic crustaceans, algae and fish to compare the impact of agricultural pesticides versus that of wastewater-derived pollutants. To this end, using a toxic unit (TU) approach based on EC50 or LC50 values from the literature or from QSAR predictions is used.
560 Current-Use Pesticides in Sediment and Biofilm “Integrative
Samplers” in Coastal California Streams and Relations to Aquatic
Invertebrate Health

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In spring 2017, the U.S. Geological Survey (USGS) Regional Stream
Quality Assessment (RSQA) measured current-use and selected legacy
pesticides in biofilm and bed sediment from 54 small streams in Coastal
California in a range of land-use settings. One objective of the study
was to evaluate samples of biofilm colonized on deployed tiles as an
alternative to bed-sediment samples for time-integrated assessment of
current-use pesticides. Of the 96 pesticides analyzed, 25 were detected
in at least one bed sediment sample and 34 were detected in at least one
biofilm sample; the maximum number of pesticides detected at a site was
22 (in biofilm, 2 sites). Seven compounds were detected in both media at
more than 10% of sites: the legacy pesticide DDT and its degradates DDE
and DDD; the herbicides pendimethalin, oxadiazon, and oxyfluorfen; and
the pyrethroid insecticide bifenthrin. On the basis of the pesticide toxicity
index for pesticide mixtures in sediment (Sed-PTI), which sums Likely-
Effect-Benchmark Quotients for individual pesticides in the mixture,
there was potential acute toxicity to aquatic invertebrates from pesticide
mixtures in sediment (Sed-PTI=1.0) at 4 of the 52 sites. An additional 15
sites had Sed-PTI values >0.1 and <1.0. The pesticides with the largest
contribution to a Sed-PTI=0.1 were bifenthrin (12 sites), esfenvalerate (3
sites), boscalid (3 sites), and cyhalothrin (1 site). There were non-linear
relations between field-based metrics for aquatic invertebrate commu-
nity health and concentrations of boscalid, bifenthrin, and oxyfluorfen in
sediment, biofilm, or both. In general, more pesticides were detected in
biofilm than sediment at a site (63% of sites), but the difference in number
was small (medians of 4 and 3 pesticides in biofilm and sediment, respec-
tively). Each medium has advantages and disadvantages relative to the
other, but the time-integrated view of current-use pesticide occurrence in
Coastal California bed sediment was generally consistent in bed-sediment
samples and biofilm samples.

561 Sediment chemistry, sediment toxicity and aquatic communities
across an urban gradient of streams in the Northeast United States

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Stream sediment contaminants are infrequently measured on broad geo-
graphic scales. As part of the US Geological Survey’s (USGS) National
Water-Quality Assessment (NAWQA) project, sediment samples were
collected from streams representing an urban gradient in the Northeast
United States; including the states of CT, MA, NH, NJ, NY, PA, RI, VT.
The study evaluated relations between sediment chemistry (metals,
pesticides, organochlorines, and polycyclic aromatic hydrocarbons),
sediment toxicity and macroinvertebrate communities across 92 sites.
Sediment toxicity was evaluated by conducting whole-sediment labora-
tory toxicity testing with the amphipod Hyalella azteca (28-d exposure)
and the midge Chironomus dilutus (10-d exposure) following ASTM
and USEPA methods. Organochlorines were the class of contaminants
most commonly measured in stream sediments; with chlordanes and
total PCBs measured at 82% of sites, dieldrin 73%, and DDXs 69%.
Of the current use pesticides, bifenthrin was measured at 71% of sites,
fipronil sulfide 49%, and chlorpyrifos 44%. However, the contami-
nants most likely to exceed their sediment benchmark for “likely” or
“probable” invertebrate effects was bifenthrin, 29% of measured sites,
followed by total chlordanes [as the sum of 5 congeners] 2% and fipronil
sulfide 2%; on an organic carbon normalized basis. Roughly half (49%)
of sites had statistically significant reduced survival or biomass in the
H. azteca or C. dilutus toxicity tests. Total PAHs (TPAHs) in sedi-
ments were the best single predictor of H. azteca survival (adj r²=0.34)
and biomass (adj r²=0.26). Stepwise regression models with up to four
contaminant classes gave minor improvements in the total variance
explained; H. azteca survival (TPAHs >bifenthrin >total chlordanes
>metals- adj.r²=0.44) and for H. azteca biomass (TPAHs >total chlordanes
>bifenthrin >metals- adj.r²=0.32). C. dilutus survival was poorly
predicted by any contaminant class and C. dilutus biomass was best
explained by metals (adj. r²=0.21), with minor improvements when total
chlordanes or bifenthrin were included. These same contaminants were
generally inversely related to common macroinvertebrate metrics (ie.
Ephemeroptera, Plecoptera, Ephemeroptera, Intolerant taxa), through
the upper 70th to 90th quantiles from quantile regression. These results,
and their relation to macroinvertebrate communities, will be discussed
in relation to parallel datasets in other regions of the U.S.

562 Evaluating Soil & Water Assessment Tool (SWAT) Capability to
Simulate Glyphosate Transport on a Watershed Scale

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Glyphosate (N-phosphonomethyl glycine) is an herbicide that is heavily
used in agricultural industries worldwide. Few reports have quantified
human exposure to glyphosate in rural communities, and concentrations
are not currently monitored in most areas. With growing concern for the
health effects of chronic glyphosate exposure, it is critical to understand
glyphosate transport to make informed watershed management decisions.
This presentation will present glyphosate monitoring data from rudimen-
tary water treatments systems in villages in Belize. Many rudimentary
systems rely on surface water, and may be exposing villagers to water
contaminated with glyphosate. Therefore, water and sediment samples
were collected from sites of rudimentary water treatment systems within
subcatchments where glyphosate is routinely applied. The entire water-
shed was simulated using a hydrological transport model called the Soil
and Water Assessment Tool (SWAT), and simulated concentrations were
compared to observed concentrations to evaluate model capability. A
parameter sensitivity analysis was conducted to identify the factors that
glyphosate transport is most sensitive to, and therefore how to best man-
age it within the watershed. While analyses of results are still underway,
literature has shown concentrations are typically higher with precipitation
events causing increased runoff and soil erosion, and typically higher in
sediment than in the water column. Because glyphosate is applied year-
round in this region and samples were collected during the rainy season,
glyphosate presence in surface water and sediment is expected during
the time of sampling. Other studies have demonstrated the capability of
SWAT to model complex transport and degradation processes to predict
concentrations of various pesticides, so it is expected to be capable of
modeling glyphosate. This research seeks to advance knowledge of
glyphosate transport in the environment and presents a method for simu-
lating it for the purpose of watershed management.

Advances in Passive Sampling Across Environmental
Compartments - Part 2

563 Evaluation of POM air-sampler in assessing atmospheric hydro-
phobic organic contaminants at a confined disposal facility

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Price, D. Acevedo-Mackey, L. Thai, US Army Engineer Research and
Development Center

Volatile losses of hydrophobic organic contaminants (HOCs) such as
PCBs and PAHs from confined disposal facilities (CDFs) during place-
ment and disposal of contaminated sediments is of substantial concern
to surrounding communities. Conventional high-volume air samplers
(HVAS), are expensive to maintain and analyze, do not directly capture
long-term average concentrations of HOCs and suffer from interferences
from particle related sources not associated with local evaporation from the CDF. To overcome these problems, a passive sampling approach was developed using polyoxymethylene (POM) to absorb and quantify PAHs and PCBs in the atmosphere. Laboratory experimentation conducted by exposing POM air sampler (PAS) over a sediment slurry, showed a consistent uptake of HOCs on POM with measured $K_{\text{POM-AIR}}$ that was approximately given by the theoretical relationship of the POM-water partition coefficient and the Henry’s constant ($K_{\text{POM-w/Raw}}$). The time required for equilibration of the POM with air varied by the hydrophobicity of the compound of interest but averaged approximately 28 days for the mid-range PCBs and PAHs expected to be important in air (relative to the more hydrophobic air contaminants). Field sampling at 10 stations surrounding the CDF was conducted three times (two fall/winter and one summer) over two years. The highest concentrations ($\Sigma\text{PCB} \sim 23 \text{ ng/m}^3$) occurred during summer dredged material placement when the ambient temperature was 20-25 C. Partitioning to the POM during the fall/winter periods (temperature averaged 3-5 C) were corrected for temperature effects which may increase uncertainty in the measured concentration. ($\Sigma\text{PCB}$ ranged from 0.3 to 7 ng/m$^3$) and $\Sigma\text{PAH}$ from 3.5 to 45 ng/m$^3$ during the two winter seasons. The POM measured air concentrations were lower than measured by HVAS during the first winter sampling period which is expected due to particulate bound contaminants in the HVAS samples. PAHs, in particular, are likely dominated by particle related sources other than evaporation from the CDF and showed HVAS concentrations approximately 10 times higher than the POM.

564 A wearable polydimethylsiloxane-based passive air pollutant sampling device: Development of calibration constants

E.Z. Liu, J. Koelmel, Yale University / Environmental Health Sciences; S. Seethapathy, Thermo Fisher Scientific / GC Applications; K. Pollitt, Yale University / Environmental Health Sciences

Evaluation of cumulative exposure to air pollutant mixtures has been challenging by traditional measurement techniques to the weight, limited battery life and cost of these monitoring devices. Wearable passive air pollutant monitors have emerged as a tool for assessing personal exposure to environmental chemicals. These monitors concentrate airborne pollutants onto a substrate which can subsequently be analysed off-line for a broad range of compounds using mass spectrometry (MS). Longitudinal exposure assessment in vulnerable populations is facilitated by the lightweight, wearable form factor of these monitors. The low cost of this sampling technique further enables deployment across large populations, increasing the quantity of environmental data available for evaluating environmental risk factors for disease. We have applied a polydimethylsiloxane (PDMS) sorptive extraction technique to passively concentrate non-polar airborne compounds. Glass rods are coated with a thin PDMS film and mounted into a wristband (the Fresh Air Wristband). The wristband is worn by an individual for several hours to days depending on ambient levels. Sample analysis is performed using thermal desorption gas chromatography high resolution MS (Thermo GC Q-Exactive). Using this sampling device, time-weighted personal exposure concentrations are evaluated for a broad range of semi-volatile organic compounds, including PAHs, PCBs, and PBDEs. Calibration constants for a selection of analytes from these chemical groups were estimated from linear temperature programmed retention indices measured using a pure PDMS stationary phase GC column. This calibration approach facilitated quantification of analytes identified through nontargeted analysis. We have used the Fresh Air wristband for personal exposure assessment in several large epidemiologic studies based in the U.S., Canada, South Africa, and China. These deployments have enabled characterisation of unique exposure profiles which is a novel advancement towards identifying disease risk factors.

565 Effect of Environmental Factors on the Performance of Polyurethane Foam Sampling Column of Flow-through Atmospheric Sampler

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Flow-through sampler (FTS) is a novel energy-saving atmospheric sampling technology developed in recent years, which using wind energy to carry POPs through the polyurethane foam (PUF) sampling column and quantitatively absorb the target compounds. Its sampling mechanism is similar to active sampling, so the environmental factors such as temperature and wind speed have significant impacts on its sampling efficiency. In order to improve the accuracy of atmospheric sampling and quantitatively describe the environmental behavior of POPs, the adsorption properties of various compounds on the FTS sampling column under different environmental conditions were investigated. An orthogonal test design was adopted, which use active sampling pumps with different flow rates connected with an FTS sampling column to control the wind speed to sample in different seasons (at different temperature) with different sampling volumes (controlling through sampling time). Frontal chromatography theory and multi-parameter linear solvation energy relationship (LSER) was applied to analyze the breakthrough profile of each chemical on the FTS column. The quantitative correlations between the theoretical plate number and the break-through volume of the compound under different wind speed and temperature were established. These relationships were further used to develop simplified methods to estimate the loss rate for each target compound during the sampling process. The estimated loss rates were comparable with experimental values, which are obtained by integral of the breakthrough profile for each compound. It shows that the simplified formulas obtained in this study can accurately estimate the loss rate of the compound within the experimental temperature and wind speed range. For chemicals with serious breakthrough, the few PUF discs in front of the FTS sampling column can be treated as equilibrium state passive air samples. The temperature dependence of the partitioning of POPs between PUF media and air were also discussed.

566 Integrating air-, water- and porewater-phase passive sampling data for quantifying transport of polychlorinated biphenyls (PCBs) in an urban watershed

M. Bokare, N. Lombard, S. Magee, University of Maryland, Baltimore County / Department of Chemical, Biochemical and Environmental Engineering; T. Wilson, US Geological Survey; U. Ghosh, University of Maryland, Baltimore County / Chemical, Biochemical, and Environmental Engineering

Persistent organic pollutants such as polychlorinated biphenyls (PCBs) are responsible for impairment of several waterways in the Chesapeake Bay, such as the Anacostia River in District of Columbia (D.C). Previous quantitative assessments of PCB sources in this watershed are based on the Total Maximum Daily Loads (TMDL) approach, which does not account for differences in bioavailability of particulate-bound and dissolved PCBs, while also lacking quantification of diffusive exchange of PCBs across the air-water and sediment-water interfaces. These TMDLs are also limited by the difficulties in accurately measuring the low dissolved PCB concentrations in surface water and porewater, which govern the diffusive exchange of PCBs. To improve the quantitative assessment of PCB transport in this watershed, low density polyethylene passive samplers were used to measure the dissolved PCB concentrations in the surface water and sediment porewaters of the Anacostia River. Additionally, gas-phase PCB concentrations in the watershed were also measured using passive samplers. Results from our study showed that the atmosphere served as a sink for PCBs in the water column, while flux of PCBs from sediment hot-spots into surface water was nearly balanced by flux of PCBs from surface water into cleaner sediments. PCB measurements from passive samplers deployed in several major tributaries of the Anacostia River were integrated with suspended sediment sampling data from United...
States Geological Survey (USGS) to provide an improved assessment of PCB loads from these tributaries, with particular focus on the dissolved PCBs and the variation in their concentrations and loads across base and storm-flow conditions. Results from multiple sampling periods were used to evaluate seasonal variations in pollutant loads and air-water exchange of PCBs. By using passive samplers to accurately measure dissolved and gas-phase PCB concentrations which govern fate, transport, and bioaccumulation, the study aims to provide an improved TMDL framework that accounts for the significantly higher impact from dissolved PCBs.

567 Peeping at Background - Porewater Passive Sampling to Quantify Naturally Occurring Metals in Anoxic Sediment


In many areas of the Willamette Basin, elevated concentrations of naturally occurring metals such as arsenic and manganese are present and may occur in anoxic zones of sediment porewater where lower redox conditions promote solubility. As a result, there is a need to identify the influence of anoxic sediments to the porewater concentrations of metal/metalloids at the Portland Harbor Superfund Site, Portland, Oregon, to refine the conceptual site model and understanding of background conditions. Measure anoxic porewater presents a challenge since common sediment porewater sampling methods disturb the sediments, exposing them to oxygen, which provides an unrepresentative chemical characterization. Passive sampling resolves these issues by allowing the porewater to chemically equilibrate with a volume of water through a semi-permeable membrane providing little sediment disturbance and isolation from oxygen during retrieval. Additional refinement of the sampling design, such as a reverse tracer, diver-less camera deployment, and careful monitoring of ammonia and sulfides, allowed for robust data collection by eliminating some of the uncertainty associated with passive sampling. This presentation will discuss the implementation of passive porewater sampling in conjunction with innovative methods during the Portland Harbor Pre-remedial design investigation with a focus on the steps taken to demonstrate the reliability of the results to stakeholders.

568 Peepers for Sediment Porewater: Doing it Right and Doing it Better

J. Roberts, M. Healey, S. Sande, SIREM; M. Vanderkooy, J.M. Conder, C. Martin, Geosyntec Consultants

Measuring freely-dissolved chemicals in sediment porewater is a powerful technique for improving sediment assessment and management. Peepers are a reliable method to collect representative samples of hydrophilic chemicals (e.g., metals, ammonia, etc.) in sediment porewater. Peepers contain a sample of ultra-pure de-oxygenated water separated from the porewater environment by dialysis membrane. Over the deployment period, usually about 4 weeks, hydrophilic chemicals in porewater diffuse into the peeper until concentrations in the peeper water approaches concentrations in the adjacent sediment porewater. After the deployment period, the peepers are retrieved and analyzed to represent concentrations in the sediment porewater surrounding the peeper. Over the past 18 months, SIREM has successfully provided peepers for 6 project studies. Each study has included project-specific customizations that make field deployments and retrieval technically more effective and easier. This presentation will describe the scientific basis for how sampling with peepers works, how peepers should be properly deployed and retrieved to maintain high data quality and avoid potential low or high biases, and recent innovations to help make peepers more effective and easier to use. Details will cover: 1) the scientific basis for peepers and supporting data; 2) calibration for equilibrium with equilibration tracers; 3) procedure to avoid the impact of oxygen on samples before and during deployment and retrieval; 4) innovations to reduce and streamline field efforts, including diverless deployment.

569 Actively Shaken In Situ Deployment: An Innovative Approach to Accelerate Equilibrium in Passive Samplers

M. Jalalizadeh, J.M. Conder, Geosyntec Consultants, Inc.; U. Ghosh, University of Maryland, Baltimore County / Chemical, Biochemical, and Environmental Engineering; O. Ghosh, University of Maryland, Baltimore County; M. Healey, SIREM

Passive sampling for the measurement of freely dissolved concentrations (C_free) of organic pollutants in sediment porewater has emerged as a very promising approach, but in situ measurements are complicated by slow mass transfer of strongly hydrophobic compounds. This results in passive sampling deployment periods that are often 28 to 56 days, a time period that can delay rapid site-decision-making and jeopardize measurement. Additionally, slow mass transfer of very hydrophobic compounds can result in uncertain or highly variable results. Previous work has shown through laboratory experiments that periodic vibration greatly enhances sampling rates for passive samplers in sediment, reduces the required deployment times by at least 2 to 4 times, and improves the accuracy of estimating the porewater concentrations. We have developed a robust platform incorporating a vibration device that can be adapted to an existing commercially available passive sampler. The initial design operates in a small waterproof housing that has been tested to water pressures at 30 m depth. Initial field tests in marine sediments for 7-14 days demonstrated that periodic vibration of the passive samplers (5 second pulse every 4 hours), enhanced the mass transfer of PCBs compared to samplers deployed statically. Results suggest deployment times may be able to be reduced to 7-14 days, a marked improvement over typical deployment times for passive samplers. The initial design remained stable and waterproof, and there was no need to recharge the battery or service the device during deployment, allowing for an efficient and effective field program. In addition, as shown in previous research, closer approaches to equilibrium improves the accuracy of C_free measurements, especially for the more hydrophobic compounds. Overall, this technology is mature for application, improves the accuracy of C_free measurements, and reduces the costs and risks associated with in situ deployments. Ongoing work is further optimizing the layout of the vibration device to reduce power consumption, increase the efficiency of vibration, and increase the mass of deployable polymer to enable measurement of dioxins and furans.

570 3D printed design for remediation and monitoring of dredged material contaminants

M. Ballentini, A.J. Kennedy, US Army Corps of Engineers / ERDC; L. May, US Army Engineer Research and Development Center / Environmental Laboratory

The US Army Corps of Engineers maintains approximately 400 ports and 25,000 miles of waterways with dredging operations. Federal regulatory statutes and guidance require the US Army Corps of Engineers to evaluate direct, indirect, and cumulative environmental impacts associated with management of dredged material including the potential for release of contaminants at disposal sites. As limitations to the placement of dredge material in confined disposal facilities increase, the development of sustainable alternatives for dredged material management, are being pursued. This multi-phase effort is prototyping new materials to reduce the bioavailability of multiple contaminants of concern in dredge material and designing recoverable devices that contain both remediation capability and passive samplers that will provide long-term monitoring of the efficacy of remediation measures. Passive samplers 200 um squares were 3D printed in low-density polyethylene, polyactic acid (PLA), and acrylonitrile butadiene styrene (ABS) were tested for uptake along-side commercially purchased high-density polyethylene in a sediment slurry for 30 days to test baseline update of contaminants of concern. To follow up the baseline experiment of update, 3D filament were extruded containing 25% of SIR-300, SIR-600, and activated carbon individually added to PLA. The newly made filament was then used to 3D print a series of five paddle wheel models with increasing surface area. Sediment slurries containing the same sediment type as the baseline uptake experiments are
being carried out using the 3D printed additive enhanced paddle wheel models to test for uptake efficiency and surface area effect between the different filaments containing the additives. Future phases of this effort include gyroscopic buoyancy models will be created using the previous generated data for each of the filament additive to generate kinetics of sequestration of the contaminants of concern followed by a field demonstration using the optimized 3D printed floatable remediation technologies and gyroscopic retrievable passive sampling devices.

Chemistry and Exposure in the Indoor Environment - Part 2

571 Indoor house dust: Sources, composition and potential health impacts

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Indoor house dust is a source of human exposure to persistent pollutants and is linked to potential health risks. The Fort McMurray, Alberta wildfire event in May 2016 raised questions about potential exposure to fire-related pollutants. To assess the long-term impacts of the wildfire emissions and any other sources on indoor air quality, dust was collected in Fort McMurray homes during four sampling campaigns in 2017-2018 and the concentrations of trace elements, organic contaminants were analyzed. Copper, zinc, cadmium and lead were found to be enriched in the indoor environment, suggesting indoor sources of these elements. Outdoor sources contribute to other elements such as arsenic and potassium. Neighbourhoods affected by the fires showed higher levels of arsenic, likely from combustion of treated wood. Polycyclic aromatic hydrocarbons were mostly associated with indoor use of wood fireplace. The potential of indoor dust to cause oxidative stress and adverse health outcomes was assessed using dithiothreitol assay, and its relationship to chemical composition will be discussed. Lastly, urinary metals from residents were measured and the association with house dust concentrations will be investigated. Overall this study provides insights into environmental exposure to house dust and subsequent health impacts.

572 Indoor Dust/Air Partitioning: Evidence for Kinetic Delay for Low-Volatility SVOCs

A. Parnis, T. Taskovic, Trent University / Department of Chemistry; A. Celzius, Queens University; D. Mackay, Trent University / Chemistry

Partitioning of Semi-Volatile Organic Chemicals (SVOCs) between an air phase and indoor dust is investigated by calculating Henry’s Law constants (HLCs) for selected SVOC’s from air to octanol and 8 organic oligomers and one inorganic oligomer similar in chemical structure to reported components of household dust. The HLCs were computed using the Henry’s law function contained in the first-principles COSMO-RS quantum chemical program and converted to values of KOA and KDust-Air, assuming an organic matter content in dust of 50%. The octanol results are compared with a large body of reported monitored partition ratios with good agreement for the more volatile SVOCs of vapor pressure (VP) exceeding 10-5 Pa and with the equivalent log KOA of less than 9.5. For less volatile SVOCs, reported values of KDust-Air are significantly lower than predicted, with the deviation increasing with reduction in VP. This effect is attributed to a kinetic delay in which characteristic times for equilibration exceed the dust-air contact time and equilibrium is not achieved. The nature of kinetic delay and the limitations for use of dust as a sampling probe for indoor air concentrations will be discussed.

573 Human activities influence exposure to semi-volatile organic compounds: a multimedia modeling experiment

J. Kvasnicka, University of Toronto / Environmental Health Sciences; E. Hubal, US Environmental Protection Agency / Computational Exposure Division; M.L. Diamond, University of Toronto / Department of Earth Sciences

Multimedia models have proven to be useful predictive tools for assessing the fate of neutral organic compounds released in indoor environments. These predictions have then been used to estimate human exposure. In these models, the representation of human occupants has been limited to passive individuals with static and continuous behaviors. However, evidence clearly shows that individuals alter their surrounding microenvironments indoors, which can influence exposure. Here, we developed and employed a multimedia model of the indoor environment for three purposes: 1) To investigate how typical human behaviors affect the multimedia distribution of phthalates indoors on a dynamic basis, 2) to determine how and why these behaviors, in turn, influence exposure by comparing the typical indoor activities and resultant exposures of an adult versus a toddler with different physical attributes and behavior patterns. For instance, more frequent movement, including hand-to-mouth contact, for the toddler can be shown to result in higher exposures per unit body weight compared to the more sedentary adult. The demonstrated framework may be an important step toward better understanding the role of human occupants as autonomous agents of chemical movement indoors with, in turn, consequences for exposure variability.

574 PCB Emissions from Paint Colorants and their Effect on Room Concentration

J. Jahnke, University of Iowa / Environmental Engineering and Science; K. C. Hornbuckle, University of Iowa / Civil and Environmental Engineering

Polychlorinated Biphenyls (PCBs) are currently produced as byproducts of pigment manufacturing. These pigments are used in consumer paints that can be purchased at many hardware and paint stores in the United States. Most of the congeners produced through these processes are the most volatile of PCBs: Monochloro- and dichlorobiphenyls associated with pigments have been measured in air worldwide. Although it is possible that the manufacturing process itself contributes to environmental contamination, we hypothesize that use of architectural paint is the major source of these congeners to air. For example, previous work has shown that paint is responsible for 0.000001% of PCB stocks in Chicago but is responsible for up to 7% of total PCB emissions. We investigated the emissions of PCB congeners from freshly applied paint colorant. We quantified the emissions of ∑PCBs over time (6 weeks) using a new polyurethane foam passive emissions sampler (PUF-PES) method. The PUF-PES method involves placing a PUF over a sample to capture any PCBs that volatilize from it. Due to the nature of the sampler, we only collect PCBs from the sample found in the air directly above it. The PCBs found in the applied colorant were detected on the PUF after one day. By the end of the experiment all PCBs found in the colorant were also found on the PUF including PCB 209, the highest chlorinated PCB. Lower chlorinated congeners (e.g., PCB 1, PCB 2, and PCB 3) were released from the colorant at a faster rate than higher chlorinated congeners (e.g., PCB 146 and PCB 147/149). We used our emissions data to predict concentration in a room using a mass-transfer model. Our results show that non-Aroclor PCBs associated with pigments readily volatilize, consistent with reports of the same compounds in ambient air. A currently manufactured source of PCBs could lead to detectable concentrations in indoor air. This work addresses an important source of toxic air pollutants in residential and school environments as well as outdoor natural environments that has only recently been recognized.
575 PCBs in Older Buildings: Measuring Levels of PCBs in Caulk and Window Glazing Materials

I. Osemwegie, US Environmental Protection Agency / Public Health Chemistry Branch

A method for the determination of polychlorinated biphenyls (PCBs) in caulk and glazing materials was developed and evaluated by application to a combination of 36 samples of caulk and glazing materials, from four older buildings. The quality control analysis of this method showed a range of 45 to 170% for spike recovery from the various samples and a range of 10.9 to 20.1% difference in measured precision. The method is useful for the evaluation of caulking materials in older buildings and has been recently published. The result for the samples analyzed showed that three of the four buildings sampled contained caulk and glazing materials with levels of PCBs in the range 54.6 μg/g to 445,000 μg/g. These results are consistent with other studies that evaluated PCBs in older buildings. The PCBs determined in the samples, exhibited characteristic chromatographic patterns similar to those of Aroclors 1242, 1248, 1254, 1260, 1262, and a 1016/1254 mix. This finding combined with the findings of studies in Finland, Germany, and Sweden, indicates that the presence of PCBs in caulk in older buildings is of potential concern. The presentation will provide information on the method development and how this new method can be used for characterizing caulking materials in older buildings.

576 Oxidative potential of inhalable engineered nanoparticles - investigating physical barrier effects through formation of secondary organic matter

P. Shahpoory, Q. Liu, T. Harner, J. Liggio, Environment and Climate Change Canada / Air Quality Research Division

In recent years, there has been a rapid increase in the production and application of engineered nanoparticles (ENPs), but the number of studies addressing the toxicity of ENPs is still limited. As to human exposure to ENPs through inhalation and related health effects, indoor exposure is expected to be more important because the ENP concentrations in ambient air are generally low. Oxidative potential (OP) is a measure of inhalation toxicity of airborne particles. The redox-active constituents of particles react with lung antioxidants in the epithelial lining fluid, resulting in oxidation of antioxidants. The excessive loss of antioxidants leads to oxidative stress, inflammation of the epithelial tissue, and chronic diseases. Some ENPs are known for their ability to pose oxidative stress; this ability depends on the ENP surface chemistry and particle-size distribution. However, it is not well known if the modification of ENP surface through coating with organic species, such as secondary organic matter (SOM), would influence their OP. In this work, we investigated three ENPs, namely TiO2, CeO2, and SiO2 - the first two ENPs are known to have OP in their bare form while SiO2 is relatively ineffective. In laboratory chamber experiments, we simulated the chemical aging of these particles in air through reaction of two volatile organic compounds (α-pinene and toluene) with OH radicals and O3 and eventual formation of SOM-coated ENPs. Different aging times and SOM coating thicknesses were considered. The OP of the samples was investigated using a recent method that we developed in-house. The method simulates the reaction of ENPs with major lung antioxidants in the simulated lung lining fluid and determines the redox state of the samples. We evaluated our results using the electrochemical reduction potentials of the studied ENPs. The results showed that the presence of organic coating on ENPs considerably reduces the OP of very redox-active ENPs, whereas continued chemical aging of the same particles leads to increase in OP. We found an opposite pattern with SiO2 samples. In addition, we found good agreements between these results and the measured values of reduction potentials. This work is particularly interesting in that it provides an insight into the dynamics of ENP physical and chemical transformation in indoor environments, and introduces a new method for evaluating the toxicity of inhalable ENPs indoors.

577 Investigating the Photoenhanced Uptake of Gaseous NOx on Indoor Surfaces

S.H. Jones, D.J. Donaldson, University of Toronto / Chemistry

Despite the significant amount of time that humans spend indoors during their lifetime, little is known about the chemistry of the indoor environment in comparison to the outdoor environment. Photochemical reactions play an integral role in the chemistry of the outdoor environment but such reactions are thought not to be important indoors owing to the lack of significant UV radiation < 320 nm. However, photosensitizing compounds are prevalent indoors in a variety of forms such as TiO2 which is present in many indoor paints and polycyclic aromatic hydrocarbons which are commonly found in household dust. The presence of such photosensitizers in combination with the high surface-to-volume ratio of the indoor environment suggests that it is important to study photosensitized heterogeneous chemistry indoors. Previous work has shown that renoxification can occur from indoor surfaces illuminated with common indoor light sources. Building on these findings, the photoenhanced uptake of gaseous NOx on illuminated substrates painted with commercial paints has been explored using a custom experimental set-up combined with a NOx analyser. Gaseous NOx is present in the indoor environment from a number of sources including cooking and cleaning emissions as well as from infiltration of outdoor air. The effects of relative humidity, different paint pigments and the addition of an organic film to the substrates have been investigated to better understand chemical transformations indoors. Initial results suggest that the presence of an organic film on an illuminated painted substrate compared to an organic film on an illuminated plain glass substrate significantly alters NOx uptake which could have implications for the chemistry occurring in different types of indoor environment.

578 Selective High Surface Area Scrubbers: Metal-Organic Frameworks for Decontamination of Harmful Indoor Air Pollutant Nitrous Acid

D. McGrath, Memorial University of Newfoundland / Chemistry; C. Young, York University / Department of Chemistry; M. Katz, Memorial University of Newfoundland / Chemistry

A variety of nitrogen oxides (NOx) are present in both indoor and outdoor air. The NOx species posing the most significant threat to both the environment and human health are nitrous oxide (NO) and nitrogen dioxide (NO2). NO2 can interact with other compounds present indoors to produce a wide array of secondary pollutants. An example of this is the reaction of NO2 with water on surfaces (e.g., paint) to produce nitrous acid (HONO). In the absence of light, HONO builds up via these reaction pathways. Upon exposure to light from the sun or from indoor light sources, HONO undergoes photolysis to form NO and hydroxyl (OH) radicals, which can be oxidized to form other dangerous compounds (e.g., ground-level ozone). Posing a threat to indoor air quality, levels of HONO are over 20x higher than outdoors. HONO can react with amines, such as those from cigarette or cooking smoke, to form carcinogenic nitrosamines (e.g., third hand smoke). Due to the constant flux of NOx from various sources, there is a necessity for a material to selectively decontaminate NOx and its reaction products. Metal-organic frameworks (MOFs) are porous materials known for their wide-spread applications such as chemical sensing, separations, gas storage, and chemical reactivity. The advantage of MOFs, versus other porous or high-surface area materials, is that every reactive site in the MOF is readily accessible. With this in mind, this presentation will report the successful employment of a functionalized MOF for improved quantitative measurements and selective decontamination of average indoor concentrations of HONO.
Micro- and Nano-Plastic Methods Research: Harmonizing Methods and Addressing Challenges - Part 2

579 How to sample microplastics in streams
W. Cowger, A.B. Gray, J. Guilinger, University of California, Riverside / Environmental Science

Sampling microplastics at the surface of a stream in order to derive average concentrations and estimate microplastic loading without recognition of hydrologic processes is misguided. These methods were adapted from oceanic sampling and are employed for ease. Surface sampling assumes equal concentration of microplastics within the water column. Here we show that such surface sampling methods can introduce up to eight orders of magnitude uncertainty in any assessment of average concentrations. This uncertainty is due to the potential concentration-depth profiles of plastics in the water column. To effectively monitor fluvial microplastic transport we need to assess the hydrologic mechanisms that affect our measurements, correct for them in our reporting of abundance, and develop new methods for assessing the concentration depth profile of microplastics in streams.

580 Toxicity Assessments of Micro- and Nanoplastics Can Be Confounded by Preservatives in Commercial Formulations
Q. Pikula, E. Xu, D. Berk, N. Tufenkji, McGill University / Department of Chemical Engineering

The presence of plastic debris in the aquatic environment has raised ecological concerns. The environmental weathering of large plastic debris in natural waters leads to the formation of micro- and nano-sized plastic particles that can be ingested and accumulated in aquatic organisms. Commercial formulations of micro- and nano-sized polystyrene particles (PS-NPs) are widely used as model plastics for toxicity assessment studies. However, many of these commercially available formulations contain different preservatives, antimicrobials, or surfactants such as sodium azide, Tween(R) 20, and sodium dodecyl sulfate, that may introduce artifacts in toxicity assessments. In this study, we carried out acute toxicity tests on Daphnia magna, using commercial 20 nm and 200 nm polystyrene nanoparticles (PS-NPs) containing 2 mM sodium azide as an antimicrobial preservative. The acute toxicity of non-dialyzed PS-NPs, dialyzed PS-NPs, and sodium azide alone was compared. Mortality was observed in animals exposed to non-dialyzed PS-NPs as well as in animals exposed to equivalent concentrations of sodium azide. However, no mortality was recorded for animals that were exposed to dialyzed PS-NPs after the removal of sodium azide by dialysis. Fluorescence microscopy showed visible rupture in the gastrointestinal tracts of animals exposed to non-dialyzed PS-NPs. These results suggest that the acute toxicity of the commercial formulation of PS-NPs was mainly associated with sodium azide and not the particles themselves. This study is the first to show that the observed mortality of D. magna can be directly attributed to a preservative (in this case, sodium azide) present in a PS-NP suspension. As the number of toxicity studies on micro- and nanoplastics continues to increase, the results of this study call for a more careful assessment of the toxic effects of the additives in commercial particle formulations.

582 Challenges of isolating and enumerating microplastics within the gut of a marine apex predator, the bottlenose dolphin (Tursiops truncatus)
F. Battaglia, College of Charleston; B. Beckingham, College of Charleston / Environmental Geosciences; W. McFee, NOAA/ NOS / National Centers for Coastal Ocean Science

Plastic pollution is documented to be a common and persistent problem impacting marine and estuarine ecosystems globally. An increasing number of studies report exposure of diverse biota, primarily lower trophic organisms like zooplankton, polychaetes, bivalves, crustaceans, and fish, to microplastics (< 5 mm, MP) and explore the potential physical and chemical impacts of this exposure. In contrast, research on MP ingestion at higher trophic levels is limited and presents some unique challenges. The bottlenose dolphin (Tursiops truncatus) is a long-lived apex predator and can be a sensitive gauge for environmental quality within its range. The present study aims to provide a measure for MP ingestion in T. truncatus by analyzing the gut contents of stranded dolphins recovered in South Carolina, USA. It is hypothesized that T. truncatus may be exposed to MP through ingestion of contaminated prey. A method was developed that has features which harmonize with recently published protocols for monitoring MP in cetaceans (Lusher and Hernandez-Milian, 2018: https://bio-protocol.org/e3087). The gastrointestinal tract of stranded dolphins is removed, segmented, and the contents washed into glass containers. Intact prey items and otoliths are stored for separate prey analysis while the remaining gut contents are sieved into size fractions (125-355 μm, 355 μm-1 mm, and 1-5 mm). 1M potassium hydroxide (KOH) is added to eliminate organic material and facilitate the visual identification of MP in samples, and density separation is applied as needed to samples containing sediment and calcareous organic matter. Material remaining in samples is then filtered, dried, and MP are visually detected under a stereomicroscope with the aid of hot needle test. Unlike with other taxa, acquiring samples for cetaceans is restricted to stranded animals, which vary greatly in decomposition state. In addition, their large size and heterogeneous gut contents comprised of various prey hard parts (e.g. bones, otoliths, cephalopod beaks) and soft tissues, and in some cases plant material and sediment, present challenges for isolation of microplastics. For instance, a relatively large volume of MP-free pressurized rinse water is required, and MP size measured by image analysis software indicated that sieving was ineffective for fibers. Findings from this investigation will aid future studies examining MP in marine apex predators like T. truncatus.

583 What are the current frontiers and recommendation for the study of microplastics in seafood: proposition of the “MIMS” concept
L. Hermabessiere, University of Toronto / Ecology and Evolutionnary Biology; A. Dehaut, G. Duflos, Agence nationale de sécurité sanitaire de lalimentation, de l'environnement et du travail (Anses) / Laboratoire de sécurité des aliments LSA

Since the 1950’s, mass plastic production and waste mismanagement have resulted in significant contamination of the global environment, including the marine environment. The first mention of seafood contaminated with microplastics (size < 5 mm) was recorded in the early 1970’s, and to date numerous studies have been carried out on fish, shellfish and crustaceans. Using published studies, the goal of the current work consists of reporting the numerous methodologies and practices described so far. By examining multiple aspects including problems related to the definition of the term microplastic, contamination of the laboratory environment, sampling, extraction, quantification and identification, the objective of the present work was to point out current limitations and research needs to reach reliable and reproducible practices for future studies on microplastics in seafood. A final part is devoted to the minimum information for publication of microplastics studies (MIMS). Globally, practices and methodologies are improving as of recently. However, some gaps remain. Indeed, information on the prevention of contamination, blank management and the identification of unknown particles are still missing in some studies. Based on the aspects discussed, MIMS can act as a starting point for harmonisation of analyses of microplastics in seafood and other matrices.

584 A First Open International Interlaboratory Study on Microplastics Analysis
H. Leslie, Vrije University Amsterdam / Environment & Health; B. Van Bavel, NIVA; S. Crum, Alterra Wageningen UR / ERA team; L. van Mourik, Vrije Universiteit Amsterdam / Institute for Risk Assessment Sciences; W. Cofino, Wageningen University; J. de Boer, VU University / Environment & Health

The field of microplastics analysis in environmental samples is rapidly growing. Reports appear in the literature with sometimes alarming microplastics concentrations in the marine and freshwater environments. However, often the methods have not been validated. This is partly due...
Re-centering standardization for Indigenous, northern-led, and citizen sciences

M. Liboiro, Memorial University / Department of Geography

Calls for standardizing methods within aquatic plastic pollution research have been steadily increasing. While standardization allows for better comparison between studies, standardization can also make certain environments, ways of working, and ways of knowing central while pushing others to the periphery. This presentation uses case studies of Indigenous science, kitchen science (sometimes called citizen science), and northern-led science of marine plastic pollution research as case studies to highlight crucial considerations, existing pitfalls, and unexamined politics of standardization that can create unintended power dynamics and inequity in knowledge systems. At the same time, these same cases show that the ability to compare studies, be accountable to quality assurance and contamination, and share protocols are crucial for moving forward on marine plastic pollution. The presentation concludes with the types of standards cases have found work best across diverse knowledge systems and contexts, including scales of plastic identification, methods of sample collection, and practices of categorization. These findings aim to ensure that when new standards are forwarded in our scientific communities, they are accountable to the politics and best practices of standardization.

Rethinking Microplastics As A Diverse Contaminant Suite


Microplastics are not microplastics. “Microplastics,” like other classes of chemical contaminants, is a catch-all term for a variety of unique chemical compounds. Yet, many scientific publications, policy reports, and media articles present microplastics as if they are simply a single compound or type of material. Such simple communications have consequences, leading to simplified studies and protocols that may be inadequate to inform us of the sources and fate of microplastics, as well as their biological and ecological implications. Moreover, not recognizing the diversity of materials in a microplastics sample may overlook the complexity necessary to inform robust quality analysis and quality control (QA/QC) needed in sampling and analytical measurement techniques. For instance, some methods are better at recovering specific sizes, shapes, or types of microplastics. Simplifying microplastics as a single compound has also led to confusion around the need for new policies and strategies to reduce future emissions of microplastics. For example, some policy makers and scientists are under the impression that banning microbeads from rinse-off personal care products has eliminated future releases of microplastics in general to the environment. In reality, such bans eliminate only one source of the diverse and complex emerging global contaminant suite that is “microplastics.” This can be compared to banning one specific use of a pesticide (e.g., in the home), leaving the market full of other applications of diverse pesticides that need to continue to be assessed for environmental persistence, bioavailability, and toxicity. We make the case that it is necessary to rethink microplastics (plastic particles < 5 mm in size) and consider them a suite or class of contaminants, in the same way we do for pesticides, trace metals, or flame retardants. Microplastics are diverse; they come from many different product types; incorporate a broad range of sizes, colors, and morphologies; are composed of various polymers; and include a broad array of chemical additives. This diversity is important to consider, and thinking of them like we do other classes of contaminants may help us advance methods for sampling and analysis and help us better understand the sources from which they enter the environment; their fate in water, sediment, and organisms; their toxicity; and relevant policies for mitigation.

Incorporating New Approach Methodologies to Improve Ecological Risk Assessment - Part 2

Exploiting new approach methodologies in risk assessment: Towards more holistic chemical safety decisions

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In recent years there has been a paradigm shift towards gaining more mechanistic toxicological insights in risk assessments (RA). The drivers for this shift are a desire to move away from the animal testing requirement of conventional risk assessment as well as to move towards more transparent and robust approaches to toxicology. Whilst recent advances in technology have resulted in an explosion of mechanistic data being generated across multiple species, there is little evidence of it being used in chemical risk assessment or for making risk-based decisions. However, there is a growing recognition that mechanistic approaches to understanding cross species target and pathway conservation/homology provide significant opportunities in RA for both Human Health (HH) and environmental safety. Specifically, it has been recognized that a more comprehensive and reliable understanding of pathways will better enable the extrapolation of potential adverse impacts across species. Ultimately, this would allow a mutual exploitation for HH and Ecological RA to coherently and more efficiently characterize overall hazard. Given the broad inter-species differences occurring at multiple levels of biological organization, there is unlikely to be a “one-size-fits-all” solution that can effectively characterize species similarities/dissimilarities completely. Nevertheless, there are some pragmatic first steps that can be taken using New Approach Methodologies (NAMs). Thus, there is a need for NAMs to identify, characterise and (ideally) quantify those differences and how mechanisms of action may differ across species. Motivated by these questions, we show how we can make better use of existing data and
how to efficiently generate new data to derive an improved mechanistic understanding between humans and environmentally relevant species, ultimately aiming at more efficient, holistic chemical safety decisions. We will highlight gaps, key challenges, and identified research priorities for the future within the risk assessment arena. NAMs can be included in risk assessments either on their own or alongside conventional data as part of a WoE approach to gain better mechanistic insight. Here we also propose a framework to demonstrate how new mechanistically derived data can complement our current approaches to deliver a robust risk assessment applicable across both human health and the environment.

588 Novel Cell-Based Toxicokinetic Toxicodynamic Models to Improve Ecological Risk Assessment of Endangered Species

J.D. Pierro, Texas Tech University / Environmental Toxicology; A.L. Peace, Texas Tech University / Department of Mathematics and Statistics; C. Witmaack, Texas Tech University / Department of Environmental Toxicology; B.M. Higgins, NOAA National Marine Fisheries Service; C.A. Godard, Texas Tech University / Environmental Toxicology/TIEHH

Little toxicological data is available for endangered megafauna, such as sea turtles, due to inherent restrictions in in vivo toxicity testing. This study provides in vitro toxicity testing of Benzo[a]pyrene (BaP), Polychlorinated Biphenyls 77 (PCB 77), Perfluorooctanoic Acid (PFOA) on loggerhead sea turtle cells, as well as mathematical models, based on this empirical data, that allow for prediction of toxicity over time. All three chemicals are common marine contaminants found in loggerhead tissues, prey items, and ocean waters. BaP is a prototypical polycyclic aromatic hydrocarbon commonly produced through incomplete combustion. PCBs were components of dielectric fluid used in capacitors. PFOA is commonly found in non-stick wares and fire-fighting foam. In a number of animal studies, including those with reptiles, these toxicants have been proven to have adverse effects on cell viability, renal and hepatic systems, and are considered mutagenic. We examine the cytotoxic effects of BaP, PCB 77, PFOA on loggerhead skin fibroblasts using the MTT viability assay. Cells are exposed to each contaminant for standard toxicological periods of 24, 48, 72, and 96 hours, using exposure concentrations based on scientific precedent. This toxicological data was then used in the General Unified Threshold Model of Survival (GUTS) to predict loggerhead sea turtle cell survivability overtime. GUTS is a toxicokinetic toxicodynamic (TKTD) modeling tool, that identifies the sensitivity of the cells to the contaminants. There are two types of survivability models encompassed by GUTS—the individual tolerance (IT) and the stochastic death (SD) models. With the IT approach, survivability is based on individual sensitivity of each cell to the contaminant; the SD perspective presupposes that survivability rates decrease at the same rate for all cells, without consideration of individual sensitivity. Both SD and IT models were examined for effectiveness using confidence intervals and parameter sensitivity analysis. Standard ecological risk assessments can use these models as a tool, due to their standardized provision of fifty percent lethal concentration (LC50) predictions. These are the first TKTD models to look at toxicological effects of common contaminants on loggerhead sea turtles and is the first application of GUTS to cell populations. This research provides precedence for future ecological risk assessment of endangered species using novel cell-based TKTD models.

589 Assessing potential risk to data-poor species: Applying Dynamic Energy Budget theory for interspecies extrapolations

N. Galic, J.D. Maul, R. Brain, Syngenta Crop Protection, Inc. / Environmental Safety

Ecological risk assessments are typically based on apical endpoints related to survival, growth, and reproduction (i.e., lethal and sub-lethal effects) in standard test species. Although there is a wealth of toxicological and life-history information on standard test species, it is not yet fully understood how representative they are as surrogates for other species, particularly those that are data-poor or listed under the Endangered Species Act (ESA). There is often a considerable lack of basic toxicological and life history information for listed species, further challenged by regulatory limitations on data collection. One approach to address the lack of detailed life history and toxicological information for listed species is to apply biological theory in order to identify commonalities across species. Applying common physiological principles, such as those in the Dynamic Energy Budget (DEB) theory, may enable extrapolation of physiological traits across species. It may also highlight why and how sensitivities to different chemicals vary across species. In its simplest form, DEB theory suggests that the metabolic organization, emerging from specific rules on resource acquisition and allocation, is shared across all species. Differences among species mainly occur in the magnitudes of different processes (rather than in the processes themselves) allowing for comparisons across species. Here we illustrate this approach based on two case studies: freshwater fish and avian species. We show how applying DEB theory allows identification of similarities and informing data gaps in many species, including those that are listed. Finally, we highlight the challenges of such an approach and ways forward for the assessment of data-poor species.

590 The importance of differential life stage susceptibility and population structure at time of toxicant exposure to population viability

J.D. Stark, Washington State University / Dept of Entomology

Pesticides and other toxicants may be more toxic to certain life stages of a species than to others. When this occurs, the population structure or the percentage of individuals in each life stage should play a major role in how the population responds to the exposure. Differential susceptibility and population structure is rarely if ever considered when developing risk assessments for chemicals. In this talk, examples of differential stage susceptibility of species to toxicants will be presented followed by population models showing how these variables affect population viability. Consideration of incorporating these variables into ecological risk assessment will be discussed.

591 Using Integral Projection Models for Estimating Impacts of Chemical Exposure in Aquatic Populations

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Wildlife populations are challenged by a variety of natural and anthropogenic stressors. In the aquatic environment, size plays a critical role in the factors that determine population vital rates. Ecologically, size influences accessible prey, predator avoidance, the onset of reproduction, mating success, and over-winter survival. In aquatic toxicology, size is a non-destructive and readily quantified attribute of individuals; it is the natural way to measure growth effects, and is a reasonable currency for understanding and incorporating differential effects of chemical exposure on survival and reproduction within a population. Integral projection models (IPMs) have emerged as a flexible and powerful approach for linking size specific effects to demography. In this paper, we present a novel application of size-structured IPMs to explore the effects of chemical and non-chemical stressors to survival, growth, and reproduction endpoints using the fathead minnow (Pimephales promelas) to develop our case studies. We demonstrate the utility of IPMs for use in ecotoxicology. By linking our IPM to existing aquatic exposure and effect models, we demonstrate how IPMs can be used to explore complex exposure scenarios and their value in modeling the impact of chemical and non-chemical stressors.
592 The missing piece in the eel puzzle? New evidence indicates dioxin-like compounds might be responsible for recruitment failure in European eels

M. Brinkmann, University of Saskatchewan / School of Environment and Sustainability & Toxicology Centre; M. Freese, J. Pohlmann, Thünen-Institute of Fisheries Ecology; J.A. Doering, US Environmental Protection Agency / Mid-Continent Ecology Division; M. Damerau, L. Marohn, R. Hanel, Thünen-Institute for Fisheries Ecology; M. Hecker, University of Saskatchewan / School of the Environment & Sustainability and Toxicology Centre

European eels (Anguilla anguilla) have seen a dramatic stock decline over the past decades, and recruitment failure as a result of maternally transferred contaminants has been proposed as one of several potential causes. Dioxin-like chemicals (DLCs) have been identified as a class of chemicals of concern as they tend to bioaccumulate, are highly embryotoxic, and maternally transferred in eels. However, to date researchers have been unable to locate reproducing adult eels or developing embryos in their natural spawning grounds, and embryotoxicity data to identify causative chemicals are thus unavailable. In this study, we isolated and sequenced isoforms of the aryl hydrocarbon receptor (AhR) from eels and constructed a species-specific in vitro luciferase reporter gene assay using transfected COS-7 cells. A previously developed quantitative adverse outcome pathway (qAOP) based on the relationship between AhR activation and embryo lethality across nine species of fishes exposed to DLCs was used to predict eel-specific relative potencies of DLCs. Using this data, mortality of early-life stages of eels was estimated based on measured internal concentrations in artificially matured eels or levels predicted using a physiologically-based toxicokinetic (PBTK) model. Based on our results, European eels appear to be among the most sensitive species to DLCs and exposure levels are likely sufficient to significantly contribute to the observed decline in recruitment of eels.

593 An Approach for Assessing and Managing Underwater Sound Risks Associated with Dredging Operations

A.D. McQueen, US Army Corps of Engineers / ERDC/EL; B. Suedel, US Army Corps of Engineers / ERDC; F. Thomsen, DHI; C. de Jong, TNO

There is an increasing international focus to understand and quantify the potential ecological risks of low-frequency underwater sounds produced from anthropogenic activities (e.g., commercial shipping, dredging, construction, and offshore energy production). For dredge operations, a risk-based approach has been proposed for identifying, assessing, and managing risks; however, specific details of the framework and demonstration of the approach are lacking. Thus, the goal of this study was to provide a practical, concise, and reliable framework for assessing the effects of dredging sounds on aquatic life. The specific objectives were to: 1) outline a risk-assessment approach for assessing underwater sounds from dredging operations, 2) demonstrate the approach using a real-world dredge operation case study, and 3) document the strengths and limitations of the approach. The risk framework was adapted for underwater sounds to include a problem formulation step, an analysis step where characteristics of exposure and biological responses are assessed, a risk characterization process where the preceding steps are integrated and uncertainty is addressed, and lastly a risk management step. A key beneficial component of this framework is the use of a tiered approach, whereby a screening-level step offers a process that utilizes existing or readily available information to evaluate risk. In general, a limitation of evaluating risks to dredge operations is the degree of uncertainty surrounding effect thresholds for many marine species; however, this approach emphasizes the importance of documenting and communicating uncertainty to regulators, stakeholders, and practitioners in the decision making process. A case study example is included to illustrate how the framework can be applied in practice. The primary strength of this method is the intrinsic flexibility of the framework to adapt as the scientific understanding improves and new data become available in the rapidly evolving field of underwater acoustics.

594 Don’t Ditch All Animal-based Testing Just Yet; Remember the Critters in the Field

L.V. Tannenbaum, US Army Public Health Center

Where reasonable arguments can be put forth for minimizing animal-based testing approaches in support of terrestrial ecological risk assessment work, this amounts to concerns for what transpires in the laboratory. Chemical dosing studies in the lab bear little resemblance to the chemical exposures experienced by ecological receptors in the wild. Further, for all of the interest that forays into computational modeling and in vitro methods may be generating these days, we are only removing ourselves more from the actual exposures that occur in the field. With the proper direct assessment methodologies applied, the most minimal numbers (perhaps only 10!) of small rodents of both a contaminated environment and a matched reference location, can well inform on the overall health of all mammal species inhabiting the former. Properly conducted hands-on field methods, not all of which are destructive, and involving minimal animal numbers, can fully address the chemical mixtures concern, and illustrate that contaminated sites do not support sufficiently large populations to warrant concerns in the first place.

595 What does “translational science” mean in the environmental sciences?

A. LeHuray, Chemical Management Associates, LLC

Translational science has developed as a means to adapt new findings in basic medical and pharmaceutical research into improved patient outcomes and better public understanding. Similarly, translating and communicating research in the wide range of disciplines that together comprise the environmental sciences can be understood as improving public policy to reduce risk and developing new approaches to environmental protection. Unique to environmental science, however, is that public policies were often implemented with little understanding of the scientific foundations of the choices made. Environmental legislation and regulation were put in place decades before environmental research programs became common at universities and other research organizations, and before research funding mechanisms were established. Looking back, it is remarkable that many of the policy choices of the 1970s and 80s have been proven to comport well with deeper scientific knowledge. Some early policy choices, however, have fared less well. Translational environmental science should be understood as providing a mechanism for improving outcomes by reconsidering existing policy as well as introducing new regulatory initiatives. In this presentation, both successes and instances when translational methods should be applied to effect improvement will be highlighted.

596 Solutions-Driven Research: USEPA Office of Research and Development’s approach to translational science to protect the environment and public health


The USEPA’s Office of Research and Development (ORD) is committed to producing research that addresses real-world problems and helps EPA’s national and regional programs and other stakeholders to make timely decisions based on best available science. ORD recently issued its Strategic Research Action Plans for 2019-2022, focusing on Solutions-Driven Research (SDR) as an approach to help achieve these goals.
Principles of ORD’s SDR approach include 1) stakeholder engagement is critical throughout the research process, 2) solutions-oriented outputs should drive development of research plans, 3) coordination, communication, and collaboration are critical to develop integrated research outputs that meet stakeholders’ needs, 4) essential outputs from SDR identify and communicate the achievement of stakeholder goals and the implementation of solutions -- journal articles additionally provide the underlying scientific support for stakeholder solutions. ORD’s SDR approach builds on the successful model of translational science from the National Center for the Advancement of Translational Science which emphasizes a virtuous cycle of discovery, application, and evaluation. Translational science seeks to understand and overcome barriers and improve transitions between stages of translational research. ORD’s SDR model incorporates translational science concepts and is centered around stakeholder needs and involvement throughout the research process. ORD has initiated two pilot projects that apply and evaluate methods of SDR for planning, conducting, applying, and evaluating integrated research that addresses needs of stakeholders. These projects are addressing problems related to a) management of nutrients from septic systems and b) exposure to smoke from wildland fires. Through these pilots, ORD hopes to learn effective ways to 1) engage with stakeholders to build trust, maintain a dialogue to understand needs and research activities, and collaborate to develop and implement solutions, 2) integrate research efforts to deliver solutions-driven research results, 3) translate research results to inform stakeholder needs and enable solutions, 4) evaluate the effectiveness of science-based solutions. We will present the nutrients and wildfire smoke pilot projects as two examples of SDR, explore how ORD is integrating these approaches across its research programs, and discuss lessons learned and next steps.

597 A Review of 10 Years of Research and Monitoring at Environment and Climate Change Canada to Inform Chemicals Management Regulatory Decision-Making

G. Tardif, Environment and Climate Change Canada

The Government of Canada’s Chemicals Management Plan (CMP) was launched in 2006 with the primary goal of assessing approximately 4,300 priority substances by 2020, and implementing appropriate risk management measures for those deemed toxic to human health and/or the environment. Environment and Climate Change Canada (ECCC) is the federal department responsible for assessing and managing risks of substances to the environment. These regulatory activities require a wealth of data on the sources and fate of substances in the environment, their levels in various environmental compartments, their bioaccumulation potential, mode of action, and hazard to various species. To foster the generation of these data to inform regulatory decision-making, the CMP Research and Monitoring Programs were created within ECCC to fund research and monitoring activities and ensure alignment with CMP priorities. After over 10 years of activities, we examine the extent to which results from each of the CMP Research and Monitoring Programs have successfully been used and translated into regulatory outcomes. Our analysis indicates that, between 2007 and 2019, close to 100 research projects were funded to support the CMP, and over 500 substances and/or groups of substances were monitored in up to six environmental compartments (air, water, sediments, fish, wildlife, wastewater/biosolids). Results from these scientific activities have supported evidence-based regulatory decision-making by helping identify environmental compartments of concern, quantify the levels of toxicity and environmental exposure, inform the selection of appropriate risk management instruments and measure the effectiveness of these instruments, among other examples.

598 Drivers and Obstacles to the Adoption of Toxicogenomics Tools for Chemical Risk Assessment: A Review and Insights from Social Science

G. Pain, McGill University / Natural Resource Sciences; S. Maguire, The University of Sydney / Business School; G. Hickey, M. Mondou, McGill University / Natural Resource Sciences; D. Crump, Environment and Climate Change Canada / National Wildlife Research Centre; M. Hecker, University of Saskatchewan / School of the Environment & Sustainability and Toxicology Centre; N. Basu, McGill University / Faculty of Agricultural and Environmental Sciences

At the turn of the century, the scientific community recognized that the omics fields of biology - genomics, transcriptomics, proteomics, and metabolomics - could help to advance human health and ecological chemical risk assessment. In the two decades that followed, advances were made, some toxicogenomics solutions accepted, and their advantages over conventional toxicity testing methods acknowledged in specific cases. Yet, the breadth and speed of adoption of toxicogenomics for chemical risk assessment have not met the initial expectations of ‘omics proponents. To explore this situation, we review the literature addressing the adoption of toxicogenomics tools in chemicals management, and we assemble an inventory of drivers and obstacles described therein. Because the processes underlying the adoption of new practices have long been of interest to social scientists, we then apply frameworks from the literature on innovation adoption to analyze these drivers and obstacles. We identify 11 drivers and 12 obstacles, the most salient of which we describe, as well as how they facilitate or hinder the adoption of toxicogenomics tools in chemical risk assessment. Our analysis shows that the most common arguments in support of toxicogenomics, which point to superior and novel functionality offered by the new tools, may in fact deter potential adopters because they tend to overlook potential adopters’ primary concerns: simplicity of use and compatibility. We further identify two perspectives on ‘omics adoption and explain how over-reliance on the predominant innovation-centric (as opposed to adopter-centric) perspective may undermine efforts to promote toxicogenomics. We build on these insights to offer recommendations for policy and practice. Proponents of toxicogenomics in chemical risk assessment may need to put more emphasis on understanding the practices and routines of potential adopters and, in turn, ensuring that the new tools they are promoting fit with them. Priority should also be given to ensuring that new tools are not overly complex to use or unecessarily disruptive of established risk assessment practices. In other words, researchers working to develop more elaborate ‘omics methods should heed considerations of compatibility and simplicity, lest their efforts come short of improving risk assessment practice and undermine technology adoption. This work supports the EcoToxChip project (www.ecotoxchip.ca).

599 Acute Fish Toxicological Threshold of Concern: TTC - a Meta-Analysis

H. Plugee, Verisk 3E / Safer Chemical Analytics; J. Kostal, George Washington University

TTC’s (Toxicological Thresholds of Concern) are in vogue with certain regulatory agencies i.e. EFSA (European Food Safety Agency), to predict chemical concentrations below which effects are unlikely to occur. Derivation of accurate TTC’s would result in a drastic reduction of the need for animal testing of chemicals. All of this furthers regulatory objectives under e.g. TSCA (Toxic Substances Control Act), to provide realistic scientific data without a dependency on animal testing. TTC does assume that exposure models can adequately predict environmental concentrations under real-world exposure conditions. Here we have applied this concept to a Meta-Analysis of Acute Fish Toxicity Assay data. A TTC can be calculated by determining the statistical distribution of as large a dataset as can possibly be derived. Calculation of confidence intervals provides a 95/99 percentile confidence limit (lower confidence interval 2.5 or 0.5% resp.) Application of a safety factor of 10 (or 100) then results in a prediction of a .25 or 0.05 (0.025 or 0.005) percentile concentration below which chemicals are predicted to have no effect. It is then postulated that no or very few effects from chemical exposure can be observed below this concentration. Obviously this requires a large database to
accurately predict statistical parameters with as broad a scope and as small a confidence interval as can be achieved. Verisk 3E has a database of 70,000 acute fish assays for 7400 plus chemicals. Approximately 30% of the data is provided by 180 plus of the chemicals, all with LC50 counts of greater than 50 after normalization of the main database. Not only can we thus derive statistical parameters for the overall database but we can also calculate TTC’s for individual species and (sub) classes of chemicals, albeit it of lower statistical confidence limits (due to reduced sample size, even at higher concordance). Based on preliminary data analysis we determined that data, i.e. LC50’s (for select chemicals) even at n = 100 were not normally distributed for even a single chemical. We thus focused on non-normal distribution based statistics i.e. using geometric means, which assume a log-normal data distribution. We calculated these statistics including a geometric mean confidence interval for the overall databases including many of the individual chemicals. A novel, more sophisticated uncertainty analysis of the same data is presented elsewhere.

**600 Environmental monitoring and impact assessment guidance for marine oil spills on the Pacific coast of Canada**

P. Allard, Azimuth Consulting Group / Institute for Society and Genetics; T. Siemens Kennedy, L. Du Gas, SNC Lavalin, Inc. / Environment & Geoscience; C.E. Mackintosh, C. Bullen, Azimuth Consulting Group; E. Chiang, J. Banning, M. Herborg, Fisheries and Oceans Canada

An oil spill in the marine environment can potentially cause significant environmental impacts; the timely and efficient collection and evaluation of relevant monitoring data following a spill at sea is essential to understanding and mitigating these impacts. Fisheries and Oceans Canada (DFO) supported the development of draft interim technical guidance for environmental monitoring and impact assessment (EMIA) of marine oil spills on the coast of British Columbia (BC). The technical guidance, which builds on recent national and international work, incorporates a risk-based approach and provides users with operational procedures for developing and implementing a spill-specific monitoring plan. This presentation describes key components of the draft EMIA guidance. The first component consists of information necessary for completing the problem formulation stage of a risk assessment (i.e., identification of oil contamintants of potential concern [COPCs], human and ecological receptors of concern [ROCs] and operable exposure pathways, and development of a conceptual site model [CSM]). The second component guides decision-making during each phase of environmental monitoring post spill incident (i.e., key questions being addressed, types of data being collected, and a description of decision nodes associated with those phases). The next two components of the technical guidance present the key aspects of a scientifically-defensible monitoring program that inform environmental recovery from a spill incident (i.e., strategy development based on CSM, selection of endpoints and lines of evidence [LOEs], weight of evidence [WOE] interpretation, study designs and statistics, and characterization of reference conditions) and outline operational procedures, including a monitoring plan template, checklists for selecting COPCs and LOEs, and methodology for the collection and analysis of data related to relevant media and ROCs. This technical document is intended to contribute as a foundational first step towards building a holistic risk based approach that informs environmental monitoring, recovery and impact assessment of marine oil spills.

**601 Sustainable Fish Productivity: Effect on Sediment Remediation Goals**

D. Pfeiffer, P.D. Anderson, ARCADIS US, Inc.

Background: Fish consumption rates are one of, if not the, most critical assumptions when deriving sediment remediation goals. To be protective of the human populations that consume fish, high-end fish consumption rates are often used when deriving remediation goals with no, or at best little, consideration of whether a site can sustainably produce fish at the assumed fish consumption rate. This presentation reviews and summarizes fish productivity information and then presents examples of how sustainability information can be applied to the development of sediment remediation goals. Approach: Fisheries biologists have developed estimates of sustainable productivity for a range of waters throughout the United States. That information can be combined with the area of fishable waters at and adjacent sediment sites to estimate sustainable production of edible-sized fish. This presentation reviews and summarizes production data in geographically diverse locations that can be used to determine fish population dynamics and to develop estimates of the fraction of the standing fish biomass that can be removed sustainably. The estimates of sustainable production of edible sized fish were combined with assumptions of preparation of fish meals and the size of contaminated sediment sites to develop a range of fish consumption rates that could be sustained for the long-term (i.e., years). Results: Sustainable production findings combined with a range of fish meal preparation methods (e.g., consumption of fillets only or both fillets and whole fish) lead to sustainable consumption rates of edible portions of fish ranging from about 1 to 5 grams of fish per hectare per day. The range of sustainable consumption rates per hectare can be combined with the size of a contaminated sediment site to estimate the total amount of edible fish that can be produced and consumed from a site, leading to maximum fish consumption rates that are sustainable and upon which to base sediment remediation goals. Finally, examples of estimates of population risk (i.e., the potential number of cancers in the exposed population) were developed by combining sustainable production rates, site size, concentration of contaminants in fish and toxicity. Such estimates provide risk managers perspective about the benefits realized by cleanup of contaminated sediment sites.

**602 North American Urban Fisheries: A Public Health Analysis for the Future of Fishing and the Need for Management Policy**

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As urbanization has spread across much of North America over the past century, with approximately 80% of the total population residing in urban areas throughout Mexico, Canada, and the United States, there has been an increase in efforts to preserve the tradition of fishing through the creation of urban fisheries. Every state in the U.S. has at least one urban area with a system of recreational urban fisheries, and the southwestern state of Arizona is home to the largest. Prior research indicates 58% of surveyed anglers in the major metropolitan area of Phoenix consume the fish they catch. A pilot study detected various pesticides, polycyclic aromatic hydrocarbons, phthalates, and heavy metals within fish sampled from ponds in the Phoenix-metro area. Aluminum and Mercury were detected in concentrations calculated to be potentially toxic if fish are consumed regularly. The aims of this study were to identify characteristics of the population at risk, and pinpoint deficiencies in management policy that allow such vulnerability. A survey was administered to 53 anglers fishing at four urban ponds in the Tucson, Arizona, area (another major metropolitan area) to analyze their demographic and quantitate the potential public health risk. Survey results indicate 57% of surveyed anglers consume the fish they catch, with an average of approximately 45 fish consumed per year. Anglers that consume fish and report fishing at least once per week (47% of the total sample size) consume approximately 59 fish per year. Many urban ponds are artificially constructed, which excludes them from protection and monitoring under the U.S. Clean Water Act. Through a comprehensive review, similar gaps in policy concerning urban fisheries were also found in Mexico and Canada. Utilizing EPA oral reference doses, participant weight, number of fish consumed per week, and a conservative estimated fish size of 1 pound (0.4536 kg), safety thresholds specific to each participant were calculated for metal contaminants which participants are exposed to through the consumption of fish. Assuming contaminant concentrations in fish from the Phoenix area are similar to those in the Tucson area, of the anglers that reported to consume fish: 37% are potentially at risk for toxic effects from Aluminum, Arsenic, and Mercury, 17% from Selenium, and 3% from Nickel and Zinc. Additional and more stringent management policy concerning urban fisheries is needed to minimize this current public health risk.
Benthic and Pelagic Harmful Algal Blooms and their Toxins: Detection, Fate, Effects, Monitoring and Management

603 An automated non-targeted method for the instrumental analysis of microcystins and anatoxin-A in harmful algal blooms

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Microcystins are hepatotoxins produced by cyanobacteria in marine and freshwater environments such as the Great Lakes. They have a cyclic heptapeptide structure, with different possible amino acid substitutions. Anatoxin-A is a bicyclic amine alkaloid also produced by certain cyanobacteria species with acute neurotoxicity to animals, including humans. Conventional approaches for the individual analysis of these toxins entail long sample preparation to lyse the cells, extract the toxins, and concentrate them to a small volume prior to the instrumental analysis, usually carried out by liquid chromatography coupled to a triple quadrupole (LC-MS/MS) or quadrupole time-of-flight (LC-QToF) mass spectrometer. The whole process can take up to several days, leading to a reduced sample throughput and slow response in case of emergency. To address this issue, an automated method for the analysis of cyanotoxins was developed using on-line solid phase extraction prior to the LC-QToF analysis, including 12 different microcystin variants and anatoxin-a in the same chromatographic run. Method dynamic range spans from 0.01-5.00 µg L⁻¹, with 5.14% of expanded uncertainty. Sample throughput is significantly increased to 72 samples day⁻¹, and results can be reported in less than 3 hours from the moment the sample is received in case of emergency. Over 250 different microcystin variants have been reported in literature to date, but that is only about 0.1% of the theoretical structures based on the permutations of the known amino acids. This suggests that there must be microcystin variants still unknown, and non-targeted methods for their analysis should be developed. The present study will describe an experimental workflow for the detection and structural elucidation of previously unreported structures, using data dependent acquisition, diagnostic fragment screening, and amino acid structure determination based on accurate mass measurements and fragmentation with a custom-made script. A step-by-step structural elucidation of ILe-microcystin-YR will be showcased as an example.

604 Global assessment of cylindrospermopsin in the environment: Review and analysis of environmental occurrence, bioaccumulation, and aquatic toxicity

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Harmful algal blooms (HABs) appear to be increasing in magnitude, frequency and duration, in response to climate change and anthropogenic activities, including salinization and eutrophication. Subsequently, production of secondary products such as cyanotoxins present risks to public health and the environment. Here we examined an understudied HAB species, Cylindrospermopsis raciborskii, critically reviewed refereed literature for environmental occurrence in surface waters, and aquatic toxicity and bioaccumulation of cylindrospermopsin, its primary cyanotoxin. Lacustrine systems were the most common system type, with the majority of available data from Asia/Pacific, Europe, and North America. Interestingly, the Asia/Pacific region had the lowest number of detections, but the highest percentage exceedances. Limited data was found and used in the analyses for both Africa and South America, emphasizing need for further studies in more temperate regions where CYN may occur. Probabilistic environmental hazard assessments were then performed to identify exceedances of global guideline values (GVs). Specifically, these determined GV values were compared with the developed environmental exposure distributions (EEDs) of all identified surface water data, which included both intracellular and extracellular data. Common GVs of 0.5 µg/L (lowest drinking water), 1 µg/L (lowest recreational water), and 20 µg/L (highest drinking and recreational) were exceeded by 52.64 %, 40.60 %, and 6.04 %, respectively. Highest GV percent exceedances were for reservoir systems with 54.68 %, 44.0 %, and 9.50 %. Aquatic organism toxicity and bioaccumulation data were subsequently evaluated and critical data gaps were identified. Information from the current study will be useful for forthcoming efforts to understand cylindrospermopsin exposure and associated adverse outcomes to ecosystems and human health.

605 Development of methods for measuring total microcystins in Fish Tissue using the 2-methoxy-3-methyl-4-phenylbutyric acid (MMPB) procedure


There are limited methods for the analyses of multiple algal toxins in aquatic food waters, phytoplankton, zooplankton, periphyton, macroinvertebrates, forage fish, bottom feeders and top carnivore fish. Algal toxins in freshwater systems do not necessarily occur as single contaminants; mixtures of toxins may be produced from Cyanobacteria, Prymnesium parvum, and Euglena sanguinea, including microcystins, saxitoxins, cylindrospermopsin, anatoxin-a, prymnesins and euglenophycin. The objective of the first phase of this research was to spike existing fillet and whole fish homogenates with 3 congeners of microcystins (LR, LA and RR) individually and as mixtures, and to develop a method for their recovery and measurement using the MMPB derivatization method. The second phase of the project is to field-test this method on fish collected from water bodies experiencing algal blooms and compare results with individual congeners measurements. Extraction methods and analytical methods being developed for this research will be a starting point for developing extraction procedures for plankton, periphyton, and macroinvertebrates. Fish homogenates weighing 10 and 100 mg from fish containing 1, 4 and 14% lipids were spiked with 4 and 40 ng of each of the microcystin congeners, LR, LA and RR. Various extraction techniques and conditions were tested to optimize recovery and simplify the procedure. Overall toxin recoveries were found to range from 30 to 50%. The lipid content was found to not interfere with generation of MMPB; however, it did impact the workup/extraction procedure in ways which were quantifiable through the use of a surrogate standard and standard addition procedures. The MMPB technique can be reliably employed for microcystin quantification in fish tissue. During the second phase of the project fathead minnows that were deployed in experimental streams that were dosed with different nitrogen and phosphorus concentrations in 2017 and 2018 were analyzed as well as periphyton slurries collected from the streams in 2018. In addition, fish collected in 2018 from lakes with historic algal blooms in Utah, Florida, Connecticut and New Jersey were analyzed. For toxin quantification in tissues, the measurement of total microcystins via the MMPB method provides improvements over extraction of individual toxin congeners, particularly with very polar or hydrophobic MCs. Results from phases 1 and 2 will be presented.

606 Development of analytical techniques for qualification and quantification of Lyngbya wollei toxins

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Lyngbya wollei is a harmful benthic algae in fresh and brackish waters with high biomass production once established. The relationship between biomass and toxin concentration is not well established, so control is difficult to predict, plan, and execute. In this study, a Lyngbya wollei bloom in Lake Wateree, SC was monitored from July 2018 to September 2019 at multiple grab sites, including three sampled every two weeks. Additional mapping of the bloom was carried out in coordination with WaterWatch,
a citizen's science group of trained volunteers. Samples were lyophilized, extracted, centrifuged, and analyzed by hydrophilic interaction liquid chromatography along with two complementary mass spectrometry techniques. High resolution mass spectrometry was applied using an Agilent quadrupole time-of-flight instrument to confirm the structure of the *Lyngbya wollei* toxins (LWTs) present. The high-resolution fragmentation analysis presented provided an unprecedented range of fragment ions that can be used to conclusively indicate the presence and retention time of LWTs even in the absence of commercial standards. A triple quadrupole instrument was used for quantification of toxins and routine analysis of the samples. This data showed a significant amount of noise deriving from the samples themselves. Grab sampling techniques were found to be susceptible to artifacts from deposited sediments on the bloom, inadvertent collection of aquatic vertebrates and invertebrates, and inadvertent harvesting of other members of the microbial community. A 16S rRNA gene sequence assay demonstrated the presence of a diverse community of microbiota present in the grab samples. Application of improved fragmentation schemes, suppression elimination studies, and sample-based correction strategies reduced error in the apparent biomass to LWT ratio, indicating that LWTs are in fact directly correlated with bloom biomass. This information is essential to planning the most risk-averse strategy for controlling this bloom in a way that minimizes worker and environmental exposure to toxins.

### 607 Use of passive samplers for the detection of extra cellular algal toxins in stream mesocosms, lakes and streams

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Freshwater Harmful Algal Blooms (HABS) are occurring frequently throughout the U.S. and many parts of the world. Most of the emphasis on freshwater HABs has been on reservoirs and lakes with recreation and drinking water uses. However, there is mounting evidence that attached benthic cyanobacteria may be increasing and dominating the benthic periphyton community and may be contributing toxins to streams and rivers. Most methods for detections of HABs have been through water sampling for toxin measurements and cyanobacteria identification. Some newer methods have been developed and implemented in California to detect toxins in rivers using passive samplers called Solid Phase Adsorption Toxin Tracking (SPATT). In addition, North Carolina State University has been conducting passive sampler studies in China comparing several different passive samplers, SPATTs, Polar Organic Chemical Integrative Sampler (POCIS) and other Passive Sampler Devices (PSDs). What they found is that Large Format non-selective PSDs (LF nsPSDs) seemed to reflect water concentrations of microcystins better than other PSDs that were tested. For the past 4 years USEPA has been testing the consequences of nutrient additions to stream mesocosms. Macroinvertebrate and periphyton communities have been assessed using various measures for their responses to various concentrations of nitrates, phosphates and combination of nitrate/phosphates. At certain doses of these nutrients, cyanobacteria tend to dominate the benthic community. In addition, USEPA and their collaborators have also been studying a nearby lake that has bloomed for the past 8 years. The purpose of this study was to evaluate SPATT and LF nsPSDs to determine their performance in measuring extracellular algal toxins in stream mesocosms, Lake Harsha and in downstream habitats of Harsha lake. At the end of each of the 16 stream mesocosms and in 2 influent mesocosms both PSDs were deployed for 2-week intervals during the dosing period. Every 2 weeks during the dosing period, water samples were collected, PSDs retrieved and then replaced with fresh PSDs. For the lake a similar format was followed at the surface and at 2 different depths. Four stream locations were chosen below the outlet of the lake to see what the contribution of algal toxins to the stream community resulted for the lake blooms. The results of this study will be presented comparing the 2 PSDs and describing the pattern of algal toxins in each experimental unit.

### 608 Assessing potential human health risks from cyanotoxins in recycled water

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Recycled wastewater is used primarily for irrigation (non-potable uses) in California and reduces the strain on freshwater and groundwater drinking water supplies in the face of climate change. This tertiary-treated, disinfected, recycled water is of high-quality, but when stored in holding ponds prior to distribution, it has the potential to promote the growth of cyanotoxin-producing blue-green algae. A harmful algal bloom (HAB) occurred in 2018-2019 at a recycled water holding pond at a municipality in California, USA, where recycled water provides irrigation for residential, public recreational, agricultural, and commercial properties. The blue-green algae *Microcystis* spp., which produces the liver toxin microcystin (MC), was detected in this HAB. We conducted a human health risk assessment according to U.S. Environmental Protection Agency guidance to identify and characterize potential risks associated with exposure to MC by users of the municipality’s recycled water. Complete and potentially complete exposure routes were identified and assessed for municipal and agricultural workers, children who might play in sprinklers, people consuming food grown in gardens or crops irrigated with recycled water, and for domestic pets. Conservative human health and dog benchmarks developed by State and Federal agencies to be protective of recreational exposures in waterbodies containing MC were used for the evaluation. No potential for human health risks from MC in 2018-2019 were identified. Conservative exposures for domestic pets (i.e., dogs) exceeded screening-level benchmarks, but a refined assessment with more realistic exposures did not exceed subchronic action levels for California. Potential risks were also uncertain for several exposure pathways (e.g., people consuming food grown in gardens or crops irrigated with recycled water) and more research is needed to refine exposure parameters for these pathways and inform the fate and transport of MC in exposure models. Results were used by the municipality to inform a HAB mitigation and prevention strategy, refine routine monitoring, and design a communications plan for public outreach. These efforts will help identify and minimize the potential for future health risks associated with exposure to MC from this recycled water system.

### 609 A quantitative methodology to address challenges in sampling of subtidal macroalgal biomass, benthic algae, sediment, and water, from small vessels

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Eutrophication is the presence of excessive nutrients in lakes, estuaries, or other bodies of water. This results in a dense growth of plant life and death of marine life due to lack of oxygen. Regulatory requirements in the form of Total Maximum Daily Load (TMDLs) are shifting from the use of more causative/numeric stressor indicators, such as nitrogen (N) and phosphorus (P), to measurements of biological response. One of the key biological indicators being proposed for meeting TMDL objectives is macroalgal biomass. However, the use of this indicator in waterbodies where macroalgae is predominant has been hindered by a lack of standardized, quantitative methods which allow for sampling across the diversity of tidal elevation gradients. This is important in that macroalgal blooms are known to proliferate in both intertidal and shallow subtidal environments, so protocols to assess macroalgal abundance must be applicable across the tidal elevation gradient. The use of intertidal measurements alone to represent the system as a whole are complicated by the fact that nutrient effects on aquatic ecosystems are moderated in how they are expressed by many natural factors (e.g., light penetration,
hydraulic residence time, presence of herbivore grazers and other food web interactions, and habitat considerations). As a result, large portions of the waterbody, in particular the subtidal areas, go unmeasured. Protocols are therefore not well validated for quantifying the true level of algal biomass for a given waterbody. A new quantitative methodology has been developed which utilizes a small, portable device which can be mounted to a small vessel, like a kayak, and is not limited by the reach of your arm, allowing rapid (<5 min/sample), repeatable sampling at depths up to 3.66 meters. Furthermore, both current and proposed biological (biostimulatory) approaches to demonstrate compliance with TMDL monitoring requirements, mandate a multiple lines of evidence approach to demonstrate compliance. This requires multiple substrate sampling (e.g., water, algae, and sediment) which can be costly, time consuming, involve separate substrate-specific collection protocols, as well as pose site-specific, inherent challenges in collecting appropriate samples. With further calibration and validation to standardized methods, the use of this portable device has the potential to consolidate methods by allowing for simultaneous multiple substrate collection in one sample.

610 Whole transcriptome characterization of the hepatocyte response to microcystin-LR and RR

A. Biales, D.C. Bencic, US Environmental Protection Agency / ORD/NERL/EMMD; D.A. Gordon, US Environmental Protection Agency / National Exposure Research Laboratory; R. Flick, W. Huang, USEPA / ORD/NERL/EMMD; A. de la Cruz, USEPA / USEPA/ORD/NERL

Little is known about the risk posed by the majority of microcystin congeners, and knowledge gaps exist for even the most highly characterized. This may have implications for human and ecological health, as harmful algal blooms often contain mixtures of microcystin congeners. This work aims to identify potential intracellular targets and modes of action (MOA) by characterizing the early transcriptional response of HepaRG cells to microcystin-LR (MC-LR) and -RR. Transcriptome-wide responses of hepatocytes exposed to two concentrations (1000, 10 mg/L) of LR and RR for two hours were characterized using RNA-seq. Oxidative stress and the production of ROS appeared to play a central role leading to endoplasmic reticulum (ER) stress and the initiation of the unfolded protein response (UPR) and, in the case of LR, apoptosis. Evidence for ER stress was evident in both the MC-LR and -RR responses; however, the LR specifically triggered the PERK arm of the UPR and apoptosis, whereas, the ER stress response to MC-RR appeared to be less severe and was compensated for. A number of aldehyde dehydrogenases were up-regulated in response to both congeners, suggesting lipid peroxidation. Several congener specific responses were also observed. Members of the FOS family of proteins, constitutents of AP-1, were among the most highly differentially expressed in response to MC-LR. This was consistent between the 1000 and 100 mg/L exposures but was completely absent in any LR treatment. AP-1 is a central factor in many cellular pathways including apoptosis via TNF-a/JNK pathway. In the MC-RR treatments, complement was highly enriched in both the high and medium RR exposures, and not in any LR treatment. Though complement is generally associated with the inflammatory response, it has more recently been shown to respond to liver injury, where it is reduces apoptosis in hepatocytes. Congener specific differences suggest the potential for additional or uncharacterized MOA outside of the canonical inhibition of protein phosphatase (PP). These other MOA may help explain differences in the cytotoxic potential of MC congeners that cannot be explained through PP inhibition. Additionally, these non-canonical targets and MOA may need to be considered when estimating risk posed by MC mixtures.

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Advancing the OMICS into Regulatory Frameworks: Case-Studies and Perspectives - Part 1

611 Ecogenomics based assessment of ecological effects of Selenium: a lake mesocosm study

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Selenium (Se) is not only an essential micronutrient but also one of the most hazardous trace elements to animals. Se is mainly bio-accumulated in primary aquatic consumers through their diet (e.g., microorganisms, detritus) and can be biomagnified concentrations able to cause reproductive failure and teratogenicity effects in vertebrates. However, important knowledge gaps remain concerning the ecological effects of Se during its bioconcentration. Here, Se was added to freshwater boreal lake mesocosms as selenite (IISD-Experimental Lake Area, Manitoba, Canada) following a regression design (concentrations: 0.5, 1, 2, 4, 7, and 10 μg Se/L) and three non-treatment control limnocorrals. Water, zooplankton, and sediment were sampled at multiple time points to study both short-term (3 and 7 days-post-exposure (dpe)) and medium-term (21 and 63 dpe) ecological responses to Se addition. Multiple communities, including bacteria, algae, protozoa, zooplankton, and macroinvertebrate, were characterized by environmental DNA (eDNA) metabarcoding. Ecogenomics based composition, alpha- and beta-diversities were compared to tracking the natural and disturbed changes to communities. This study presents comprehensive ecological responses of controlled mesocosms to Se, and highlights the power of emerging ecogenomic tools for regulators, scientists, and local communities to monitor and predict future trajectories for freshwater ecosystems.

612 Modifications to existing transcriptomics dose-response methods to help improve performance in ecological species

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Methods of measuring whole-transcriptome changes in gene expression, such as microarrays and RNA-sequencing, have great potential for applications in screening and prioritization of environmental contaminants by regulatory agencies. One emerging strategy for linking changes in gene expression to adverse outcomes of regulatory concern is through dose-response modeling. It has been shown previously that benchmark doses computed using gene expression are consistently within one order of magnitude of benchmark doses computed using apical outcomes. However, the analytical method used to generate these findings, implemented in the EPA software “BDMExpress,” was developed using mammalian species and relies on gene set libraries such as KEGG, the Gene Ontology, or Reactome. This makes it difficult to use for ecological species, which typically have limited genome annotation resources. Additionally, the method is computationally intensive because it requires fitting multiple statistical models to 1000s of individual genes. The objective of this study was to modify the transcriptomic dose-response approach implemented in BDMExpress to improve its performance in ecological species. First, whole-transcriptome data were summarized using our own gene sets, a collection of 21 “toxicity modules,” which were designed for the interpretation of toxicogenomics data and can be rapidly defined in species with no existing functional annotation. Next, benchmark doses were calculated by fitting statistical models to module-level responses. This significantly decreases the computational time because models are fit to only 21 outcomes (toxicity modules), rather than to 1000s of outcomes.
614 eDNA Shaping a New Era of Ecotoxicology

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Aquatic ecosystems, such as rivers and lakes, are exposed to multiple stressors from anthropogenic activity and changes in climate, which have resulted in a general decrease in biodiversity, alteration of community structures, and can ultimately result in reduction of resources provided by natural ecosystems. Adverse outcomes caused by pollutants to ecosystems are determined not only by toxic properties but also ecological contexts of ecosystems, including indigenous biodiversity and community composition. It is therefore important to identify key factors, such as diversity of species and traits that determine the vulnerability of structures and functions of ecosystems in response to toxic substances. Detection and quantification of biodiversity and its activities using environmental DNA (eDNA) is arguably one of the most important technical advances in ecology in recent years. A huge opportunity has appeared to allow more relevant approaches for assessments of risks posed to ecosystems by toxic substances. eDNA approaches provide effective and efficient tools to evaluate the effects of chemical pollutants on (1) the occurrences and population of wildlife, (2) communities, and (3) the function of ecosystem in the field. Here a conceptual framework of adverse outcome pathways to relate molecular initiating events to apical ecosystem-level responses is proposed to connecting laboratory-based prediction to observations under field conditions. Particularly, future research opportunities on effects on biodiversity, community structure, and ecosystem function by toxic substances will be discussed.

615 Addressing the “so what?” question: The transcriptome as an indicator of changes in fish health in a pesticide hot spot

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It is well known that concentrations of pesticides in the Great Barrier Reef Catchment Area exceed water quality criteria, however, whether these pesticides are having detrimental impacts on the health of the system was uncertain. To address this uncertainty, we conducted transcriptome profiling via RNASeq in Barramundi (Lates calcarifer) collected from rivers with comparatively good and from agriculturally influenced water quality. Fish from agriculturally influenced rivers showed altered transcriptomic patterns, including transcripts that regulate lipid metabolism, xenobiotic metabolism, and immune response. Further surveys showed that these changes only occurred when fish were collected during the wet season, when agricultural run-off is highest and pesticides are present, suggesting that the changes are unlikely to be occurring as a result of habitat modification. Subsequent studies examined higher levels of organisation and found that pesticide exposed fish had consistent changes in the transcriptome, gross histological alterations including lipodosis, and differences in some lipid classes. The work conducted to date shows that there may be “real world” impacts from pesticide exposure and may indicate a decrease in health of pesticide exposed fish. The findings of this and related studies are being used in stakeholder engagement to work with farmers to reduce pesticide load.

616 Developing models predictive of heart rate across a large set of compounds in the Environmental-Predictive-Information-Connectivity map

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The adverse outcome pathway framework (AOP) has provided the ecotoxicology community with a great framework to conceptualise the knowledge generated in recent years. To date developing AOPs has focused on collecting data and knowledge and combining these into the framework. This can be time consuming and challenging particularly with more novel or less characterized stressors. To reduce the time required to develop AOPs, a data-driven approach is needed that can guide the researcher/regulator to the potential underlying molecular key events important for the adverse outcome (AO). The Environmental-Predictive-Information-Connectivity map (EPIC-map) attempts to address this need by developing a single dataset of dose response relationships across more than 150 compounds of environmental concern in Danio rerio embryos and by combining the power of OMICS, QSAR and Read-across approaches link chemical structural information to transcriptional data and to the observed AOs. The EPIC-map collected a vast amount of qualitative measures of adversities, including developmental, behavioural and morphological measures as well as a number of
quantitative measures, such as hatching success, heart rate, and rate of deformations. Transcriptional data is being generated which will be used to define a chemical classification based on molecular responses and to act as a proxy between chemical structural components and observed adverse outcomes. In this talk we will focus on the analysis of observed heart rates in zebrafish embryos and develop models linking chemical structural information to these. Our preliminary analysis shows that a highly predictive model (R² > 0.84) can be developed which includes lipophilicity and the total number of tertiary carbons. This suggests that there are chemical structural components that can be directly linked to observed changes in heart rate. With the additional transcriptional data we will then be able to associate a molecular response to the change in heart rate and provide a more comprehensive understanding of the underlying biology. Finally, we will show how we will be able to develop a data-driven AOP identifying the important key-events using this type of data.

617 Change of Reproduction Stage Differentiates Time-Course Regulation of Metabolites in Daphnia magna

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Daphnia magna is an indicator species widely used in environmental quality assessments. Metabolic researchers have utilized the organism to investigate molecular responses to aquatic contaminants and environmental changes. However, the impact of reproduction stage on metabolic variation and regulation has not yet been studied. This study was performed to understand the relationship between metabolic variation and reproduction cycle. 54 metabolites were quantified using liquid-chromatography with tandem mass spectrometry during different reproduction stages and sampling times (hours). The variation of metabolite concentrations was compared between the variables and time-course metabolic regulation was analyzed to investigate if the metabolic regulation is dependent on reproduction stage. The results showed that the metabolite concentrations were significantly differentiated by the reproduction stage in addition to the sampling time. The most affected metabolites included nucleotides and amino acids, which implies that the differentiated metabolite concentrations are likely related to embryo development and time-dependent algae uptake. The patterns of time-course regulation were observed to be dependent on reproduction stages and the latter stages, stages 2 and 3, showed similar time patterns of metabolite abundance regulation. In summary, this study revealed that the reproduction stage is a variable affecting D. magna metabolic profiling. Considering that the whole body metabolite profile is a typical endpoint in metabolomics and the metabolic impact of reproduction cycle needs to be considered as an important variable in Daphnia metabolomics and more studies are required to further understand reproduction stage dependent regulation under stressed conditions such as poor water quality.

618 Metabolomics in Regulatory Toxicology: Use Cases, Best Practice and Reporting Standards

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Researchers are increasingly using metabolomics to evaluate potential risks from exposure to environmental stressors. Much like the other OMICS approaches, metabolomics has proven to be a powerful tool for identifying and understanding contaminant mode(s) of action/adverse outcome pathways and discovering indicators of exposure/effects in ecologically relevant species. Despite these strengths, the application of metabolomics to regulatory toxicology has been limited. While several factors contribute to this slow translation, the roadblocks most commonly cited by chemical regulators and government and industry scientists is the lack of standardization, best practice guidelines, and data and metadata reporting formats. Here we will describe the final report of the MERIT project, which brought together a team with a wide range of expertise from multiple sectors to address this need. MERIT sought to define best practice guidelines and minimal reporting standards for designing, undertaking, reporting and assessing the quality of both untargeted metabolomics and targeted metabolite analyses for application to regulatory toxicology. To provide context, the most relevant-use cases for metabolomics in toxicology were also identified, including discovery of chemical mode(s) of action and cross-species extrapolation of toxicity pathways. The MERIT guidelines included experimental design; QA/QC; sampling and extraction; data acquisition and processing of mass spectrometry and NMR spectroscopy assays; data processing and statistical analysis; and metabolite identification. A strategy and architecture for integrated data management, sharing and exploitation in regulatory toxicology was also developed. We concluded that most steps in the regulatory toxicology application of untargeted metabolomics and targeted metabolite assays are already well established, including significant recent progress in QA/QC. These and other aspects of the MERIT project will be presented along with recommendations for critical “next steps” to advance the use of metabolomics in regulatory toxicology. The contents of this abstract neither constitute nor reflect USEPA policy.

Current Methods in Teaching at the Interface of Chemistry and Toxicology

619 Teaching Toxicology to Chemists: Exploiting Chemical Knowledge to Allow Chemists to Effectively Assess Chemical Risk

J.C. D’eon, University of Toronto / Chemistry

Understanding the end of use implications of chemical production is an increasingly important aspect of university chemistry education. This is particularly true at the University of Toronto as we are signatory to Beyond Benign’s Green Chemistry Commitment that solidifies our commitment to infuse our undergraduate curriculum with the twelve principles of Green Chemistry, of which “Design Benign Chemicals” is the fourth. This presentation will outline how we have incorporated toxicology concepts into a third-year environmental chemistry class. Time will be reserved at the end of the presentation for an open discussion on appropriate learning objectives for toxicology education within chemistry education.

620 Helping Chemists Assess Chemical Risk: Using Models to Visualize Chemical Fate

S. Baskaran, University of Toronto, Scarborough / Chemistry; J.C. D’eon, University of Toronto / Chemistry

Models can be used in environmental chemical risk assessment to visualize the environmental fate and partitioning of chemicals; however, they are underutilized in undergraduate education. We built a simplified Air-Water Model for use in a third-year environmental chemistry course to improve student comprehension of the core environmental chemistry concepts of chemical partitioning, persistence and environmental fate. The model is a component of a term project that allows students to understand how these properties can be used to assess chemical risk by performing an assessment themselves. The project is scaffolded such that students first develop a product generation scheme to identify the degradation products formed via hydroxyl reaction, hydrolysis, or photolysis. They then determine relevant physical-chemical properties for each of these chemicals, including the Henry’s law constant, using online resources such as the EPA’s CompTox Database. Finally, students edit the code for this model
in Visual Basic for Applications in Microsoft Excel with their own mass balance equations in order to predict the fate of their contaminants and degradation products over a 100-year period based on the reaction scheme and the chemical-physical properties previously identified. The environmental fate model allows students to visualize the difference in the fate and partitioning of legacy and emerging chemicals in the environment and adds to their overall learning experience in the class.

621 Project Based Learning in Environmental Chemistry: Student-led Projects Using Personal Air Samplers

M. Ross, MacEwan University / Physical Sciences; R. Zhao, S. Styler, University of Alberta / Department of Chemistry

Undergraduate laboratory experiments are often conducted under rigid experimental procedures, constraining students’ creativity and limiting their exposure to the trials and tribulations of “real-world” scientific research. With this in mind, we aimed to develop a new project-based learning (PBL) experience for undergraduate students enrolled in 3rd-year environmental chemistry courses at the University of Alberta and MacEwan University. PBL is a pedagogical approach in which students actively participate in the investigation of real-world problems and in the process gain experience in asking questions, predicting results, designing and carrying out experiments, analyzing data, and communicating results to others. The project utilized AirBeam personal air samplers, which are low-cost, portable instruments to determine PM2.5 mass concentrations in ambient air. In this project, students were asked to engage with the primary literature to discover areas of interest in urban and indoor air quality, ask a relevant research question, formulate a hypothesis testable using the AirBeam, and design and conduct an air sampling campaign or laboratory-based experiment to test their hypothesis. Students analyze and interpret their data, and present the main findings and broader implications of their experiment as both an oral presentation and a journal-style write-up. A PBL component into our courses has enriched the course considerably and has enabled students to gain experience with the entirety of the scientific research process.

622 Evaluating the Student Experience of a Student-Directed Group Project in an Interdisciplinary Capstone Environmental Analytical Chemistry Laboratory

R. Hems, University of Toronto / Department of Chemistry; J.C. D’eon, University of Toronto / Chemistry

The environmental chemistry curriculum at the University of Toronto includes a capstone laboratory course, CHM410-1410 Analytical Environmental Chemistry. In the fall of 2014, four of the structured labs were removed and a student-directed final group project was introduced. Students work in lab groups of 3-6 to plan, execute, and present an environmentally-relevant analysis of their choosing. The aim of these projects is to provide an authentic learning experience, to increase student investment, and encourage peer-to-peer learning, which is difficult to implement in single 3.5-hour lab periods. These projects offer students the chance to make decisions in the chemistry lab, to learn from their mistakes, and to deal with the ambiguity of generating “real” analytical chemistry data. In addition to the laboratory skills learned and practiced, the students gain valuable project management and communication skills. Student survey responses before and after implementation of the projects indicated increased satisfaction with the class as a whole. To investigate how the student experience of this laboratory compares to other senior chemistry laboratories and to determine if the teaching objectives were being met, we conducted a focus group from the fall 2018 cohort of students and an in-depth survey of past and present teaching assistants. The course attracts undergraduate and graduate students from both chemistry and engineering and one of the challenges has been teaching to these different backgrounds. The focus group highlighted that the projects provided an opportunity for peer-to-peer learning and skill development in students with different expertise. Responses from the focus group also indicated that students felt ownership over their project and were invested in the class. Results of this analysis will be presented in the context of the student experience of these projects, as well as the feedback received from the teaching assistants on how to best support students in this type of open-ended project-based learning experience in the chemistry laboratory.

623 Advantages of studio-style for teaching toxicology to undergraduates

A.D. Harwood, Alma College / Environmental Studies/Biology

One of the major problems teaching undergraduate science courses, particularly toxicology, is the integration of lecture content with the skills and methodologies experienced in the laboratory. Often students struggle to make connections between the two components of the course. One solution to this issue is the use of studio-style courses. In this format, rather than meet for three-one-hour lectures and a weekly three-hour separate laboratory, sections meet for two hours three times per week. This format has several advantages. Lecture content can be directly linked to experiments and students can spend more time doing hands-on activities. This also allows for 48 or 96 h experiments to be conducted without requiring time outside of class. The longer regular meeting time also allows for extended practice exercises and paper discussions. In 2017, an introductory toxicology course was taught at a small liberal arts college using a studio style format. Other modifications to the course included an emphasis on application and data analysis, teaching content through primary literature, and grouping students based on previous coursework. While less lecture content could be delivered in this format, overall student ability to interpret data, prepare laboratory reports, and design experiments was greatly improved. The complexity of examination questions and the level of understanding among students was greatly improved from previous versions of the course. The quality of student writing was also improved. Overall student feedback also reflected these observations, students felt more confident in their laboratory skills and content application. Therefore, moderate changes in course structure can have major implications on student learning.

624 Discipline-based education research: What is it and why it is important to environmental toxicology

C.M. Lee, Clemson University / Engineering and Science Education Department

In 1990, Ernest Boyer, who was President of the Carnegie Foundation for the Advancement of Teaching, called for scholarship to be reconsidered to include the scholarship of discovery, application, integration, and teaching. Others expanded the idea of the scholarship of teaching to include learning and still others have defined discipline-based education research (DBER) as the systematic investigation of questions about teaching and learning grounded in theory and in a specific discipline. Several models of DBER exist such as tenure-track researchers embedded in disciplinary departments (e.g., biology, chemistry, and mathematics) and departments devoted to education research serving as the tenure home for researchers who have joint appointments in disciplinary departments. Examples of both models and their pros and cons will be discussed with particular attention to the sciences important to environmental toxicology as well as the benefits derived for educating the environmental scientists of the future.
625 Finding Success in “Failure” of Undergraduate Research

J. Longstaffe, University of Guelph / School of Environmental Sciences

One of the benefits of teaching at a small university is the opportunity to work closely with undergraduate students on scientific research projects. In such scenarios, students are able to develop, execute, and present research projects, often of their own design, which helps prepare them for careers within the sciences. With various time commitments outside of research, however, challenges arise with undergraduate researchers, particularly in terms of completing research projects that produce publishable results. While such learning experiences are invaluable to students, success of tenure-track faculty advisors mentoring these students depends on publication of scientific literature. As such, finding a balance between independent, innovative student research and foolproof experimentation guaranteed to lead to publication can be difficult for early career faculty. Given the campfire nature of this session on Chemistry Education, the goal of this presentation will be to share stories of negative or confounding results from student led research in order to spark discussion of how to make the best of such scenarios. Should these situations be avoided until reaching tenure? Are negative results publishable, and if so, will they be valued as highly as more significant findings? Does mentorship of undergraduate research count as scholarly activity in one’s chosen field of study? These questions, and more, need to be discussed in a wider context.

626 How do we increase interest/ reduce apprehension about chemistry for students in environmental and agricultural sciences?

J. Longstaffe, University of Guelph / School of Environmental Sciences

Chemistry has a central role in nearly all aspects of environmental and agricultural sciences, including soil health, water quality, food security, and toxicology. Despite this importance, students in these disciplines often enter their upper year courses with either minimal preparation in chemistry or a significant degree of apprehension for any topic that may seem chemistry related. This impairs the ability of instructors to present more advanced and in-depth topics related to environmental chemistry, soil chemistry, and environmental toxicology. This talk will discuss ideas that the Ontario Agricultural College at the University of Guelph is exploring to improve the presentation of chemistry to environmental and agricultural science students with an effort to increase student engagement in this important subject area.

Emerging Environmental Contaminants: Human Exposure and Associated Risks - Part 1

627 Silicone pet tags associate tris(1,3-dichloro-2-isopropyl) phosphate exposures with feline hyperthyroidism

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Feline hyperthyroidism is the most commonly diagnosed endocrine-related disease among geriatric housecats and is histologically identical to human toxic nodular goiter, but the causes remain unknown. Exposure to endocrine-disrupting compounds with thyroid targets, such as household flame retardants (FRs) may contribute to the disease development. Silicone passive sampling devices, or pet tags, quantitatively assessed the bioavailable fraction of FRs for 78 cats (age 7 y) in New York and Oregon using gas chromatography mass spectrometry. Pet tags were analyzed for 36 polybrominated diphenyl ethers (PBDEs), six organophosphate esters (OPEs), and two alternative brominated flame retardants (BFRs). In non-hyperthyroid cats, serum free thyroxine (fT4), total T4 (TT4), total triiodothyronine, and thyroid-stimulating hormone concentrations were compared with FR concentrations. Tris(1,3-dichloro-2-isopropyl) phosphate (TDCIPP) concentrations were higher in hyperthyroid than non-hyperthyroid pet tags (adjusted odds ratio, p< 0.07, Mantel-Cox, p< 0.02). Higher TDCIPP concentrations were associated with air freshener use (p< 0.01), residences built since 2005 (p< 0.002), and cats preferring to spend time on upholstered furniture (p< 0.05). Higher TDCIPP concentrations were associated with higher TT4 and T4 concentrations (p< 0.05). This study provides proof-of-concept data for the use of silicone pet tags with companion animals, which can act as sentinels for human FR exposure. This study further indicates that bioavailable TDCIPP exposures are associated with feline hyperthyroidism.

628 Using silicone rubber brooches and wristbands for measuring exposure of Canadian e-waste workers to flame retardants

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The mass of e-waste produced globally is growing dramatically. Flame retardants (FRs) are added to electronic and electrical equipment in order to meet flammability standards but may pose a health concern for workers in recycling facilities. Passive samplers made from silicone rubber are one option to measure workers’ exposure to flame retardants in air and dust but have previously been used to measure personal FR exposure over a week or more (Hammel et al., 2016; Okeme et al., 2018). Here we report the use of silicone brooches and wristbands for measuring FR exposure of e-waste workers over shorter deployment times. Sampling was conducted at three e-waste facilities in Quebec, Canada, during Summer 2017. E-waste workers (n=37) wore pre-cleaned silicone brooches and wristbands while working (range 6-10 hours). Samples were extracted and analysed for 42 flame retardants, including novel brominated flame retardants (NBFRs), polybrominated diphenyl ethers (PBDEs) and organophosphorus esters (OPEs), using gas chromatography mass spectrometry (GC-MS). Concentrations below the limit of detection (LOD) were substituted with LOD/√2. Fifteen PBDEs and 11 NBFRs had detection frequencies of more than 70% in both brooches and wristbands. The median amount (in ng) of \( \sum_{29} \) PBDEs and NBFRs found on wristbands were twice as high as on brooches. The profile of FRs collected from brooches and wristbands were similar. BDE-209 accounted for ~96% of PBDEs and NBFRs collected by both sampling media. Concentrations of BDE-209 in brooches, expressed as equivalent air concentrations, was 770 ng/m³, followed by decabromodiphenylethane (DBDPE) with a median value of 22 ng/m³. The median level of BDE-209 in wristbands (1,280 ng day⁻¹ sample⁻¹) was one to three orders of magnitudes higher than in silicone wristbands worn by Bangladeshi e-waste workers (156 ng day⁻¹ sample⁻¹) (Yang et al., in prep) and US students and office workers (45 ng day⁻¹ sample⁻¹) (Romanak et al., 2019). In conclusion, e-waste workers in this study had elevated exposures to flame retardants, often exceeding levels observed in some informal recycling facilities. Silicone brooches and wristbands deployed for a full workday on workers in e-waste recycling facilities accumulated sufficient mass of flame retardants to allow approximation of equivalent air concentrations.
629 Are Organophosphate Esters in House Dust a Risk Factor for Childhood Asthma?

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Organophosphate esters (OPEs) are widely used in household products and building materials as flame retardants and plasticizers and are released into the indoor environment. Human exposure to OPEs is ubiquitous, and children are particularly vulnerable to exposure from indoor sources due to their frequent hand-to-mouth contact and proximity to floor dust. The Canadian Healthy Infant Longitudinal Development (CHILD) Cohort Study is a population-based birth cohort designed to examine the origins of asthma and allergy. We present results of OPEs in dust collected from a subset of CHILD homes, when infants were 3-4 months old, to assess the association between OPE exposures and development of childhood asthma. Pregnant mothers were enrolled in CHILD between 2008-2012 from 4 cities and 1 rural area in Canada. Dust samples were collected by trained research assistants from the floor of the most used living area and combined floor and bed in the child’s sleeping area. Dust samples for a subset of these subjects (n=100), included in an ongoing case-cohort study within CHILD, were analyzed for 33 OPEs using 25mg of a homogenized subsample combined from both rooms. Results from the subset show high levels of OPEs in all samples relative to those reported in the literature. The sum-OPEs range from 1-10 mg/g dust. TBOEP was generally the highest, followed by TPhP and TDGCPP. Constituents of Firemaster 550(C) (i.e. iso-propylated TPhP) and Firemaster 600(C) (tert-butyalted TPhP) were also found, but in lower concentrations. The Mann-Whitney U-test was used to identify median OPE concentrations in dust from homes of children diagnosed with asthma at 5 years to non-asthmatics. Results from this pilot analysis showed higher levels of several isopropylated TPhP compounds among children with asthma compared to those without. We will present data for a larger subset of the study subjects to confirm and strengthen our preliminary results.

630 Legacy and emerging compounds in nail salons: exposure of nail salon workers to phthalates, di(2-ethylhexyl) terephthalate and organophosphate esters

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Nail salons, one of the fastest growing industries in the USA, represent a potentially important source of exposure of workers and customers to volatile and semi-volatile organic compounds as well as an emission source to the environment. Women make up 97% of nail salon employees, many of whom are of reproductive age. Little is known about exposure to volatile and semi-volatile organic compounds in nail salons since the replacement of some phthalates in nail polish began. We therefore assessed exposure to phthalates as well as phthalate alternatives such as di(2-ethylhexyl) terephthalate (DEHTP) and organophosphate esters in 10 nail salon workers in the Boston, MA (USA) area during one work day. We collected urine samples pre- and post-shift; workers also wore silicone wrist bands on their wrists and pinned to their lapsels. Silicone wrist bands were analyzed for parent compounds and urine samples for metabolites. Concentrations of analytes generally increased in urine samples from pre- to post-shift, but the largest increase was for a DEHTP metabolite, mono(2-ethyl-5-carboxypentyl) terephthalate (MECPTP), that more than tripled from 11.7 to 36.6 µg/g creatinine (p<0.05). DEHTP biomarkers were higher in post-shift urine samples than NHANES females 2015-2016. MECPTP and another DEHTP metabolite were significantly correlated (r=0.72-0.73, p<0.05) with DEHTP on the silicone wrist bands, indicating exposure while at work rather than diet or other sources. Nail technicians are exposed to a number of phthalates, phthalate alternatives and organophosphate esters. Silicone wrist bands were effective as a measure of external exposure during a one day shift.

631 Per- and Polyfluoroalkyl Substances (PFAs) in Children’s Car Seats, and in Carpets and Indoor Dust from Childcare Centers

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Per- and polyfluoroalkyl substances (PFASs) have resulted in their ubiquitous presence in the environment globally. Public concern over the potential health risk posed by PFASs has triggered increasing number of studies conducted to address their environmental occurrence and associated toxic effects. However, knowledge remains limited in children exposure to PFASs, particularly the emerging analogues synthesized to substitute legacy PFASs. In this study, we examined seven PFAS classes, i.e., perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkyl sulfonic acids (PFSAs), fluoroalkyl sulfonamides, fluoroalkyl sulfonamideethanols, telomer carboxylic acids, telomer alcohols, and telomer sulfonic acids, in 36 children's car seats (sold in 2018), as well as in paired carpets and indoor dust collected from 32 California childcare centers in 2018 as well. PFASs were detected in 97% of the car seat samples and in all the childcare carpets and dust. Median ∑PFASs (total PFAS concentrations) in the car seats was 16.3 ng/g, significantly lower than those observed in the carpets and in the dust samples. While the legacy PFAS compounds (e.g. C₆₋₁₀ PFASs) were still frequently detected, some of their replacements, like short-chain perfluoroalkyl acids (C₄₋₅ PFCAs and PFSAs) and telomer acids, also substantially contributed to the PFAS burdens in our samples. Young children likely spend a significant amount of time strapped in car seats, especially in big cities where commute is long, and in daycares, which result in significant exposures in a critical time of development.

632 Per- and polyfluoroalkyl substances (PFAs) in breast milk from the United States

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Breastfeeding is an important exposure pathway to many persistent organic pollutants in infants, including PFAS. Although occurrence of PFAS in breast milk has been documented in several studies around the world, there is only study on PFAS in breast milk from U.S. mothers. In this study, we collected breast milk samples from the first-time mothers residing in the greater Seattle area (n=50) and analyzed them for twenty-seven PFAS. Seventeen PFAS were detected in the samples. Thirteen different PFAS were identified in breast milk with detection frequencies over 70%. Mean concentrations of PFOA and PFOS in were 10.0 and 20.6 pg/mL, respectively, which were lower than those reported in Massachusetts in 2004 (PFOA: 43.8 pg/mL; PFOS: 131 pg/mL). PFAS with 10 to 14 fluorinated carbons, including PFDA, PFDoA, PFtDA and PFtDeA, were found at high detection frequencies for the first time. The results reported here suggest early-life exposure to PFAS through breastfeeding is important to consider in the broader context of PFAS exposure.
633 Synthetic Phenolic Antioxidants: Environmental Occurrence, Human Exposure, and Excretion
R. Liu, University of Toronto / Department of Chemistry; S. Mabury, University of Toronto / Chemistry

Synthetic phenolic antioxidants (SPAs) are a group of widely used anthropogenic antioxidants, whose potential for human exposure and toxicity has recently received increased interest. In this investigation, SPAs were analyzed in indoor dust and personal care products (PCPs) collected in Toronto to investigate their occurrence and human exposure in North America. Eight SPAs were detected in indoor dust with a geometric mean (GM) concentration of 1489 ng/g, among which 2,6-di-tert-butyl-4-methylphenol (BHT) was the primary congener and had a GM concentration of 642 ng/g. Nine SPAs were detected in the PCPs, of which only BHT (mean: 35,602 ng/g) was observed with a detection frequency of >50%. Preliminary calculations suggest dermal sorption via PCP use may be an important exposure pathway for BHT (mean: 565,879 ng/day), although this is a negligible exposure pathway for other SPAs. Five SPAs were quantified in human sera samples collected from donors in the United States. The measured total SPA concentrations (GM: 7.77 ng/mL) were dominated by BHT and 2,4-di-tert-butylphenol (DBP), which contributed 42% and 57% on average to the total concentrations, respectively. Four BHT metabolites were also detected in human serum (GM: 0.77 ng/mL), with concentrations lower than those of BHT (GM: 2.66 ng/mL). Interestingly, despite BHT being detected at low concentrations (GM: 0.85 ng/mL) in human urine, five of its metabolites were detected at relatively high concentrations (GM: 12.1 ng/mL), suggesting BHT in humans is excreted via urine following transformation to metabolites. DBP was unexpectedly detected at extremely high concentrations in human urine (GM: 25.8 ng/mL), although its major human exposure pathways remain unclear. This comprehensive study advances our understanding of the occurrence, human exposure, and excretion of SPAs in North America.

634 Make-up your mind: Prioritising Endocrine Disruptors in Personal Care Products
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Personal Care Products (PCPs) are often used in daily rituals of personal hygiene, toiletry and aesthetic interventions (e.g. soaps, body lotions, hair products, make-up, toothpastes, perfumes etc.), and in various stages of our lifetime. Concerns have been raised regarding consumer safety and potential adverse health effects of PCPs ingredients on humans, as a result of potential chronic human exposure from an early age through the adult life. Hence, human exposure to PCP ingredients such as antimicrobial agents, preservatives, fragrances, surfactants and formulation stabilisers can be characterised as chronic. The lack of prompt and rigorous screening of PCPs can lead to harmful and restricted chemicals re-entering the market, often exceeding the established tolerable safety doses. Our present study proposes: a) risk-based prioritisation criteria for PCP ingredients and container impurities on an evidence-based manner with a leap towards future human biomonitoring studies on chemicals of emerging concern and b) the development and optimisation of a multi-residue analytical method for the assessment of potential endocrine-disrupting ingredients present in rinse-off and leave-on PCPs with diverse and complex fatty matrices, e.g. shampoos, hair conditioners or sunscreens available in the Czech Republic, followed by dispersive SPE (dSPE) clean up and high-resolution MS/MS (Orbitrap Fusion(TM)) instrumental analysis. In the present study, we have identified and categorised PCPs and their ingredients based on: a) end consumer use (i.e. rinse-off, leave-on) and b) chemical category, respectively. Our preliminary results showed that currently restricted PCP ingredients such as low molecular weight parabens and preservatives, were found below the established safety limits, whereas, emerging PCP ingredients (e.g. bisphenols, UV filters) lacking comprehensive legislative safety thresholds could be present in the PCP matrix as compound-container impurities or oxidation by-products. The ambiguous disparities in addition to the regulatory complexity governing each PCP category (e.g. food supplements, biocides, medicines) worldwide, may result into different levels of product safety provided to the consumers (e.g. borderline products, imports of over-preserved cosmetics).

Alternatives Assessment and Informed Substitution: The Transition to Safer Chemicals, Materials, Processes and Products

635 The Nexus between Alternatives Assessment and Green Chemistry
R. Simon, University of Massachusetts, Lowell / Public Health; J.A. Tickner, University of Massachusetts, Lowell / Community Health and Sustainability; S. VanBergen, Washington State Department of Ecology

Increasing regulatory and market pressures for companies to eliminate chemicals of concern from the products they source and create may force manufacturers and retailers to respond quickly, focusing only on the removal of such chemicals without understanding their replacements. This approach can lead to the adoption of regrettable substitutes, where replacements for a chemical of concern have similar or greater health or environmental impacts or lower performance. This issue has propelled the growth of a new science-policy approach, alternatives assessment, to guide the evaluation and inform substitutions of chemicals of concern. Similar to alternatives assessment, green chemistry shares the objective of addressing the health and environmental impacts of chemicals but focuses on the design of new chemistries and chemical products that reduce or eliminate the use or generation of hazardous substances to achieve that goal. The foundations for both techniques center around the chemical function and a goal of understanding the options to achieve that function in a more sustainable manner. Both approaches also require attention to chemical toxicity, cost, and performance. Finally, both suffer from the challenge of defining the meaning of “safer” and “more sustainable.” Despite the clear connections between alternatives assessment and green chemistry, the two fields—and their respective scientific communities—have not been highly integrated. Yet, the scientific disciplines involved in sustainable chemical design (i.e., chemical engineering and chemistry) and the hazard assessment component of an alternatives assessment (i.e. toxicology and environmental health sciences) ultimately provide complementary and overlapping skills and tools to drive the transition to safer, more sustainable chemistries. To better understand the nexus between alternatives assessment and green chemistry in driving safer chemistry, as well as gaps and needs for each, this presentation provides a foundational evaluation of the two concepts and analyzes case examples where companies have utilized the tools and approaches of both disciplines in developing safer chemical solutions. The case examples and analysis illustrate how the approaches and underlying skillsets of alternatives assessment and green chemistry can be complementary in supporting the design, evaluation, application and scale of safer, more sustainable chemicals.

636 Safer alternatives by functional use: Improved informed decision-making in consumer products via Quantitative Chemical Hazard Assessment
J.P. Rinkevich, C. McLoughlin, P. Beattie, SciVera, LLC

Leading consumer products brands are driving the requirement for deeper understanding of industrial chemicals used in products and upstream manufacturing processes. Where Safety Data Sheet (SDS) disclosure, Authoritative List Checking (ALC), and chemical testing once were sufficient, these methods do not enable informed decision-making to avoid regrettable substitutions to meet brand (and market) requirements. A variety of approaches and certifications exist to support efforts to identify safer chemicals toward specific goals of regulatory compliance, industry governance initiatives, product safety, product stewardship, and corporate sustainability goals. Many methods and certification programs still
637 Facilitating Hazard Evaluation in Alternatives Assessment via an Uncertainty Scoring System that Integrates Mixed Toxicity Data Streams

J. Kostal, The George Washington University / Chemistry; H. Plugge, Verisk 3E / Safer Chemical Analytics

To systematically evaluate and identify safer alternatives to existing chemicals of concern on the market, one must reliably assess chemical hazard, considering all available measured as well as predicted data. For such a decision-making process, which necessitates combining multiple pieces of evidence from several sources, it is important to articulate the concept of uncertainty. Uncertainty invariably accompanies every qualitative or quantitative metric, whether measured, calculated or derived from an expert judgment. However, in current hazard assessment practices, controversies and uncertainties are typically assumed to be absent; they lack methodological transparency; or they poorly integrate qualitative and quantitative sources of information. To this end, the Kostal group at GWU has developed a novel Uncertainty Scoring System (USS), which allows the non-expert user to quantify uncertainty for all data under consideration in order to make the best-possible decision. The system can incorporate user’s expert judgement; furthermore, it can be trained and parametrized to reproduce a specific decision-making paradigm, so as to capture individual preferences and to ensure consistency in complex decision analyses. USS is a robust mathematical model that has been internally tested and validated on toxicological data. While designed to aid with hazard and alternatives assessments in toxicology, the system’s applicability extends to any decision-making process that calls for synthesis of incongruent data streams into a single outcome. Herein, we demonstrate the utility of our system on a dataset of approximately 70,000 acute fish assays carried out for over 7,400 chemicals. For chemicals with frequently repeated assays and those of approximately 70,000 acute fish assays carried out for over 7,400 outcome. Herein, we demonstrate the utility of our system on a dataset.

639 Bridging Life Cycle and Exposure Ontologies to Enable Integration of Data Streams for Risk-Based Alternatives Assessment

E. Hubal, US Environmental Protection Agency / Computational Exposure Division; S. Bailin, Knowledge Evolution, Inc.; P. Egeghy, USEPA / National Exposure Research Laboratory; D. E. Meyer, USEPA / National Research Management Laboratory; D. Vallerio, USEPA / National Exposure Research Laboratory

In recent years, several US States have passed laws requiring manufacturers to evaluate the use of chemicals in consumer products. Some legislation requires manufacturers to perform an alternatives analysis to identify chemical alternatives that reduce impacts to human health and the environment. The USEPA asked the NRC to recommend a framework for evaluating human health and ecological risks associated with new chemical substitutes that would foster an analytical approach for evaluating chemicals by integrating multiple and diverse data streams for a more holistic consideration of potential chemical impacts. The resulting 2014 NAS report, A Framework Guide for the Selection of Chemical Alternatives, includes an increased emphasis on comparative exposure assessment, integration of information across disciplines, and life cycle thinking. To realize the NRC vision and support emerging requirements for alternative assessments, tools are needed to access and exploit the limited available data on chemical manufacture, use, and occurrence for important chemical exposure scenarios and pathways across the product life cycle. Tools for more efficient exposure estimation have advanced, and accessible exposure information has grown significantly in recent years. Data that have been developed and curated for exposure forecasting and for life cycle assessments (LCA) provide a rich source of information to support informed substitution. The goal of this research is to extend and bridge the core ontologies in exposure science and LCA and thereby enable the use of these data to streamline and improve evaluation of safer alternatives. Application of this new ontology bridge to support life cycle human exposure calculations will be demonstrated using the case study of p-dichlorobenzene in air freshener. Integrating information from these separate knowledge domains, and more generally facilitating access to linked open data, will greatly enhance the efficiency of comparative exposure assessment and risk-based alternatives assessment for chemicals in consumer products. In particular, bridging ontologies will allow implementation of workflows tailored to specific alternatives assessment requirements.
640 High Throughput Exposure and Risks for Alternatives Assessment of Chemicals in Toys and Building Products

P. Fantke, N. Aurisano, Technical University of Denmark / Quantitative Sustainability Assessment Division; L. Huang, University of Michigan / School of Public Health; O. Jollivet, University of Michigan

Introduction: Evaluating exposure is an important component to identify viable alternatives to harmful chemicals in products. Yet, Alternatives Assessment (AA) methods lack efficient and flexible approaches to quantify exposure for the many thousand product-chemical combinations. To address this gap, we a) develop an operational matrix-based high-throughput framework efficiently coupling multi-pathway near-field (worker and consumer) with far-field (general population) exposures for use in AA, and b) apply it to case studies of chemicals in toys and in building materials. Method: We first determine the chemical mass in a product and calculated fractions transferred from toys or building product interior to other compartments and humans in a matrix. Inverting this matrix yields cumulative environmental transfer fractions and Product Intake Fractions (PiF) linking chemical mass taken in by humans to a unit mass of chemical in the product. We finally determine exposure doses expressed in mg/kgBWd or on a product function basis. Our framework was applied to generate high-throughput exposure results for commonly used chemicals in toys and in building products. Results: For chemicals in toys, exposure is restricted for pathways such as dermal contact or dust that are associated with the use of a single toy of e.g. 0.4kg, but becomes substantial when considering a total mass of 18.3 kg, toys purchased per child and per year in developing countries and the related releases to indoor air. The PiF widely ranges from a median of 0.002 to a max of 0.04 (or 4%). Resulting exposure doses for product users can vary from a median of 4E-6 to 4.9 mg/kgBWd, dominated by inhalation and dermal gaseous uptake. For each product application, we are able to determine the chemical-specific contributions of pathways and population groups to overall exposure and compare the relative exposure magnitude for all chemicals in a given product. Combining these exposures with toxicity data, we are able to calculate Hazard Quotients from a median of 4E-4 to 299, identifying main chemicals of concern and ranking alternatives. For building products, resulting exposure doses for product users range from a median of 1.3E-2 to 3.7 mg/kgBWd, and Hazard Quotients from a median of 0.7 to 222. Systematic sensitivity studies enable us to identify the most important product and chemical attributes affecting the Product Intake Fraction and produce heat maps to easily determine exposure, for use in the screening AA, as will be illustrated for chemical alternatives in several product types. The more detailed mass-balanced-based framework is readily available for use by AA practitioners to screen a wide range of product-chemical combinations.


H. He, University of California, Irvine / Materials Science and Engineering; S. Tian, University of California, Irvine / Advanced Power and Energy Program; C. Glaubensklee, University of California, Irvine / Biomedical Engineering; B. Tarroja, S. Samuelsen, University of California, Irvine / Advanced Power and Energy Program; G. Movie, School of Public Health; J. Schoenung, University of California, Irvine / School of Management; T. Ogunseitan, University of California, Irvine / School of Medicine; M.-derived Chemical Assessment Framework, has been applied to investigate the disability-adjusted life years caused by human health effects and various environmental impact categories. In this study, not only the primary materials used to manufacture the battery components are considered, the associated processing materials are also assessed. The results indicate that the some of the primary materials used in the electrolyte and cell stacks are chemicals of concern. When expanded to processing materials, many of the components currently use additional chemicals of concern in the production chain. With the combined use of the chemical hazard assessment and life cycle impact assessment, the inherent hazard potential of the chemicals as well as their relative emissions and exposures are addressed and compared in highlighting the health impacts associated with different life cycle stages. The results provide insight into the effects of material selection choices on the potential health effects of these new energy storage devices and can be applied to compare and prioritize materials and process alternatives for a safer battery system with reduced potential human health impact.

642 Exploring the Role of Decision Analysis in Chemical Alternatives Assessment

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Alternatives assessment (AA) involves the identification, assessment, and comparative evaluation of alternatives to hazardous chemicals with an aim to remove hazardous materials from consumer products. Completing an AA often requires trade-offs and value-based choices in terms of prioritizing one type of concern over another (e.g., reducing ecological impacts versus maintaining technical performance). Guidance for conducting alternatives assessment typically focuses on the data gathering and scoring of alternatives but provides less direction concerning the use of specific tools to facilitate decision making. We report on a workshop in which a group of practitioners from US corporations, government agencies, NGOs, and consulting organizations were confronted with three AA case studies. Participants were asked to select a preferred alternative in each case using a different decision analysis method: their own current default decision-making method, an individual or group multi-criteria decision analysis (MCDA) method, and a facilitated group structured decision-making (SDM) method. For the latter two methods, participants were given a brief tutorial on the underlying decision theory as well as training on the use of specific software tools. As concerns the participants’ current default decision making method, despite employing a range of approaches, we observed that a large majority of participants selected the same alternative. After instruction in MCDA and SDM, participants reported these tools substantially increased their understanding of the trade-offs between alternatives relative to their current default decision approach. Participants were personally quite positive about using more structured decision-making methods to the context of AA but were less confident their organizations would adopt such tools. It also was clear that an appropriate facilitation approach and managing group dynamics were important factors in whether MCDA and SDM are used successfully.

Overall, we find that structured decision-making methods have promise in the context of AA, but that practitioners will need more guidance to use such tools successfully. The presentation will conclude with suggestions for enhancing familiarity and understanding of decision making tools in the expanding alternatives analysis community.
**Fate and Effects of Metals: Biogeochemical Perspective**

643 The ever changing nature of DOC - possible implications for metal research

A. Holland, La Trobe University / Ecology, Environment and Evolution; J. Stauber, CSIRO / CSIRO Land and Water; D.F. Jolley, University of Technology Sydney / School of Chemistry

Dissolved organic carbon (DOC) plays an important role in the bioavailability and toxicity of metals within freshwater systems. This is highlighted by the inclusion of DOC concentration within methods such as multiple linear regressions and the biotic ligand model (BLM) to derive site specific guidelines for metals in some countries. The type and characteristics of DOC has also been shown to be important factors when considering toxicity and bioavailability of metals to aquatic organisms. However, DOC is heterogenous in nature with the concentration, type and key characteristics (aromaticity, molecular weight and abundance fulvic, humic and protein-like components) of DOC intrinsically linked to various allochthonous and autochthonous processes which differ considerably spatially and temporally within and between freshwater systems. Thus, DOC is ever changing in its concentration and characteristics and this poses a potential risk when trying to determine the bioavailability and toxicity of contaminants such as metals within these systems. This presentation will bring together data from Australia and across the globe to look at how DOC varies within and between freshwaters both temporally and spatially in regards to concentration and characteristics. It will also use case studies to highlight possible effects of these changes on toxicity of metals such as copper and nickel and the importance of considering DOC dynamics.

644 The effect of particle size on oral bioavailability/bioaccessibility of Ni from different sources

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Particle size can be an important source of variation in metal concentration and speciation in soils and dusts. Samples not sorted by particle size (“bulk”) may yield different metal concentrations than some or all the constituent size fractions. The objective of the present study was to correlate in vivo bioavailability with ex vivo bioaccessibility for elevated Ni in soils/dusts of different origin and explore attribution of any variation in this correlation to source’s particle size. We tested three Ni-elevated soils/dusts of different origin and explored attribution of any variation in this correlation to source’s particle size. There are additional factors that may convolute this relationship, such as Ni concentration within methods such as multiple linear regressions and the biotic ligand model (BLM) to derive site specific guidelines for metals in some countries. The type and characteristics of DOC has also been shown to be important factors when considering toxicity and bioavailability of metals to aquatic organisms. However, DOC is heterogenous in nature with the concentration, type and key characteristics (aromaticity, molecular weight and abundance fulvic, humic and protein-like components) of DOC intrinsically linked to various allochthonous and autochthonous processes which differ considerably spatially and temporally within and between freshwater systems. Thus, DOC is ever changing in its concentration and characteristics and this poses a potential risk when trying to determine the bioavailability and toxicity of contaminants such as metals within these systems. This presentation will bring together data from Australia and across the globe to look at how DOC varies within and between freshwaters both temporally and spatially in regards to concentration and characteristics. It will also use case studies to highlight possible effects of these changes on toxicity of metals such as copper and nickel and the importance of considering DOC dynamics.

645 Development of a Marine Ni BLM. Part I: Speciation, Bioaccumulation and Effects Data

S.D. Smith, W. Chen, Wilfrid Laurier University / Department of Chemistry and Biochemistry; S. Sherman, Wilfrid Laurier University / Biology; T. Blewett, University of Alberta / Biological Sciences; C. Cooper, International Zinc Association / Department of Marine Sciences; E.M. Leonard, McMaster University; J. McGeer, Wilfrid Laurier University / Biology; C.M. Wood, University of British Columbia / Zoology; R.C. Santore, Windward Environmental LLC

The Biotic Ligand Model (BLM) is a computational tool used in a range of risk-based regulatory approaches for metals, including the establishment of bioavailability-based environmental quality guidelines and chemical safety certifications. In freshwater (FW) environments the BLM approach has been successfully applied as a cost-effective means of meeting site-specific environmental protection goals for the metals industries and regulatory bodies. However, it is estimated that 70% of the world’s population live in coastal environments and metal impacts in saltwater (SW) environments are potentially significant, with sources from municipal/industrial effluent, building material runoff, plumbing, anti-fouling paints and sometimes directly from mines and auxiliary facilities operating in coastal areas. To date, metal bioavailability in SW environments has not received as much research attention as in FW environments. The chemistry and biology of both metals and organisms change as salinity increases. Previous research on Cu demonstrated that BLM approaches are valid in SW and this current project focuses on the development of a working BLM for nickel in SW. This research is presented in two parts. The first presentation focuses on the primary ecotoxicity and geochemistry data, and the second presentation applies these data to develop a computational BLM for Ni in SW. Effect concentrations were determined using urchin and mussel embryo tests, as well as a seven day mysid test, in samples ranging from laboratory solutions with model ligands to coastal samples from the Canadian Arctic to Southern Florida in the United States, with the bulk of samples obtained from Gaspe in Quebec as well as Connecticut and Rhode Island. Direct bioaccumulation of Ni on urchin embryos was determined using radiolabelled Ni and chemical speciation of Ni was determined using the Ion Exchange Technique (IET), specifically developed for application in SW. Much of the work focused on relationships between Ni toxicity and DOC quantity/quality. For bioavailability-based decision making, a tool is required to take speciation into account for Ni risk assessment in SW. Bioavailability tools that have a mechanistic basis, and account for speciation, have the most promise in terms of being accepted for making regulatory decisions. Funding provided by NSERC and NiPERA.

646 Development of a Marine Ni BLM. Part II: Model development, calibration, and application

R.C. Santore, K.E. Croteau, Windward Environmental, LLC.; S.D. Smith, W. Chen, Wilfrid Laurier University / Department of Chemistry and Biochemistry; S. Sherman, Wilfrid Laurier University / Biology; T. Blewett, University of Alberta / Biological Sciences; C.A. Cooper, Wilfrid Laurier University / Chemistry; E.M. Leonard, McMaster University; J. McGeer, Wilfrid Laurier University / Biology; C.M. Wood, University of British Columbia / Zoology

The Biotic Ligand Model (BLM) has been successfully used to explain and predict the effects that toxicity modifying factors have on the bioavailability and toxicity of a number of metals in freshwater environments. The development of a copper BLM in marine waters has demonstrated that the same conceptual model also works well for marine organisms. The marine model for copper has shown that natural organic...
matter (NOM) in marine systems is among the most important of the toxicity modifying factors to consider in saltwater environments, while salinity was of lesser importance but still could be significant factor in estuaries. The success of the marine copper model suggests that development of marine models for other metals would be feasible. However, there are far less marine speciation data available for other metals that can be used for model development and calibration. For this project, the marine copper BLM was used as a starting point for the development of a marine BLM for nickel. The marine copper model used copper titration data to determine binding strengths and binding-site concentrations for marine NOM interactions with copper. We used quantitative structure activity relationships (QSAR) to adjust the binding strengths of the copper speciation model as a preliminary estimate of the effects of marine NOM on nickel. This preliminary model was then refined using nickel speciation data from this project (described in Part I). An important difference in the marine models for copper and nickel is that application of the copper model to saltwater sites demonstrated that the quantity of NOM is more important than the quality of NOM (as defined by physicochemical and optical properties). For nickel, it appears that NOM quality has a much more significant influence on nickel speciation, bioavailability, and toxicity than it had for copper and should be considered in bioavailability modeling. After refining the Ni BLM with speciation data, the biotic ligand interactions were then calibrated to accumulation data on urchin embryos, and the resulting model was then used to predict nickel toxicity to urchins in a variety of marine water samples from Canada and the United States.

**647 Improving Life Cycle Inventory/Life Cycle Impact Assessment for Metal Mine Tailings**


The addition of human health and ecotoxicity metrics into Life Cycle Impact Assessment (LCIA) tools has increased the focus on trace amounts of metal impurities in metal mine tailings and their potential release to the environment. As a consequence, research has been undertaken to develop life cycle inventory (LCI) datasets for sulfidic metal disposal from metal ore beneficiation. The basis for these LCI datasets is an empirical model developed from a landfill leachate emission model. For this work, the tailings model was reviewed and some areas for potential improvement regarding its implementation in LCI/LCIA analyses were noted. Based on the review, it was clear that certain simplifications were made when adapting the landfill model to address tailings disposal facilities. These include continued use of first-order release kinetics and limited consideration of pH dynamics. In addition, the potential for metal attenuation through precipitation and sorption in the groundwater receiving tailings leachate is not considered in the tailings model nor in the consensus LCIA model. Finally, common tailings management practices (e.g., seepage barriers, water covers, etc.) are not considered in the tailings model. The following actions/recommendations address the above issues: (1) available geochemical models for tailings are being evaluated for use as a resource to validate/define the LCI tailings model formulation; (2) the short term and long term effect of applying the Best Available Techniques (BATs) for tailings management should be assessed and included in the model; and (3) attenuation of leachate metals in groundwater is expected but must be quantified and included in life cycle analysis. Experts in the field of mine tailings management and life cycle assessment should work collaboratively to improve the metal emission inventory estimates associated with mine tailings.

**648 Influence of Salinity on Copper-Ligand Formation Constants**

F.M. Barnawi, S.D. Smith, Wilfrid Laurier University / Department of Chemistry and Biochemistry

Natural Organic Matter (NOM) is known to reduce metal, such as copper, toxicity in aquatic environments. Copper is essential for organisms, but elevated concentrations of dissolved copper can potentially be toxic. The toxicity of copper is related to its bioavailability, which is influenced by toxicity modifying factors, such as NOM (quantified as Dissolved Organic Carbon (DOC) in mg C/L), alkalinity, pH and major cation and anion concentrations. The principles are the same for fresh and saltwater, but the influence of high salt concentrations, such as in estuaries, and associated activity corrections, can modify NOM complexation of metals (i.e., modify logK values). The magnitude of such corrections has not been systematically studied in the context of risk assessment tools such as the Biotic Ligand Model (BLM), and the mathematical tools currently used to correct logK values for salt effects have not been fully tested experimentally. The purpose of this study is to address these gaps by determining logK values across a range of salinities for copper association with salicylic acid as a proxy to NOM. This study used varying concentrations of salt, either as artificial seawater (10 to 100%) or simply as sodium sulfate (Na2 SO4). In these salt solutions, logK values for copper binding to salicylic acid were determined using fluorescence quenching titrations and nonlinear regression (the so-called Ryan-Weber method). Salicylic acid is a well-defined compound, so these logK values can be compared to certified values from the National Institute of Standards and Technology (NIST) measured at different ionic strengths. In addition, comparisons can be made to calculated logK values determined using the extended Debye-Huckel (DH) equation. These comparisons determine how well the experimental results match with both the NIST and theoretical values. Through this experimental and theoretical research, this study tries to explain the influence of ion activity on copper binding to NOM. These results will help with managing pollution in estuarine environments and will improve the chemical side of bioavailable metal models, such as the BLM.

**649 Comparison of the laboratory Toxicity Identification Evaluation (TIE) and the in situ Toxicity Diagnostic System (iTodS)**


The in situ Toxicity Diagnostic System (iTodS) is a biological, fractionation protocol that systematically identifies chemical classes of contaminants of concern frequently linked to adverse biological effects. The objective of this study was to improve the technology and evaluate its effectiveness in identifying toxicity compared to the USEPA’s laboratory TIE Phase 1 approach. The in situ test was in San Diego Harbor, California and the lab evaluation conducted concurrently in an adjacent Navy facility. Comparison studies consisted of a control holding unspiked sea water and one holding both seawater and a copper (Cu) band with an estimated leaching rate of 163 g cm² d⁻¹. Commercially available resins (3 -5 g) used in the deployment included Chelex, Oasis C18 SPE, and Oasis HLB as active resins, and glass wool as a control. The iTodS units were deployed in triplicate and pumped at 45 mL h⁻¹ for 24 h. Strongylocentrotus purpuratus, Mytilus galloprovincialis and Brachionus plicatilis were placed inside exposure chambers to assess the acute effects of water filtered through each resin. The TIE modified Phase 1 used a series of five-stage manipulations: baseline toxicity, 0.45 um filtration, aeration, metal sorption (EDTA), and organics sorption (C18 SPE). After each fractionation, organisms were assessed for acute effects. In situ results showed Chelex removed 93% of Cu, while HLB and C18 SPE removed only 6% and 16% of Cu, respectively. No rotifers were recovered from exposure chambers in Reference or Cu treatments. Urchin recovery was low in general, likely resulting from resin saturation and Cu.
breakthrough. Mussel larvae only survived in the Chelex treatment, showing Cu was the toxicant and adequately removed by the metal-specific resin. For the lab-based TIE, rotifers showed EDTA and C18 treatments reduced toxicity. Aeration and 0.45 um filtration slightly reduced toxicity. For the mussel embryo-larval development test, only the EDTA treatment had survival (97% normal development). Urchin embryo-larval development showed similar results with 88.5% normal development in the EDTA treatment. Through time, the iToDS has been more sensitive at detecting ambient toxicity than the traditional TIE and requires fewer resources. The current iToDS prototype 3 is robust, reliable, and easy to use in the field. Its applications to a wide range of contaminants of concern suggest it should become a standard diagnostic assessment technology at chemically contaminated sites.

650 Gravel Bed Reactors: Semi-Passive Water Treatment of Metals and Inorganics
S. Mancini, E. Cox, L. deVlaming, K.M. Bechard, Geosyntec Consultants, Inc.; R. James, Geosyntec Consultants, Inc. / Remediation; A. Przepiora, F. Risacher, Geosyntec Consultants, Inc.

Metal and inorganic impacts to groundwater and surface waters are a critical issue facing many industries across North America. A wide range of treatment solutions exist; however, the operational requirements of many industries make most conventional technologies expensive and difficult to comply with water quality discharge criteria. An in situ semi-passive water treatment technology called a Gravel Bed Reactor (GBR™) can provide an alternate option for treatment of a variety of water quality issues including acidity, metals and metalloids, inorganics, and organic chemicals. A GBR consists of an engineered bed of gravel/media through which water containing constituents of concern is passed and treated. For anaerobic biological treatment, required amendments such as electron donors and nutrients are added to the water at the inlet of the GBR to promote the growth and activity of natural microbes that are capable of reducing the inorganics, sequentially immobilizing the metals in the gravel bed. Denitrification is the microbially mediated mechanism by which nitrate concentrations in waste waters are reduced to nitrogen gas in GBR systems. Selenium can be removed from water by reducing the soluble forms of selenate (Se(VI)) or selenite (Se(IV)) to elemental selenium (Se(0)) which can then be sorbed onto solid phases, precipitated or incorporated into the biomass within the GBR. This presentation will present case studies and performance results from pilot and full-scale operations in which GBRs were implemented to successfully reduced concentration loading to surface water, and/or reduced the requirement for conventional treatment. The results of pilot testing and full-scale operations of GBRs indicate that this treatment system can provide several benefits in comparison to other anaerobic biological treatment approaches such as active water treatment facilities, packed bed bioreactors and fluidized bed reactors. Advantages include the use of less tankage and equipment and the ability to use waste rock from mining applications as bioreactor packing media. This facilitates the need for less infrastructure, easier installation of smaller systems in less accessible locations such as montane topography, and the potential to treat water at or near the source. This is specifically relevant to industrial and mining operations including Western Canada, where recent water quality focus has been on metals and inorganics such as selenium and nitrate.

Toronto Flood Protection and River Building Project - Part 1

651 Project Overview: Flood Protection Project Addressing Adaptability and Climate Resilience
K. Dion, Waterfront Toronto

Port Lands Flood Protection (PLFP) is a project led by Waterfront Toronto in partnership with Toronto and Region Conservation Authority (TRCA) and CreateTO, and with the support and involvement of PortsToronto. Funded by the City of Toronto, Province of Ontario and Government of Canada, this $1.25B project will protect approximately 250 hectares of urbanized land from flooding during a major storm (up to a Hurricane Hazel-sized event). This project will transform 30 hectares of industrial brownfields in the Port Lands into a naturalized, multi-outlet river valley system with associated channel spanning infrastructure. The result: unlocking the Port Lands for revitalization and facilitating billions of dollars in investment. Grass-roots visioning for this project was initiated as far back as 1989 with a large public meeting seeking to “Bring Back the Don.” From this initial meeting, years of study and consultation occurred, culminating in the undertaking of two large environmental assessments: Don Mouth Naturalization and Port Lands Flood Protection Project Environmental Assessment (DMNP EA); and the Lower Don Lands Transportation and Servicing Master Plan Class EA. With approvals of these EAs in 2014-2015, Waterfront Toronto proceeded with a Due Diligence study that consolidated both EAs into a single project, the Port Lands Flood Protection and Enabling Infrastructure Project. This Due Diligence study explored in more detail, the challenges, opportunities, costs, risk and schedule of the works identified in the two EAs. PLFP provides an “address the water and contaminated soils hazard first” solution, from which informs all other planning in the area. It relies on innovation to build resiliency due to change (e.g. climate) into an area undergoing a rapid and extensive transformation. It explores how the project would be able to respond through active and passive adaptation, to events outside of the “norms” related to higher or lower flood levels and the influences on ecology, river operations and other infrastructure related concerns. This presentation will detail the processes of merging these two EAs into a single project and provide an overview of the key project sub-components, and outline some of the passive and active adaptive components of the design.

652 Vision: Sustainable placemaking
S. Baker, Waterfront Toronto

The Port Lands Flood Protection and Enabling Infrastructure (PLFP) Project is a $1.25B project led by Waterfront Toronto, the City of Toronto, Toronto and Region Conservation Authority (TRCA) and CreateTO, and with the support and involvement of PortsToronto, and funding from the three levels of government. In addition to providing flood protection to approximately 250ha of flood vulnerable lands, this project will transform ~30 hectares of industrial brownfields into a naturalized, multi-outlet river valley system with associated channel spanning infrastructure, while unlocking the area for revitalization and facilitate billions of dollars in investment. PLFP will improve quality of life, bring nature back to an underused industrial site and better protect our neighbourhoods from extreme weather conditions. A comprehensive vision for the renaturalization of the river has been developed, recreating a river which then acts as an organizing structure for a system of new parks and public open spaces that will become catalysts for a range of memorable activities and experiences. At the intersection of two major systems - urban waterfront and natural river corridor - the project focuses on flood control, naturalization, and placemaking to bring the Don Valley and the Toronto’s public realm together in a robust and meaningful way. A sustainable approach to design has also been woven throughout the approach to the enabling infrastructure planned for the site. With the reconstruction of three major roads, Cherry Street, Commissioner’s Street and the Don Roadway, a low impact development approach has been integrated into the design to manage stormwater and provide for passive irrigation of streetscaping. Additionally, innovation solutions have been proposed to knit both the roadway and the parks together, taking a systems-based approach to design. This presentation will highlight the major project elements related to sustainable placemaking that combine to make the Port Lands Flood Protection and Enabling Infrastructure Project one of the most significant changes to the Lake Ontario shoreline in decades, and one of largest infrastructure projects in Canada.

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The Regulatory Flood for this area is from flows generated in the Don River, up to and beyond the Regulator Flood. The Regulatory Flood for this area is from flows generated in the Don Watershed under a storm with the intensity of Hurricane Hazel, which would produce a discharge of approximately 1,560 m³/sec, and would far exceed a storm with a return period of the 1:500 years. The preferred alternative arising from the Don Mouth Naturalization and Port Lands Flood Protection Project EA (DMNP EA), identified a new river mouth that directs flows through three functionally different outlet sectors: a modified Keating Channel; a new river valley that discharges into Polson Slip through a meandering and naturalized river channel system; and a new naturalized spillway that connects to Lake Ontario through the Ship Channel, and only becomes activated by stormflows from the Don River during events in excess of the 1:50 to 1:100 year storm. The project also involves creation of flood protection landforms, an in-channel sediment trap and landside management area, and bridge modifications among other improvements. Two dimensional hydraulic (2D) modelling is used for the design and verification of flood protection. The hydraulic model was developed at a high-resolution in order to test multiple river configurations, bridge crossings and other infrastructure features, and in-valley surface treatments to confirm that the requisite flood conveyance conditions are being established with the new river mouth throughout the project. The location of the PLFP site at the mouth of the Don River is historically where the sediment delivered from the watershed would deposit, creating a river delta and the Ashbridges Marsh. The continuous supply of sediment from the highly urbanized watershed will require active management to ensure flood protection for the adjacent lands. A 2D coupled unsteady hydrodynamic (EFDC) and sediment transport model (SEDZLLJ) is used to predict the hydrodynamics and morphological changes to the bed in the Keating Channel, the new river valley, and the naturalized spillway to the Ship channel. This model was used to inform the design and to develop the future dredging and sediment management strategy. The presentation will discuss details of the technical studies used to address flood risk, some of the challenges of implementing flood remediation in an urban environment, some lessons learned to date, and how hydraulic modelling has been an asset throughout the entire planning and design process.

**654 Contamination and Human Health/Ecological Risk Assessment: Building the Site Strategy**

**K. Barfoot, A. Wojtyniak, Jacobs / Global Environmental Solutions**

Plans are underway to flood protect and revitalize underutilized brownfield lands in the Toronto Port Lands through re-naturalizing the mouth of the Don River and extending the river south and west; however, due to the former industrial use of the Port Lands, the planned river route and related redevelopment infrastructure traverse through a heavily contaminated area containing non-aqueous phase liquid (NAPL), as well as other contaminants. A risk-based approach was used to understand the long-term risk management requirements, and the management of excess soils for reuse in the construction of landforms and barriers. Statistical methods were used to select Contaminants of Concern incorporating the use of left-censored data, the distribution and potential outliers of observed COC concentrations and the use of a risk index (concentration/toxicity reference value). Statistical methods were also used to support development of “like-to-like” COC concentration targets for the reuse and relocation of contaminated soil. The process resulted in focusing risk assessment on dozens instead of hundreds of COCs, and developing defensible target concentrations for placement and reuse of soil.
will outline the approach and considerations used to derive sediment IVs that will be protective of both human and ecological receptors exposed to sediments in the newly designed river valley.

657 Communication and Engagement for Port Lands Flood Protection

M. Shenker, Waterfront Toronto / Communications

Port Lands Flood Protection (PLFP) is one of the biggest infrastructure projects in North America. Funded by the City of Toronto, Province of Ontario and Government of Canada, this $1.25-billion project is really dozens of sub-projects. Engineering a river that will look and act like a natural river, modelling our design to ensure we will achieve flood protection, remediating impacted soil and reusing it to raise grades...creating a new island! This project complex to say the least. Its scale and scope make it a project of regional significance. The conditions of our approved Environmental Assessments require us to conduct ongoing consultation as detailed design for new parks, bridges, roads and flood protection infrastructure advances. So, how do you explain the science behind this game-changing transformation to a GTA-wide, general audience? This can be as challenging as the engineering work itself. Communications and engagement for a project of this scope and ambition requires a strategy that accounts for multiple audiences, some with no awareness of the project, or even the project area, and others with deep project knowledge. Thanks to years of advocacy and engagement in the initiative to renaturalize the Don, this presentation will detail the communications and engagement strategies that help communicate what this project will accomplish and why it matters.

658 Citizen Advocacy and Campaign for Flood Protection and River Naturalization

J.K. Wilson, CSS, Inc.

Citizen Advocacy has inspired, defended and sustained the Toronto Port Lands Flood Protection project for almost 30 years. The concept of naturalizing the post-industrial Don River channel first appeared in Bringing Back the Don, the 1991 vision document of the citizen-led Task Force to Bring Back the Don - a dream of a clean, green, accessible river mouth as centrepiece of a transformed Toronto central waterfront. Through iterative cycles of dreaming, inventing, refining, negotiating, organizing, campaigning and advocating, this presentation will tour the high points of a determined citizen campaign. Now federal, provincial and municipal governments together have embarked on this project, which will culminate in an environmental brownfield transformation that is virtually unprecedented in scale, sustainability dividend, and public commitment. As the co-chair of the West Don Lands Committee and eleven years as the chair of the Task Force to Bring Back the Don and from a perspective of central role in CodeBlueTO citizen activist collective, the presenter will provide an overview of the role of citizen advocacy in providing support for this Don River flood protection and naturalization project.

Environmental Risk Assessment of Pharmaceuticals: Connecting Across Disciplines

659 Occurrence, distribution and risk assessment of azole antifungal drugs in wastewater treatment plants

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Presence of azole antifungal drugs in the environment is an emerging concern due to their persistence, ecotoxicology as well as their contribution to the selection of drug resistant fungi in the environment. In this study, the occurrence, distribution and preliminary ecological and human health risks of eight commonly used azole antifungal drugs were seasonally investigated for the first time in three wastewater and one drinking water treatment plants in South Africa. Clotrimazole (CLZ), econazole (ECZ), fluconazole (FCZ), itraconazole (ITZ), ketoconazole (KTZ) and miconazole (MCZ) were detected at least once in either the influent or effluent water samples, while posaconazole (PCZ) and voriconazole (VCZ) were not detected (ND) in the samples of all seasons. FCZ was detected in about 78% of the samples with concentrations ranging from ND to 1303.657 ng L⁻¹. CLZ had the second highest frequency of detection (33.33%) with a concentration up to 143.315 ng L⁻¹. The maximum concentration and detection frequency for KTZ and MCZ were 66.576 ng L⁻¹ and 16.664 ng L⁻¹; about 26% and 18%, respectively, while ECZ and ITZ were detected only occasionally. The preliminary ecological risk assessment based on risk quotient (RQ) calculation indicated that CLZ, ECZ, ITZ and MCZ could pose medium to high risk to fish, while CLZ could pose low to high risk to daphnia and algae. Results of human health risk assessment revealed that FCZ can potentially pose a high risk to human health. Furthermore, risk estimates showed a potential for the detected concentrations of FCZ and ITZ in water samples to pose moderate to high risk for development of antifungal drug resistance. The study highlighted that some of the azole antifungal drugs are ubiquitous in treatment plants and future evaluation and monitoring programs should include those drugs that seem to pose human and ecological risk.

660 Occurrence and Aquatic Risk Assessment of Pharmaceuticals and Other Contaminants in Minnesota Lakes

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Investigations over several years demonstrate that antibiotics and antidepressants, alkyphenols, and disinfectants are common surface water contaminants. Concern is growing over the effects of these chemicals on fish and wildlife as well as human health. In 2015, 50 Minnesota lakes, selected at random, were sampled for a broad suite of pharmaceuticals, alkyphenols, hormones, illicit drugs, anti-corrosive chemicals, and disinfectants. Of the 163 chemicals tested, 55 were found in lakes at least once. All 50 lakes contained at least one contaminant. Detections included eleven antibiotics or anti-fungal medications, five antidepressants, two lipid lowering drugs, and two hormones. Estrone was detected the most frequently, at 70% of the locations, followed by DEET at 50%. The alkyphenols 4-nonylphenol and 4-octylphenol were found in 46% and 24% of the lakes, respectively. The antidepressants sertraline and fluoxetine were detected in 30% and 26% of the lakes, respectively. The anticorrosive chemicals benzothiazole, benzotriazole, and the derivatives of benzotriazole were frequently detected. Based on statistical analysis of these data, 75 percent of Minnesota lakes are likely to contain the hormone estrone, and 43 percent are likely to have detectable concentrations of nonylphenol. Thirty six percent of lakes likely contain oxycodeone and cotinine, 29 percent likely to contain DEET, and 26 percent bisphenol A. The antidepressants sertraline and fluoxetine and the x-ray contrast agent iopamidol are each likely present in 23 percent of the state's lakes. Five of the 39 chemicals that were evaluated for aquatic toxicity - the DEET, estrone, bisphenol A, nonylphenol, and octylphenol - are considered high priority aquatic contaminants. The maximum concentration at which bisphenol A was detected - 177 ng/L - exceeded the acute toxicity value of 60 ng/L. Nineteen of the 55 chemicals are considered intermediate priority at the concentrations detected in this study. Several pharmaceuticals are expected to have half-lives greater than 6 months in water. Only two of the 55 chemicals detected - the mono- and diethoxylates of nonylphenol - are predicted to readily biodegrade in the aquatic environment. However, the likely product of that biodegradation, nonylphenol, is more toxic and more persistent in the aquatic environment than the parent chemicals.
661 Transport and fate of antibiotics in the soil-plant system
R. Johnson, University of York; E. Bergstrom, J. Thomas-Oates, University of York / Chemistry Department; J.B. Sallach, University of York / Environment

Bioactive pharmaceutical compounds are commonly detected in wastewater effluent as a result of inefficient metabolism in the human body and incomplete removal in wastewater treatment facilities. Increasingly, treated wastewater has become a valuable commodity as a source of fresh water for irrigation in an effort to meet demand in water stressed regions throughout the world. The use of treated wastewater for irrigation represents a key pathway for pharmaceuticals to enter agricultural environments. Among these pharmaceuticals are antibiotics which are of high concern as a result of their bioactivity targeting microbes and their potential to select for resistance at sub-inhibitory levels typically found in the environment. Environmental compartments are increasingly recognized for their role as reservoirs for antibiotic resistance. Here we derived an environmentally relevant mixture of antibiotic compounds based upon prescription data from the United Kingdom. A synthetic wastewater effluent combined with the antibiotic mixture was used for irrigation in a 16 week mesocosm study with barley (Hordeum vulgare) as the model crop. The transport of antibiotics in the soil plant system was monitored via targeted analytical measurement of antibiotic concentrations in soil pore water and mesocosm leachate using high performance liquid chromatography with triple quadrupole tandem mass spectrometry. Preliminary findings suggest that some of the antibiotics (e.g. tetracycline, oxytetracycline) are not detectable in the soil pore water. Risk quotients were derived from the measured concentrations using recently published predicted no effect concentrations (PNECs) for the selection of antimicrobial resistance. From this it is possible to identify and prioritise antibiotic compounds posing the most significant risk in the agricultural environment. Laboratory degradation experiments are used to determine antibiotic stability, with degradants being identified using non-targeted high mass accuracy LC-MS. Further experiments to investigate the photolytic degradation products use novel gas-phase UV spectroscopic techniques. From these studies, stable degradation products were identified. The degradation products identified in hydrolysis and photolysis studies were then investigated in soil pore water using non-targeted capillary LC-MS. Results from the present work seek to provide new insights into the fate and transport of human use antibiotics in the agricultural environment.

662 Sorption Characteristics of Pharmaceutical with Soils, Sediments and Sludges
J.A. Elmoznino, Pfizer, Inc. / Environmental Sciences PDM

Adsorption/desorption studies gather information on the mobility and distribution of a chemical in solid-water compartments. These data are fundamental in determining the potential for persistence and bioavailability, for the assessment of environmental fate, and for estimation of potential risk. Since the European Medicines Agency (EMA) environmental risk assessment (ERA) testing guideline was finalized in June 2006, the OECD 106 protocol has been routinely conducted in Phase II Tier A testing for all human pharmaceutical marketing authorization applications. The OECD 106 Adsorption-Desorption Using a Batch Equilibrium protocol is designed for estimating the adsorption/desorption behavior of a chemical with a variety of soils with different physical characteristics, such as organic carbon content, clay content, texture and pH. As per EMA ERA testing guidelines, a sorption study using 2 types of sludge and 3 soil types, following OECD 106, is preferred. Given that active pharmaceutical ingredients (APIs) are introduced into surface waters mainly by discharges from wastewater treatment plants, and that relatively fewer APIs trigger Phase II Tier B terrestrial fate and effects analysis, Pfizer’s strategy since 2009 has been to include 2 sediments, 2 sludge and 2 soils in the OECD 106 study. To date, Pfizer has conducted sorption studies following the OECD 106 protocol utilizing soils, sludge and sediments for 13 APIs; using soils and sludge for 8 APIs, and using only soils for 4 APIs. The primary aim of this study is to relate the OECD 106 Tier 2 sorption kinetics and Tier 3 equilibrium isotherm sorption data obtained for 25 APIs; comparing the distribution coefficients (Kd, Koc, KP) derived, and examining relationships with sludge/soil/sediment physical characteristics. As the new 2019 EMA draft guidelines specify that in the Phase II Tier A assessment for sediment, the highest soil Kd value, should be utilized for the sediment predicted environmental concentration (PECs) calculation, an additional goal of this study is to compare the PECs derived using the highest soil Kd with the PECs derived using the sediment Kd, to ascertain if the use of the soil Kd is a suitable representative for sediment PEC calculations.

663 Sorption of organic cations to organic matter: Use of molecular dynamic simulations in determining binding interactions
S. Scott, Ohio State University / Environmental Engineering; A. MacKay, Ohio State University / Civil, Environmental and Geodetic Engineering

The development of an environmental sorption model incorporating electrostatic interactions is challenged by the lack of knowledge on the specific types of binding mechanisms. Current sorption models for organic compounds are typically derived from their octanol-water partition coefficients (Kow) but are often inaccurate for charged species as they do not adequately account for contributions from ionic interactions. Use of probe compounds in conjunction with a suite of derivatives has been suggested to offer a way to determine structural effects on binding affinities. Herein, a suite of Benzylamine derivatives with varying sizes, polarities, and structural moieties were used to evaluate structural effects to Pahokee Peat binding. Column chromatography studies were performed to obtain empirical sorption coefficients. Isothermal titration calorimetry was used to obtain the full thermodynamic parameters of the experimental systems and electrostatic potential maps were generated and normalized in Gaussian for the suite of Benzylamine derivatives. These maps, in conjunction with the above empirical findings, suggest that binding affinity tends to improve with localization of positive charge (lower amine order) as well as presence of neutral aromatic substituents to enhance the compound push from the water. These qualitative trends provide insight to shifts in the types and extents of interactions with changing compound structure. However, there is still a need to quantify such substituent-specific energy contributions as well as determine underlying binding interactions. Computational techniques may provide a way to identify specific binding mechanisms as well as calculate interaction energy contributions. Molecular docking outputs using AutoDock suggest that primary, secondary, and tertiary amines interact with organic matter carboxylic groups via hydrogen bonds with electrostatic, and van der Waals contributions from the rest of the cation structure. Quaternary amines tend to partition into hydrophobic organic matter pockets rather than participate in hydrogen bonds, and interact through electrostatic and van der Waals interactions. Molecular dynamic simulations using GROMOS and organic matter models built from the Vienna Soil Organic Matter Modeler will be performed with these Benzylamine derivatives to look for further evidence of these binding mechanisms. Understanding such systems at this level may be beneficial in the development of sorption models that can also account for charged species.

664 Using in Vitro and in Silico Data to Assess Potential (Anti-) Estrogenic Activity of Pharmaceuticals in Fish at Environmentally Relevant Concentrations
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Endocrine-active pharmaceuticals can cause adverse reproductive and developmental effects in non-target organisms. Aquatic vertebrates may be susceptible to the effects of such pharmaceuticals as the structure of hormone receptors and the physiology of the endocrine system are highly conserved across vertebrates. To aid in the regulatory review of the environmental impact of pharmaceuticals, we demonstrate an approach to screen and support the prioritization for further testing of pharmaceuticals based on their ability to interact with estrogen receptors (ERs) at environmentally relevant concentrations. Tox21 high-throughput
screening in vitro results from ER agonist and antagonist assays were retrieved for 1,123 pharmaceuticals marketed in the year 2016. In silico predictions from the Collaborative Estrogen Receptor Activity Prediction Project (CERAPP) models were used to estimate ER agonist and antagonist activity for 170 pharmaceuticals which were not tested in the Tox21 assay platform. The “estrogenic effect ratio” (EER) and “anti-estrogenic effect ratio” (AEER) were calculated by comparing the activity concentration at half-maximal response (AC50) for ER agonism and antagonism, respectively, to estimated pharmaceutical concentrations in fish tissue based on bioconcentration factors and high-end estimates of environmental exposures. This approach, using in vitro and in silico data, may help determine the need for submission of environmental assessment data for new drug applications, and support the prioritization of pharmaceuticals for their potential to disrupt endocrine signaling in vertebrates.

665 Environmental risk assessment of veterinary medicinal products in the European Union

S. Hickmann, German Environment Agency (UBA)

The environmental risk assessment of veterinary medicines in the EU follows the VICH guidelines GL6 and GL 38. They inter alia specify the OECD studies for the basic data set on fate and effects in the environment. The use of the VICH guidelines for risk assessment has shown that for specific cases additional guidance or refinement options are necessary. Examples include the published EMA (European Medicines Agency) guidelines on a testing strategy for plants to better characterize the risks of antibiotics, or the assessment of risks for human health and groundwater communities from veterinary pharmaceuticals in groundwater. Work is still ongoing in other fields, such as higher tier testing for dung fauna for parasiticides. In January 2019, the European Commission has published a new regulation on veterinary medicines which will apply from 2022. The Commission has also published a strategy on pharmaceuticals in the environment in March 2019. Additional issues will have to be addressed such as the role of the environment for the development and dissemination of antimicrobial resistance and a new guideline will be developed to assess the risk for the environment from the use of veterinary medicines in aquaculture. The new veterinary legislation also asks the European Commission to investigate the feasibility of a substance based review system (monograph system) until 2022. Such a system would be of high importance to address the fact that there is still no comprehensive information available on the environmental fate and effect of the products authorized before 2005. A topic of importance in European chemicals policy are substances classified as persistent, bioaccumulative, and toxic (PBT), or very persistent and very bioaccumulative (vPvB). When the regulation applies in 2022, PBT substances in veterinary medicines cannot be authorized for food-producing animals unless they are essential to prevent or control a serious risk to animal health. An EMA guideline has been developed for the PBT assessment and a reflection paper discusses management options under the current legal framework. The presentation will provide an overview of recent developments in the environmental risk assessment of veterinary medicinal products in the EU. It will show case studies where research has been translated into regulatory guidance and identify future aspects for collaboration between research and regulatory groups.

666 Veterinary pharmaceuticals in water systems: potential health impact of waste water reuse as management strategy for water security

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South Africa is water stressed and the growing effects of climate change with its extreme weather conditions and erratic rainfall pattern is aggravating the situation with incidence of droughts in many parts of South Africa, including Cape Town in particular, which is a major tourist centre in South Africa. As a result, water security became a concern which could impact on people’s health and on the cities’ economic activity. One of the water management strategies being developed by government is wastewater reuse for both domestic and agricultural uses. However, with the increasing occurrence of some pollutants of emerging concern in the wastewater systems, there are concerns that this practice may expose people to these chemicals which may pose a health threat to them. Emerging contaminants (ECs) are substances whose presence and significance are only being recognised. Many ECs are persistent in the environment and have been associated with several disease in humans. Our studies in the Cape Town environment have indicated the presence of such chemicals in wastewater systems. Veterinary pharmaceuticals such as antibiotics, anti-parasitic agents and hormones (natural and synthetic oestrogens and androgens) are classified endocrine disruptors (EDs). High Performance Liquid Chromatography coupled to ultraviolet detector (HPLC-UV-Vis) method was optimized and validated for the separation and detection of phenols and prioritised pharmaceuticals. Multi-residue solid phase extraction (SPE) procedure was developed and validated for the recoveries of acetaminophen (AC), dichlophenac (DP), salicylic acid (SA), tetracycline (TC), chloramphenicol (CHR), ciprofloxacin (CP), bisphenol-A (BPA), 17β-estradiol (E2), estriol (E3), and ivermectin (IV). These pharmaceuticals were determined in wastewaters from agricultural wastewaters using the hydrophilic-lipophilic balance (HLB)-SPE column. The list of the 10 priority pharmaceuticals were developed by a screening programme and from information on the pattern of use in the Western Cape Province. Bioassay methods which are specifically aimed at providing information that could be related to potential human health effects of residues of the investigated pharmaceuticals were used to assess the health risks of the pharmaeuticals at the levels they occur in the water systems. The bioassays included the Ames mutagenicity test, and the YES (yeast oestrogen screen) test, for oestrogenic activity. These provide a broad indication of effluent quality and are often recommended as screening tests for wastewater reuse. Ten priority pharmaceuticals were identified from the screening programme - acetaminophen (AC), dichlophenac (DP), salicylic acid (SA), tetracycline (TC), chloramphenicol (CHR), ciprofloxacin (CP), bisphenol-A (BPA), 17β-estradiol (E2), estriol (E3) and ivermectin (IV). Recoveries of pharmaceuticals using HLB-SPE cartridges and HPLC-UV/vis varied between 76.62% for 17β-estradiol and 94.34 % for acetaminophen. Several levels of veterinary drugs were detected in the wastewater samples using HPLC-MS systems - AC, < 0.48 - 1.07 µg/l; SA, < 1.37 - 15.49 µg/l; TC, < 3.45 - 4.57 µg/l; CP, 0.45 - 2.46 µg/l; and IV, < 1.74 - 1.63 µg/l from the various livestock activities - poultry, cattle, sheep and pig. The results of the health risk assessment clearly showed mutagenic activity being observed in samples from sheep and poultry farms. Observations from quantitative health risk assessment bioassay suggested that where the concentration of 17β-estradiol approached the maximum concentration detected in the environmental samples, there was a slight indication of the risk of developing cancer through accidental ingestion via recreational activities only. The Ames test results also revealed clear mutagenic activity in samples from sheep and poultry farms, with mutation ratios ranging from 6 times, to close to 8 times the natural background mutation rate. Also, high levels of oestrogenic activity were observed in effluent from the pig farm, with considerably lower levels in the effluent from a sheep farming area. The estrogenic activity from the poultry farm effluent was below the level of detection. If the wastewater were used for domestic purposes and sufficient treatment to remove the emerging contaminants of concern was not made, or if the water was used for irrigation purposes, greater risks could be expected.
Environmental Radiation Sciences

667 Fate and transport modelling of the decommissioned Beaverlodge Uranium Mine Site
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Uranium-bearing minerals were first discovered in the Beaverlodge area of northern Saskatchewan in 1934. Mining and milling started in 1952 and continued for a 30-year production period. Decommissioning and reclamation were undertaken according to the approved plan; the work was completed by 1985. Since that time, monitoring of the receiving environment has continued as specified in the decommissioning plan. Measured data demonstrate that recovery in the immediate and downstream environments is occurring slowly, and generally as predicted; however, levels of radionuclides such as radium-226 and uranium, as well as other contaminants, remain above background and environmental quality guidelines. In recent years work has been undertaken to develop a final site clean-up strategy which would allow for ultimate close-out of the area. In order to aid the decision making process, contaminant dispersion modeling has been carried out in the post-decommissioning period for the immediate and downstream environment employing a tool called the Beaverlodge Quantitative Site Model (QSM). Model calibration was carried out using 13 years of water quality and occasional sediment data. This presentation will review the current state of the environment in the area of the decommissioned Beaverlodge mine site 30 years after decommissioning. The investigations and modelling of the fate and transport of Ra-226 and uranium will be discussed. This will include an examination of controlling factors, which can vary between the former mining areas and within the tailings management area. The water quality shows significant seasonal variability in smaller waterbodies due to the influence of ice cover and spring freshet. Recent fish chemistry data are available from the area including information on lake trout, lake whitefish, northern pike, and white sucker. The differences in concentrations, that relate to environmental concentrations and diet preferences, will be discussed as well as the implication on dose.

668 Evaluation of Radiation Doses for Workers in the Oil and Gas Exploration Sector
S. Landsberger, University of Texas / Nuclear and Radiation Engineering Program

Perhaps the first discovery of radioactivity in oil dates back to 1904 at the University of Toronto, just a short eight years after its discovery by Bequerel in 1896 in Paris. Burton discusses the presence of a highly radioactive gas obtained from crude petroleum. In 1904 McLeenan also at the University of Toronto University discussed the radioactivity of mineral oils and natural gases. Interestingly these samples were from Ontario oil and gas fields. While the existence of radioactivity of oil has been known for a long time, it was not till the early 1990’s that many papers and reports were published on well characterized activity levels in different oil and gases. By the early 2000’s and beyond a multitude of papers were published from many oil producing nations. At the University of Texas we have performed Monte Carlo (MCNP) simulations with the Oak Ridge National Lab human phantom to calculate the dose distribution throughout the human body and thus demonstrating radiation effects in each individual organ based on typical radioactivity levels found in west Texas oil scale. Results have shown that for the average worker in the field dosimeters should be kept at the lower ends of the body instead of the usual chest height.

669 Dynamic Modeling of Radionuclide Transfers in the Marine Environment in the English Channel from Discharges to Biota
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Radionuclide transfer parameters between water and biota recommended in the literature are generally limited to the concentration factor values (CF). So a steady state must be assumed when using them for modeling. But in the event of an accident or in the close vicinity of a regular input source where concentrations are maximal, sharp changes in seawater concentration are likely to occur and the assumption of a steady state is usually not met. Dynamic modeling requires taking into account the kinetics of the transfer, usually characterized by the radionuclide biological half-life (t1/2), but recommendations for t1/2 values are still scarce. The nuclear reprocessing plant of ORANO La Hague (France, Normandy) is the major source of liquid radioactive discharges to the marine environment in the English Channel. A hydrodynamic model has been extensively validated by matching several thousands of calculated and locally observed concentrations in seawater. It is now available to reliably predict the dispersion of radioactive discharges in this area. It is also possible to calculate the corresponding seawater radionuclide concentrations in locations where long time-series measurement in biota are available. Using the calculated signal in seawater and the observed signal in biota, it is possible to derive dynamic transfer parameters (CF, t1/2) to model radionuclide transfers between seawater and the biota. This data processing was performed with radionuclides data including Cs-137, Co-60, I-129, monitored in algae, mollusks, crustacean and fish, around La Hague Cape. In addition, a distribution analysis of the residual between the calculated and observed values was carried out. On the basis of this data processing, recommendations for dynamic transfer parameters (CF, t1/2) values are proposed for these radionuclides and these recommendations are supported by documenting the reliability of the modeling from the discharges down to the biota.

670 Impact of iron-55 and stable iron chlorides on uptake and sorption of plutonium-239 in liquid cultures of common environmental microorganisms
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The mechanisms and impact of low doses of ionizing radiation on biological and environmental systems have been historically difficult to study. Modern biological tools have provided new methods for studying these mechanisms but applying these tools to a dose-response relationship may require refinement of dosimetry techniques, particularly when assessing the impact of low doses of ionizing radiation on environmental systems. In this work, Escherichia coli, Pseudomonas putida, and Saccharomyces cerevisiae grown in liquid culture were exposed to low dose rates of plutonium-239 and iron-55, both alone and in combination. The fractionation of plutonium-239 and iron-55 between the growth media and cell pellets was analyzed via liquid scintillation counting. Plutonium binds readily to many organic compounds and cell surfaces at near neutral pH, however cellular production of chelating agents, especially siderophores meant for transporting iron, has been observed to allow for direct uptake of plutonium into cells in the literature. By investigating the uptake and sorption of plutonium-239 in cells grown with and without iron-55, we can better understand the impact of cellular ligand production on plutonium uptake/sorption and improve assessments of dose and response. This work is part of a project focused on evaluating the potential of common environmental microorganisms to serve as biosensors for the field of nuclear forensics and non-proliferation. The implications of these findings, however, also provide broader insight for the investigation of low-dose radiation effects on biota.

671 Effects of in vivo exposure to tritium (HTO and OBT) in fish
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Canadian Nuclear Laboratories (CNL) and France’s Institut de Radioprotection et de Surete Nucleaire (IRSN) conducted a collaborative
field study at Chalk River Laboratories (Ontario, Canada) to characterize the effects of tritium on fish health. Fathead minnows were exposed, through water and feed, to tritium activity concentrations ranging from 2 to 23,000 Bq/L for 60 days, followed by a 60-day depuration period. A battery of biological health indicators were measured and tritium effects were dissociated from confounding factors using multivariate analyses. No effects were observed on survival, fish condition or metabolic indices for internal dose rates reaching 0.15 µGy/h. It was, however, noted that tritium exposure increased DNA damage and induced changes in fatty acids of minnows. Tritium was also found to increase the responses of the immune, neural and antioxidant systems. Following the field investigation, a complementary experiment was conducted in a laboratory setting. Male fathead minnows were exposed to tritium activity concentrations up to 180,000 Bq/L for 60 days, followed by a 60-day depuration period. The highest internal dose rate was estimated to be 0.65 µGy/h. In agreement with the field study results, no effects were observed on survival, fish condition or metabolic indices and, tritium was shown to increase DNA damage and modulate the immune responses at the highest exposure levels. Changes in other markers, including the neural system, oxidative stress and fatty acid composition, were also observed. No effects were seen on anti-oxidant activities. Fish health results from the field and laboratory studies were in general agreement. It was, however, noted that immune makers did not correlate as well with DNA damage markers in a field context. In addition, the phagocytosis activity was much higher in the field compared to the laboratory.

672 Environmental radiation levels accurately predict past radiation exposure in Chernobyl birds
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Ecological research in Chernobyl has shown that local populations of birds from contaminated sites are experiencing deleterious genetic, physiological and morphological effects. These effects seemingly translate in reduced reproductive success and increased mortality for local populations of birds, exerting selection pressures that might have contributed to adaptation to radiation. Some of these findings, however, have been deemed inconclusive based on the lack of direct measures of the doses received by local birds, which have been typically inferred from environmental measurements. We tested whether environmental radiation measurements using a hand-held dosimeter accurately predicted past radiation exposure in a diverse community of understory birds. To this aim, we captured birds in woodland sites and farms that differed for environmental radiation levels over more than three orders of magnitude. We then conducted gamma spectrometry of individual birds in the field using a portable SAM 940 Radioisotope Identifier (Berkeley Nucleonics, San Rafael, CA) equipped with a sodium iodide (NaI) detector. We also estimated the external dose received by birds using GR-200A LiF:Mg,Cu,P thermoluminescent dosimeters (TLDs), attached to standard aluminum bird bands. Environmental levels measured in the site of capture of each bird accurately predicted the internal dose received by the birds, as indexed by activity concentrations in their body. Environmental radiation levels also predicted the dose received by the TLDs during a month-long period between subsequent captures for a subsample of birds. For both relationships the strength of the association varied among closely-related passerine species, thus highlighting the limitation of radiological protection approaches based on reference animals. Environmental radiation levels in the site of capture of wild birds overall reliably indicate past radiation exposure. The existence of variation across species in this relationship suggests that species-specific behavioral and ecological traits are involved in determining a species’ exposure to radionuclides under realistic ecological conditions, thus calling into question the validity of dose estimation approaches based on reference organisms.
Broadening the Scope of Chemical Assessments Using Toxicokinetic Data

675 Evaluation and comparison of intrinsic metabolic clearance using isolated hepatocytes from humans, rats, and rainbow trout
S.R. Black, RTI International / Discovery Sciences; K.A. Fay, General Dynamics Information Technology / Office of Chemical Safety and Pollution Prevention; J.W. Nichols, US Environmental Protection Agency / ORD NHEERL / Mid-Continent Ecology Division; S. Matten, US Environmental Protection Agency / Office of Science Coordination and Policy; S.G. Lynn, US Environmental Protection Agency / Endocrine Disruptor Screening Program (EDSP)

The US Environmental Protection Agency (EPA) is statutorily required under the amended Toxic Substances Control Act to reduce and replace vertebrate animal testing to the extent practicable and scientifically justified. To this end, EPA conducted in vitro metabolic clearance assays using cryopreserved hepatocytes to collect chemical and species-specific data for use in in vitro to in vivo extrapolation (IVIVE) models. A total of 54 chemicals were evaluated for in vitro clearance at two concentrations using hepatocytes derived from humans, rats or rainbow trout. Hepatocytes were incubated with a test chemical and sampled over time to determine clearance rates, with heat-treated controls (HTC) run concurrently. Each dataset (live cell and HTC depletion data for each chemical/dose/species) was evaluated and binned based on HTC recovery to determine if clearance rates from the live cell assays could be reported. Of the 238 unique datasets, 75 datasets were excluded due to poor performance in HTC recoveries (< 50% or > 130%). A total of 34 datasets had HTC recovery ranging from 50 to 80%. For these datasets, the ratio of the slope derived from the live cell assays to the slope derived from the HTC assays was evaluated. A total of 21 datasets had a ratio > 20, indicating substantial hepatic clearance of the chemical above HTC loss, while the remaining 13 datasets were excluded from rate reporting. Of the 150 datasets meeting reporting criteria, a total of 22 had 2 or fewer data points above the Limit of Quantitation and were simply reported as having “Fast” clearance, leaving 128 datasets with reportable rates. Clearance rates varied among species, generally indicating slower chemical clearance by trout hepatocytes. In general, clearance rates with rat or human hepatocytes were within 2-fold agreement; however, 3,3’5,5’-tetrabromobisphenol A, mestranol, picoxytroisin, terbutylazine, and triclocarban were cleared at least 3 times more quickly by rat hepatocytes. Conversely, cerceoxib was cleared faster by human hepatocytes. Overall, this work provides a large collection of in vitro clearance data for cross-species comparisons and supports IVIVE applications such as reverse toxicokinetic modeling and bioconcentration factor predictions. The views expressed in this abstract are solely those of the authors and do not represent the policies of the USEPA. Mention of trade names or commercial products should not be interpreted as an endorsement by the EPA.

676 Using S9 clearance rates and membrane-water partitioning to predict surfactant bcf values for fish
S. Droge, University of Amsterdam / IBED Institute; M. McLachlan, Stockholm University / Environmental Science and Analytical Chemistry (ACES); J.W. Nichols, US Environmental Protection Agency / ORD/NHEERL / Mid-Continent Ecology Division; J.M. Armitage, AES Armitage Environmental Sciences, Inc. / Physical and Environmental Sciences; J.A. Arnot, ARC Arnot Research & Consulting

Surfactants are challenging chemicals to work with, as they may: accumulate at all kinds of interfaces, occur in complex mixtures, be readily biodegraded during testing, and fall outside the applicability domain of current test guidelines and models. In particular, there are often no or highly uncertain octanol-water partition coefficients (Kow) for surfactants. In the CEFIC-ECO37 project we focused on series of individual surfactant structures and measured cell membrane-water partition coefficients (Kmw) to potentially replace Kow model parameters. In addition, we measured in vitro intrinsic clearance (CLint) using trout liver S9 fractions to determine the potential impact of biotransformation on fish bioaccumulation factors. Trends in Kmw and CLint with surfactant structure have been identified that allow for extrapolations to analogue structures within various surfactant types. In parallel, we determined in vivo fish BCF values for strategically composed mixtures of surfactants with rainbow trout, in order to evaluate and further refine model predictions based on Kmw and CLint. The model captures the influence of ionization, pH and key sorptive and biotransformation properties that influence uptake and elimination rates. Currently, a matrix of in vivo and in vitro data have become available for a set of 12 cationic surfactant structures, and 8 nonionic surfactants. BCF values increase with stronger sorptive properties, and decrease with stronger ionization. Including biotransformation appears to align the model predictions closer to observed values resulting in agreement within a factor 10 for most tested compounds. Remaining challenges of the approach, e.g. in terms of quantitative in vitro-in vivo extrapolation (QIVIVE) and surfactant chemical domains, will be discussed.

677 Measurement of unbound chemical fractions of hydrophobic chemicals in rainbow trout liver S9 fractions and blood plasma using a passive dosing method
L.J. Saunders, Simon Fraser University; G. Diaz Blanco, Polytech Nice Sophia / Department of Environmental Engineering; Y. Lee, V. Otton, F. Gobas, Simon Fraser University / Resource & Environmental Management

Recent studies demonstrate the utility of in vitro-in vivo extrapolation (IVIVE) approaches for evaluating the impact of biotransformation on chemical bioaccumulation in fish. In the IVIVE approach, a chemical biotransformation rate is measured in a hepatic in vitro system and is then extrapolated to estimate a whole-body biotransformation rate in fish, which are in turn can be used as an input in a mass balance models to predict a steady-state bioconcentration factor (BCF). Although the inclusion of in vitro biotransformation rates substantially improves BCF predictions, there remains a consistent tendency for IVIVE methods to overestimate BCFs relative to empirical BCF values. Several studies show that BCF overestimates are typically observed when hepatic clearance is assumed to be controlled by the unbound (i.e. free) chemical concentration in vitro and in vivo. Instead, improved agreement between predicted and empirical BCFs was obtained by assuming that chemical bioavailability in S9 fractions and blood plasma is effectively the same (TU = 1.0). Several studies have highlighted the uncertainty in algorithms used to estimate the fraction unbound and represents a priority research need. Here we present results from passive dosing experiments (sorbent phase dosing with ethylene vinyl acetate [EVA]) performed to obtain equilibrium partitioning measurements for several hydrophobic test chemicals (log Kow 4-8) in rainbow trout liver S9 fractions and blood plasma. For all test chemicals, equilibrium in the EVA test-system was achieved within 24h. The unbound chemical fractions in liver S9 fractions (ϕS9) and blood plasma (ϕP) were obtained for the test chemicals and were compared to predictions using available binding algorithms. Binding correction factors (TU = ϕP/ϕS9) determined for the test chemicals were always less than 1.0 and was expected given the higher lipid content of blood plasma (1.27%) compared to liver S9 fractions (0.01%). Our findings also suggest that lipid may be a more important determinant of binding for hydrophobic chemicals than protein, and should be considered when evaluating the fraction unbound in subcellular fractions.

678 Toxicokinetic Modelling of Trophic Transfer of Octylphenol between Chlorella vulgaris and Daphnia magna
J.C. Achar, J. Jung, Korea University / Environmental Science and Ecological Engineering

Octylphenol (OP) is widely used in the production of plastic additives and non-ionic surfactants, causing endocrine disruption, carcinogenicity and reproduction inhibition on aquatic organisms. The bioconcentration of OP in freshwater algae and subsequent transfer to aquatic invertebrates is very important to evaluate its ecological risk. We applied one
Evaluating the PBT potential of organic chemicals in the environment. Quantification of biotransformation rate remains a major challenge in Environmental Engineering.

Determining Biotransformation Rate Constant Using Early Biota Concentration Data

Quantification of biotransformation rate remains a major challenge in evaluating the PBT potential of organic chemicals in the environment. A simplified approach is proposed for the derivation of biotransformation rate constant (kM). It is proposed that kM can be estimated using the molar equivalent fraction of residual parent compound at early times during the uptake phase. This method requires no data fitting or model estimates on other toxicokinetic parameters. The proposed equation was tested against experimental kM's derived from data regression or optimization of kinetic data. The short-cut method performed accurately (n=42, RMSE=0.31) and superior to accuracy of typical toxicokinetic models. The proposed equation satisfies the major requirements needed for a valid kM equation. Theoretical analysis shows that the short-cut method converges with the solution of established toxicokinetic equations for biotransformation under both constant exposure and decay exposure scenarios. The behavior and limitations of the short-cut method are demonstrated by simulation results. It is found that the error in log kM estimates increase with larger depuration or transformation rate constants. This is also consistent with the expectation that kM is accurate using measurements made at early times. A general protocol for efficient characterization of large number of organic compounds in diverse biota is discussed. The proposed short-cut method will support and speed up investigation on interspecies difference on biotransformation of organic contaminants.

Toxicokinetic modeling of systematic pesticides in aquatic organisms: The impact of transformation on bioaccumulation

Pesticides have become a great threat to ecological biodiversity at a global scale and it is imperative to evaluate ecological risk related to pesticide use. Degradation and biotransformation are critical processes modifying the bioaccumulation and toxicity of organic pollutants in the environments. Compared with legacy organochlorine pesticides, current-use pesticides have a greater tendency to be transformed in abiotic environment and biota, requiring better understanding on the roles of degradation and biotransformation on their bioaccumulation. In this presentation, two systematic insecticide, fipronil and imidacloprid were selected as the representative chemicals of easily metabolizable pesticides. The study included two exposure scenarios for fipronil. One is the biotransformation and bioaccumulation of waterborne fipronil in fish (tilapia, Oreochromis niloticus). The other is the degradation, biotransformation and bioaccumulation of sediment-bound fipronil in a benthic invertebrate (blackworm, Lumbriculus variegatus). Toxicokinetic models were developed to simulate the kinetic processes of fipronil and its more toxic metabolites in both organisms. Tissue-specific accumulation, biotransformation and elimination of fipronil in tilapia were quantified by combining in vivo measurements and the newly developed multi-compartmental pharmacokinetic model. The multi-compartmental model quantitatively demonstrated the highly dynamic intercompartmental transport and rapid branchial clearance of fipronil in fish. Modelling results also suggested that uptake and biotransformation were the stronger driving forces for the inter-compartmental transport of xenobiotics in fish than the intrinsic partitioning capacity. While fipronil sulfone was the main metabolite in fish, fipronil sulfone and sulfide were detected in sediment and the lugworms. To incorporating the degradation of fipronil in sediment into toxicokinetic model of fipronil in the blackworms better explained the biotransformation and bioaccumulation of fipronil in organisms. In addition, varying toxicity of imidacloprid to four invertebrates were explained by their different toxicokinetic processes. Overall, our findings highlight the importance of degradation and biotransformation on the internal disposition and bioaccumulation of fipronil in aquatic organisms, which helps to improve the aquatic toxicity assessment of easily metabolizable pesticides.

Interpreting OECD 305 dietary bioaccumulation tests with the ADME-B calculator: BCFs, BMFs and biotransformation rates

Current OECD 305 guidelines for bioaccumulation tests include the option to conduct a dietary bioaccumulation test for assessing a chemical's bioaccumulation behaviour. However, the one-compartment toxicokinetic model that is used to analyze the results of dietary bioaccumulation tests is out-of-step with the current bioaccumulation science and experimental practices and information needs for bioaccumulation and risk assessment. This study presents (i) a two-compartment toxicokinetic modeling framework for describing the bioaccumulation of neutral hydrophobic organic chemicals in fish; and (ii) an associated toxicokinetic analysis tool (ADME-B calculator) for the analysis and interpretation of the results from dietary bioaccumulation test in terms of the adsorption, distribution, metabolism and excretion (ADME) of chemicals for the purpose of bioaccumulation (B) assessment; and (iii) an error analysis and statistical tests for comparing bioaccumulation metrics to criteria values. The model framework and ADME-B calculator were applied to the analysis of 32 OECD-305 dietary bioaccumulation tests involving 166 unique organic chemicals. Bioconcentration and biomagnification factors, as well as somatic and intestinal biotransformation rates were derived from this analysis. The findings indicate that the advantage of the two-compartment fish toxicokinetic model over the one-compartment fish model is that the effect of the exposure pathway on the bioconcentration and biomagnification factor of biotransformed chemicals can be quantitatively taken into account. This is important for the application of a weight-of-evidence based approach to bioaccumulation assessment where information from both aequous and dietary bioaccumulation tests needs to be interpreted in terms of the chemical's bioaccumulation potential in the environment.

Perfluoroalkyl acids: Aquatic food web biomagnification insights

Despite nearly two decades of environmental monitoring of perfluoroalkyl acids (PFAAs), unusual patterns in these compounds’ bioaccumulation and trophic transfer suggest incomplete understanding of these complex processes. More specifically, trophodynamic studies on aquatic food webs have found low trophic level organisms can accumulate equal or greater PFAA concentrations relative to top predators. These findings suggest that additional aspects beyond direct trophic transfer govern PFAA trophodynamics. PFAAs are essentially chlorine-substituted endogenous fatty acids, and literature has routinely highlighted the importance of protein-ligand interactions in PFAA accumulation/elimination. Work in progress seeks to gain insight regarding the potential relationship between blood protein variability and PFAA accumulation among multiple fish species of the Lake Ontario aquatic food web. To accomplish this, paired analyses
of protein content and PFAA concentrations in blood serum from alewife (
*Alosa pseudoharengus*), deepwater sculpin (*Mxyoscephalus thompsonii*),
and lake trout (*Salvelinus namaycush*) were performed with the goal of
identifying whether intra- and/or interspecies blood protein variability
may drive differences in PFAA burden.

**Integrating Pest Management, Risk Assessment and Environmental Sustainability**

*683 Effectiveness of an Integrated Wetland Treatment System in Reducing Pesticide Concentrations Associated with Agricultural Runoff*

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Laboratory at Granite Canyon / Environmental Toxicology; B.M. Phillips,
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The Salinas Valley in Monterey County, California, USA, is a highly
productive agricultural region that produces much of the country’s salad
greens, strawberries, artichokes, and cruciferous vegetables such as
broccoli, cauliflower, and Brussels sprouts. Agricultural irrigation runoff
containing pesticides at concentrations toxic to aquatic organisms poses
a threat to aquatic ecosystems within local watersheds. This study was
designed to monitor the effectiveness of a constructed wetland treatment
system with a granulated activated carbon (GAC) filter installation at
reducing pesticides associated with agricultural runoff. The addition of
pennywort (*Hydrocotyle*

 Additional samples were analyzed for 172 fungicides, herbicides and
insecticides. Input water was toxic to *H. azteca* in two trials and *C. dilutus*
in one trial, but toxicity was reduced as water moved through the treatment
system. Toxicity to *C. dilutus* occurred and persisted during the first
trial, likely influenced by elevated conductivity. Collectively, the system
reduced fungicides by 44%, herbicides by 55%, and insecticides by 60%. The GAC filtration component provided additional average concentration
reductions in all pesticide groups across all trials. Results suggest that a
wetland treatment system coupled with GAC filtration can significantly
reduce pesticide concentrations in agricultural runoff.

*684 Ants on Cucurbits: Their diversity, ecological role, and exposure
to pesticide residues*

A.D. Fairweather, J.M. Schmidt, N. Raine, University of Guelph / School
of Environmental Sciences

Ants (Hymenoptera: Formicidae) are highly abundant in terrestrial habi-
tats, in which they often provide a range of important ecosystem services.
Surprising little is currently known about the value of ants in crop-
ning systems. Here we investigated the abundance and diversity of ants
found in cucurbit crops, their role as ecosystem service providers (e.g.
biocontrol), how they are exposed to pesticides, and the impacts of that
exposure. We have documented 16 species of ants across four subfamilies
interacting with cucurbit crops on 6 major farms and 1 field test site in
southern Ontario. Two species, *Lasius alienus* and *Prenolepis imparis*,
were discovered nesting in all areas of these crop fields. *Lasius alienus*
preferentially nested in the root systems of cucurbits and was observed
feeding on major cucurbit pest species. These ants potentially provide
significant beneficial pest regulation services, while simultaneously being
exposed to pesticides via contact with soil or plant surfaces, or ingestion
of contaminated nectar. Our research is the first exploring the ant diver-
sity and ecology found on a high value crop in southern Ontario, and their
exposure to pesticides. This research has important implications for pest
control in Cucurbita fields, environmental risk assessments, and increas-
ing our ecological knowledge about these agriculturally relevant ant taxa.

*685 The Pesticide Loss from Agricultural Field Model*

S. Lyons, K.J. Hageman, Utah State University / Chemistry & Biochemistry

Global pesticide usage has been estimated to total over 6 billion pounds
annually with costs to producers exceeding $50 billion. Due to the costs
associated with pesticide usage as well as the adverse effects on human
health and sensitive, non-target ecosystems, it is vital that pesticide fate is
better understood so improved management practices can be implemented
to save money and preserve the health of the environment and its inhabit-
ants. With this in mind, the Pesticide Loss from Agricultural Field model
was developed using partition coefficients and photodegradation rates
on leaves to predict pesticide losses following application. A key model
output is the time for dissipation to half of the initial concentration (DT50)
due to volatilization plus photodegradation. The model was validated by
comparing modeled DT50 values to 40 measured values reported in the
literature that covered 7 pesticides and 23 plant types. Along with DT50,
other outputs of the model include loss contributions from volatilization
and photodegradation, the cumulative loss after 24 hours, and estimated
concentrations for the soil and plant compartments. The model was used
to probe questions related to how time of day and time of year of applica-
tion impacts dissipation. Simulations for the seven pesticides used in
validation were run to mimic a summer and autumn application. In addi-
tion, time of day of application was also varied to represent a morning,
afternoon, and evening application. The extended DT50 values predicted
for the autumn application is expected due to increased volatilization
and photodegradation occurring in the summer months when tempera-
tures and solar radiation are elevated. Time of day of application is less
important than the time of year, however, it becomes an important factor
for pesticides that dissipate rapidly as is shown by some pesticides having
their DT50 extended by over 50% when the application occurs later in the
day. All of this shows the model’s ability to represent pesticide fate for
a variety of conditions and its value in providing farmers with informa-
tion regarding the fate of pesticides on plants following application. In
the future, dissipation and photodegradation studies will be conducted to
expand and optimize the model and it will be linked with toxicity thresh-
olds to provide farmers with information on how long their pesticide is
effective against pests and when it is safe to introduce pollinators.

*686 Digital tools and data science enable conservation on agricul-
tural lands*

P.M. Bachman, Bayer Crop Science / Regulatory Science; P. Carroll, F.
Dohleman, S. Ward, The Climate Corporation

Modern agricultural innovations, including the application of digital tools
and data science can help support sustainable and productive agricultural
practices and decision making, and can facilitate the incorporation of
habitats to support biodiversity in agricultural as well as non-crop areas
of the landscape. Digital applications also can help characterize and
maintain functional habitats on public and private lands. Specific to agri-
culture, satellite imagery, data analytics, and vegetation maps can help
farmers identify and elect to set aside patches of habitat alongside crop
fields for the benefit of multiple non-target species including those that
support ecosystem services. Suitable habitat sites could be non-crop areas
in agricultural landscapes, including field borders, conservation strips,
riparian buffers, roadsides, Conservation Reserve Program (CRP) land,
marginal land, wetlands, easements, and utility rights-of-ways. Ensuring
functional habitats for non-target species can appear to be at odds with
a variety of land use objectives: crop and livestock production, urban-
ization, housing, transportation, and industry. To be successful, these
efforts generally require cooperation of multiple stakeholders including
private landowners, government agencies, academia, non-governmental
organizations, and the private sector. This presentation will focus on how cross-sector partnerships and the application of digital tools to promote landscape management decisions that can meet multiple land use objectives, have been developed and utilized to support multi-species habitat efforts and conservation programs.

687 Topeka shiner populations in the context of multiple stressors: a hybrid modeling approach
A. Schmolke, Waterborne Environmental, Inc.; S.M. Bartell, Cardno, Inc.; C. Roy, N.S. Green, D. Perkins, Waterborne Environmental, Inc.; N. Galic, R. Brain, Syngenta Crop Protection, Inc. / Environmental Safety

Threatened or endangered species face challenges to their continued existence from multiple stressors. For example, habitat loss and modification were indicated as substantial threats to the Topeka shiner (Notropis topeka), a small cyprinid fish endemic to the US Midwest, when it was listed under the Endangered Species Act. Topeka shiner habitats are associated with intensive row crop agriculture, overgrazing, urbanization, road construction, and hydrologic alteration. However, assessments of risks to the species are usually limited to individual factors, such as direct effects from potential exposures to pesticides. We developed a hybrid modelling approach to assess Topeka shiner population dynamics and viability within the context of multiple factors including physical habitat characteristics, water quality, and land management practices. Topeka shiner habitat restoration efforts in Iowa are focused on restoring oxbows. Therefore, we simulated physical and chemical characteristics of these oxbow habitats, including their food web structure, as well as aspects of Topeka shiner biology and ecology. Land management was modeled indirectly by characterizing associated alterations of environmental inputs to the modeled oxbow. Land management influences included alterations to oxbow hydrology, temperature, light exposure, and influxes of nutrients, sediments, and pesticides. We analyzed scenarios of realistic ranges of these conditions in Iowa oxbows to assess their implications for long-term population dynamics of the Topeka shiner. With this hybrid modeling approach, we present a methodology for integrated assessments of ecological risks posed by land management and benefits of conservation measures designed to recover listed species. This modelling approach is intended to complement endangered species assessment by informing conservation/stewardship activities in an effort to enhance species viability.

688 Refinement of pesticide exposure estimates through robust incorporation of spatial datasets
M.F. Winchell, H. Rathjens, Stone Environmental Engineering & Science, Inc. / Environmental Systems Modeling

A critical component to advancing pesticide ecological risk assessments is the improvement of pesticide exposure estimates across the landscape. Numerous environmental factors contribute to variability of pesticide exposure potential in both space and time. Traditional screening level approaches to estimating pesticide exposure make generalizations in landscape characteristics that lead to conservative scenarios assumed to apply over broad geographic regions. This generalization of conservative exposure predictions does not allow for the identification of actual locations and conditions that lead to the highest exposure risk, which in turn does not allow for the adoption of conservation measures that result in the greatest ecological benefit. Methods and data sets that allow for spatially explicit predictions of pesticide exposure have been developed over the past decade or longer and are gradually making their way into more routine ecological exposure and risk assessments. Many of these methods rely upon multiple years of high-resolution land use and crop data sets at the national scale to characterize potential pesticide use sites and are coupled with high resolution landscape data sets, such as elevation, slope, and hydrography. Application of these methods allow for prediction of probabilistic pesticide exposure distributes at a spatial scale, such as a water body or small catchment, that can more accurately assess risk to ecological communities or individual species and strategically target effective conservation measures. Examples of these spatially explicit pesticide exposure modeling approaches will be presented along with a discussion on how barriers to their wide implementation in ecological risk assessments might be overcome.

689 Genetically Engineered Crops: An Integral Component to Achieve the Benefits of IPM
S. Levine, Bayer AG - Crop Science Division / Regulatory

Over fifty years ago, an integrated concept combining chemical and biological control became the foundation for all integrated pest management (IPM) programs. Genetically Engineered (GE) crops producing insecticidal Bacillus thuringiensis (Bt) proteins have become an important component of IPM, particularly in cotton. GE crops were planted on over 100 million hectares in 2018 and have been one of the most quickly adopted pest control technologies in part because of the role in IPM. Assessment of environmental safety has been, and continues to be, a key element of research for GE crops. Extensive laboratory and field testing has been conducted to evaluate the potential impacts of Bt crops on multiple species of natural enemies. These studies have shown that commercialized Bt proteins are highly selective. Because of their high specificity for their targets they have become a cornerstone in overall integrated pest management (IPM) that compliment other approaches required for sustainable pest control. This presentation summarizes the impact of GE Bt crops on natural enemies through the perspective of risk assessment and how GE crops have enabled biological control to become a more effective component of IPM.

Citizen Science in Environmental Chemistry and Toxicology

690 A citizen science approach estimating titanium dioxide released from personal care products
E. Wu, Jinan University / School of Environment; M. Seib, Madison Metropolitan Sewerage District; A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering

Titanium dioxide (TiO2) has been widely applied in personal care products (PCP), with up to 36% of TiO2 found in PCPs present at the nanoscale. Due to the high quantity produced and wide application of TiO2, it can enter the wastewater treatment plant (WWTP) and ultimately the environment, along with a great potential for human exposure through various routes. Citizen science is utilized to inform the prevalence and usage of TiO2 containing PCP on a household scale, which generates information as to the quantity of TiO2 entering the WWTP, the portion ultimately discharged to the environment, and the individual exposure concentrations. Citizen science inventories were generated to estimate the quantity of TiO2 entering the WWTP from consumer products and to determine which products had the greatest contribution. The estimated values were compared with water samples from the WWTP which quantified the amount of total titanium present using ICP-AES. In terms of exposure, results suggest sunscreen and body wash are two major contributors for dermal route of TiO2 exposure, while toothpaste has some potential for exposure through the oral route. 0.153 - 3.9 mg/day of TiO2 (0.06 -1.4 µg/day of TiO2 NP) was estimated to be ingested when 10% toothpaste ingestion was assumed. The estimated average daily TiO2 exposure ranges from 2.8 to 21.38 mg TiO2/person-day (an estimated 1 to 7.7 mg TiO2 NP/person-day). These values estimated in present study were at a similar level with previous top-down estimations, suggesting that a citizen science approach is valid to estimate the loading of TiO2, and potentially other emerging contaminants, while at the same time engaging with community stakeholders.
691 Microplastics in the Ottawa River: Utilising citizen science to expand spatial sampling for microplastics in water and sediment samples

S. Forrest, J. Vermaire, Carleton University / Geography and Environmental Studies; L. Holman, Ottawa Riverkeeper

Citizen science methods were developed to engage the public and to quantify microplastics in river water and river sediments throughout an approximate 600 km length of the Ottawa River, Ontario, Canada. An established group of volunteers already sampling water quality through a ‘citizen science’ hub for the Ottawa Riverkeeper, engaged in two citizen science projects to expand spatial coverage for detecting microplastics in water and sediment of the Ottawa River. The first project involved filtering 100 L of river water from the Ottawa River, then the volunteers were asked to obtain a 1 L bulk sample of river sediment in a subsequent project. All but one of the river samples (n = 43) contained microplastics, with the vast majority of microplastics identified as microfibres. Microplastic concentrations ranged from 0.02 to 0.41 microplastic pieces per litre. Utilising citizen scientists, or citizen samplers in microplastic quantification for a freshwater ecosystem provides numerous advantages including actively engaging citizens in the research, ease of recruiting volunteers within the established Ottawa Riverkeeper network, and expanded spatial coverage at minimal additional costs. However, despite these advantages, there are some important considerations while working with volunteers. For example, during the research, a small number of volunteers mislabelled sample sheets (e.g. labelling as control instead of river sample) and for the water sampling project, lower volume samples were prone to microfibre contamination. Recommendations for future citizen science sampling programs for freshwater microplastic research include utilising an established and engaged network, ensuring both field and laboratory control samples are included in the research to obtain estimates of contamination with microplastic fibres, and increasing the amount of water filtered to obtain more reliable estimates of microplastic pollution in our freshwater ecosystems.

692 Using citizen science to increase herbicide monitoring data across the state of Wisconsin

A. White, University of Wisconsin, Madison / Civil and Environmental Engineering

The herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) is used in Wisconsin as a treatment for invasive Eurasian watermilfoil. However, the degradation rate and resulting lifespan of 2,4-D can vary widely, with complete degradation observed to range from 70 to 150 days, potentially increasing risk for off-target effects to fish and aquatic plants due to unintended long exposure times. We investigated the microbial and photochemical degradation of 2,4-D in aquatic environments using a large field campaign to monitor 2,4-D loss following whole-lake herbicide treatments in 8 lakes across the state of Wisconsin. We enlisted the help of homeowners on each lake that was studied to collect daily water samples at multiple locations on the lake to better calculate degradation rates. Stakeholders were actively engaged and involved in additionally weekly regular sampling and were shown how to use field equipment as well as were given an opportunity to provide valuable feedback on their perceptions and values around whole lake herbicide treatments. The involvement of the community created a richer data set than just weekly sampling would have allowed and fostered a connection between the community and scientists for long with the intentions of supporting future collaboration and follow up studies.

693 Proper Disposal of Pharmaceuticals: Targeting Communications to Veterinarians

S. Zuck, Illinois-Indiana Sea Grant / University of Illinois Extension; W. Sander, University of Illinois at Urbana-Champaign / Department of Veterinary Clinical Medicine

Pharmaceutical compounds from medications have been detected in waterways for over two decades throughout the United States and internationally. Veterinarians play a significant role in prescribing, directing, and administering medications to all animal patients ranging from dogs and cats to cattle and swine. Better understanding attitudes and practices of veterinary disposal practices provides an avenue to address environmental concerns through education and outreach, policy discussion, and possible interventions. Illinois-Indiana Sea Grant, in collaboration with the American Veterinary Medical Association, the University of Illinois College of Veterinary Medicine, and other partners, have engaged this audience with outreach and communication efforts since 2011. But while prescribing and disposal practices are well known in human healthcare, much less has been characterized in veterinary healthcare, which leaves a gap in the knowledge of how best to reach this audience. A cross-sectional survey of pharmaceutical disposal practices among veterinarians in the Great Lakes Region (Minnesota, Wisconsin, Illinois, Indiana, Michigan, and Pennsylvania) was administered electronically in the summer of 2019. The survey gathered information on each veterinarian’s disposal practices as well as their instruction to clients and outreach needs. Results of this survey will help inform, target, and refine communication of best management practices. By understanding the role of the veterinarian, we can better reach this audience with necessary outreach and communication and a greater impact can occur on reducing medication entering the waterways and the environment.

694 Organic Micropollutants in Lakes in Upstate New York: Citizen-Science Based Monitoring

S. Wang, T. Zeng, Syracuse University / Civil and Environmental Engineering; M. Perkins, Upstate Freshwater Institute; S. Moran, SUNY-ESF / Department of Environmental Studies

Engaging citizen volunteers offers a promising way to form a transferable and scalable monitoring framework with large spatiotemporal coverage while raising public awareness on environmental issues. Citizen-based water quality programs rarely incorporates concurrent monitoring of organic micropollutants (OMPs). To address this gap, we piloted a citizen-based OMP monitoring study in collaboration with lake associations in Upstate New York. We engaged citizen monitors from 18 lakes within the Citizens Statewide Lake Assessment Program (CSLAP) in water sample collection for OMP analysis during summer 2018. We applied a suspect screening method using liquid chromatography-high-resolution mass spectrometry to screen for over 2000 OMPs contained in an in-house database. We confirmed and quantified a total of 35 OMPs and their transformation products in lake water samples collected by citizen monitors. Overall, the summed concentration of OMPs in 18 CSLAP lakes ranged from 4,000 ng/L to 18,000 ng/L, and the most frequently detected OMPs were atrazine, atrazine-2-hydroxy, metolachlor OA, DEET, and benzothiazole. We divided the confirmed OMPs into three categories by their primary uses: pharmaceuticals, pesticides and transformation products, and household chemicals. Based on concentration similarities of OMPs, 18 lakes were clustered into three groups by cluster analysis. We then applied a non-target screening method to identify common mass spectral features present within each lake group. The purpose of the non-target screening is to identify more OMPs in the samples that are not included in the suspect screening. In total, 108 and 81 unique features were prioritized in lake groups 1 and 2, respectively, for further analysis. Our ongoing work focuses on expanding the OMP monitoring network within the CSLAP program and exploring the relationships between OMP occurrence patterns and general water quality and land use data.

695 Mischief in the Harbour: Experiential learning course designed to bridge the gap between scientists and policy makers

E.M. Leonard, McMaster University

This experiential learning course designed at McMaster University (ON, Canada) was a collaborative initiative between McMaster students, the Bay Area Restoration Council (BARC) and CityLAB Hamilton to support the environmental priority created by Our Future Hamilton’s 25 Year Community Vision. The aim is to provide students with fieldwork experience in a relevant context while helping create a better
community in Hamilton, ON, Canada. Hands-on field experience is difficult to obtain during undergraduate and graduate degrees, however, field work is one of the most sought after skills in many government, consulting and industry jobs in the environmental sectors. The field component of this course gave students a sound foundation of field-work basics, as well as providing context to their efforts and most importantly bridged the gap between scientists and policy makers. These skills will be essential for employability and transition to the workforce. Students also gained a greater understanding of the interdisciplinary nature of issues facing the City and how important it is that we all work cohesively together. We provided the City of Hamilton with preliminary data on whether the implementation of boulders to rehabilitate the shoreline will favour the success of the invasive fish species, the round goby. Our results indicate that after a year of boulder implementation, there is a slight increase in round goby success. Students conceptualized a project to help rectify this issue by adding breeding habitat for the two native fish species (long perch and rock bass) that were found in the area and therefore have the biggest probability of success. We hope that these habitats can be implemented in a follow-up course in the spring. It is evitable with our changing climate that weather events, such as heavy rainfall and high winds, that occurred in the City of Hamilton in 2017 will continue at a greater scale and therefore the use of boulders to provide structure to preserve shorelines will continue to be implemented. Therefore, understanding the effects on shoreline ecosystems is paramount to both the support of native fish habitat as well as deterring the success of the invasive round gobies along these shorelines. Creating more experiential and interdisciplinary courses such as this will create sound foundations of communication between universities, policy makers and the community to share knowledge, increase scientific understanding, and improve the overall impact of research being conducted at institutions.

Integrative Avian Ecotoxicology in a Changing World

696 Emerging contaminants in European raptors: Review and recent developments for analysis of bisphenols and benzophenones

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The European Raptor Biomonitoring Facility (ERBF) COST Action is an open network of researchers and practitioners working towards coordinated Europe-wide monitoring of contaminants in raptors (https://www.cost.eu/actions/CA16224). The overall goal of the ERBF is to support the implementation of EU chemicals regulations and thereby reducing chemical risks to raptors themselves, to the wider environment and to human health. In the framework of the ERBF, we have performed a thorough literature review concerning the presence, concentrations, and (bio-)analytical methods currently available for emerging organic contaminants in raptors (birds of prey and owls) in Europe. We aimed to identify the occurrence and recent trends in emerging contaminants, but also to identify gaps and to provide general guidelines for future raptor biomonitoring initiatives at a pan-European scale. In addition, we have performed analysis on raptor tissues for both bisphenols and benzophenones at the Norwegian University of Science and Technology (NTNU). We searched Web of Science and PubMed for articles related to the analysis of flame retardants (including polybrominated diphenyl ethers - PBDEs), poly- and perfluoroalkyl substances (PFASs) and other emerging contaminants, such as neonicotinoids, parabens, bisphenols, UV-filters (benzophenones) and microplastics in raptors in Europe. Among 44 articles found, 30 included PBDEs, 9 reported on novel flame retardants, 12 on PFASs and only 4 on other emerging contaminants (i.e. neonicotinoids (2), parabens (1) and UV filters (1)). Results indicated that most of the studies were from Western Europe only and that there is still a great lack of published studies on emerging contaminants in raptors. All concentrations reported in these articles were at the ng g⁻¹ level. Screening results at NTNU indicated that the most suitable tissues and species for the determination of bisphenols and benzophenones in raptor tissues were both preen gland and liver from white tailed eagles (Haliaeetus albicilla - WTE) because of higher concentrations and less matrix effects. The highest concentration was found for bisphenol A (BPA) at 805.9 ng g⁻¹ in a preen gland sample. In addition, 38 livers from WTE from Norway were analysed for bisphenols and benzophenones. BPA was found in 55% of the samples (1.08 - 87.31 ng g⁻¹ ), while bisphenol AF, a fluorinated alternative, was found in 84% (1.80 - 11.12 ng g⁻¹) and benzophenone-1 was found in 26 % (2.80 - 14.30 ng g⁻¹).

698 Bioaccumulation of Environmentally Novel Highly Brominated and Methoxylated Contaminants in Great Lakes Herring Gulls and Possible Terrestrial Sources

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It has become increasingly clear that abiotic and biotic transformation processes can greatly influence contaminant persistence and fate in the environment and accumulation in wildlife and other biota. Herring gulls (HG, Larus argentatus) have been used as a sentinel species for long-term contaminant monitoring in the Laurentian Great Lakes (GL) for over 40 years. In 2011, several novel methoxylated polybrominated diphenoxybenzenes (MeO-PB-DiPhOBzs) were measured in HG eggs, and was the first report of these contaminants in the environment. MeO-PB-DiPhOBzs are believed to be metabolites of photodegradation breakdown-products of the tetradecabromo-1,4-diphenoxybenzene (TeDB-DiPhOBz) flame retardant following dietary accumulation, and are subsequently transferred to their eggs. To date, MeO-PB-DiPhOBzs have only been reported in GLHG eggs and tissues, while any corresponding hydroxy-PB-DiPhOBz metabolites and non-conjugated PB-DiPhOBz by-products have yet to be reported in any environmental medium. It was previously hypothesized that the gulls were exposed to the photolytic PB-DiPhOBz by-products via their aquatic diet component, but previous work did not detect these by-products in fish or sediment samples collected from the GL. Recently, MeO-PB-DiPhOBzs were detected in regurgitant samples collected from the HG nesting colony on Channel-Shelter Island (CS Isl.) within the Saginaw Bay, Lake Huron. This suggests instead that MeO-PB-DiPhOBzs are bioavailable contaminants and HGs are exposed to them directly (via the diet), which then bioaccumulate, and are transferred in ovo to their offspring. To assess potential terrestrial exposure to MeO-PB-DiPhOBzs, the objective of the present study was to adapt existing organic flame retardant (OFR) methods to quantify MeO-PB-DiPhOBzs in soil samples collected from nesting sites on CS Isl. via GC-ECNI-MS. Two of the same (pentabromo) MeO-PB-DiPhOBz congeners previously measured in HG tissues and eggs were measured at low part-per-billion (ppb, wet weight) levels in 7 of the 9 soil sites sampled. Two previously unmeasured penta-brominated congeners were also tentatively identified and confirmed through GC-EI-MS measurement of the corresponding molecular ion clusters centered around m/z 686. Additionally, earthworms collected from CS Isl. were analyzed and found to contain the same MeO-PB-DiPhOBz congeners measured in the soil, and may suggest a possible terrestrial diet source for accumulation in the HGs.
699 Intrinsic and extrinsic drivers of trace element and perfluorinated compound burdens in blood of a coastal avian predator: An integrative approach
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Anthropised coastal environments receive a plethora of chemical pollutants from agricultural, industrial and urban sources. Coastal avian species are thus exposed to a complex mixture of contaminants via food ingestion, especially those that feed on the seabed. Yet, few integrative studies have quantified how concurring intrinsic and extrinsic factors determine contaminant exposure in these species. This hampers our ability to use them as bioindicators of coastal pollution, and to understand toxic effects. Here we quantified 11 trace elements and 17 perfluorinated compounds in blood cells and plasma, respectively, of benthic-feeding European shags Phalacrocorax aristotelis breeding in the Firth of Forth, a Scottish estuary with a long history of petro- and agrochemical releases. By using an exceptional long-term dataset, and a novel combination of approaches, our aim was to test the effect of individual traits (sex, age) and trophic ecology on individual variation in contaminant burdens. Shags had high mercury (Hg) burdens (range 0.65-3.21 µg/g wet weight, ww), while selenium (Se) burdens were relatively low (1.59-8.60 µg/g ww), when compared to other seabirds. PFOS, PFOA and PFNA concentrations were exceptionally high (63-396, 3.46-53, and 4.48-44 ng/g ww, respectively), comparable to those found in the congeneric double crested cormorant Phalacrocorax auritus breeding in the highly-polluted North American Great Lakes. In contrast to age, sex-related differences were strong, and were in different directions depending on the contaminant. Males had Hg, PFOA and PFNA concentrations two-fold higher than females, while the opposite was true for Se and PFOS. Biologging data (GPS, time, and depth recorders) revealed unexpectedly strong sexual segregation in foraging sites, despite the small foraging range (~15 km from the colony). Females relied extensively on sandy seabed areas, whereas males targeted rocky seabeds. This sexual segregation was reflected in bulk stable isotopes of carbon and nitrogen (δ15N), and in δ15N values of specific amino-acids in seabeds. This sexual segregation was reflected in bulk stable isotopes of carbon and nitrogen (δ15N), and in δ15N values of specific amino-acids in blood. Isotopic values were strong predictors of Hg, Se and PFOS loads. Collectively, these results suggest that females and males fed on prey from distinct coastal food webs, exposing themselves to different contaminant mixtures. This study stresses the importance of feeding specialisation on contaminant exposure at highly localised scales, and raises toxicological concern for the focal shag population.

700 Comparative effects of three neonicotinoids on food consumption and body mass in common farmland birds
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Seed-eating birds that stop to refuel or breed in agricultural areas could be exposed to neonicotinoids through several pathways, including the ingestion of treated seeds. Previous studies in white-crowned sparrows (Zonotrichia leucophrys) found that exposure to sublethal concentrations of imidacloprid significantly reduced body mass and fat stores, and decreased food consumption. We hypothesized that neonicotinoids can reduce body mass by acting as an appetite suppressant. Therefore, we compared the effects of three common neonicotinoids following single oral exposure to sublethal concentrations (0, 10, 20, 30 mg/kg) relative to a food restricted diet (10 or 50% reduction) in a common farmland bird species, red-winged blackbirds (Agelaius phoenicuclus). We found that imidacloprid significantly reduced food consumption (high dose decreased 68%) and body mass (high dose decreased 5%), and birds in the two highest dose groups exhibited significant neurotoxic symptoms. For clothianidin and thiamethoxam, there was no significant effect of dose on body mass over time, and no overt neurotoxicity, confirming their lower relative toxicity to imidacloprid in a songbird species. However, there were dose dependent trends (increasing body mass in clothianidin, decreasing body mass in thiamethoxam, reduced food consumption for both compounds) suggesting potential for fueling effects in situations where exposures are repeated or chronic. When food availability was restricted to approximate the amount of food consumed by imidacloprid exposed birds, mass loss was similar to that of the imidacloprid treatments. We will also present results from analysis of plasma triglycerides (indicates fattening), glyceral and β-hydroxybutyrate (measures of fasting and fat catabolism) to characterize the physiological effects of neonicotinoid exposure compared to fasting. Sublethal effects on fueling and condition in migrating and breeding birds can have subsequent effects on reproduction and survival, providing a mechanism link between neonicotinoid exposure and population-level consequences.

701 Assessment of the transcriptome in tree swallow (Tachycineta bicolor) nestlings from the Great Lakes Maumee River Area of Concern
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Tree swallow (Tachycineta bicolor) have proven uniquely suited for assessing contaminant exposures and biomarker responses in birds from the Great Lakes, in response to Polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins and dibenzo-furans (PCDD/PCDFs), polybrominated diphenyl ethers (PBDEs), and a variety of pesticides and other contaminants of emerging concern (CECs). In 2016, nestlings were collected from six locations on the Maumee River, across different land uses. Transcriptome-wide gene expression projects have been initiated in collaboration with the USGS and funded by The Great Lakes Restoration Initiative. RNA-Seq analysis was carried out on nestlings collected from the Maumee River. We built a tree swallow genome using linked-read technology with scaffold N50 > 15.6 Mbp and a BUSCO score of 88%. The tree swallow genome was further annotated using the transcriptome assembly and avian proteome. We assessed the in situ transcriptomic effects of multiple environmental contaminants exposure to tree swallow (Tachycineta bicolor) nestlings in the Maumee River AOC. Transcriptomic patterns between different sampling sites were correlated with different types of land uses, such as agricultural, industrial, and urban. PBDEs and an organochloride were correlated with transcriptomic variation between sampling sites, which was consistent with the findings of a metabolomics study of the same populations. Associated functional terms and pathways were determined and compared with enriched pathways from metabolomic responses.

702 The effects of weathered MC252 ingestion on red blood cell integrity, aerobic scope, and flying performance in zebra finches (Taeniopygia guttata)
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Crude oil spills that occur at stopover sites for migratory birds are of particular concern due to the potential to delay arrival at summer breeding grounds. In addition to external oiling impairing feather integrity, crude oil ingestion can damage red blood cells (RBCs). However, direct links between RBC damage, metabolic scope for activity, and flying performance have not been established. In this study, we orally dosed zebra finches (Taeniopygia guttata) with 2 or 6 ml kg⁻¹ of artificially weathered MC252 crude oil for 28 days and measured RBC integrity using traditional and novel endpoints, basal and maximal metabolic rates using a ‘hop-flutter’ chamber, and vertical flight speed and take-off acceleration using a high-speed camera. Crude oil ingestion caused
a decrease in packed cell volume (PCV) and an increase in reticuloocytes, indicating regenerative anemia. Furthermore, we also detected an increase in fluorescent heme-degradation products (HDPs), a novel tool for measuring oxidative damage. HDP fluorescence was negatively correlated with maximal aerobic scope, indicating a link between oxidative damage to RBCs and metabolic scope for activity. Interestingly, we found that birds exposed to crude oil increased vertical flight speed. Crude oil ingestion also caused a decrease in fat-score, which may explain why oiled birds increased flight speed. Our results suggest that RBC damage has metabolic consequences, but the metabolic effects do not influence short-range, burst flight.

703 The ins and outs of birds’ feather moult: Effects of methylmercury contamination

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Although the deleterious effects of methylmercury (MeHg) on wildlife have long been studied, many questions remain unanswered. In particular, how exposure to environmental stressors interacts with MeHg exposure is little studied. In addition to toxicity damage, MeHg may affects birds’ annual cycle transitions, affecting the timing of reproduction, moult and migration. Moult is a particularly challenging period for birds as it is energetically costly and involves reduced flight and escape ability. Because optimal timing is necessary for birds to survive during these transition periods, a delay or advance in seasonal life-stages, such as moult, may increase risks for bird populations. In order to better understand how stressors and MeHg exposure combine to affect seasonal transitions more experimental studies are required. To study this, we exposed song sparrows (Melospiza melodia) to either environmentally relevant doses of MeHg, unpredictable food stress, or both. During a 3-months exposure and further 3-months post-exposure period we measured the birds’ moult as well as two mediators of energy balance: basal metabolic rates and the thyroid hormone T4. Preliminary results indicate that unpredictable food stress decreased males’ basal metabolic rates, while MeHg exposure decreased T4 and increased birds’ basal metabolic rates. Furthermore, moult duration was increased in MeHg exposed birds and was affected by T4 levels. Neither stress nor basal metabolic rate influenced moult duration. The effect of MeHg on moult duration was primarily driven by advancing moult initiation, perhaps to facilitate depuration. Longer moult duration could lead to poorer flight performance and reduce survival and potentially affect bird migration. Although we did not find interactive effects of unpredictable food stress and MeHg, our results highlight that MeHg can affect annual cycle transitions, even after mercury exposure has ended.

Effects of Abiotic Factors and Chemical Additives on the Toxicity of Environmental Contaminants to Aquatic Organisms

704 Risk determinations of chemical mixtures are primitive and unreliable: Accepting complexity and improving site assessments

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There have been many efforts by scientists and regulators to develop methods and models to predict chemical mixture toxicity. Some of these efforts were addressed in Pellston Workshops (e.g., Valencia) with a host of international experts. None of these approaches seem reasonable in terms of accurately determining adverse ecological effects or thresholds, given the plethora of possible synergistic, additive, and antagonistic chemical interactions at fluctuating concentrations, in changing environments, to a wide range of species. Indeed, this is beyond the capability exposures derived in the laboratory. Critical exposure knowledge on temporal/spatial variance, degradation rates and metabolites, diurnal flux of fate/effect drivers for the tens of thousands of chemicals (in the presence of inorganic/organic particles) are unknown. If we do not know these real-world exposures - we do not know their risk. This level of complexity makes modeling mixture effects an academic exercise and not useful for effective ecosystem management decisions. We suggest a better approach to chemical mixture risk is to accept this reality and rather focus on in situ toxicity-based endpoints, as lab-based assays cannot replicate important fluctuating site conditions. If the goal of environmental management is protecting and restoring ecosystems, it should be done accurately, moving beyond mandates of using antiquated assessment tools.

705 Incidence of Apoptosis in Larval Red Drum (Sciaenops ocellatus) Co-exposed to Crude Oil and Ultraviolet Radiation

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Poly cyclic aromatic hydrocarbons (PAHs) are ubiquitous in the environment as a result of both natural and anthropogenic activity. Exposure to ultraviolet (UV) radiation can significantly increase the toxicity of crude oil PAHs to aquatic organisms through a process known as photo-induced toxicity. Photo-induced toxicity of PAHs is well documented in aquatic organisms and can result in increased mortality, reduced fecundity, delayed hatching, impaired development, and increased oxidative stress. Red drum (Sciaenops ocellatus) are an important fishery resource in the Gulf of Mexico and in the southeastern Atlantic Ocean. Co-exposure to UV radiation significantly increases the toxicity of crude oil to red drum larvae, leading to increased mortality. However, less is known about the sub-lethal effects of photo-induced PAH toxicity on early life stage red drum. The present study investigated the incidence of cell apoptosis in early life stage red drum following co-exposure to crude oil and UV radiation. Larval red drum (24 hours post fertilization) were exposed to a sub-lethal concentration of weathered crude oil (0.29-0.30 µg/L ∑PAH50) with and without UV radiation. Larvae were sampled following 24 h and 48 h exposure and apoptosis was quantified using a TUNEL assay. Transcriptomic effects were assessed using RNA sequencing. Apoptotic fluorescence significantly increased in the eyes following 24 h and 48 h exposure to crude oil with and without UV. Apoptotic fluorescence was greatest in the skin following 24 h and 48 h exposure to crude oil with UV, indicating photo-induced toxicity. Consistent with these phenotypic responses, pathways associated with phototransduction, eye development, and dermatological disease were among the top predicted pathways impacted in red drum larvae co-exposed to oil and UV determined through bioinformatic, RNA sequencing analysis. These results suggest that increased apoptosis is one sub-lethal effect of photo-induced PAH toxicity in larval red drum which may impair development and physiological function. This research was supported by the Gulf of Mexico Research Initiative (GoMRI) Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER II).

706 Influence of ultraviolet radiation on transcriptomic effects in larval red drum (Sciaenops ocellatus) following exposure to weathered crude oil

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The Deepwater Horizon (DWH) oil spill released millions of barrels of oil into the Gulf of Mexico, coinciding with peak spawning periods of economically and ecologically important fish species, such as red drum...
The goal of this research is to better understand the underlying mechanisms of toxicity of oil to early life-stage fish, relative to oil exposure alone. Disease associated with heart failure was predicted in larvae co-exposed for 24 hours, relative to 362 DEGs when co-exposed to oil and UV. The alone induced 21 differentially expressed genes (DEGs) in larvae exposed to oil and UV for 48 hours. This data suggests that UV exposure enhances the toxicity of oil to early life-stage fish, relative to oil exposure alone. The goal of this research is to better understand the underlying mechanisms of photo-induced toxicity in early-life stage fish exposed to oil. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER II).

707 Buoyancy Control as a Mechanism of Stressor Avoidance in Pelagic Fish Embryos

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Since the Deepwater Horizon (DWH) spill over 9 years ago, more than 50 peer reviewed studies have been published addressing impacts of this environmental disaster on different species of teleost fish. The majority of studies exploring DWH oil toxicity in fish utilize acute exposures (1-2 days), mid-range test temperatures (26-28°C) and otherwise ambient laboratory conditions, leaving a pressing need for more long-term exposures, exposures at the upper and lower levels of environmentally relevant temperatures, and studies investigating combined effects and interactions of oil with other environmental stressors. Stressors occurring in surface waters in the Gulf of Mexico (GoM), such as increased temperature, cardio-toxic oil slicks and ultraviolet radiation (UVR), pose a serious threat to the fitness and survival of the vulnerable early-life stages of pelagic fish. Therefore, a mechanism in which embryos can alter buoyancy and thus control their vertical position in the water column may be indispensable to the sustainability of these fisheries. Co-exposure to crude oil and other environmentally relevant stressors, such as increased temperatures and UVR altered buoyancy in developing mahi-mahi (Coryphaena hippurus) embryos. Further, recovery of normal buoyancy was observed once the exposure period was completed and all the stressors had been terminated, indicating this response is highly dynamic and not solely pathological. To further investigate this mechanism, specific gravity of mahi-mahi embryos exposed to different environmental conditions was measured using density gradient columns and values were subsequently employed to estimate terminal velocity. Loss of buoyancy at earlier time points in exposed embryos resulted in altered vertical distributions in the natural environment, significantly reducing exposure to UVR and other stressors known to be most intense in surface waters. Buoyancy control as a mechanism of UV-avoidance has recently also been characterized in cobia (Rachycentron canadum) embryos, providing evidence that this response is not unique to mahi-mahi. The finding that pelagic embryos regulate buoyancy following exposure to certain stressors may have significant implications for how we perform and interpret future toxicity tests. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).

708 Effects of acute and chronic co-exposures to hypoxia and lead on the cladoceran, Daphnia magna

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Hypoxia is a common stressor in many freshwater ecosystems owing to a variety of factors, such as temperature, eutrophication, and water column stratification. Lead (Pb), a non-essential metal and pervasive pollutant, represents another source of stress in many aquatic environments; yet, little is known regarding the potential interactive effects of co-exposure to hypoxia and Pb in aquatic animals. This study focused on the acute and chronic effects of co-exposure to hypoxia and Pb on the water flea, Daphnia magna. A number of known responses are elicited by hypoxia in D. magna, including elevated ventilation and heart rates, a dramatic increase in hemoglobin (Hb) concentration and an increase in Hb oxygen binding affinity. Exposure to Pb, on the other hand, has been shown to decrease Hb production in a variety of animals, including D. magna. The significance of Hb in convective oxygen transport within D. magna presumably changes with development, becoming more important as it grows beyond the critical size limit for purely diffusive oxygen transport (< 1 mm in normoxia). Thus, sensitivity to Pb might be related to oxygen transport effects that likely vary with age-related size differences and oxygen availability. To examine this possibility, acute (48 h) mortality bioassays were performed for different life stages of D. magna (neonates and adults) using Pb exposures in normoxia and hypoxia. Additionally, the effect of prior long-term acclimation to hypoxia was assessed for adults. Chronic (21 d) Pb bioassays were also performed in normoxia and hypoxia to assess various sublethal endpoints, including reproductive output and growth. To gain insight as to the potential role of Pb-induced impairment on convective oxygen transport in contributing to the observed toxicity, Hb concentrations and oxygen consumption rates were measured. Finally, laser ablation ICP-MS was used to localize Pb accumulation and identify the likely target tissues of Pb in adult D. magna. This data should aid in predicting the toxicity of Pb to D. magna in conditions of environmental hypoxia and help clarify the mechanistic underpinnings of such toxicity.

709 Interactive effects of wastewater effluent and hypoxia on the health and metabolic physiology of Atlantic killifish

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Modern wastewater treatment plants (WWTP) are currently unable to remove some contaminants from the discharged effluent, including pharmaceuticals and personal care products (PPCPs), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). Effluent receiving waters can also experience periodic and sometimes severe episodes of oxygen depletion (‘hypoxia’). Our objective was to examine the interaction between these stressors, and determine whether exposure to WWTP effluent disrupts the adaptive responses of fish to hypoxia. We tank exposed adult Atlantic killifish (Fundulus heteroclitus) for 21 days to 100% effluent from a secondary treatment WWTP, to one of two levels of hypoxia (O2 tension of 5 or 2 kPa), or to control conditions in a full factorial design. We then measured standard and maximal metabolic rates, aerobic scope, hypoxia tolerance, and various indices of body condition (body mass, condition factor, hepatosomatic index). Neither wastewater exposure or hypoxia, alone or in combination, altered body condition. Exposure to chronic hypoxia alone led to expected improvements in hypoxia tolerance. However, although wastewater exposure had little effect in normoxia, fish that were concurrently exposed to chronic hypoxia had reduced standard metabolic rates and impaired hypoxia.
tolerance. Therefore, wastewater exposure disrupted the adaptive physiological adjustments of killifish to chronic hypoxia, which would likely constrain their ability to cope in environments where these stressors co-occur. This suggests that the combination of stressors near WWTPs can have significant interactive effects on the physiology and fitness of fish.

710 Combined effects of temperature and pharmaceuticals on freshwater ecosystem processes
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Freshwater ecosystems are affected concurrently by multiple stressors, and it is hard to predict the consequences of combined stressors based on the knowledge of stressors separately. Global warming marked by elevated temperatures is a significant ecological stressor, and there is an urgent need to understand its effects on freshwater ecosystems in combination with other stressors. Pharmaceuticals are emerging as contaminants of global concern. Despite abundant evidence of the widespread nature of pharmaceutical compounds (PCs) in freshwater ecosystems, empirical evidence for their effects on ecosystem processes such as nutrient cycling remains scarce. The decomposition of leaf litter is a critical ecosystem process in freshwater ecosystems. Using laboratory bioassays, our study reports the combined effects of temperature and a mixture of four common PCs on the decomposition rates of leaf litter. The four pharmaceuticals; caffeine (stimulant), paracetamol (analgesic), sertraline (antidepressant), and amoxicillin (antibiotic) were mixed at a range of concentrations. Leaf decomposition rates were tested in the presence of the mixture at three different temperatures. Experiments were carried out with and without mayfly Atalophlebia sp. to assess any invertebrate-mediated effects on leaf litter processing. We assessed the combined stressors’ effects on extracellular enzymes (ECEs) released from freshwater microbes by measuring their activities fluorometrically, and on leaf litter breakdown overall using weight loss. With Atalophlebia absent leaf decomposition rates were low at high temperature and high PCs’ mixture concentrations. The same observation noticed in the presence of Atalophlebia. The activity of β-glucosidase was highest with Atalophlebia absent, low PC concentrations and high temperatures. For leucine-AP there was a reduction in activity as the temperature increased in PC controls and all PC treatments. No significant effect was observed of either temperature or PC concentrations on phosphatase activity. Phosphatase and leucine-AP activities were significantly reduced at high temperature for both but at low mixture concentration for phosphatase and high PCs mixture concentrations for leucine-AP. This study suggests that there is potential for profound and unexpected ecosystem-wide effects of combined pharmaceuticals and temperature stressors in freshwater ecosystems.

711 Sediment, Surface Water and Porewater PCB Concentrations and Bioaccumulation Before and After Sediment Remediation by In Situ Activated Carbon
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Historic manufacturing and operational activities at an industrial complex have resulted in elevated levels polychlorinated biphenyls (PCBs) in the sediments of the waterbodies surrounding the site. Due to the concern of potential ecological and human health risk from elevated PCBs entering the aquatic food chain, remediation of the sediment was completed using both sediment removal via dredging and in situ activated carbon amendment. Pre-treatment bioaccumulation, whole sediment, surface water and porewater data were collected for areas targeted for the in situ treatment. Approximately 2,500 tons of AquaGate affixed with 10% powdered activated carbon (PAC) was placed over 13.7 acres to amend the top 6 inches of surface sediments with a targeted 5 percent loading of PAC. Surface water and porewater concentrations were measured using passive polyethylene sheet samplers. Porewater concentrations were also measured using passive samplers in the Lumbriculus variegatus test chambers. The total dissolved PCB concentrations in sediment porewater pre-treatment ranged from 11.2 ng/L to 57.2 ng/L, with an average of 25.6 ng/L. Post-treatment porewater PCB concentration ranged from 0.271 ng/L to 2.29 ng/L, with an average of 0.889 ng/L. This represents an average porewater reduction of 96.5%. Pre-treatment near sediment surface water concentrations ranged from 7.2 to 35.1 ng/L while post-treatment the near sediment surface water total PCB concentrations were reduced to 1.6 to 8.1 ng/L. This represents nearly an 89% reduction in near sediment surface water concentrations. Pre-treatment bioaccumulation tissue PCB concentration ranged from 0.273 to 0.793 µg/g, with an average PCB concentration of 0.429 µg/g wet weight. Post-treatment tissue concentrations ranged from 0.020 to 0.0349 µg/g, with an average of 0.0196 µg/g. This represents an average reduction of 95.4%. Biota sediment accumulation factors were reduced by an average of 84%. The in situ treatment was effective in reducing the sediment porewater and bioaccumulation tissue PCB concentrations. The five year post remediation goals for sediment porewater and invertebrate tissue were an 80% and 70% reduction, respectively. The one-year post remediation results indicated a 96.5% reduction in porewater and a 95.4% reduction in tissue concentration indicating that the five-year goals have been met only one year post remediation.

Fate and Effects of Metals: Regulatory and Risk Assessment

712 Differential selenium uptake by periphyton in boreal lake ecosystems
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Selenium (Se) is an essential trace element with a narrow margin between essentiality and toxicity that is released into aquatic environments by certain industrial practices. Excess Se is rapidly and efficiently assimilated into food webs in a site-specific manner by primary producers and transferred to higher trophic levels through dietary pathways. Most field studies focused on the ecological risk assessment of Se have been conducted in warm-water systems, and more research is needed regarding the effects of increased Se loading in cold freshwater systems and how certain site-specific factors influence the incorporation of Se into food webs by periphyton. The objective of this study was to diminish this uncertainty by quantifying Se uptake at the base of food webs in representative boreal lake ecosystems. This was achieved by investigating if concentration-dependent differences exist in periphyton enrichment functions (EFs) of Se and determining if water chemistry plays a role in Se uptake by periphyton. Periphyton samplers composed of textured glass plates were deployed in five lakes with variable water chemistry at the IISD-ELA (International Institute for Sustainable Development-Experimental Lakes Area) and grown naturally for six to eight weeks. Periphyton plates were then removed and exposed to environmentally relevant concentrations (control [0.1-0.2], 0.5, 1, 2, 4 µg Se/L) of Se as selenite, and allowed to incubate under ambient conditions for eight days. Aqueous and periphyton total Se concentrations, and periphyton community composition were quantified. Significant concentration-dependent differences in EFs were found within the five lakes tested (0.0497< p< 0.0001), with the highest EFs in four of the five lakes occurring in the lowest (0.5 µg Se/L) treatment. Enrichment functions generally decreased with increasing Se concentration, and significant differences in EFs were also found between lakes at the 2 and 4 µg Se/L treatments. The results of this research provide insight on the biodynamics of Se assimilation at the base of boreal lake food webs, which can potentially inform ecological risk assessments in cold freshwater ecosystems in North America.
713 Resolving selenium exposure risk in the San Francisco Estuary using a conservative physical transport model, a benthic bivalve, and a native cyprinid


Estuaries provide critical habitat for migratory birds, shellfish, and juvenile fish and serve as migration corridors for anadromous fish. They are also under constant threat from a range of stressors including climate change, eutrophication, contaminants and invasive species. Estuaries are arguably among the most challenging environments to manage for threats due to layered complexities of physical transport in a tidal environment, biogeochemical gradients, habitat utilization, and competing resource needs from fish and wildlife and those supporting economic development and urbanization. In the San Francisco Bay Estuary (SFE) geological sources of selenium (Se), an essential element and potent teratogen, are concentrated and mobilized through core economical activities including oil refining and agriculture to levels that could threaten fish and wildlife. Ecosystem models for Se evaluate the potential risks of Se in different environments, including the SFE. However, refinement of the factors and processes parameterized in the model is still needed to effectively estimate and regulate for individual and population-level impacts of Se on fish and wildlife. Particular challenges include how to optimally: (1) represent spatial and temporal variation in tissue concentrations and turnover rates of Se in endemic species and (2) link tissue exposures to dietary and ultimately aqueous exposures. Here we present preliminary results for the aqueous transport and distribution of Se loads in the SFE based on a 3D coupled hydrodynamic-water quality model (no biogeochemical reactions). In addition, we assess the consequence of those distributions on Se exposures in a benthic clam (Potamocorbula amurensis) and its predator, a native demersal minnow Sacramento Spleitail (Pogonichthys macrolepidotus). Overall, Se exposures in Spleitail reflected broad regional gradients in Se concentrations in their prey Potamocorbula and in modeled aqueous Se. In contrast, Se concentrations in Potamocorbula, sampled on a monthly timescale, showed a complex relationship with modeled aqueous Se through time (seasonally and inter-annually), highlighting the need to consider other biotic processes including lags for tissue Se uptake rates and factors affecting the biogeochemical cycling of bioavailable Se in determining Se exposures. These results highlight the value of using a conservative physical transport model with tissue exposure data as a first step in identifying processes that should be considered when refining ecosystem models for Se.

714 Effect of Body Size on Mercury Concentration in Shoreline Spiders

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Recently, terrestrial shoreline spiders have been proposed as biosentinels of bioaccumulative aquatic contaminants such as mercury (Hg). Terrestrial shoreline spiders become contaminated with Hg when they feed on Hg-contaminated emergent aquatic insects. Although the effect of body size on contaminant bioaccumulation in other biosentinels, such as fish, has been thoroughly examined, there has been much less research on the effect of body size on concentrations of Hg in shoreline spiders. In this study, we determined the effect of body size on Hg concentrations in six taxa of shoreline spiders belonging to four families (orb-weavers, [Araneidae], long-jawed orb-weavers, [Tetragnathidae: Tetragnatha spp.], jumping spiders [Salticidae] and wolf spiders [Lycosidae: Pardosa spp., Rabidosa spp. and Schizocosa spp.]). We collected 683 spiders during the day using sweep nets or by hand at night on May 14, June 5, 11, 20 and July 6, 2018, from 14 human-made ponds at the Lyndon B. Johnson National Grasslands, Texas, USA. Average total Hg (THg) concentrations (mean ± SE) ranged from 63 ± 4.0 ng/g to 246 ± 20.1 in Schizocosa spp. and Araneidae, respectively, and were significantly different between spider taxa. We measured the length of the tibia + patella of the first leg as a proxy for body size and found that spider THg concentration increased significantly with spider body size for Araneidae, Tetragnatha spp., Salticidae and Pardosa spp. The percent of variation in THg concentration explained by spider body size ranged from 16% to 40% for Pardosa spp. and Salticidae, respectively. This study indicates that concentrations of Hg in shoreline spiders differ between spider taxa and within taxa by spider size. We recommend that future studies of Hg in shoreline spiders assess spider size.

715 Application of the Biotic Ligand Model (BLM): A Case Study in Assessing Metals’ Risk to Vernal Pool Species

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An ecological risk assessment is being performed at a former munitions manufacturing site in Connecticut. The majority of the site is forested upland habitat, with limited or no contaminant migration pathways associated with historical activities; aquatic and ephemeral and permanent wetland habitats are also present, including vernal pools. As such, exposure of vernal pool biota to site-related metals is being addressed as part of the risk assessment. A screening evaluation of existing wetland and vernal pool surface-water data indicated potential for ecological risks associated with copper, lead, and nickel based on exceedance of applicable ecological screening values, including hardness-based Water Quality Criteria for Aquatic Life. However, the initial screening did not account for two site-specific factors in assessing potential risk due to metals in vernal pools and aquatic habitats: site-specific metals bioavailability and site-specific receptors of concern, including the obligate vernal pool invertebrate and amphibian species. To account for site-specific metals bioavailability, sample-specific water quality criteria were calculated based on the application of the Biotic Ligand Model for copper. The Model incorporates site-specific bioavailability-modifying factors such as dissolved organic carbon, pH and alkalinity. For the existing datasets with estimated dissolved organic carbon and alkalinity, exceedances of BLM-based criteria for copper were minor, indicating generally limited aquatic bioavailability of copper at the site. To further account for the site-specific receptors of concern, amphibian-specific No Observed Effect Concentrations (NOECs) were derived based on literature data. Metals exceedances were also generally minor relative to the amphibian-specific NOECs, indicating that potential risks are likely limited to an important group of site-specific receptors. Surface-water samples were collected in May 2018 to represent current site conditions, fill data gaps for a refined evaluation of bioavailability, and capture the most relevant season for aquatic exposure of vernal pool species. Evaluation of the current data includes an initial screening and subsequent refinements using BLM-based water quality criteria for copper and amphibian-specific NOECs. The focus of this presentation will be the results of the BLM-based evaluation of site-specific metals bioavailability and toxicity, and consideration of site-specific receptors of concern for the on-site vernal pools and wetland habitats.
716 Subsistence Fish Consumption in Alaska: Using Regional Monitoring Data to Evaluate Risk and Bioavailability of Dietary Methylmercury

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US Federal fish consumption guidelines recommend that women and children (10-years of age and older) consume 227-340-grams of fish low in mercury (the majority of which is present as methylmercury; MeHg) per week. This ingestion rate (IR) is thought to maximize the health benefits conferred by fish, while protecting against concerning levels of dietary MeHg exposure. However, subsistence communities in Alaska (AK) often rely on fish (especially salmon) as a primary protein source. As a result, the statewide mean fish IR in AK is 1,043-g/week, which is more than 3 times the maximum weekly Federal consumption recommendations. Growing concerns about dietary MeHg exposure have resulted in declining fish consumption rates in subsistence communities, a trend accompanied by marked increases in diseases of poor nutrition and declines in mental health (this phenomenon has also been documented elsewhere). These trends prompted State health officials to issue less restrictive fish consumption guidelines, citing public health concerns and historically low MeHg concentrations in AK fish. Moreover, Federal fish consumption guidelines do not consider dietary co-exposure to selenium (Se), which reduces MeHg bioavailability when present in molar ratios \( \geq 1 \) (Se:Hg). In order to determine whether the risk posed by increased MeHg exposure outweighs the benefits of traditional subsistence diets in AK, we used data from multiple statewide monitoring programs to perform an integrated evaluation of risk. Our analysis considered [Hg] and [Se] data from the Fish Monitoring Program (AK Division of Environmental Health- Office of the State Veterinarian), regional surveys of subsistence harvests and natural resource use (AK Department of Fish and Game- Division of Subsistence), data from the AK Maternal Hair Mercury Monitoring Program (AK Division of Public Health-Environmental Public Health Program), and disease incidence surveillance reports (AK Division of Public Health-Section of Epidemiology). Results of multiple analyses indicate that the benefits of traditional subsistence diets outweigh the risks associated with increased MeHg exposure in AK, in nearly all scenarios.

717 A regional comparison of long-term responses to stream restoration in mining impacted watersheds


Predicting the period of time required for disturbed communities to recover following the removal of a stressor is one of the key challenges in restoration ecology. However, despite investments exceeding $1 billion (U.S.) per year in stream restoration, our ability to quantify the effectiveness of these projects remains limited. In this study we describe results of a large-scale comparative analysis of 4 western watersheds (Arkansas River, CO; Clark Fork River, MT; Leviathan Creek, CA; Panther Creek, ID) recovering from the long-term impacts of historical mining pollution. Physicochemical data, metal concentrations and benthic macroinvertebrate communities were collected from reference and impacted sites for 20-29 years in each of the 4 watersheds. Because data in each watershed were collected before and after initiation of restoration treatments, this project provided an unprecedented opportunity to compare long-term responses to improvements in water quality across a broad geographic region. The primary objectives of the study are to: a) quantify responses to restoration treatments across broad geographic regions; b) assess differences and similarities in the timing of recovery across regions; c) identify biotic and abiotic factors that determine responses to restoration; and d) identify species trait syndromes that are especially responsive to changes in water quality. Results showed significant reductions in metal concentrations in each watershed following treatment, but the magnitude of these improvements was influenced by seasonal and annual variation in stream discharge. Responses of benthic communities to improvements in water quality and the length of time required to achieve reference conditions also varied among watersheds and among endpoints. For example, measures of abundance and species richness rapidly returned to reference conditions in some watersheds, whereas recovery of metal-sensitive taxa (e.g., grazing mayflies) failed to recover in others. Our results demonstrate the importance of long-term studies for assessing restoration effectiveness in mining-contaminated watersheds within the broader context of regional changes in climate.

718 Validating Predictions of the Freshwater Copper Biotic Ligand Model in an Effluent-Dominated Very Hard Water


Site-specific water quality criteria for copper (Cu) derived using the Biotic Ligand Model (BLM) is under consideration for a power generating station’s discharge to an ephemeral watercourse in the arid Western U.S. The receiving water is usually dry, and only contains water in response to precipitation, or during effluent discharge. Water quality characteristics of both the effluent and the receiving streams consisted of highly elevated concentrations of cations and anions used for BLM inputs. Furthermore, a synthetic metal chelant, Versene 100 (a commercial form of ethylenediamine tetraacetic acid; EDTA) is added to the effluent to eliminate Cu toxicity to the cladoceran Ceriodaphnia dubia. Because of the high ion concentrations and the use of a synthetic form of dissolved organic carbon (DOC), it was unknown whether the BLM would accurately predict toxicity and, hence, derive protective Cu criteria. We conducted toxicity tests with Cu in effluent and two downstream site waters to empirically evaluate the extent to which the BLM accurately predicts Cu toxicity in these waters to C. dubia, along with another sensitive cladoceran, Daphnia magna. Samples were collected when water was present only owing to facility discharge. BLM parameter input concentrations exceeded software validation ranges by 2-5x, and also were higher than previously published examples of BLM prediction accuracy in very hard waters. Observed LC50 values were higher than those predicted by the BLM in all but one case, with the highest difference (4.25x) being observed in water collected from the first downstream location using D. magna. However, other than this value, all the observed/predicted ratios were less than +/- 2x. Therefore, BLM toxicity predictions tended to be conservative, but were within ranges known to adequately predict Cu toxicity in all but one test. These results support the accuracy of the BLM even under conditions of strongly elevated input ion concentrations 2-5x outside the model parameter ranges, and in the presence of a synthetic form of DOC. Therefore, regulatory use of the BLM may still be reasonable and protective under such conditions, reducing the need for additional validation testing or use of empirical alternatives for criteria derivation such as the water-effect ratio.

719 Comparative Performance of Multiple Linear Regression and Biotic Ligand Models for Estimating the Bioavailability of Aluminum and Copper

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Predicting the bioavailability of metals in aquatic ecosystems is critical to assessing risks posed by elevated metal concentrations and for setting water quality guidelines that are not under- or over-protective. It has been well established that multiple toxicity modifying factors (TMFs) influence metal bioavailability and ultimately toxicity to aquatic organisms. Two general modeling frameworks are currently used to estimate metal bioavailability: mechanistically-based Biotic Ligand Models (BLMs) that predict metal accumulation at a hypothesized site of toxic action and statistically-based Multiple Linear Regression (MLR) models that estimate the effects of TMFs on observed toxicity. Both modeling approaches
Advancing the OMICS into Regulatory Frameworks: Case-Studies and Perspectives - Part 2

720 The re-evaluation of quinone toxicity contribution within particulate matter
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Particulate matter (PM) is a type of air pollution known to increase the risk for respiratory diseases such as asthma and lung cancer. It is an ongoing problem for highly populated cities such as Beijing and Delhi. Quinones are secondary-emission pollutants found in PM and are a major PM toxic component alongside transition metals. Quinones exert toxicity either through reactive oxygen species (ROS) production or through protein alkylation. Traditional toxicological assays for atmospheric pollutants, such as the dithiothreitol (DTT) assay, primarily focus on ROS-mediated toxicity, thereby ignoring the cysteine-mediated pathway. In our study, we tested for the oxidative potential response for both transition metals and quinones with the DTT assay and the Antioxidant Response Element (ARE) assay which measures for cellular oxidative responses via the nuclear factor-like 2 pathway. We determined that the DTT assay overestimates the oxidative potentials of metals and underestimates the oxidative potentials of quinones when compared to the ARE assay results. Our results suggest an overlooked pathway in quinone toxicity which may be cysteine-mediated. We then obtained in vitro cell lysate results using a chemo-proteomics method and several quinones showed strong cysteine reactivity (20 μM or less) including methylquinone and benzoquinone; both of these quinones were underestimated in the DTT assay. Furthermore, using high-resolution quadrupole Orbitrap mass spectrometry, we explored and identified the kinetics and cysteine modification by quinones respectively. Our chemo-proteomics, ARE, and mass spectrometry results were mainly in agreement. In addition, the cysteine-reactivity of quinones using in vivo chemo-proteomics and the identities of several cysteine-affected proteins by quinones using global mass spectrometry proteomic analysis will be discussed. In sum, our study suggests that cysteine-mediated toxicity must be considered in tandem with traditional ROS studies when evaluating the toxicity of quinones in PM thus allowing for better evidence-based regulation and prioritization of atmospheric pollutants.

721 The genomes of the marine copepods Tigriopus japonicus and Paracyclopina nana: expression profiles of 98 cytochrome P450 genes upon cypermethrin
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Copepods are globally distributed in aquatic environments and play important roles in the aquatic ecosystem. The benthic copepod *Tigriopus japonicus* and the pelagic copepod *Paracyclopina nana* are considered suitable model organisms for ecology, evolution, and ecotoxicology. In this study, we assembled and characterized both copepods genome. The total length of the assembled genome of *T. japonicus* was 196.6 Mb and the number of final scaffolds was 358 with an N50 value of 1.69 Mb. A total of 22,505 genes were annotated after manual curation, while the total length of the assembled genome of *P. nana* was 197 expression and hypomethylation of CpG island of HTR4. Finally, in vivo experiments showed that respiratory resistance of wild type mice was 1.5 to 3.5-fold of that of HTR4-null mice (p < 0.01) after 10-days inhalation exposure of FA. Development of lung inflammation and fibrosis were also alleviated in HTR4-null mice. Our study demonstrated the use of CRISPR genomic screen in providing candidate genetic variations to molecular epidemiology through uncovering the link between genes and toxic effects of chemicals.

722 Identification of Critical Role of HTR4 for Susceptibility of Lung to Formaldehyde Using Genome-Wide CRISPR-Cas9 Screening
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Formaldehyde (FA), a common air pollutant, can induce human lung inflammation and fibrosis, which has been linked to chronic obstructive pulmonary disease (COPD). Understanding on interactions between genetic susceptibility of COPD and FA exposure is limited. Here we conducted a CRISPR genomic screen to identify key gene deletions essential for sensitivity of human alveolar epithelial cells (A549) to FA. The results revealed that HTR4, the top under-represented gene, might be involved in susceptibility of human lung to FA exposure. Firstly, deletion of HTR4 could decrease resistance (1.5 to 2-fold) to cytotoxicity induced by FA. Second, HTR4 was required in the molecular mechanism mediated inflammation and fibrosis responses induced by FA in A549 cells. FA up-regulated HTR4 because of suppressed miR-197 expression and hypomethylation of CpG island of HTR4. Finally, in vivo experiments showed that respiratory resistance of wild type mice was 1.5 to 3.5-fold of that of HTR4-null mice (p < 0.01) after 10-days inhalation exposure of FA. Development of lung inflammation and fibrosis were also alleviated in HTR4-null mice. Our study demonstrated the use of CRISPR genomic screen in providing candidate genetic variations to molecular epidemiology through uncovering the link between genes and toxic effects of chemicals.

723 What can gastrointestinal omics contribute to the discussion? - A case study with single-walled carbon nanotube exposures in largemouth bass
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Single-walled carbon nanotubes (SWCNTs) are a class of nano-sized molecules utilized in a variety of industrial, medical, and commercial applications. Limited regulation coupled with predicted increases in production and subsequent environmental release of these materials outline the necessity for studies exploring their environmental impact. Previous studies from our team have found that SWCNTs may impact nutrient uptake and growth during dietary exposure. However, our evidence suggests that SWCNTs are not absorbed across the gastrointestinal epithelium, leading to our hypothesis that SWCNTs are interacting...
at the gut-epithelium-luminal interface before excretion to cause these responses. In two separate chronic feeding experiments, we fed adult largemouth bass (Micropterus salmoides) food coated with single-walled carbon nanotubes (SWCNTs, 2.5 mg/kg) for 1.5 months. To explore the potential interactive relationship between the gut and SWCNTs in vivo, we employed a targeted and non-targeted multi-omics approach, including targeted semi-quantitative gene expression analysis, 16S metagenomic sequencing of the fecal microbiome, and non-targeted gut lipidomics. Though we did not see an impact on select genes related to intestinal inflammation, stability, and nutrient metabolism, analysis of both the intestinal microbiome and lipidome revealed significant differences between exposed and control animals. Metagenomic analysis of 16S data revealed numerous impacted KEGG functional pathways related to nutrient homeostasis in the intestinal microbiome, including microbial biosynthesis and metabolism of essential biomolecules. Fish exposed to dietary SWCNTs for 1.5 months had a differentially impacted intestinal lipidome, with an overall reduction across several lipid classes, including numerous bioactive lysophospholipids. The implications of this case study are two-fold: (1) The gastrointestinal system may serve as an early indicator of exposure and effect, and should be considered in regulatory approaches that utilize ‘omics approaches, especially in the case of dietary exposure to chemicals with nonspecific mechanisms of toxicity, such as SWCNTs; (2) These data indicate that while transcriptomics based approaches are most common in discussion in integration of ‘omics into regulatory frameworks, these data alone do not tell the whole story and a multi-omics approach may help to identify new or cryptic adverse outcome pathways.

724 Effects of single and combined low concentrations of neuro-active drugs on Daphnia magna reproduction and transcriptomic responses

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Assessing the risks of emerging contaminants such as neuro-active pharmaceuticals in the environment requires an understanding of their joint effects at low concentrations across species. Here, we assessed effects of single and ternary equi-effective mixtures of environmental relevant concentrations of propranolol, diazepam and carbamazepine on the crustacean Daphnia magna. We report enhancing reproductive effects in D. magna adults and global transcriptomic effects on pre-adolescent individuals employing a whole transcriptome cDNA microarray. Joint mixture effects on cumulative reproduction were additive and the same pattern was observed on the global transcriptome. The three compounds affected a total of 3248 genes, which were grouped into four clusters: two of them included 1897 gene transcripts behaving similarly in single and mixture treatments. The third and fourth clusters grouped genes differently transcribes upon exposure to diazepam and propranolol. Functional transcriptomics indicated that the four clusters shared major de-regulated signalling pathways implicated on energy, growth, reproduction and neurological related processes, which may be responsible for the observed reproductive effects. Our study, thus, showed additive effects at the transcriptional and physiological level and is providing a novel approach to the analysis of environmental relevant mixtures of neuro-active compounds.

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725 Using a multiomic approach to unravel the mecanisms of acrylamide neurotoxicity

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Acrylamide is a recognized carcinogen that has strong neurotoxic effects in humans and in experimental animals, although the molecular mechanisms underlying these neurotoxic effects are not completely understood. We studied acrylamide neurotoxicity in the brain of adult zebrafish using an integrated approach that included biochemical, transcriptomic (RNAseq), proteomic (MALDI-TOF mass spectrometry) and metabolomic (proton-NMR)d ata. We detected the formation of acrylamide adducts with thiol groups in the brain metabolome, and the accumulation of acrylamide conjugates and propionamide adducts in Cys residues of proteins. These combined effects resulted in a quasi-complete depletion of glutathione and to the inactivation of different components of the thioredoxin system. Multi-omic functional analyses identified microtubules, thioredoxin-related proteins, transmembrane transport, redox metabolism and catalytic activity, as the cellular functions significantly altered by acrylamide in the fish brain. We propose that the combined loss-of-function of both redox metabolism-related systems configure a perfect storm that explains most, if not all, observed acrylamide neurotoxic effects.We derived an Adverse Outcome Pathway for acrylamide neurotoxicity at different levels of organization, from molecular interactions to behavioral changes. We think our mechanistic approach may be applied to other neurotoxicants that may share its toxic mode of action.

726 Systems toxicology assessment of chemical induced development cardiotoxicity in zebrafish larvae

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One of the main challenges that needs to be addressed before OMICS technologies receive regulatory acceptance in chemical risk assessment is a specific and quantitative connection to adverse outcome of regulatory concern. We present a multidisciplinary pipeline that can be used to develop causal biological networks that describe the current knowledge on adverse outcomes of interest and evaluate the perturbation of the network, based on measured transcriptomics datasets. The pipeline includes semiautomatic literature curation and annotation based on the BEL language, causal network development and integration of transcriptomics data for the purpose of network scoring. To demonstrate the utility of our approach for zebrafish cardiotoxicity, we developed a zebrafish cardiotoxicity network, which includes approximately 400 nodes (including mRNA abundance, protein activity, biological process activation, etc) and >500 connections. We then screened 20 different chemicals environmentally relevant chemicals for cardiotoxicity using the fish embryo toxicity test and additional measurements of cardiotoxic outcomes (eg cardiac edema, bradycardia) and took samples for RNA-Seq after 120 h of chemical exposure. The RNA-Seq datasets were to score the perturbation of the cardiotoxicity network and the results of our screening approach will be presented at the conference.
727 Environmental in vivo NMR metabolomics study of small aquatic living organisms
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Metabolomics, the final downstream product of gene transcription and the closest to the phenotype of biological systems, is one of the omics that with other omics will prove beneficial to allocate capturing the entire view of a complex biological system in response to stressors. Metabolomics is highly time-dependent and monitoring metabolites’ fluctuation in a real time by implementing in vivo metabolomics allows clearer metabolite pattern and hence better reflection of responses to stressors. Nuclear magnetic resonance (NMR) spectroscopy is the most common technique for metabolomics, and, so far, the only non-destructive and non-invasive analytical tool that meets this demand and allows to study alive organisms, in vivo. Moreover, the water flea Daphnia is a very common test model organism in regulatory toxicology and freshwater ecology. The current study indicates how the in vivo NMR metabolomics technique can be applied to the small aquatic living organism, Daphnia magna. Also, to demonstrate the application of the technique, D. magna are monitored over time and their metabolic trajectories are compared in two control and exposed conditions.

Structural Fires and Wildfires: Environmental Hazards and Firefighter Health

728 Ambient Air Quality Assessment around Olusosun Dumpsite: Hazards and Firefighter Health
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Olusosun dumpsite is one of the largest waste repositories in sub-Saharan Africa and also an economic hub for the low-income class in Lagos. Olusosun dumpsite has gradually experienced a massive expansion towards residential and commercial areas perhaps due to rapid urbanization, population growth and injudicious use of the dumpsite and on the 14th March 2018, it witnessed a serious fire outbreak that destroyed many properties, causing a displacement of people and lasted for about 12 weeks - attributed to the build-up of methane from the anaerobic decomposition of piled-up waste. Hinged on this concern, this study assessed the air quality around Olusosun dumpsite during and after the incident for health risk assessment. Ten ambient air quality parameters which include temperature, wind speed, carbon monoxide (CO), volatile organic compounds (VOCs), hydrogen sulphide (H2S), nitrogen dioxide, sulphur dioxide, nitrogen monoxide, and particulate matter (PM2.5 and PM10) were jointly monitored by the Lagos State Environmental Protection Agency (LASEPA) monitoring team at ten different sampling points around Olusosun dumpsite using standard air quality monitors with readings taken as mean values (μgm-3) and compared with WHO and LASEPA permissible limits. During the fire outbreak, CO ranged from 1.20±0.13 to 8.95±3.52 (exceeded the limit of 5.00 ppm); VOC ranged from 0.05±0.03 to 1.87±0.81 (exceeded the limit of 0.008 ppm). PM2.5 ranged from 377.16±60.34 to 815.40±80.04 (exceeded the limit of 25 μgm-3); PM2.5 and PM10 during and after the fire outbreak exceeded both LASEPA and WHO permissible limits. PM2.5 positively correlates with wind speed at 0.05 significant levels. Based on the findings in this study, it could be adjudged that people living or working around Olusosun dumpsite are likely to be exposed to high levels of CO, VOC, PM2.5 and PM10 which could cause respiratory disorders and other health havoc. Hence, periodic monitoring for air quality and compliance in this area should be done. Nonetheless, there is a critical need for government and relevant stakeholders to stimulate genuine concern for environmental sustainability via implementation of integrated waste management and public sensitization on health risks associated with injudicious use of dumpsites; otherwise it would be a disservice to humanity.

729 Investigating the Fate of Polycyclic Aromatic Hydrocarbons in Fort McMurray Wildfire Ash
L. Chan, University of Alberta / Department of Chemistry; Y. Zhang, University of Alberta / Department of Laboratory Medicine and Pathology; S. Styler, University of Alberta / Department of Chemistry

The 2016 wildfire in Fort McMurray, Canada was a major environmental disaster that released significant amounts of toxic pollutants into the atmosphere, causing severe and widespread negative impacts on both local air quality as well as that of distant regions. Polycyclic aromatic hydrocarbons (PAHs), which are one of the major toxic pollutant classes produced by the wildfire, decay in the environment primarily through heterogeneous oxidation mechanisms on environmental surfaces. Previous studies on other surfaces (e.g. soot and silica) have shown that PAH reactivity is highly substrate dependent, but thus far no studies have been conducted on fire ash, which limits our ability to predict PAH lifetimes on this substrate. In this study, we subjected Fort McMurray wildfire ash to photochemical and oxidative transformations in a simulated atmospheric chamber, and thereby determined the kinetics of PAH decay in situ. These kinetic parameters are valuable because they can be used to predict the lifetime and long-term environmental contamination potential of wildfire PAHs and may help determine when safe PAH thresholds are reached to direct post-fire remediation efforts and inform public health guidelines.

730 Assessing wildfire influence on indoor/outdoor chemical concentrations and diffusive flux between soil and air of PAHs in the Western United States
C.C. Ghetu, Oregon State University / Environmental and Molecular Toxicology; D. Rohlman, Oregon State University; K.A. Anderson, Oregon State University / Environmental and Molecular Toxicology

This study focused on the development and testing of a proof of concept, community engagement approach to understanding the fate of polycyclic aromatic hydrocarbons (PAHs) from wildfires, and their potential for human exposure. Passive sampling devices were deployed in air at 13 sites, and co-deployed at the air and soil pore air interface at 5 sites across Washington, Idaho, California and Oregon from September to October of 2018. At each of these sites, volunteers placed samplers in a room inside their home and outside their home during the wildfire season, for about three weeks. These passive samplers were extracted and analyzed by gas chromatography mass spectrometry for parent and alkylated PAHs, parent and alkylated PAH compounds specific to forensic source determination and a quantitative screen of 1530 organic chemicals. Air Quality Index data and NASA satellite imaging was also collected for the corresponding locations during their sampling period. PAHs were detected at all sites sampled, with PAHs including mainly 2-4 ring. Forensic source identification indicate that all samples were pyrogenic in nature. Additional PAH ratio information were used to examine the influence of wildfires on the PAH signatures of all samples. Results also indicate that PAH concentrations in the air are higher indoors than outdoors, even in locations where the home was not a primary residence. This is the first study to compare concentrations indoors and outdoors during wildfire season. Repeat measures collected in summer of 2019 at the same locations are compared. We report air and pore air concentrations and the bulk movement of vapor phase contaminants between the soil and air, which is referred to as diffusive flux. The diffusive flux between air and soil during wildfire season will be demonstrated for the first time with low density polyethylene passive samplers in this study. The diffusive flux vaporization from soil and/or deposition from air at each site during wildfire season will be presented. We will also present on the results of a 1530 organic chemicals analysis for previously unmonitored contaminants.
731 Thoughtful Stakeholder Engagement Through Solutions-Driven Research Approaches to Better Understand Human and Ecological Impacts from Wildfire


While devastation in communities burned in recent wildland fires is readily visible, adverse human health effects of smoke exposure are less visible, and yet substantial in communities near and far from fires. The USEPA Office of Research and Development (ORD), supports a breadth of research and outreach designed to help federal, state, local, and tribal organizations prepare and respond to impacts from wildland fire. This work is designed to fill gaps in scientific information in air quality, public health, toxicology, emissions measurement and modeling, and social science. This information is used to develop tools to prevent and reduce impacts of wildland fire smoke, and support translation of research and tools into action that reduces the public health burden of smoke. This presentation highlights projects designed around wildland fire smoke and health: Wildland Fire Framework: Developed to state ORD’s vision of wildland fire research, indicate where EPA’s role is in wildland fire research, and outline and coordinate research priorities through problem statements and research questions related to air quality, public health, water quality and aquatic resources, chemicals, and preparing for and building resilience to wildland fires. Smoke Sense: A crowdsourcing, citizen science research project with > 25,000 participants that aims to better understand public awareness of and responses to exposures to smoke from wildland fires, and the subclinical impacts of exposure to wildland fire smoke. The Smoke Sense projects are working to increase issue awareness and engagement in health protective behaviors related to smoke. Preliminary findings from two years of data will be shared along with future plans. Cardiac Care and Air Pollution: This study draws upon insights from cardiac patients, physicians, and non-physician health care providers to inform how air quality information could be integrated into cardiac rehabilitation, where individuals who are at risk to exposure to air pollution receive regular healthcare provider attention after an acute cardiac event. Findings will inform health risk communication research and outreach. We will also share critical stakeholder engagement activities that shaped these research products to meet needs of partners. Disclaimer: The views expressed in this report are those of the authors and do not reflect the views or policies of the USEPA.

732 Exposure Risks in Today’s Fire Service

G. Horn, University of Illinois Fire Se / Fire Service Institute

Risk facing today’s fire service are constantly evolving as fires progress more rapidly and produce more toxic smoke than ever before. Not only are the fuels changing in the structures during emergency response, the training ground is undergoing rapid changes as it evolves to improve the training firefighters receive to prepare for these threats. Cancer is a primary chronic health concern associated with firefighting. Sudden cardiac events are the leading cause of line-of-duty deaths in the Fire Service and a primary acute health concern. In an on-going series of project between IFSI Research, UL FSRI and NIOSH, we have developed a deeper understanding of the exposure risks associated with firefighting activities. This presentation will provide a brief overview the critical results from those efforts with a focus on implications from this study as well as straightforward means to reduce exposures to these risks while operating on today’s fireground and training ground.

733 Military-Style Silicone Dog Tags Examine Occupational Firefighter Chemical Exposures

C. Poutasse, Oregon State University / Environmental and Molecular Toxicology; W.C. Poston, S. Jahnke, C.K. Haddock, National Development and Research Institutes, Inc. / Center for Fire, Rescue, and EMS Health Research; L. Tidwell, P. Hoffman, K.A. Anderson, Oregon State University / Environmental and Molecular Toxicology

Firefighters are charged with protecting the citizens and property in the communities they serve, but occupational hazards specific to the fire service are hypothesized to play a role in the increased risk of cancers. These hazards include exposures to recognized or probable carcinogens, such as polycyclic aromatic hydrocarbons (PAHs). However, exposure classification for fire service studies is often rudimentary and based on inexact surrogates, resulting in tremendous variability between and within departments with respect to exposures to environmental carcinogens. Passive sampling devices, such as silicone wristbands, have previously provided personal exposure assessments and often partner with demographic data assessed by questionnaires to infer lifestyle and behaviors associated with chemical concentrations. This study presents the military-style dog tag as a new necklace configuration of the silicone passive sampling device. Firefighters (n=56) recruited from two different stations wore the dog tag for 30 shifts to capture accurate measurements of bioavailable occupational chemical exposures. Firefighters served as their own controls (on-shift vs. off-shift) at each station (high volume vs. low volume). This research is the first to provide comprehensive characterization of firefighter chemical exposures with the analysis of over 1500 analytes using gas chromatography mass spectrometry, an analytical method which includes PAHs, polychlorinated biphenyls, flame retardants, pesticides, and personal care products.

734 Cardiovascular Health Response to Biomass Smoke Particulate Matter Exposure Among Wildland Firefighters

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The characterization of smoke exposures and the biological (or clinical) monitoring among wildland firefighters is limited due to the inherent hazards of interfering with firefighting tasks during “active” wildfire environments. Wildland firefighters are the largest group of public safety employees exposed to biomass smoke on a regular basis. Cardiovascular diseases are the leading cause of mortality and morbidity, accounting for more than half of work-related deaths. Even though occupational smoke inhalation during active fire events has been identified as the primary risk factor for disease development, respiratory protection is rarely practiced by wildland firefighters due to the cumbersome weight and limited air capacity of most currently available respirators. The purpose of this study was to utilize the strengths of situ occupational exposure monitoring and cardiovascular health assessments to determine the effects of biomass smoke’s particles on acute cardiovascular function among wildland firefighters during active fire events. Personal exposures to particle composition and size distribution (total, course, fine) were assessed by lightweight continuous particle counting monitors attached to the shoulder-pads of each firefighter. These monitors were worn throughout the duration of each burn event and collected measures in one-minute intervals. Changes in cardiovascular function were measured by cross-shift blood pressure monitors and ambulatory heart monitors. The ability of the arteries to dilate was quantified by measuring blood pressure using desktop and ambulatory sphygmomanometers. Changes in cross-shift peripheral blood pressure (pBP), augmentation index for arterial stiffness, and pulse rate variability were obtained by utilizing a desktop supra-systolic oscillometric blood pressure monitor. Activity during periods of exposure were determined utilizing the ambulatory heart rate monitors. During this study, firefighters were exposed to PM ranging from 0.1 to 10.2 mg/m³ over
735 Firefighters’ exposures to polycyclic aromatic hydrocarbons and other environmental mutagens during emergency fire suppression

J. Keir, U.S. Akhtar, University of Ottawa / Department of Biology; D. Matschke, Ottawa Fire Service; P.A. White, Health Canada; T.L. Kirkham, University of Toronto / Occupational & Environmental Health Division; H.M. Chan, J.M. Blais, University of Ottawa / Biology

Firefighters experience above average risks of cancer and other serious illness. Their exposures to combustion emissions, including polycyclic aromatic hydrocarbons (PAHs), metals, and other products of combustion are a concern. Few studies have examined firefighters’ exposures to combustion emissions during on-shift, emergency fire situations. To assess firefighters’ occupational exposures to combustion emissions during emergency fire suppression, we measured exposures to PAHs, antimony, cadmium, and lead using (1) personal air samplers worn by firefighters during emergency fire suppression; (2) wipe samples of skin, personal clothing, and personal protective equipment (PPE) collected before and after emergency firefighting; and (3) urine samples collected before and after emergency firefighting. We examined chemical exposures by measuring PAHs and metals in air and surface wipe samples of skin, clothing, and PPE. We determined urinary PAH metabolite concentrations and urinary mutagenicity using the Salmonella mutagenicity assay (Ames test). Urinary Clara Cell 16 (CC16) and 15-isoprostane F2t (8-isopGF2α) concentrations were used to assess lung injury and oxidative stress, respectively. Air concentrations exceeded occupational exposure limits at two fire events for lead and nine for PAHs. After fire suppression, PAH concentrations were significantly higher on skin and PPE (p < 0.001), antimony on skin, clothing, and PPE (p < 0.001, 0.01, and 0.05, respectively), and lead on skin and PPE (p < 0.001). Post-event concentrations of urinary PAH metabolites were, on average, 2.9-to 5.3-fold higher than pre-event values, depending on the PAH metabolite (p < 0.0001). Average post-event urinary mutagenicity showed a significant 4.3-fold increase (p < 0.0001). Urinary CC16 and 8-isopGF2α did not increase. PAH concentrations in personal air and on skin accounted for 54% of the variation in fold changes of urinary PAH metabolites (p < 0.002). The results indicate that emergency, on-shift fire suppression is associated with significantly elevated exposures to combustion emissions. Future studies are required to determine effective ways to reduce such exposures to ultimately reduce disease and illness in firefighters.

736 Derek Muir’s adventures on the AMAP trail

C. de Wit, Stockholm University / Environmental Science and Analytical Chemistry

Derek Muir’s Arctic science trajectory began in 1988, with his first publications on organochlorines in Arctic biota. In 1994, he was appointed one of two co-leads of the Persistent Organic Pollutants (POPs) Expert Group within the Arctic Monitoring and Assessment Programme (AMAP). At that time, Canada and Sweden were the international leaders in driving policy and regulation of hazardous chemicals, thus Canada’s interest in filling one of the co-lead positions of this expert group. In this capacity, he was strongly involved in the planning, writing, and editing of AMAP’s four major scientific assessments of POPs and chemicals of emerging concern in the Arctic. These assessments as well as his work with Canadian Northern Contaminants Program assessments played crucial roles in the development of chemicals policy in Canada, the creation of the Persistent Organic Pollutants (POPs) Protocol of the Convention on Long Range Transport of Atmospheric Pollutants in 1997 and the UN Stockholm Convention on POPs in 2001. He has also been deeply involved in planning and writing parts of assessments on temporal trends in Arctic biotic and abiotic media, which have supported the Stockholm Convention Global Monitoring Plan. These have included his own research such as his long-term studies of contaminants in ringed seals and Arctic char. In his AMAP work, he has attended and co-led numerous workshops of international POPs experts in the preparation of assessment reports, taken part in various AMAP Working Group meetings to discuss results of assessments with policymakers, presented results of the assessments at AMAP conferences and at special sessions at international conferences. He has also been engaged in helping to update the AMAP Monitoring Programme and AMAP’s assessment strategies. This presentation will highlight Derek’s work within AMAP in more detail, his scientific work in identifying new potential POPs and the important role he has played as an expert in the development of international chemicals regulation.

737 A Muir legacy: Understanding contaminant dynamics in arctic food webs

A. Fisk, University of Windsor / Great Lakes Institute for Environmental Research; K. Børgå, University of Oslo / Department of Biosciences; G.T. Tomy, The University of Manitoba / Department of Chemistry

Contamination of the Arctic by industrial and agricultural chemicals was first recognized almost 50 years ago. Although a vast majority of these contaminants originate from temperate regions, concentrations of chlorinated compounds in arctic marine top predators are among the highest of any animals on earth, and Inuit, through their diet rich in marine mammals, face the highest exposure levels of any humans. Bioaccumulation and trophic transfer of organochlorine contaminants, such as DDT and PCBs, were known to contribute to elevated levels in higher trophic level organisms, but the extreme levels in Arctic marine apex predators were initially difficult to explain. Detailed and well-planned studies across the entire Arctic, most led, including or inspired by Derek Muir, demonstrated that the long life, high lipid content, varying biotransformation capacity of Arctic marine animals and the persistent nature of these compounds contributed to efficient trophic transfer of organochlorine contaminants in polar food webs. These factors were later used to explain the biomagnification of other types of contaminants, including brominated and fluorinated compounds, in Arctic food webs, with Muir again spearheading many of these studies. Documenting the presence and the potential for bioaccumulation of these contaminants in the Arctic was a central part in global agreements to reduce their use and emissions, and to develop effective consumption guidelines for wild Arctic foods. This talk will review and celebrate the expansive research of Derek Muir on the bioaccumulation and biomagnification of contaminants in Arctic food webs, and its important impact on global policies.
between the species. PCBs and PBDEs were highest in the limpets and sea urchins. HCB and pp-DDE were the most prevalent OCPs, followed by HCHs, heptachlor and oxychlordane. OCP concentrations generally did not differ among species. Limpets contained POPs with higher logKow and logKoa, related to their grazing behaviour on biofilms and potential limited exchange with the water due to their shell. Sea squirts and cucumbers contained POPs with relatively high water solubility, which indicates a water-borne exposure. The sea star and sea urchin were somewhat in the middle ground between the mentioned groups. Tissue concentrations and patterns will be related to the dissolved and particulate concentrations. Temporal changes will be presented and accumulation kinetics in the particulate matter will be related to seasonal algae blooms and uptake patterns in the animals. Drivers of seasonal accumulation will be derived and examined in contrast with the Arctic, for which much more data and knowledge already exists. Thereupon, overarching patterns of environmental partitioning and accumulation of POPs in both polar regions will be discussed, placing the immense impact of Derek Muir on Arctic research in an even wider perspective.

739 Contrasting temporal trajectories of legacy and current use flame retardants in Herring Gull (Larus argentatus) eggs in the Laurentian Great Lakes
S. de Solla, Environment and Climate Change Canada / Wildlife Landscape and Science Directorate; A.O. De Silva, Environment and Climate Change Canada / Water Science and Technology Directorate; R.J. Letcher, Environment and Climate Change Canada / Ecotoxicology and Wildlife Health Division; G. Lu, Hong Kong University of Science and Technology / Shenzhen Research Institute / Marine Environmental Laboratory; G. Su, Nanjing University of Science and Technology / School of Environmental Science and Engineering; D.J. McGoldrick, Environment and Climate Change Canada / Water Quality Monitoring and Surveillance Division; P.A. Martin, Environment and Climate Change Canada / Wildlife and Landscape Science Directorate

Following the discovery of widespread adverse reproductive and developmental impairment in fish-eating colonial waterbirds nesting in the Canadian Great Lakes, Environment and Climate Change Canada started monitoring contaminants in the Herring Gull (Larus argentatus) eggs in 1974. Here we contrast the spatial and temporal trends of both legacy contaminants, some of which are flame retardant chemicals, such as Polychlorinated Biphenyls (PCBs) and Polychlorinated Naphthalenes (PCNs), with flame retardants currently in production, such as organophosphate esters (OPEs) and Dechlorane Plus (DDC-CO) isomers. In general, the temporal trajectories of legacy compounds in gull eggs were consistent with first order exponential declines. An exception were PCNs in gull eggs from colonies immediately downstream of the Detroit River, in which concentrations peaked again in the early 2000s. PCN concentrations appeared to have a temporary resurgence following dredging of sediment for remediation of contaminated within the Detroit River, the effect of which was detectable at least as far downstream as eastern Lake Ontario. Compared to legacy contaminants, concentrations of DDC-CO have increased over time, whereas temporal trends of OPEs were inconsistent. Spatial trends of all persistent contaminants (e.g. PCBs, PCNs and DCC-COs) appear to be associated primarily with industrial activity or nearby centers of human population. Conversely, OPE temporal trends in gull eggs were only weakly related to the trends seen in sediment, and body burdens appeared to be driven not by municipal density but instead are heavily influenced by metabolism in the maternal birds or by embryos.

740 Photodegradation of naphthenic acids and other organic classes in oil sands process-affected water extracts
J.K. Challis, University of Saskatchewan / Toxicology Centre; A. Parajy, J. Anderson, University of Winnipeg / Department of Chemistry; E.K. Asiedu, University of Alberta / AET Division; J.W. Martin, Stockholm University / Department of Environmental Science and Analytical Chemistry; ACES and Science for Life Laboratory; C.S. Wong, Southern California Coastal Water Research Project Authority / Chemistry; M. Ross, MacEwan University / Physical Sciences

Naphthenic acids (NAs) are persistent and toxic natural constituents of bitumen that are solubilized and concentrated in oil sands process-affected water (OSPW) during oil sands extraction. Few studies have investigated environmentally-relevant photochemical transformation of NAs. We hypothesized that NA-like compounds are susceptible to phototransformation, and this process may be a significant removal pathway. To examine direct photolysis via wavelengths in solar radiation (i.e., >290 nm), changes in NA profiles (i.e., C and z numbers) were characterized following bench-top scale studies using OSPW, and acid- (AF) and base-extracted fractions (BF). Intensities were measured by HPLC and ultra-high resolution mass spectrometry in negative (-) and positive (+) modes. Photolysis reduced all constituent groups in OSPW-, OSPW+, AF-, and BF+, over the course of the 18-day irradiation period. Total NAs in OSPW were reduced by 99% and by 87% in AF-. Highly photolabile species included O2-, O3-, O4-, O4S-, O4S-, and O5S- containing structures, which were degraded by 93% to 100% after 5 days and by 94% to 100% after 18 days. Following photolysis, there was a noticeable shift towards smaller species with less cyclicity, double bonds, or aromaticity. On Day 18, mean carbon number and z-values in OSPW- shifted to 12 and -4, respectively, from 15 and -8 on Day 0. First-order kinetic models were used to investigate removal trends. Half-lives of heteroatomic classes ranged from 2.7 (O4S-) to 14.9 (O3-) days for OSPW-, and from 3.9 (O3S+) to 20.9 (O5+) days in OSPW+, indicating differences across structures, but overall efficient NA removal via photolysis.

741 Muir & Mabury: 24 Years of Collaborative Discovery & Impact with OrganoFluorine
S. Mabury, University of Toronto / Chemistry

Starting with the smalled perfluorinated alkylcarboxylic acid TFA, the collaboration between Muir and Mabury has produced 52 joint publications that averaged over 96 citations/paper and a resulting H-factor of 34; sixteen of these papers have over 100 citations. Funded through two NSERC Strategic grants, a TSRI, and a number of smaller grants, this collaboration has involved mentoring and training of at least 27 students, many of whom were joint formal supervisions of M&M. Significant discoveries and advances in our understanding of the role Fluorine plays in the fate, disposition and persistence of organofluorine compounds have been made possible by this collaboration. They include a number of newly identified pollutants such as the long-chain perfluorinated acids and volatile precursors; the extent of Arctic contamination and temporal response; and physical properties (BCF/BAF) of fluorinated chain length; these and others will be used to highlight why this collaboration was so productive.

742 Advances in environmental chemistry over 40 years and a look forward
D.C. Muir, Environment and Climate Change Canada / Aquatic Contaminants Research Division

The last 40 years has seen many advances in measurement of persistent organic pollutants in environmental media, in understanding fate and distribution, and regulating them at the national and global level. SETAC has been a major forum for this research with advances in measurements, bioaccumulation, biodegradation, ecotoxicity and modelling often reported for the first time at these conferences since 1979. Highlights for me, have been the confirmation of the importance biomagnification both in the field and on a fundamental level using fugacity, modelling of global long range transport, the expansion of measurements from semi-volatiles
Thursday Platform Abstracts

744 Site-specific and standard toxicity tests for ecological risk assessments of oil spills

P.V. Hodson, J. Adams, Queens University / School of Environmental Studies; R.S. Brown, Queens University / Department of Chemistry

Ecological risk assessments (ERAs) of oil spills rely on laboratory tests of the toxicity of crude and refined oils to aquatic organisms. The more that test conditions reflect site-specific conditions such as temperature, salinity, and test species, the more useful and reliable the test data will be. However, ERAs also include reviews of published toxicity data for species and test conditions that are not specific to a spill site. Differences among studies in estimated toxicities will add uncertainty to risk estimates if the underlying causes of those differences are not understood. These uncertainties can be reduced through experimental design, specifically the inclusion of appropriate controls and standard tests that provide perspective on why toxicity varies among studies. We will review factors that affect the outcome of oil toxicity tests, including the storage and handling of test oils, the methods chosen for mixing oil and water, the characterization of test solutions that may be highly dynamic, the species and developmental stages of test organisms, and details of test conditions such as the materials of test tanks. When site-specific toxicity tests are matched by tests conducted under standard conditions and supported by detailed chemical characterization of test solutions, experimental characteristics that affect oil toxicity and the extent to which they change toxicity, can be identified. This more complete detailed understanding of how methods affect oil toxicity will support a better interpretation of toxicity data and more reliable ERAs.

Oil Toxicity Testing: Current Experimental and Analytical Methods, Exposure Metrics and Risk Interpretation

743 A Path Forward for Improving Aquatic Toxicity Testing of Hydrocarbon Substances

A.C. Bejarano, Shell Health - Americas / Shell Health Risk Science Team; G. Coelho, Sponsor Group, Inc.; C.L. Mitchellmore, UMCES / Chesapeake Biological Laboratory; D. Wetzel, Mote Marine Laboratory / ELF

Petroleum substances are complex mixtures of many chemical constituents with different physicochemical properties that determine their partitioning into the aqueous exposure media, and therefore their bioavailability to exposed organisms. Because of these complexities, assessing their hazard to aquatic resources relies on the use of established standard toxicity testing protocols that include detailed chemical and physical characterization of the exposure media. For nearly four decades, members of the scientific community have strongly encouraged the use of standardized toxicity testing protocols, for example, Chemical Response to Oil Spills Ecological Effects Research Forum, and modified versions developed during the Deepwater Horizon oil spill. Despite these efforts, the continued use of dissimilar testing and exposure media preparation methods has generated irreproducible toxicity test results that are inappropriate or inadequate for inclusion in hazard assessments. Consequently, there is a continued need to employ toxicity testing methods that are supported by current scientific knowledge and that can be applied to likely real-world exposure regimes. Studies must, at a minimum, follow rigorous protocols that ensure reproducibility across laboratories, have well defined and accepted statistical criteria for result validation and interpretation, and include chemical and physical characterization of exposure media to determine the constituents contributing to toxicity. Generating reliable test results is imperative as these data are essential to generate comprehensive toxicity models and decision-making tools used for supporting spill response, and to support environmental assessments. The purpose of this presentation is to highlight key challenges associated with current practices, but more importantly, to present suggestions for a path forward aimed at generating test results that are easily interpreted by environmental decision-makers. Specific discussions will be focused on rigorous established approaches that include: experimental design, test media preparation with/without dispersants, the role of mixing energy and presence of oil droplets, the influence of chemical characterization methods, minimum and ideal chemistry requirements, and the potential role of passive sampling methods. The primary objective of this presentation is to encourage multi-disciplinary collaboration for generating meaningful data with practical real-world applications.

The Chemical Aquatic Fate and Effects (CAFE) database is a tool that facilitates assessments of accidental chemical and oil releases into aquatic environments. CAFE contains aquatic toxicity data summarized in the form of species sensitivity distributions (SSDs) with associated 5th percentile hazard concentrations (HC5s). Since its initial release in 2015, CAFE has been used in hundreds of chemical and oil spills. However, for many chemicals and oil gaps, in species diversity and toxicity data limited the development of SSDs. In CAFE’s upcoming web version, some of these data gaps were addressed with Interspecies Correlation Estimation (ICE) models. The incorporation of ICE predicted values into CAFE allowed the development of >800 new SSDs and increased diversity in SSDs by an average of 34 species. Multiple analyses showed that SSDs supplemented with ICE-predicted values generally produced HC5 estimates that were within a 3-fold difference of estimates from measured SSDs (58%-82% of comparisons), but that were often more conservative (63%-76% of comparisons) and had lower uncertainty (90% of comparisons). ICE SSDs did not substantially underpredict toxicity (<10% of comparisons) when compared to estimates from measured SSD. With the addition of ICE models into CAFE’s upcoming web version, more SSDs are generated, increasing CAFE’s capacity to respond to chemical and oil spills.
746 From Models to Beakers: A Comprehensive Evaluation of Oil Toxicity

B.S. Echols, Environmental Toxicology Associates, LLC; W.A. Stubblefield, Oregon State University / Environmental and Molecular Toxicology

The complex chemical composition of oil, comprised of soluble and insoluble constituents, contributes to the difficulty in both the laboratory assessment of potential toxicity to aquatic organisms, as well as the interpretation of test results. Additionally, the presence of microdroplets in test material and poorly characterized exposure concentrations are also factors contributing to the difficulty in reliably assessing crude oil toxicity and extrapolating that information to real-world scenarios to evaluate oil spill risk to aquatic receptors. Oil solubility and toxicity models enhance our ability to understand exposure and toxicity by predicting the bioavailable fraction of oil in exposure media and the toxicity potential of that fraction across a range of experimental methods, oil types and species. The current study aims at comparing model predicted toxicity in terms of total oil exposure to a robust empirical dataset. These data include acute and chronic toxicity test data for fresh and field-collected Macondo oil with and without chemical dispersant (Corexit 9500). By comparing model-predicted estimates to empirically determined lethal concentrations generated from laboratory tests, we will not only be able to provide further validation of model estimates but also provide a more comprehensive understanding of species sensitivity to various stages of oil weathering.

747 An antibody-based biosensor method for the rapid assessment of polycyclic aromatic hydrocarbons in porewater to predict sediment toxicity

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A biosensor that quantifies 3-5 ring polycyclic aromatic hydrocarbons (PAH) to sub-pb concentrations in small volume (1-5 mL) aqueous samples was developed that allows analysis in minutes at spatial and temporal scales not possible by GC-MS methods. Biosensor measurements in porewater were highly correlated to benthic amphipod toxicity at field sites and in PAH-spiked sediment samples. Porewater measurements were much better at predicting toxicity than whole sediment concentrations due to sediment properties altering the partitioning and bioavailability of the contaminants. Porewater measurements are difficult to obtain by standard analytical methods so our biosensor analysis is being evaluated as a potential tool for near real-time evaluation of sediment toxicity. Sediment porewater from field collected creosote contaminated sediments and oil-spiked sediment samples were analyzed for total PAH by biosensor and/ or solid phase micro extraction followed by gas chromatography (SPME/GC) and evaluated for toxicity to the benthic amphipod (Leptochirus plumulosus) in 10-day survival tests. Both SPME/GC and biosensor measurements were strongly correlated to amphipod toxicity. When total 3-5 ring PAH concentrations in sediment porewater exceeded 10-20 μg/L amphipod toxicity increased dramatically. Survival curves were very steep and typical of PAH with a narrow range where toxicity spanned from 0-100%. Differences in results between oil-contaminated and creosote-contaminated sediments may result from differences in the complex mixtures not measured by the rapid analytical methods. However, the narrow concentration range where toxicity occurs shows that these analyses can be valuable tools for toxicity assessment. Combined with the ease of collecting data in the field, near real-time assessment of sediment toxicity is feasible at PAH contaminated sites during oil spills, flood events or to guide remediation.

748 Variability in toxicological response of Atlantic cod (Gadus morhua) larvae exposed to petroleum hydrocarbons

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Oil and gas exploration and production activities have existed for decades within the productive environment offshore of Newfoundland & Labrador and Nova Scotia. These activities are expected to continue expanding to new areas of Canadian frontier lands offshore. These same areas overlap with historical highly productive oceanic feeding and spawning habitat for complex marine species assemblages, including Atlantic cod (Gadus morhua). A series of bioassays were performed with larval Atlantic cod from 16 crosses with contributions from 10 female and 8 male adult cod. Fin clips were taken from each adult cod and sent for genotyping to estimate the relatedness of individuals based on six microsatellite markers. The bioassay involves a 24-hour exposure to a series of 8 concentrations of physically and chemically dispersed crude oil. The treatments were chosen to match the microdroplet size profile and distribution results from wave tank dispersion trials (SL Ross, Ottawa, ON), which served as a proxy for the environmental conditions observed offshore Newfoundland & Labrador, Canada. At the initiation of each exposure, 10 reference organisms were collected from each test population and had morphometric measurements taken. The larval cod ranged in age from 162 to 242 degree days. Percent mortalities were obtained at the conclusion of the test and concentration-response curves were estimated by fitting log-logistic functions (drc package, in R). Median lethal effect concentration (LC50) estimates accounted for control condition, and were used to generate a distribution curve for the species based on the responses of each cross. Statistically significant differences were observed between the LC50 values of several cod crosses. The LC50 for mortality observed in cod larvae ranged from 8.6 to 44.7 mg TPH/L. The variability observed in the cod results could not be explained by age (as degree days) at time of exposure (p = 0.22), and there was no significant relationship between any of the reference organism measurements and the LC50 values. From the sensitivity distribution the HC5 was calculated as 14.2 mg TPH/L (10.3, 19.1; 95% CI) and used to determine predicted no effect concentrations which would be protective of the population. The causes and consequences of the observed experimental and natural variability will be discussed with specific implications for risk assessment.

749 A Physiologically Based Oiling Model (PBOM) to Predict Thermoregulatory Response in Oiled Birds

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When birds are exposed to oil their ability to thermoregulate is impaired as a result of damage to the insulative properties of their feathers. If an oiled bird is unable to maintain thermal homeostasis, hypothermia and death can follow rapidly. Physiological responses to oiling depend on several variables including environmental conditions (e.g., cold vs. temperate climates; air and water temperatures), life history of bird species (e.g., habitat selection and body size), and foraging strategies (e.g., divers, surface feeders and shorebirds). The most widely used approach to assess the effects of spilled oil on birds is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Type A Natural Resource Damage Assessment Model for Coastal and Marine Environments. While the CERCLA model minimally addresses body size and time spent in a hypothetical slick, it lacks the flexibility to assess other variables related to physiological response. Building on benchtop “proof-of-concept” experiments with model “birds,” we developed a dynamic physiologically based oiling model (PBOM) for birds. The PBOM has been validated against empirical data from a dose-response study in which common eiders (Somateria mollissima) were exposed to Statfjord A crude oil. At this time, PBOM is being used to predict thermoregulatory responses of five representative bird species: common eider, spotted sandpiper, great blue heron, dovekie and American white pelican. The model can predict time to hypothermia
for birds of differing body size and habitat preference, in warm or cold environments. Here we present: 1) a conceptual model of quantifiable variables (e.g., life history of bird species, environmental conditions and foraging strategies) that can influence thermoregulatory responses to oiling; 2) the approach used to validate PBOM; and 3) examples of thermoregulatory responses predicted using PBOM.

750 Antibody-based biosensor technology as a tool for near real-time measurement of PAH contamination in bivalves

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Sessile filter feeders such as bivalves are susceptible to accumulation of hydrophobic contaminants such as polycyclic aromatic hydrocarbons (PAH) due to limited metabolic capacity. During spills or flood events, quick assessment of seafood safety is crucial for stakeholders and resource managers to determine potential risk to consumers. Established quick response methods such as sensory analysis (i.e. sniff testing) are non-quantitative and met with distrust by the public. More reliable PAH quantification methods such as conventional GC-MS analyses take several weeks and are expensive. A new, highly sensitive, antibody-based biosensor method has been developed to rapidly measure total 3-5 ring PAH concentrations in individual bivalves using small volume (1-2 mL) aqueous samples. Application of the biosensor method to measure PAH concentrations in individual animals relies on fundamental partitioning of hydrophobic chemicals in a system at dynamic equilibrium. At equilibrium, an unknown concentration of PAH in one phase can be calculated from another based on the partition coefficient for the two phases. PAH concentrations in oyster mantle fluid (i.e. aqueous phase) analyzed by biosensor correlate well with PAH concentrations in field-collected oysters analyzed by GC-MS suggesting internal equilibrium within individual oysters may allow whole animal concentrations to be predicted rapidly and reliably. In a laboratory study, adult C. virginica were exposed to the water-accommodated fraction of crude oil for 3-days followed by a 14-day depuration period. Animals were sampled to compare the ability of the biosensor method to track changes in PAH concentrations over time to that of conventional body burden analysis by GC-MS. Results from this study will be discussed. Biosensor technology could serve as an important tool for rapid evaluation of potential PAH-contaminated seafood in time-sensitive situations such as oil spill response. This technique is significantly cheaper than conventional methods on a per sample basis. Further applications include assessing other bivalve species as well as rapid, economical mapping of background PAH levels for contingency planning.

Emerging Environmental Contaminants: Human Exposure and Associated Risks - Part 2

751 Re-thinking chemical fate and exposure indoors

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When we first considered the SVOC fate indoors, we brought our paradigm from the outdoor environment that fate processes were dominated by the physics of transport processes and we largely neglected the role of human occupants. However, ample evidence shows that neglecting human occupants can give a simplified and unrealistic assessment of indoor chemical dynamics. What if people’s “everyday” activities directly influence the transport and distribution of chemicals indoors which, in turn, influence exposure? We illustrate the role of human activities, and hand contact in particular, using a dataset from 51 homes and their residents in Ontario, Canada. The concentrations of 23 organophosphate esters (OPEs), 14 polybrominated diphenyl ether (PBDEs) congeners, 10 non-PBDE halogenated flame retardants (HFRs) and 6 phthalate esters were measured in air, floor dust, and wipes of surfaces of electronic devices and participants’ hands. Here we use data for 5-8 OPEs, 3 PBDEs, 2 non-PBDE HFRs and all 6 phthalates for which detection frequencies were >80%. Although we expected to find dominant flame retardants and/or plasticizers in the surface wipes of specific devices, a cluster analysis showed similar chemical profiles on most surfaces (e.g., electronic surfaces, hand backs and palms). Network analysis of chemical profiles showed the centrality or “connectedness” of hands to all other surfaces, followed by air and dust. Next, we probed the similarity among surfaces by analyzing their Euclidean distances obtained from the cluster analysis. We found a surprising similarity of chemical profiles on hands of 51 “random” participants, which we believe comes from hands contacting and transferring chemicals. The concept of hands as agents of transport is well known in terms of disease transmission. We hypothesize that our hands transport chemicals from surface-to-surface, leading to similar chemical profiles on indoor surfaces, and that hands are a reflection of our exposure to this mixture of chemicals in our indoor environments.

752 Association of emerging contaminants with biomarkers of placental disease and development during mid-gestation of pregnancy

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Perfluorinated alkyl substances (PFAS) and organophosphate flame retardants (OPFRs) are emerging chemicals of concern that may be associated with placent-mediated pregnancy and maternal health complications. However, few studies have evaluated these environmental chemicals during mid-gestation or in relation to biomarkers of placental disease and development. Thus, we performed a descriptive analysis and epidemiologic study evaluating PFAS and OPFR exposure with several molecular and morphological biomarkers of placental disease and development among N=62 pregnant women during mid-gestation. Molecular biomarkers included trophoblast invasion-promoting adhesion molecules, integrin alpha-1 (ITGA-1) and vascular endothelial-cadherin (VE-cadherin), as well as an extracellular matrix-degrading enzyme, metalloproteinase-1 (MMP-1). Morphological endpoints included leukocyte and fibrinoid deposition (potential indicators of placental stress) as well as the extent of spiral artery remodeling during placentation. We found an inverse association with ITGA-1 immunoreactivity and a positive association with morphological indicators of placental stress in multiple regions of the basal plate during mid-gestation. However, our study was limited by sample size. Further research with a larger sample size and/or expanded panel of molecular and morphological biomarkers is warranted.
753 Risk assessment of air pollutants arising from burning of tyres on exposed children

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Occasional burning of used tyres during a festive period may not be seen to produce significant air pollutants. However, it has become everyday practice in its use in roasting of slaughtered cows, goats and sheep/rams in many abattoirs in Nigeria and this has been viewed to have an economic advantage in terms of cost and “recycling of used or worn-out tyres.” In spite of the above, it has become obvious that this practice releases particulate matter, volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) especially polycyclic aromatic hydrocarbons (PAHs) into the environment. Research has shown that these PAHs could trigger some health problems ranging from respiratory irritation, cough, dermatitis, depressed immune system and a decrease in lung function. This study was aimed at evaluating the risk of exposure of school children whose schools are located in close proximity to these abattoirs. The study sought to determine the concentrations of some selected Environmental Protection Agency (EPA) priority PAHs, particulate matter in ambient air in and around the studied school environment, concentrations of some PAH metabolites and some heavy metals in post-shift urine of selected primary school children and control subjects. Lung function, cytogenetic evaluation of DNA damage in buccal exfoliates and urinary phenol of exposed children were undertaken. Some of the results show that the concentrations of 1-Hydroxypyrene (1-OHPyr) (µg/molCret), a PAH metabolite, in the post-shift urine samples of the 75% of the children were 0.68±0.06µg/molCret vs 0.32±0.05µg/molCret while urinary phenol concentrations were 18.45±0.39 mg/l vs. 7.89±1.52 mg/l respectively in exposed children and the control (children in a primary school 8-10 km away from the abattoir). The buccal epithelial exfoliates showed that karyorrhexis and condensed chromatin bodies were significantly higher in the exposed children than in the control. The above result gives an insight of possible future complex health problems which can be prevented through integrated policy and interventions that will simultaneously and holistically address the release of these pollutants from the abattoir.

754 Screening for Novel Halogenated Compounds in the Great Lakes fish using Two-dimensional Gas Chromatography with High-Resolution Mass Spectrometry

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The Great Lakes are impacted by emissions of chemical contaminants from industries, agriculture and urban centers in the region. Monitoring these chemical stressors in Great Lakes wildlife can be challenging, but vital to assessing the overall health of the system. Traditional analytical methods target select compounds or compound classes in the biota; however, these may represent only a fraction of the contaminant burden. Due to complexity of the biological matrix, classical analytical techniques are not suitable for understanding the complete halogenated fingerprint in the biota. In this study, a non-targeted screening approach was developed and applied to the Great Lakes fish using a two-dimensional gas chromatograph coupled to a high-resolution time of flight mass spectrometer (GCxGC-HR-ToF MS). More than 60 novel halogenated species were identified in whole fish lake trout from all Great Lakes and the most abundant chemical class detected was halomethoxyphenols (MeOPs). Halo-MeOPs were present at higher concentrations than PCBs, but little is known about their potential origin. To assess the risks that these contaminants may pose to human consumers, fish fillets were also analyzed. A discussion of the tissue distribution of the halogenated chemical signature will be presented with insight to possible sources of detected novel halogenated chemicals.

755 The Sorption of Pharmaceutical and Personal Care Products on High-density Polyethylene and Polypropylene Microplastics

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Wastewater treatment plants are a major transport pathway for microplastics; however, they are also a significant source of organic pollutants, especially pharmaceutical and personal care products (PPCPs). It is well known that microplastics are capable of sorbing organic pollutants to concentrations magnitudes higher than the surrounding water; however, it is unknown if microplastics may act as vectors for PPCPs from wastewater to the environment. One of the major knowledge gaps is the relatively little information known about the sorption behavior of PPCPs and microplastics. To better understand the role of microplastics as vectors for PPCPs, their sorption equilibrium should be quantified. Additionally, compounds of differing solubility (i.e., the octanol-water partition coefficient, Kow) must be tested to begin to understand the relative risk of different PPCPs. Therefore, this study will examine the sorption of (in order of decreasing Kow) venlafaxine, diphenhydramine, DEET, and caffeine with high-density polyethylene and polypropylene microplastic particles of different diameter (i.e., surface area). Results will be presented that will show the differences in sorption between particles of different surface area and polymer type. Studying the toxicity of microplastics in the environment will require an understanding of what organic pollutants, such as PPCPs, are likely to be present. This work will provide such data and will be used to create a simple model for the sorption of microplastics based on Kow for PPCPs found in wastewater.

756 Occurrence & Fate of Emerging Organic Contaminants in Water in Chennai, India

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The presence of pharmaceuticals, hormones, pesticides, perfluorinated compounds and industrial contaminants in wastewater has been well-documented in the USA, Europe, and many developed regions in the world over the last two decades. However, information on occurrence and fate is still lacking from many parts in India which is the second most populous country in the world. The goal of this study was to detect for the presence and concentration of twenty two emerging organic contaminants (EOCs) at 3 different wastewater treatment plants in Chennai which is one of the most densely populated regions in South India. The treatment plants selected were different in size and treatment capacity to mimic more urban and domestic settings. Three different sampling campaigns at different seasons were conducted at different locations in the wastewater treatment plants including the influent, primary, secondary and final effluent. The wastewater data indicated 11 EOCs were detected in every sample from every location at all sites, while only 5 EOCs were detected consistently in effluent samples. The effluent composition of the 22 EOCs were similar within the three WWTPs but quite different to those seen in the US, indicating the importance of region-specific monitoring. Diurnal trends indicated that variability is compound specific but trended within certain classes of compounds (artificial sweeteners, and pharmaceuticals). We also studied the treatment efficacy of the wastewater treatment plants for these emerging contaminants. Finally, 22 surface water sites upstream and downstream of the WWTPs were evaluated for presence of these EOCs to determine their fate and exposure to the population in the area.
757 Occurrence and distribution of antibiotics and antibiotic-resis- 
tant bacteria in the Suquia River (Córdoba, Argentina)
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Córdoba-CONICET / CIBICI-Fac. Cs. Quimicas

Antibiotics (AB) are a particular group of emerging contaminants that 
have gained a lot of attention because of their high consumption in human and 
veterinary medicine, worldwide distribution in the environment, in 
addition to association with the proliferation of antibiotic resistance bac-
teria (ARB), bearing clinically relevant antibiotic resistance genes (ARG). 
The aim of this study was evaluating the presence and environmental dis-
tribution of both AB and ARB in the urban area of Suquía River (Córdoba 
city-1,330,023 inhabitants, Argentina). Samples of water, sediment and 
natural river biofilms were collected at 5 sampling points: S1- control 
(upstream Córdoba city and the intake of water supply), S2 (dump area), S3 
(downstream a city ring way), S4 and S5 (6 and 10 km downstream the 
river and flood protect the area, over 1 million cubic metres of soil will be 
infilled with heterogenous fill placed on top of the existing peat, 

cyanotoxins exceeding human consumption limits will require advice on 
safe consumption and irrigation regimes.

758 Quantifying Potential Human Exposure to Cyanotoxins from 
Crops Grown with Contaminated Water
A. Bartos, Utah State University / Watershed Sciences; D. Drost, Utah 
State University; J. Brahney, Utah State University / Watershed Sciences

The prevalence of harmful algae blooms and their associated cyanotoxins 
in lakes near urban centers is an increasing global issue that poses an 
environmental and human health hazard. Exposure to cyanotoxins via 
consumption can result in acute and chronic neuro- and hepatic effects. 
Microcystin, Nodularin, and B-methylamino-L-alanine are common 
cyanotoxins that pose a threat to humans who use contaminated water 
for crop and garden irrigation. Experimental data is lacking on the fate of 
these toxins in the environment and for their capacity to bioaccumula-
tion in food crops. To fill these knowledge gaps, we will first quantify the 
 mobility of cyanotoxins in typical agricultural soils that vary in organic 
material content, pH, and cation exchange capacity (CEC) to determine relationships between soil characteristics and cyanotoxin mobility. Initial 
results show a positive trend of Microcystin-LR availability to plants in 
soils with decreasing CEC. An illicite clay (CEC= 33.6 mEq per 100 
grams) adsorbed 93% of Microcystin-LR in solution whereas a silt loam 
(CEC = 17.3 mEq per 100 grams) adsorbed none. The ability for soil to 
remove cyanotoxins from a soil-plant system can reduce risk for human 
exposure. Second, we will quantify uptake in lettuce crops irrigated with 
contaminated water. Three environmentally relevant concentra-
tions of cyanotoxins will be applied to lettuce grown in a random block 
design in a greenhouse. Cyanotoxin concentrations in roots and shoots of 
lettuce and the accommodating soil medium will be quantified using an 
enzyme-linked immunosorbent analysis kit. Lettuce bioaccumulation of 
cyanotoxins exceeding human consumption limits will require advice on 

759 River Valley Constructability, Design Evolution and 
Harmonization
D. Forbes, Waterfront Toronto / Project Delivery

Port Lands Flood Protection & Enabling Infrastructure Project is led 
by Waterfront Toronto with the support of the Toronto and Region 
Conservation Authority and is funded by the City of Toronto, Province of Ontario and Government of Canada This S1.25B project will protect 
approximately 250 hectares of urbanized land from flooding during a 
regional storm event. This project will transform 30 hectares of indust-
trial brownfields in Toronto’s Port Lands into a naturalized, multi-outlet 
river valley system with critical supporting infrastructure. Completion of 
this project will unlock billions of dollars of redevelopment potential. 
Once the largest wetland in the Great Lakes the mouth of the Don River 
was infilled with heterogenous fill placed on top of the existing peat, 
organic sediments and sand deposits. This resulted in extremely poor 
and highly variable geotechnical conditions in the area. Additionally, 
the Port Lands are subject to a water table that is very near surface and 
directly connected to Lake Ontario. These highly challenging geotechni-
cal and hydrogeological conditions make construction in the Port Lands 
very challenging. Over the course of the project the structural design of 
the river valley system and other flood protection features has evolved 
as the subsurface investigations have been advanced and the manner by 
which all features can be constructed determined. Integrating the design 
of the flood protection features with the river finishes, parks, roads and 
utilities has required significant coordination between multiple design 
and construction teams. This presentation will provide an overview of the 
evolution of the river valley system design, the critical factors that have 
influenced that design and will describe how this has been integrated 
with all other aspects of the Port Lands Flood Protection and Enabling 
Infrastructure Project.

760 Validity of Field Data, Bench Scale and Treatability Testing for 
Full Scale Land Use Controls
M. Janes, Waterfront Toronto / Projects

Formerly one of the largest natural wetlands in North America, the area 
was infilled in the early 1900s to make more land available to serve 
Toronto’s growing industrial sector and for shipping. While still used for 
industrial and port purposes today, these brownfield lands are generally 
underutilized, contaminated, lack adequate municipal services neces-
sary for other uses and also fall within the flood plain of the Don River. 
Plans are underway to flood protect and revitalize this valuable part 
of the city by building a new river outlet to Lake Ontario. Addressing 
metal impacts, petroleum hydrocarbons and non-aqueous phase liquid 
in redevelopment areas is challenging. Traditional practices of measure-
ment can be supplemented by advanced and specialized techniques that 
are now used to fully understand the in situ contaminant. To build the 
river and flood protect the area, over 1 million cubic metres of soil will be
excavated. A portion of the soil will be reused to construct flood protection walls. Poor environmental and geotechnical conditions complicate the soil removal and creation of a new river valley. Waterfront Toronto initiated a process in 2016 to test innovative but proven technologies in the following categories: 1. In situ remediation and/or stabilization of Non-aqueous Phase Liquid (NAPL). 2. In situ Soil Stabilization to Improve Geotechnical Conditions. 3. Ex situ soil remediation, amendment and dewatering technologies. A key component of the project is also to prevent any NAPL migration to the future river valley, reduce over-excavation for channel design slopes, and treat excavated and dredged soil to levels that would allow its reuse within the project area. It is anticipated that most of the excavated and dredged material will have to be dewatered, sorted, and remediated to reduce contaminant concentrations and/or amended to improve its geotechnical conditions. Investigation tools have used laser induced fluorescence, NAPL mobility coring and sorption isotherms. Over 300 investigation points in land and water with approximately 10,000 sediment, soil and groundwater samples were used in a 10,000 record database to model the spatial extent of the site conditions. Treatability studies were completed using sorption, thermal treatment, surfactant flushing and immobilization methods. The tested technologies include: - In situ remediation (STAR - in situ smoldering; - Electro-thermal treatment, SEPR-S-ISCO - surfactant enhanced removal with chemical oxidation); - Ex situ remediation (enhanced bioremediation, soil washing and STARs); - Risk management (block and adsorb and stabilization); and - Geotechnical improvement (urea-based soil stabilization). The decision process in selecting the final remedy will be discussed. The risk management strategy that has been developed includes a combination of barrier layers with low permeability, reactive and sorbent materials.

761 The Use of Numerical Models to Assess and Inform the Design of Environmental River Valley Risk Management Measures


The design of environmental risk management measures (RMMs) is a key component to providing long-term environmental protection of surface water, future visitors, workers, and ecosystem components within the proposed Port Lands Flood Protection and Enabling Infrastructure Project (PLFPEI) river channel. The proposed river channel RMMs consist of a concrete vertical cutoff wall, clay berm, and horizontal barrier, comprised of a geosynthetic clay liner, a geomembrane, and a granular/powdered activated carbon treatment layer. The river channel RMM design process incorporated the use of a 3-dimensional groundwater flow model and a combination of two industry standard horizontal barrier numerical chemical transport models to evaluate changing subsurface conditions over the design life of the RMMs. These models were used to evaluate the predicted future RMM performance, estimate current, interim, and post construction groundwater site conditions, and develop environmental goals that serve as the basis of design for the river channel. In this presentation we will provide an overview of how the models were constructed and discuss how the model outputs successfully supported the overall river channel RMM design in accordance with the project environmental goals while identifying the most cost-effective methods for implementation.

762 Construction of Integrated Reactive and Low Permeability Barriers for Future Sediment and Surface Water Protection in the New River

D.M. Thorson, Geosyntec Consultants, Inc.; M. Janes, Waterfront Toronto / Projects

The City of Toronto, the Province of Ontario, and the Government of Canada are undertaking a massive design and redevelopment of the Port Lands as part of the Waterfront Toronto Port Lands Flood Protection and Enabling Infrastructure (PLFPEI) Project. The Port Lands are a 1,000-acre area on the shore of Lake Ontario, immediately east of downtown Toronto. The area was man-made through decades of infilling of historic wetlands and has historically been used for heavy industry. Contaminants of concern primarily include petroleum hydrocarbons and metals. Much of the area is within the flood plain of the Don River and therefore flood protection must be created before the area can be fully developed. This includes the design and construction of a new River Valley that will connect the existing Don River to Lake Ontario. This presentation will provide an overview of the risk management measures being constructed to prevent the migration of contaminants into the new River Valley. These measures will include structural and non-structural concrete secant pile walls, concrete slurry walls, clay berms, a geosynthetic clay liner, a geomembrane, and a reactive (activated carbon) layer.

763 Isotherm and Non-aqueous Phase Liquid Treatability Tests in Support of a Horizontal Barrier System Design for the Port Lands Flood Protection Project

K.M. Bechard, H. Groenevelt, D.M. Thorson, D. Meric, D. Bertrand, Geosyntec Consultants, Inc.; M. Janes, Waterfront Toronto / Projects; M. Healey, K. Ashworth, SiREM

The design of the Port Lands Flood Protection and Enabling Infrastructure (PLFPEI) project includes a horizontal barrier system which will incorporate an engineered barrier (i.e. sediment cap) to mitigate the transfer of dissolved phase petroleum hydrocarbons (PHCs) as well as non-aqueous phase liquid (NAPL), where necessary, from the sediments to the waterway. Amendments such as activated carbon (AC) which have been demonstrated to be effective at reducing concentrations of hydrophobic compounds in the aqueous phase, and oleophilic clay (OC) media, which have been demonstrated to sequester free or mobile NAPL, are among those being considered for inclusion in the sediment cap. A treatability study was designed to obtain site-specific sorption isotherm parameters and NAPL sequestration rates to replace conservative literature values which were previously used in the horizontal barrier system design. This presentation will describe the treatability study design, challenges, and results in the contexts of amendment performance and the applicability of the data for use in modeling of the sediment cap.

764 Port Lands Flood Protection and Enabling Infrastructure Project: Design of Aquatic and Terrestrial Habitat

H. Sweeney, Michael Van Valkenburgh Associates, Inc. / Projects; M. Janes, Waterfront Toronto / Projects

As indicated earlier, the Port Lands Flood Protection and Enabling Infrastructure (PLF) Project is a $1.25B project led by Waterfront Toronto, the City of Toronto, Toronto and Region Conservation Authority (TRCA) and CreateTO, and with the support and involvement of Ports Toronto, and funding from the three levels of government. In addition to providing flood protection to approximately 250ha of flood vulnerable lands, this project will transform ~30 hectares of industrial brownfields into a naturalized, multi-outlet river valley system with associated channel spanning infrastructure, while unlocking the area for revitalization and facilitate billions of dollars in investment. PLFP will improve quality of life, bring nature back to an underused industrial site and better protect our neighbourhoods from extreme weather conditions. Built and established over a number of years PLFP will transform the new Don River corridor into a functioning aquatic and terrestrial system. The design does not attempt to duplicate pre-settlement historic conditions in the Don River Mouth area as the sediment transport regime, hydrology, and soil structure have changed dramatically in the past 150 years and cannot be restored. The Don River mouth restoration, therefore, is a new naturalized system based on regional river mouth areas that share similar urban watershed characteristics. The primary ecological goal is to establish a river channel and riparian vegetation framework that supports diverse native plant, fish and wildlife communities within the constraints of the Don River land use, hydrology and constructed valley form. The type and location of habitat features to be introduced by the project have been influenced by several specific objectives. First and foremost is the desire to establish ecological and geomorphic function within an immobile river channel. Toward this end, the design will include habitat forms and features that are resilient to site hydrology, in particular the predicted
variations in water levels throughout the project area. Another goal is to increase riverine, inner harbor shoreline, and wetland habitat quantity, diversity, and complexity for native fish over a range of flows and lake levels. The project will create wetland habitat that mimics the form and characteristics of off-channel and deltaic wetlands that historically were created naturally, including wetlands that provide a diversity of habitat types for multiple species. Habitat created by the project will include suitable nesting areas, basking and overwintering habitats for reptiles and amphibians, including turtles, in strategic locations. There will also be suitable areas for refuge, perching, and foraging habitats for wild mammal and bird species. These areas will be largely be located away from human activity to maximize the habitat value for wildlife.

765 Great Lakes Water Quality Improvement and Environmental Monitoring

M. Janes, Waterfront Toronto / Projects; V. Francella, Toronto and Region Conservation Authority

Toronto is Canada’s largest city, located on the north shore of Lake Ontario. In 1985 the International Joint Commission listed Toronto and Region as one of 42 Areas of Concern (AOC) on the Great Lakes where water quality and ecosystem functions were badly impaired due to industrialization and urbanization. Impacts to the public use of the waterfront included poor water quality and nutrients, contaminated sediments, contaminants in fish, loss of fish and wildlife habitat and populations and beach closings due to high bacteria. Since that time Implementation of the Toronto and Region Remedial Action Plan and restoration action have resulted in 4 of the 11 original beneficial uses being designated as “not impaired,” including bird or animal deformities or reproductive problems, degradation of benthos, fish tumors or other deformities, and restrictions on dredging activities. Implementation of the Toronto Waterfront Aquatic Habitat Strategy has created and restored habitats increasing the diversity of fish and wildlife species in the Toronto AOC. Levels of contaminants in fish continue to decline and there are no longer restrictions on consumption for many resident fish. Eight of Toronto’s 11 waterfront beaches are now Blue Flag beaches due to substantial reductions in E. coli loadings and beach closings. The aesthetics of Toronto watercourses and the waterfront are primarily considered excellent or good. Two pivotal projects to delist Toronto as an AOC are currently underway, the $2.8 billion Don River and Central Waterfront Combined Sewer Overflow (CSO) Project which is critical wet weather flow infrastructure to address phosphorus and E. coli, and the $1.25 billion Port Lands Flood Protection and Don River Mouth Naturalization Project. The Don River Mouth project will create 29 hectares of naturalized area in a new river valley, which includes 14 hectares of aquatic habitat and wetlands to improve biodiversity and water quality and reduce flooding and erosion.

Pharmaceuticals in the Environment - Science Innovation and Current Regulatory Developments

766 Antidepressants in Surface Waters: Fluoxetine Influences Mosquitofish Anxiety-Related Behavior at Environmentally Relevant Levels

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Pharmaceutical pollution is a serious, global issue. Indeed, the rise in production and diversification of pharmaceuticals--and synthetic chemicals more generally--is equal to, or exceeds, most other recognised drivers of global change. Of particular concern are pharmaceutical pollutants with evolutionarily conserved drug targets and the ability to alter biological function at minute concentrations. The antidepressant fluoxetine is one such pollutant, which has the potential to disrupt behavioural pathways through impacts on the central nervous system and neuroendocrine system. Despite this, it remains unclear whether environmentally relevant fluoxetine exposure can adversely impact behavioural processes in wildlife. To address this knowledge gap, we investigated effects of two field-realistic concentrations of fluoxetine (x: 60.5 and 351.9 ng/L) on sociability and anxiety-related behaviours in male and female eastern mosquitofish (Gambusia holbrooki). Sociability and anxiety-related behaviours are known to regulate important inter- and intraspecific interactions and, if disrupted, have the potential to impact the fitness of exposed wildlife. Additionally, we measured whole-body tissue concentrations of fluoxetine and norfluoxetine (fluoxetine’s primary metabolite). We found that fluoxetine exposure altered anxiety-related behaviour, whereas no significant effect of exposure on sociability was observed. What is more, observed impacts of fluoxetine on anxiety-related behavioeur were sex-specific, with females showing reduced anxiety-related behaviour at the lower dosage, while males showed an increase at the higher dosage. Fluoxetine and norfluoxetine were present in the tissue of male and female fish in both the low (x: 5.5 and 10.1 ng/g, respectively) and high dosages (x: 10.3 and 26.8 ng/g, respectively). Further, the bioconcentration of fluoxetine and norfluoxetine was size-dependent, with smaller fish showing higher relative tissue concentrations of fluoxetine and norfluoxetine. In combination, these findings provide evidence that fluoxetine at field-detected levels can alter the behaviour of fish, but also suggest that the magnitude and direction of these effects are dependent on sex and dosage. Moreover, our results provide insights into the apparent disparity of previously reported behavioural effects resulting from fluoxetine exposures.

676 How to tackle the environmental risk of mixtures? A new Adverse Outcome Pathway-informed model approach for drug mixtures in fish

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The presence of low concentrations of non-steroidal anti-inflammatory drugs (NSAIDs) in the aquatic environment has raised the concern that chronic exposure to these compounds may cause adverse effects in wild fish populations. This potential scenario has led to the inclusion of diclofenac in the European Union Watch List of emerging pollutants; however, there are currently over 20 NSAIDs on the market suggesting that mixture effects may occur. Here we present an integrated pharmacology-informed framework that enables the prediction of potential adverse effects in fish exposed to a mixture of NSAIDs. This framework combines two mechanistic visions: network-centred and target-centred. Initially we generated an in vitro bioactivity network for a mixture of nine NSAIDs. This network, including over 140 nodes, was filtered using drug uptake and pharmacokinetic parameters to generate a more simple network displaying the biological activity expected at environmentally relevant levels of exposure. This was subsequently used to generate multi-organ target-phenotype anchoring predictions, specific for zebrafish, to identify the most likely phenotypic effects that might occur under the considered exposure scenario. This network-based approach was successfully combined with a more traditional target-centred approach based on the pharmacological hypothesis that the sustained inhibition of NSAIDs primary targets; cyclooxygenase (COX) 1 and 2 in healthy tissues is the key driver of toxicity. We developed a quantitative Adverse Outcome Pathway-informed model that incorporates both pharmacokinetic and pharmacodynamic aspects of NSAIDs toxicity. This dynamic visual model enables a rapid assessment of the risk posed by environmental levels of NSAIDs, and their potential to trigger multi-scale adverse effects. Although total COX inhibition activity in the plasma of wild fish may be sufficient to trigger COX ICS5s, the mean effect concentrations for all 9 phenotypic endpoints are above predicted environmental levels. Only 9% of the effect concentration data points were within predicted environmental levels, residing within endpoints for reproduction, immunomodulation, male testosterone, and plasma prostaglandin. We anticipate that the integration of these mechanistic approaches will provide a useful predictive tool to support
the implementation of effective NSAIDs ecopharmacovigilance strategies; facilitating the regulatory interpretation of past and future toxicity data.

768 Revisiting the fish plasma model - experimental evidence for the underlying hypotheses
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The fish plasma model (FPM) combines the prediction of blood plasma concentrations of pharmaceuticals in exposed fish with extrapolation of the potency of pharmaceuticals from humans to fish. Within the research project iPIE (Intelligence-led Assessment of Pharmaceuticals in the Environment), extensive experimental and theoretical work was carried out with the purpose of widening the applicability of the FPM and validating it as a prioritization tool for environmental risk assessment of human pharmaceuticals. The various underlying hypotheses of the FPM will be revisited in this presentation, namely the predictability of fish plasma concentrations using lipophilicity as a descriptor, the evolutionary conservation of pharmacological targets mediating specific effects in fish, and the expectation that no adverse toxic effects occur in fish at plasma concentrations below human therapeutic plasma concentrations. Experimental data, made available through iPIE from both standard and non-standard studies with fish, were applied to test the hypotheses of the FPM and identify remaining uncertainties and limitations. The overarching finding is that fish plasma concentrations can be predicted from external water concentrations also for ionized pharmaceuticals, yet with remaining uncertainty. For some (but not all) selected pharmaceuticals, sub-lethal non-standard endpoints such as heart beat and enzyme activity indicated that effects in fish were indeed mediated by the pharmacological target. Effects on apical standard endpoints as obtained in a fish early life stage test according to OECD 210 appeared mostly unlikely to occur below human therapeutic plasma concentrations, providing some further support for this key hypothesis of the FPM. This work has received support from the EU/EFPIA Innovative Medicines Initiative Joint Undertaking (iPIE grant no 115735).

769 Ecological implications of the exposure of marine mussels to sulfamethoxazole antibiotic. Bioconcentration, metabolic alteration and antibiotic resistance
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Antibiotics are contaminants of emerging concern found in aquatic environments worldwide. They may alter the normal functioning of exposed organisms and microorganisms and also contribute to antibiotic resistance in the environment. The main objective of this work was to study the effects of antibiotic pollution into marine organisms through the comprehensive assessment of several ecotoxicological endpoints. Mussel specimens (Mytilus galloprovincialis) were exposed to water with 10 µg/L of the antibiotic sulfamethoxazole (SMX) and SMX occurrence in mussel’s haemolymph was monitored during the experiment. Haemolymph was also analyzed for metabolomics profiling using a non-targeted approach based on High Resolution Mass Spectrometry (HRMS). Data was further analyzed by chemometrics to evaluate the contribution of each potential marker to the distinction between the control and exposed groups. Results showed low bioaccumulation of SMX, up to 4 µg/L in mussel’s haemolymph after 96h exposure. Exposed mussels did not show any significant alteration in the enzymatic activities related to the xenobiotic metabolism and oxidative stress. However, the metabolomics approach allowed the identification of endogenous metabolites significantly altered due to SMX exposure including amino acids, nucleosides, etc. involved in different biological functions. In a second experiment, marine mussels were exposed to SMX subinhibitory concentrations (100 µg/L) to investigate the spread of antibiotic resistance. The presence of genes conferring resistance to sulfonamides (sul1 and sul2) and the class 1 integron-integrase gene (intI1) and the bacterial community composition associated with the gastrointestinal tract were investigated. Results showed that all analyzed antibiotic resistance genes (ARGs) were present in mussels, even in those used as controls. Moreover, exposure to SMX caused a significant increase in the absolute copy number of sul in mussels. Overall, our findings provided further understanding on the ecotoxicological implications of antibiotic pollution to exposed organisms. No risk for consumers derived from mussel ingestion is expected due to the low bioconcentration capacity of SMX and fast depuration. However, the presence of ARGs in these organisms, as well as the contribution of anthropogenic pollution to spread of ARGs, highlights the importance of monitoring antibiotic pollution in the aquatic media.

770 The Movement of Antibiotics in Urban Streams: Do Different Classes Influence Transport?
A.D. Gray, A.E. Hershey, University of North Carolina at Greensboro / Department of Biology

Antibiotics have been detected in various aquatic habitats (river, lakes, streams, estuaries, open ocean). Due to their widespread presence in aquatic habitats, extensive research has investigated their distribution and concentration. Several studies have tracked antibiotic concentrations over kilometer (km) scale reaches. However, monitoring data do not provide insight into controls on antibiotic transport within a reach. Reach scale uptake studies across antibiotic types are needed to understand the role of sediment processes in regulating downstream antibiotic transport and, accordingly, controls on observed larger scale patterns of antibiotic distribution. In this study, we conducted field experiments in a second order stream in Peabody Park, an urban stream that runs through the University of North Carolina at Greensboro campus. We applied solute spiraling concepts to assess Snet (net uptake rate), Vfnet (uptake velocity), and unet (uptake rate) of sulfamethoxazole, sulfameralazine, danofloxacine, erythromycin, and ciprofloxacin following introduction into a stream reach. Studies were conducted in the spring of 2019. We found that Snet of SMX, SMR, DAN, ETM, and CIP was 15.7, 16.9, 14.5, 19.8, and 158.7m respectively. Vfnet for the previously mentioned antibiotics was 1.97E-06, 6.63E-06, 2.14E-06, 1.56E-06, and 1.95E-07 m s-1, respectively. Unet was 1.58E-05, 5.62E-05, 3.31E-06, 1.31E-06, and 1.09E-08 µg m-2 s-1, respectively. These findings demonstrate that antibiotics are not transported conservatively in streams and that reach-scale retention occurs in low order streams. This study also highlights that transport and retention dynamics vary widely among antibiotics, which could enlighten understanding of patterns of antibiotic distribution among environmental compartments.

771 Predicting the reduction in total estrogenicity and fish intersex in response to wastewater treatment plant upgrades
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Endocrine-active compounds (EACs) have been associated with reproductive health effects in fish (e.g. intersex) exposed to poorly treated municipal wastewater treatment plants (MWWTP) effluents. Although many chemicals can alter endocrine function, natural hormones (17β-estradiol [E2] and estrone [E1]) and the active ingredient in birth control pills (ethinylestradiol [EE2]) have been shown to be the primary contributors to the estrogenic activity in effluents. Unfortunately, with the current analytical methods, it is difficult to detect estrogens at low concentrations in surface waters. In this study, we first employed
a consumption-based model based on population demographics and estrogen excretion rates to determine the concentrations of target EACs in major WWTP effluents in the Grand River watershed in southern Ontario (Waterloo & Kitchener). Then, the results of this model were fed onto a fate and transport model that estimated the temporal and spatial variability of the concentrations of estrogens along ~80 km river stretch. The predicted concentrations were then compared with the observed interspecies difference measured in rainbow darter (Etheostoma caeruleum) over the period when some of the treatment upgrades were made to the Kitchener MWWTP (2007-2015). The total estrogenicity (considering E1, E2, and EE2 only) during normal low flow (11m^3/s) was 0.45 ± 0.1 ng/L and 3.4 ± 0.9 ng/L E2 equivalents downstream of Waterloo and Kitchener WWTPs respectively. After the Kitchener WWTP upgrades, the total estrogenicity dropped to an average of 0.7 ng/L E2 equivalents (similar flow conditions) and is likely associated with Waterloo WWTP (located upstream) which was not upgraded at the time of our study. Furthermore, when the relationship between predicted total estrogenicity and observed interspecies difference was characterized via a concentration-response curve (four-parameter Hill equation), an effects concentration that is 10% of the maximal response (EC10) for estrogenicity was estimated to be ~0.1 ng/L E2 equivalence. This value suggests that low levels of intersex will be associated with many effluents until upgrades such as those at the Kitchener MWWTP are implemented. However, the relatively steep dose-response curve also suggests that improved treatment can dramatically reduce the intersex occurrence and severity in watersheds. The model may be used to test scenarios related to the potential effectiveness of treatment, impacts of population growth, or changes in hydrology (e.g., related to climate change).

772 The first global study of pharmaceutical contamination in riverine environments: Perspectives on drivers and risk from over 70 countries

J. Wilkinson, A. Boxall, University of York / Environment and Geography Department

Knowledge gaps exist regarding the occurrence and drivers of active pharmaceutical ingredients (APIs) in the environment, particularly in low to middle-income countries. Where data are available, use of a multitude of analytical methods hamper the ability to make robust associations with ecotoxicity risk and specific socioeconomic, health or physical drivers. Here we present the largest global API monitoring study and identify key drivers of pharmaceutical contamination and ecotoxicity risk in rivers worldwide. The study was composed of 92 sampling campaigns (n=711 sampling locations) performed across 72 countries (20 never studied before) at the time of writing. Analysis occurred for 61 APIs (19 therapeutic classes) using one interlaboratory-validated method. At least one API was detected in all of the countries analysed and as many as 35 were found in a single river (Kai Tak River, Hong Kong). Highest total API concentrations were in rivers suspected to receive discharge from API manufacturing facilities (eg, Delhi, India and Lagos, Nigeria), limited sewage treatment or unregulated waste discharge (eg, Lahore, Pakistan and Nairobi, Kenya) as well as regions of political instability (eg, Palestinian West Bank). Spatial analysis indicates while highest total API concentrations were observed in African and Asian rivers, those in Europe and N America typically exhibited a higher diversity of APIs but at lower concentrations. API contamination was positively associated with World Health Organisation disability adjusted life years. This was generally driven by specific disease pressures and the concomitant use of respective therapeutic classes of medicines. Multivariate statistics revealed associations between API contamination and socioeconomic drivers. Lowest levels of API contamination were observed in World Bank-defined ‘low’ income countries which dramatically increased in the ‘low-to-middle’ bracket before again dramatically decreasing in the ‘upper-middle’ and ‘high’ income countries. Clear geographical trends were observed in the global distribution of APIs, elucidating hotspots for potential ecotoxicity endpoints. Risk quotients for the selection of resistance to antimicrobials exceeded minimum selection concentrations by as much as 300 times (eg, Bangladesh). Our results show that API contamination is a global problem, linked to socioeconomic and health drivers for the first time, and may affect biological endpoints on a regional basis.

773 Ecopharmacovigilance of human medicinal products: Assessing and managing the real world risks resulting from patient use


Ecopharmacovigilance (EPV) is a developing science concerned with the detection, evaluation, understanding and prevention of adverse effects of active pharmaceutical ingredients (APIs) in the environment. In Europe and North America, a new regulatory submission or a line extension is normally accompanied by an Environmental Risk Assessment (ERA), but there is no regulatory requirement to monitor the environmental risks of medicines post-launch. However pharmaceutical residues in the environment and ecotoxicological studies on effects of pharmaceuticals are continuously published. To understand the significance of these emerging data and ensure that any potential risks are identified and managed appropriately, we have developed a process for EPV. This presentation will describe our EPV processes, how it works in practice and present a semi-probabilistic and spatially explicit environmental risk assessment for the patient use of several cardio-vascular and oncology APIs detected in the environmental surface waters. The EPV process includes: (i) routine literature monitoring for emerging data on APIs we have a commercial interest in, (ii) quarterly review of the data and appropriate risk management, (iii) transparency of product-specific ERA, and (iv) update of ERA where emerging data challenge the original assumptions. Over 23,000 instances of selected APIs have been reported; most are recorded on GIS maps to understand hot spots. Less than 2% of the data required more detailed investigation and most relate to a small number of well-studied compounds such as β-blockers (propranolol, atenolol and metoprolol) and some generic compounds used in AZ combination products (mostly naproxen, hydrochlorothiazide and metformin). Semi-probabilistic assessments of environmental risk have also been conducted for each API. EPV is the environmental equivalent of pharmacovigilance and allows the environmental impact of ongoing patient use to be managed through (i) routine literature monitoring for emerging data, (ii) the update of an ERA where emerging data challenge the original assumptions, and (iii) highlighting when APIs are detected in the environment at levels above published PNEC. EPV to date indicates that these instances represent < 2% of the total reported concentrations indicating site specific rather than generic risks that can be attributed to low flow, low dilution or poor wastewater treatment.

Tangible Ways to Integrate One Health into Risk Assessments

774 One Health concept is not applicable to modern chemicals management

A. Fairbrother, Exponent / EcoSciences

One Health is a seductive concept. People are no different from other species in our dependence on a functional ecosystem to maintain life and thus, keeping the planet healthy is the same goal for environmental managers and public health practitioners. Indeed, pets and livestock that live in close proximity to humans are known to share diseases and accidental poisonings to common drugs and household chemicals, so closer interactions between physicians and veterinarians would be beneficial. However, direct extension of One Health to environmental chemicals management has proven to be elusive. The “canary in a mine” analogy works for surprisingly few substances as it is dependent upon a species with a sensitivity to a chemical that is greater than that of people or that
has a shorter exposure-to-effect time. Enlightened methods of chemical risk review and management reduce the probability of an environmental surprise, such as occurred in mercury-poised cats in Minamata, Japan in 1956 or DDT-poisoned birds in the 1960s, and we now have more accurate personal dosimeters to monitor human exposures to known hazards in the workplace. A study by the U.S. National Academy of Sciences in 1991 found very little evidence of animals acting as good sentinels for chemical risks to humans, either based on cancer registries or environmental exposures. Perhaps newer information 25 years on may have a different outcome but if so, it’s not obvious. Given that various ecosystem services (clean water, clean soil, fishable rivers, etc.) are standard endpoints in ecological risk assessments, it is difficult to envision what additional advantage derives from the application of the One Health concept to modern chemicals management.

775 Ways that One Health has been integrated into contaminant risk assessments and other ideas for its future integration

M.W. Kierski, Exponent / Ecological and Biological Services Practice
One Health is defined as “the collaborative effort of multiple disciplines-working locally, nationally, and globally–to attain optimal health for people, animals, and our environment.” The practice of chemical risk assessment first developed by USEPA fosters the collaborative efforts embodied in the One Health approach in that the practice of risk assessment, both human or ecological is very multidisciplinary, and integrates both risk information about people and the myriad of other animals exposed to chemicals in the environment. However, USEPA created separate guidance for human and ecological risk assessment, with little to no guidance written to integrate the two disciplines together, which is not in the spirit or consistent with One Health. Most risk assessors do not think consciously about using a One Health approach when they do their risk assessments, however, in practice most risk assessors have integrated human health and ecological risks together which is in the spirit of One Health. This is seen most keenly in the development of the complex conceptual site models we create that help us to illustrate the potential linkages between pathways of chemical exposure and the human and other animal receptors potentially exposed and at risk. With the increasing consideration of ecosystem services in contaminant risk assessments, the linkage among all organisms becomes even more clear. This talk will explore how the integration of human health and ecological risk assessments is typically achieved when performing contaminated risk assessments and offer ideas how we can further use a One Health approach as we conduct contaminant risk assessments.

776 Problem formulation for integrated human and ecological risk assessment

G.W. Suter, US Environmental Protection Agency / ORD/NHEERL
Achieving the advantages of integrated health and ecological risk assessment depends on consistent problem formulations. Problem formulation is the process of determining the content of a risk assessment. It first appeared in the U.S. Environmental Protection Agency’s (EPA) 1992 framework for ecological risk assessment and was adopted by the EPA’s health risk assessors in 2016. However, health and ecological problem formulations are still not consistently integrated. Potential advantages of integration include efficiency due to reduced duplication of effort, more complete information as results are shared, and compatible risk assessments results due to more consistent input. Integration could be facilitated by increased formality of problem formulation so that everyone would know what is needed. For example, the recently proposed dimensions of water quality criteria can serve as a problem formulation checklist for setting criteria to protect aquatic life. If a chemical is found to be bioaccumulative, that could trigger inclusion of a dietary pathway for humans and other piscivorous species. Formalization of problem formulation would also include greater transparency of the methods. For example, problem formulations involve literature reviews and increasingly those are systematic reviews. Also, the weighing of evidence to determine the appropriate endpoints and assumptions concerning exposure should be more transparent and should follow an explicit method. The institutional silos and traditional processes are still impediments to integration, but jointly formulating the problem formulation could begin to clear those impediments.

777 The Critical Role of Environmental Quality in a One Health Framework: An NIEHS Perspective

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One Health is a concept that recognizes the interdependence of people, animals, plants, and our environment for achieving optimal health. Given its broad scope, a One Health framework requires coordination among human biomedical, veterinary, ecotoxicology, and environmental expertise to address complex health problems. Excellent headway has been made on identifying integrative solutions for waterborne/vector-borne disease transmission and anti-microbial resistance using a One Health approach. However, despite the critical role environmental contamination plays in ecosystem function, disease resilience (both animal and human), and general well-being, there has been less emphasis on the use of environmental health science in One Health approaches to risk assessment and disease prevention. Organizations, including the National Institute of Environmental Health Sciences (NIEMS), are recognizing the need and opportunity to identify tangible lines of evidence that will better delineate and quantify the role of environmental health in One Health. NIEHS supports several transdisciplinary research programs and initiatives that employ the One Health approach. For example, chemical pollution’s impact on the immune system may increase susceptibility to infection and, therefore, the incidence of waterborne/vector-borne disease transmission. NIEHS explores new approach methodologies that have potential to expand the use of non-traditional animal and in vitro models to identify common mechanisms of action that may inform risks assessment or potential interventions. The NIEHS Superfund Research Program has been identifying environmental solutions, such technologies that can reduce the bioavailability of contaminants in food, thus preventing their transfer up the food chain and protecting human health and the environment. NIEHS also is engaged in national and global health studies using a One Health approach to understand the role of environmental exposures in exacerbating poor health outcomes in agricultural communities, in areas of high Zika transmission, in mining communities, and in times of disasters such as oil spills, wildfires, and flooding. Collectively, these ongoing activities support the development of scientifically sound human health risk assessment and ecological risk assessment tools, and demonstrate the importance of integrating the consideration of environmental exposures into the One Health framework.

778 Ecological Risk Classification: A One-Health Approach for Prioritizing Organic Chemicals for Further Risk Assessment in Canada

M.A. Bonnell, Environment and Climate Change Canada / Ecological Assessment Division
In 2016 Environment and Climate Change Canada (ECCC) published the Ecological Risk Classification (ERC) approach to re-prioritize 640 organic chemicals on Canada’s Domestic Substances List (DSL) originally prioritized in 2006 as persistent (P) or bioaccumulative (B) and inherently toxic (IT). ERC was used to re-think organic chemical priorities for further risk assessment for the third phase of Canada’s Chemicals Management Plan (CMP3). ERC classifies the risk potential of organic chemicals using multiple descriptors contained in hazard and exposure profiles and is a large departure from the traditional hazard criteria approach (e.g., PBT or vPvB). ERC provides weight of evidence for risk classification by integrating data from new approach methods (NAMs)
with traditional data from human and ecological toxicology. ERC employs novel exposure descriptors that assesses exposure potential to human and ecological receptors at various spatial and temporal scales. The second version of the ERC (ERC2) is under development by ECCC for the prioritization of approximately 12200 organic chemicals on the DSL not prioritized in 2006 as P or B and it chemicals. Details of ERC2 are presented. Like ERC1, ERC2 remains a rule-based prioritization system, but expands on the one-health concept by increasing the toxicological and exposures space from ERC1. ERC2 seeks consensus within and among in vitro, in silico, in chemico, exposures space. ERC2 will provide ECCC with one mechanism for determining chemicals of most concern for post 2020 chemical's management work planning by responding to various regulatory questions such as identification of potential endocrine active substances, regrettable alternatives, high hazard or exposure concerns, potential research and monitoring priorities, etc.). A case study showing the results of a comparison of approximately 100 high priority substances identified in 2016 using ERC with the original 2006 classifications will also be presented.

779 Integrating the “One Health” approach in the design of sustainable compounds for military use

M.S. Johnson, US Army Public Health Center / Toxicology

Sustainable use of testing and training ranges within the U.S. Department of Defense is a critical goal in maintaining a ready force capable of meeting future security requirements. Large land areas are required for these purposes, many of which support valuable resources to local communities in terms of maintaining ecosystem services, preserving rare species, and providing for the general health of civilians and their families. Although there are regulations that require that environmental and occupational health aspects be considered, specific data requirements coincident with new chemical and weapon system design have not been elucidated. Working with research, testing and development entities, the Army has demonstrated a phased approach to environmental and occupational health data acquisition that is commensurate with the relative development of material research, design, testing and evaluation. This process using new and innovative approaches to initially provide relative comparisons provides a technical foundation from which to make decisions and focus toxicity testing designs that include human health and ecotoxicity. Examples will be provided.

780 Towards an Integrated Understanding of Environment and Health Risks from Inland Harmful Algal Blooms

B.W. Brooks, Baylor University / Department of Environmental Science

Though we have known for decades that nutrient enrichment of surface waters can lead to excessive algal growth, including the development of harmful algal blooms (HABs), the causes and consequences of toxins produced by these blooms has recently received heightened attention from environmental public health practitioners. Nutrient enrichment, primarily from phosphorus (P) and nitrogen (N), increases the frequency and magnitude of blooms along the freshwater to marine continuum. Climate change can affect incidents of HABs and salinity, which can be altered by both changes in precipitation and sea level rise. Whereas ecological studies and monitoring activities have previously examined “toxicity,” these efforts are routinely limited by absence of robust analytical quantitation of diverse toxins produced by specific HAB species and comparative toxicity exerted through multiple mechanisms of action including major alterations in water quality conditions resulting in differential risks to human health and ecosystems. This represents a critical consideration for management of water resources and protection of human health and ecosystems because algal growth does not necessarily predict toxins production, yet routine monitoring and surveillance activities, an essential environmental public health service, when these efforts do exist, use microscopic methods for cyanobacteria and thus do not quantify the presence of toxins. If toxins analysis occurs, it most commonly uses ELISA techniques to check for presence of microcystin. Further, commonly used water quality models lack inputs for toxins production, which inherently limits predictive capacity of HAB events. Some species of cyanobacteria have evolved unique adaptations to promote their growth under N-deficient conditions, but it remains unknown whether or not these traits actively exist simultaneously with toxins production. Developing predictive growth, toxins production and comparative toxicity models for cyanobacteria that commonly dominate toxic HAB events across relevant environmental gradients is thus imperative for forecasting, diagnosing and preventing human health and ecological risks presented by algal toxins, which appear to represent a transformative threat to water resources assessment and management. Our ongoing research is examining inland HABs and known toxins along the freshwater to marine continuum, which supports development of water quality modeling capacity for environment and health risks.

781 The Old Lead Belt in Missouri: A One Health Approach

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Lead (Pb) and zinc mining in Southeast Missouri began in 1740 with the greatest production occurring during the early 20th century. Many areas continue to be contaminated with elevated concentrations of heavy metals that are of concern to the health of both humans and the environment. The Old Lead Belt includes the Big River watershed (BRW) which was designated as a Superfund site in 1992 due to elevated concentrations of Pb in water, sediments, and fish tissues. Tissues from sportfish and hunter-harvested turkeys from the BRW were collected during 2018 to examine the concentrations of Pb and inform consumption advisories for anglers and hunters. These data will improve our knowledge of the sub-lethal effects of Pb in aquatic and terrestrial species, guide ecological risk assessments, and protect recreational activities in Missouri. The Department of Health and Senior Services advises to not consume Sunfish, Carp, and Redhorse species from the Big River due to elevated concentrations of Pb. Current results indicated that sportfish from the Big River also had a reduced organ: body mass ratio for hepatopancreas and spleen. Organ: body mass ratios will be compared to metal concentrations in fillets of fish sampled during 2018 and organ histopathology to determine whether elevated Pb concentration is associated with cellular injury. Concentrations of Pb in turkeys decreased as bone > feathers > kidney > liver > muscle. Pb concentrations in muscles from the turkey harvested from the BRW were 2.4 times higher than reference birds, but Pb concentrations were below 100 ng/g ww and considered safe for human consumption. Concentrations of Pb in liver and kidney in the BRW turkey, however, exceeded reference concentrations by over 50-fold. Pb in liver and kidney of the BRW turkey and kidneys from 2 reference turkeys exceeded human health thresholds. Fish, wildlife, and humans that share a contaminated landscape also share similar health risks. A One Health perspective on these risks is necessary to protect anglers and hunters that consume fish and wildlife to improve food security and recreational value. An evaluation of Pb concentrations in fish and wildlife from the Big River watershed will identify the spatial extent of contaminated soils in the Old Lead Belt, and support remediation and restoration of contaminated habitats.
Effective Science Communication in a Science Unfriendly World

782 International Science Communication: Starting Points For And By Environmental Scientists

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SETAC as a society could arguably be considered a very large social network which is actively teaching, and engaging people who are already interested in and understand the importance of science. However, there is increasing pressure and an expectation that both scientific institutions (viz. companies, universities, governmental bodies) and the scientists within them should communicate their research to a wider audience. Importantly, this is without any appreciable training but is duty-bound in order to improve perceived quality and credibility of the institutions and the science. Despite a high degree of interest in improving communication between the public and various disciplines including academic journals, it is still difficult for faculties and scientists to integrate social networks into their daily routines at an appreciable level. In a polarized world, environmental sciences pose many personal value-laden and ethical questions. This necessitates the identification and use of specific strategies or guidelines which encourage two-way communication and enables trust in both experts and the scientific results. Furthermore, as scientists who collaborate and work internationally, it is also important to recognize the different drivers of effective communication strategies have a cultural element. In this presentation, tools for effective science communication are outlined based on sound scientific advice that does not require further specialization in communication studies and with respect to country and cultural differences. Some examples based on SETAC regions will be outlined.

783 Nano-Titanium Dioxide in Food: What Can We Learn From France?

S.P. Toquica-Diaz, Globalomics Enterprises, Inc.

Food-grade Titanium Dioxide containing nanoparticles (nanoTiO₂) is used as a whitening, brightening and anti-caking agent by the food industry in various products (i.e. chewing gums, candies, cake icing, sauces, etc.). In Europe this food additive is registered as E171. Safety concerns are rising on nanoTiO₂. NanoTiO₂ can move across the intestine membranes and has been absorbed in blood in studies with patients suffering from ulcerative colitis. NanoTiO₂ has been found in organs such as liver, kidney, lung, brain and spleen in oral exposed rodents. Also, research in mice indicates precancerous lesions. Furthermore, children have the highest exposure and are the most susceptible receptors. For example, the food products that have higher nanoTiO₂ representation for young children are confectionery (chewing gums, chocolate and sweets) and baked goods (biscuits). France exemplifies risk management that includes NGOs and research institutes, among others to ban E171. Greenpeace, Foodwatch and the Alliance for Health and the Environment ethically that included the decision to ban E171 by 2020 and the French government followed with a ban as of January 1st, 2020. There is mounting evidence backed by Science of the harmful effects of nanoTiO₂ in food albeit uncertainty. However, how can scientists present their findings more effectively to effect change in North American policies? Especially, when the health risks seem high and when children are the most vulnerable, susceptible and exposed segment of the population. What lessons can we learn from France? Could the Precautionary Principle and examples of novel “nano” regulation be relevant for North America policy makers?

784 Possible solutions to controversy over scientific data generated for regulated products: What does industry have to offer

A. Alix, Corteva Agrisciences / Risk Management

Distrust, questioning and rejection of scientific data is an even more generalized issue when dealing with industry data that are generated for regulated chemistries. The basis for this probably lies in the lack of visibility on the purpose of these data, the data requirements that dossiers must comply with, the quality standards of the studies to be generated to address those data requirements, on the content of the studies themselves, and on the review process that is in place in all geographies to evaluated the scientific quality and reliability of regulatory data. In addition, there is little visibility on the inherent relation between regulatory data and academic science: testing guidelines, risk assessment guidance documents and additional studies used for in situ risk assessments are all based on academic research in the first place. Finally, research and development processes are covered by industrial property and secrecy, which makes difficult to communicate and illustrate how science does drive the discovery of a new mode of action, what a molecule can and cannot do, and on the selection process of a molecule that meets both efficacy and safety purposes. This presentation proposes to illustrate the initiatives in place within industry, taking the example of the pesticide industry, to address the visibility issues over the content of regulatory dossier, which match the expectations of the upcoming General Food Law in Europe. The presentation will discuss industry data into the context of regulations, i.e. for the characterization of potential risks to human health and the environment and define the conditions of use that represent negligible risks, as a basis to address the controversy issues that may be resolved by contextualization. Finally, some proposals to further increase visibility, exchange of data and communication will be presented to feed into the discussion.

785 Grassroots Organizing Strategies for Effective Science Communication in Environmental Justice Communities

M.E. Guvader, Earthjustice / Community Steering Committee Representative

Transactional engagement with the public undermines traditional methods of science outreach, particularly when working with communities directly impacted by environmental racism. Insights from grassroots organizations offer an alternative model for science communication centered upon intentional relationships and trust building. This presentation will introduce basic principles of grassroots organizing and racial justice theory, while proposing strategies for science communicators to break out of the “white savior model.” Audience members will be challenged to articulate their self-interest in science communication. Funding challenges for environmental justice research will also be discussed.

786 Challenges of communicating scientific methods to lay and technical audiences: Use of the Risk Challenge Program

R.G. Stahl, DuPont (retired); A. Liu, The Chemours Company; D. Lander, The Chemours Company / Fluoroproducts; Z. Yin, DuPont Company

We have been involved with communicating scientific methods to lay and technical groups in the U.S. and elsewhere for multiple years. Our main focal areas have been in toxicology, exposure science, and risk assessment for humans and ecological receptors. Over time, we have had to adapt the communication approach to recognize the rapid changes in communication technologies, and how members of our audience are expecting to receive new, relevant information. In our presentation we will illustrate four aspects of communicating that required us to change: 1. Our thought process and methods for assessing risks; 2. Level of detail we convey; 3. Time involved with the exercise; and, 4. Speed and ease of obtaining feedback from audiences. Our case example is built upon our Risk
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Challenge Program that we use to illustrate the approach for assessing risks to humans and ecological receptors, both for new/existing chemicals, and for a remediation site. Our discussion will draw upon recent experience gained through conduct of the Program in the U.S., mainland China, Taiwan, and South Korea.

787 Profile-building, research sharing, and data proliferation using social media tools for scientists
A.J. Williams, US Environmental Protection Agency / National Center for Computational Toxicology

Many of us invest significant amounts of time sharing our activities with friends and family via social networking tools such as Facebook, Twitter or other related websites. However, despite the availability of many platforms for scientists to connect and share with their peers in the scientific community, most do not use these tools to impact and influence their professional careers. Scientists are already being indexed and exposed on the internet via our publications, presentations and data and new “AltMetric scores” are being assigned to scientific publications as measures of popularity and, supposedly, of impact. We now have more options to contribute to science, to annotate and curate data, to “publish” in new ways, and many of these activities are part of a growing crowdsourcing network. With so many web-based platforms to share publications, presentations, data and activities, how does a scientist shortcut their way to understanding what is available and the benefits of use? Participating online, whether it be simply for career advancement or for wider exposure of your research, there are now a series of web applications that can provide a great opportunity to develop a scientific profile within the community. This presentation will provide an overview of what is available and the potential benefits of investing a small amount of time in developing an online profile and communicating your science to a networked audience, especially as an increasing number of potential employers and collaborators utilize the web to research scientists. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

788 How to effectively communicate science to a larger audience using blogging
M.L. Rodgers, University of Southern Mississippi / Division of Coastal Sciences

As the internet continues to shape our world, scientists are faced with communicating research online to non-science groups such as shareholders, friends and family, and the general public. If you’re like me, you understand that effective science communication (scicomm) can open the door to exciting career opportunities, but you may find it difficult to showcase your science communication skills using your own research. What’s a potential solution so that you can sharpen your scicomm skills without awkwardly gushing about the importance of your own science? Getting involved in talking about OTHER people’s science, especially the foundational works and the latest and greatest advances! This talk will focus on ways for scientists to hone in their science communication skills through blogging. The wonderful thing about blogging is that it’s free and you have the ability reach a large, global audience! However, starting your own blog as an individual can make it difficult to “get the word out” and have a large viewership, especially when your posts may be infrequent due to work and other responsibilities. So what’s a toxicologist to do? One way to increase frequency and visibility of posts is to work with a team to build a blog featuring free, simple, and digestible science content to readers. As a founding member, editor, and writer for the scicomm blog project Immunobites, I’d like to share my trials and triumphs of getting a scicomm blog up and running (by working with an editorial board, setting up a website, recruiting quality writers, coming up with rules for formatting and writing posts, and ensuring quality editing). I hope that this talk with inspire the early career professionals of SETAC so that we can gather as many willing toxicologists as possible to found a toxicology-based blog to promote basic concepts in toxicology and current toxicology research to readers. A large endeavor such as this can gather toxicologists from all backgrounds, skills, and areas of interests to maintain a blog that not only benefits its readers, but also benefits its contributors by helping them gain experience in editing, writing, scientific illustration, and more!

789 Effectively Engaging the Public About Your Research: Tips to translating Your Science to Everyday People
A.D. Gray, University of North Carolina, Greensboro / Biology

Science communication is a skill that is not heavily practiced in graduate school. Many researchers never really delve into the world of science communication because in most cases their work is presented to an audience of their peers at scientific conferences/meetings. In an era where the disconnect between the scientist and the public is evident, engaging to those outside of our respective field is an important way to ensure we as scientist can help bridge the gap between the scientist and the public. The world we live in now is fast pace and is driven heavily by social media. There are countless ways we as scientist can use this to our advantage to help us translate our research. Science communication is not just for those that are social media savvy, but also those that are effective at communicating to the general public. The work we do as scientist always has a broader impact, however, if the people we serve do not understand the work we do, it make appreciation of it very difficult. Through the past few years I have practiced effective science communication with my research at a local, regional, and national level. The better we are at communicating, the better we are able to close the gap between the public and scientist. The success we have in communicating can translate to policy decisions and educating individuals that previously, may not have had much insight into our respective fields.

Oil Sands Monitoring Program: Synthesis of Results and Progress Towards Cumulative Effects Monitoring

790 History, overview and governance of the Oil Sands Monitoring program
M. Dube, Alberta Environment and Parks / Environmental Monitoring and Science Division; K. Cash, Environment and Climate Change Canada; F.J. Wrona, Alberta Environment and Parks / Environmental Monitoring and Science Division; N. Hamzawi, Environment and Climate Change Canada; Y. Ilesanmi, Government of Alberta / Environmental Monitoring and Science Division; J. Dawson, Environment and Climate Change Canada; R. Hazewinkel, Alberta Environment and Parks / Environmental Monitoring and Science Division

The current Oil Sands Monitoring (OSM) Program has developed through a series of independent reviews commissioned by the Federal and Provincial governments and by the Royal Society of Canada. In 2011, Federal and Provincial governments committed to a new environmental monitoring system designed to report on changes in environmental condition associated with oil sands development. OSM initially reflected a three-year commitment to implement a program designed by environmental experts including external monitoring partners, organizations, and academic institutions to assess environmental change associated primarily with the mineable segment of the oil sands industry. The comprehensive design includes monitoring across environmental media and a commitment to a cumulative effects approach funded by industry through regulation up to $50M per year. Over $350M has been invested in the OSM program to date. Following the three-year implementation phase, a mandated review process in 2016 identified the need for more specific scientific goals, improved integration across components, more comprehensive analysis and interpretation, and greater transparency. To this end, in 2017 the governments of Canada and Alberta committed to a renewed Memorandum of Understanding. Also in 2017, OSM undertook to develop a more inclusive approach to program design, management, and implementation, with the intent to involve Indigenous communities in all aspects of the program and explicitly to incorporate Indigenous...
Knowledge in a system of knowledge co-creation. The commitment of OSM to meaningful engagement with Indigenous communities is set out in the 2018 Operational Framework Agreement, which establishes a multi-stakeholder participatory governance structure for the program. Extensive engagement with Indigenous communities and the oil sands industry, and a commitment to honouring their concerns, perspectives, expertise, and ways of knowing, has begun to rebuild trust in the scientific credibility of environmental monitoring in the Canadian oil sands.

791 Oil Sands Industry - What Development Looks Like Today and Into the Future
C. Edwards, O. Mkrlas, Canada’s Oil Sands Innovation Alliance (COSIA) / Monitoring

Canada has the third largest proven oil reserves in the world, 97% of which are located in the oil sands deposits of northern Alberta. Commercial production from the oil sands has been occurring for over 50 years with significant changes and advances in technology over that time. For example, while early development focused on surface mining, most present-day development is comprised of in situ extraction methods. In 2018, surface mines occupied only 1,039 km2 of the ~142,000 km2 oil sands deposit area (0.7%), while in situ extraction undergoes phased development throughout the area. Despite the longevity operations, uncertainty and disagreement persists with respect to the environmental impact of the various industrial aspects of oil sands development.

The Canadian oil sands are a strategic natural resource and a key driver of economic development. However, rapid expansion of this valuable resource intensifies the need for an integrated comprehensive understanding of potential cumulative environmental impacts. With annual industry funding, the Oil Sands Monitoring (OSM) Program was launched in 2012 by the Governments of Canada and Alberta to improve, consolidate and integrate previous monitoring efforts within the region. Since this time, OSM has made significant progress in the establishment of a more scientifically robust, transparent, holistic, and adaptive monitoring approach, led in partnership by government and knowledge holders, to detect and report cumulative effects of oil sands development. In this session, we present an overview of what development looks like today, the different extraction processes, and the types of infrastructure currently in place. We also discuss key environmental issues facing the industry today and how research and innovation are helping improve the industry’s environmental performance.

793 Temporal and spatial variation of snow chemistry in winter air deposition in the Athabasca Oil Sands Region
Y. Gopalapillai, Environment and Climate Change Canada / Department of Earth & Atmospheric Sciences; J.L. Kirk, Environment and Climate Change Canada / Aquatic Contaminants Research Division; C. Cooke, Alberta Environment and Parks / Environmental Monitoring and Science Division; D.C. Muir, Environment and Climate Change Canada / Aquatic Contaminants Research Division

Atmospheric deposition of pollutants (e.g., polycyclic aromatic compounds, metals) in snowpacks and their release into freshwaters during spring snowmelt has been a concern in the Athabasca Oil Sands Region of Alberta. The chemistry of the snow that will impact the bioavailability of these pollutants has not been as well studied in terms of temporal and spatial patterns. The present study was designed to evaluate the concentrations, loadings, and distribution of snow chemistry parameters (pH, major cations, anions, organic matter) in springtime snowpack and how they vary spatially and over time. Temporal data spanning several years (2008-2017) of data collected through a rigorous monitoring program, the Joint Oil Sands Monitoring (JOSM) program, are examined. Snowpack samples were collected in late winters at varying distances from the main developments. Temporal trends were divided into sites less than 8 km, 8-50 km, and 50-100 km from the major industrial site (AR6), and compared to reference sites collected from the Peace Athabasca Delta (PAD). Spatial distribution from site AR6 versus from the closest industrial site will be compared. Closest industrial site will be calculated using industrial facilities operational in the wintertime. Results of this study will help understand the impact of oil sands activity on snow chemistry, and how that may impact the bioavailability of pollutants.

794 Surface Water Quality Monitoring under the Oil Sands Monitoring Program: key findings and ongoing study design recommendations
N. Glozier, ECC / Water Science & Technology; C. Cooke, Alberta Environment and Parks / Environmental Monitoring and Science Division; K. Pippy, Environment and Climate Change Canada / Water Science & Technology Directorate; L. Levesque, Environment and Climate Change Canada / Water Science & Technology

Study design updates and results from the water quality (WQ) monitoring program outlined initially by Joint Canada/Alberta Implementation Plan (JOSM) in 2012 and now continued as the Oil Sand Monitoring (OSM) will be presented. Well over 30 WQ monitoring sites have been reported through JOSM, of which, only 5 had pre-existing water quality monitoring programs. Routine water quality sampling approaches were reviewed, streamlined, and standardized, resulting in data from well over 5000 samples, for > 270 parameters (nutrients, major ions, total and dissolved metals, total and methyl mercury and organics); resulting in at least a 5-fold increase in sampling effort. Several non-standard monitoring approaches were evaluated including detailed cross-sectional sampling, auto-monitoring deployments, and semipermeable membrane devices (SPMDs) for the collection of time integrated low level organics. Status and trend results are reported for Athabasca, Peace and Slave rivers as well as multiple tributaries and interconnecting channels of the Peace Athabasca Delta. Concentration in the larger rivers showed more similarity when compared to the smaller, tributaries. Evaluation of the cross-sectional sampling found high cross sectional variability (>50%), however, no significant difference in loading estimates were determined from the range of sampling approaches tested. Total metals as well as other parameters with high correlations with suspended sediments commonly (50-90%) showed values higher than published guidelines particularly during periods of high discharge. Long term trends on the Athabasca River near Wood Buffalo National Park showed that most trends remained consistent, however, upward trends in total phosphorus have been curtailed and dissolved phosphorus concentration has exhibited declines over the last 15 years. After these results were summarized, a workshop was held in late 2016 with the purpose of reviewing, rationalizing and optimizing water quality monitoring conducted under the JOSM Program, and an approach was developed that could be used in an ongoing manner to evaluate and make recommendations for the ongoing OSM water quality monitoring program. Key outcomes of the workshop included: a new decision framework to guide water quality monitoring site selection and sampling frequency; a review of current water quality monitoring locations based upon the decision framework as well as recommendations on water quality methodologies.

795 Current status and assessment of change in two environmental performance metrics in the Athabasca oil sands region
M.L. Olsgard, G. Goss, University of Alberta / Biological Sciences; M. Dube, Alberta Environment and Parks / Environmental Monitoring and Science Division

The mandate of the OSM Program is to assess if changes in environmental indicators are occurring relative to baseline condition in the oil sands region of Alberta. For several reasons, an integrated assessment of environmental change has not occurred to date. This information and supporting methodology is essential to understanding; environmental changes that are currently occurring, level of risk, suitability of current limits of change, uncertainties and the existing accumulated state that can be used to inform models for future scenario assessments. The research presented here focuses on analytics for allowing an integrated assessment of changes in environmental condition relative to thresholds of change. The development of an integrated data analytics platform and preliminary results of Environmental Performance Metrics (EPMs) for i) air quality
and ii) pipeline releases in habitats designated as sensitive or protected by provincial and federal government will be discussed. The presented EPMs were assessed through statistical analysis of spatial and temporal changes using available JOSM/ OSM data sets and by comparison to thresholds of change. Thresholds for assessing change were identified from various sources, including: provincial and federal guidelines/ objectives/ criteria, local Indigenous community’s health-based criteria, and toxicological effects data. Results indicate that key risk drivers for air quality and sensitive habitats with respect to pipeline releases can be identified and used to guide risk-based decisions and adaptive management of the OSM program going forward. By leveraging current EPM status and predicting future changes based on the integrated data both net environmental and economic benefits can be achieved.

796 Community-based Monitoring in the Oil Sands Monitoring Program: Synthesis and Review

D. Beausoleil, Government of Alberta / Environmental Monitoring and Science Division; M. Dube, Alberta Environment and Parks / Environmental Monitoring and Science Division

Indigenous people living in the Canadian Oil Sands Region (OSR) have been practicing their traditional rights and culture since time immemorial. Through years of lived experience on the land, Traditional Knowledge (TK) holders have gained the ability to recognize change, drawing on the inextricable link between traditional practices and environmental health. The Operational Framework Agreement of the Oil Sands Monitoring Program (OSM) provides opportunities for Indigenous participation in the design and implementation of environmental monitoring, building capacity within communities to examine indicators directly relevant to them. Community-Based Monitoring (CBM) in the OSR, such as the Berry Focus Group in Fort McKay, have filled research gaps through braiding of Western Science (WS) and Indigenous knowledge (IK). The integration of these knowledge systems enhances the relevance of OSM by examining the relationship between chemical stressors and culturally relevant indicators. We conducted a review of CBM in OSM between 2009 and 2018, across theme areas of vegetation, water quantity, water quality, fish and wildlife contamination and health, and air quality. As community driven programs, most CBM initiatives have focused their energies on community-focused reporting and engagement, rather than publications or publicly accessible reports. As such, CBM is a valuable tool to address community concerns about environmental health, cultural health, and food security. An integrated approach to environmental monitoring would pair WS and CBM to provide context to cumulative effects monitoring strategies over time and space in locations or on issues that may be understudied, and potentially inform monitoring design. Where integration supports monitoring priorities and where it meets community interests, it requires meaningful communication between collaborators, sufficient training, resources and opportunities for knowledge sharing and Elder-Youth knowledge exchange. CBM is fundamentally about empowering community members to make decisions about environmental safety and partner in environmental management decisions. This presentation will summarize the CBM activities occurring in the OSR and demonstrate how these activities build capacity, with minimal external support, and help drive sustainable, long-term projects that achieve OSM’s multi-stakeholder objectives.

797 Synthesizing a decade of environmental monitoring and research in the Canadian Oil Sands

M. Dube, Alberta Environment and Parks / Environmental Monitoring and Science Division; K. Cash, Environment and Climate Change Canada; F.J. Wrona, Alberta Environment and Parks / Environmental Monitoring and Science Division; T. Arciszewski, D. Beausoleil, E. Horb, A. Mahafey, Government of Alberta / Environmental Monitoring and Science Division; R. Hazewinkel, Alberta Environment and Parks / Environmental Monitoring and Science Division; D. Sayanda, D. Roberts, F. Wyatt, Government of Alberta / Environmental Monitoring and Science Division

The Oil Sands Monitoring (OSM) Program is jointly led by the Governments of Canada and Alberta, in collaboration with local Indigenous communities and industry. In 2019, OSM conducted a review of >300 peer-reviewed papers, published between 2009 and 2018, investigating the environmental effects of oil sands development. This review provides an integrated assessment of environmental condition using a cumulative effects approach, with a focus on five key theme areas: air, surface water, groundwater, terrestrial biology, and geospatial methods, as well as community based monitoring conducted across theme areas. OSM represents knowledge of stressor-response linkages in the oil sands via conceptual models–simplified system diagrams visualising key environmental pathways. This conceptual model framework promotes integration across theme areas by linking distinct study components using common environmental pathways. The integration of Western Science and Indigenous knowledge systems to these pathways enhances the relevance of the monitoring program by identifying and characterizing endpoints that have both environmental and cultural or spiritual significance. Our review identified stressor-based change related to atmospheric deposition of PAHs, heavy metals, nutrients, and acidifying emissions in the immediate vicinity of oil sands mines. There is limited evidence for an ecological response to these stressors, although forest ecosystems may be responding to elevated nutrient loads and sentinel species to dietary and atmospheric exposure in areas adjacent to emission sources. Response to habitat related stress varies among mammals and birds depending on their habitat preferences, resulting in complex responses at the community level. Differentiating among anthropogenic and natural contaminant sources and effects related to natural and anthropogenic exposure remains a major challenge. We also present our vision for accumulated state reporting based on geospatial analysis and mechanistic modelling to assess the environmental condition at multiple scales using a spatial-temporally explicit approach. Implementation of this approach requires integration of knowledge and data systems, and represents the next phase for the OSM program.

Invasive and Vertebrate Pest Species Control: Hazard and Risk to Non-Target Species and Innovations on the Horizon

798 Anticoagulant rodenticides: Background, exposure and toxicity in birds of prey

J.E. Elliott, Environment and Climate Change Canada / Science and Technology Branch Ecotoxicology and Wildlife Health Division; B.A. Rattner, US Geological Survey / Patuxent Wildlife Research Center; S. Hindmarch, Fraser Valley Conservancy; V. Silverthorn, Revelstoke, BC; S. Lee, Environment and Climate Change Canada / Science Technology; V. Boves, BC Ministry of Agriculture and Lands; F. Maisonneuve, Environment Canada

There is a global demand for rodent control to reduce risks to human health, and loss and damage of food stores and property. Anticoagulant rodenticides (ARs) dominate the global market for rodent control. Here we focus mainly on second-generation anticoagulants (SGARs) which in regulatory terms are PBT, persistent, bioaccumulative and toxic chemicals. Surveys of SGAR concentrations in many jurisdictions reveal
their widespread contamination of terrestrial predators and scavengers, particularly raptorial birds. We present largely new data on hepatic concentrations of anticoagulants and autopsy results for 700+ raptorial birds found dead or presented for rehabilitation, 1988-2016 in British Columbia. Larger generalist owls, e.g. barred owl (Strix varia) and great-horned owl (Bubo virginianus), had the greatest incidence of exposure; smaller owls e.g. barn owl (Tyto alba) had lower incidence, as did hawks, e.g. red-tailed hawk (Buteo jamaicensis) and Cooper’s Hawk. Bird eating merlins (Falco columbarius) had lowest incidence of exposure among diurnal raptors. We based our assessments of toxicological implications of exposure on diagnosis at necropsy, and on application of threshold guidelines, derived from modeling necropsy findings and liver residue concentrations. Recently, we have enhanced that assessment with evidence showing that a proportion of free-living raptors appear to be suffering from sub-lethal coagulopathy, which almost certainly aggravates the effects of trauma. We will further examine those relationships in the talk and a corresponding poster.

799 Rodenticide use and risk to non-target wildlife
R. Poche, D. Poche, G. Franckowiak, T. Clark, Genesis Laboratories, Inc. / Wildlife Toxicology
A number of rodent species in the United States transmit diseases to humans and pose significant public health issues when populations are left unchecked. Rodenticides have been developed over the past 80 years for control of invasive rodent species such as Norway rats, roof rats, and house mice. Certain rodenticides were eventually for use against field rodents such as voles, ground squirrels, and pocket gophers. The use of differing chemistry over the years has evolved to minimize non-target domestic and wildlife exposure. All chemicals, when used incorrectly, may pose problems to non-target animals. The key to reduced risk is defining the dose of any product, the time of usage, and adhering to label instructions stipulated by the US Environmental Protection Agency. The initial series of rodenticides made public had no antidotes. However, in the early 1950’s warfarin was developed and revolutionized rodent control having an antidote to reverse the effects of toxicosis. We present data from numerous laboratory studies conducted using acute and anticoagulant products against wildlife such as European ferrets, magpies, bobwhite quail, mallard ducks, and American alligators. Results of this research show those potential adverse effects. Acute toxicants have their drawbacks since none are species-specific, they lack antidotes, and some are not humane. A review of rodenticide development is presented along with recent laboratory and field data to show the potential effects of various products.

801 Towards a new generation of ecofriendly anticoagulant rodenticides
V. Lattard, USC1233 INRA-VetAgro Sup - Veterinary campus; I. Fourel, S. Lejebvre, USC1233 INRA-VetAgro Sup; H. Caruel, Liphatech France; E. Benoit, USC1233 INRA-VetAgro Sup
Second generation anticoagulant rodenticides (SGAR) are 4-hydroxy-coumarin-derived delayed acting molecules with a powerful and easily available antidote and are for most of them highly efficient to control rodent populations even those with resistant VkorC1 mutations. However, this benefit is associated with a major disadvantage: SGAR have very long tissue persistence and are thus often responsible for secondary poisoning of wildlife by ingestion of contaminated rodents. Here is a way to overcome this major issue. Because of the presence of two stereogenic centers in all SGAR, commercial baits containing one SGAR contain systematically a mixture of the four stereoisomers (i.e., (1R,3R), (1S,3S), (1R,3S) and (1S,3R)-isomers) of this same SGAR in proportion controlled by the authorities. For all the SGAR, the four stereoisomers have systematically different pharmacokinetic properties. Therefore, all the stereoisomers are not involved in secondary poisonings of wildlife because they are quickly eliminated first by rodent, then by wildlife if exposed. By modifying the proportion between stereoisomers, it is possible to obtain a new generation of anticoagulants efficient, ecofriendly and safe.

802 Population models as a tool for guiding development and application of new management tools: Applications to Asian carp
R.A. Erickson, US Geological Survey / Leetown Science Center
Management of invasive species often requires the integration of multiple techniques or tools. These tools can be used to limit their spread and/or decrease their population. The use of population models can extremely useful to inform managers on potential impacts of their management actions. These same population models can be used to evaluate feasibility of new control strategies and tools (e.g., under what scenarios would the proposed tool be effective?). We used this approach to evaluate potential synthetic biology applications to control Asian carp. Using population models in this way we can then prioritize the development of synthetic biology techniques to insure efficient use of resources for the greatest effects. We will present on the use of population models to evaluate the use of modified males to skew sex ratios and RNA interference as a lethal control.

803 Using population models to assess risks of chemicals and invasive vertebrates to species of conservation concern: A case study of trout
V. Forbes, C. Accolla, University of Minnesota / Ecology, Evolution, and Behavior
The greenback cutthroat trout (GCT), Oncorhynchus clarkii stomias, is classified as threatened under the U.S. Endangered Species Act and is currently believed to persist in a very few areas. One of the threats to the species is believed to be competition with introduced trout such as the brown trout (BT), Salmo trutta. Whereas BT may be highly valued by anglers, they are also considered an invasive species because they often disrupt the systems to which they are introduced. In this case study, we applied a well-established individual-based model, InSTREAM, to assess the risks of the human-derived estrogen (17-alpha ethinyl estradiol, EE2) and the presence of BT for GCT populations. We found that the two species were differentially affected by EE2, with GCT showing more sensitivity. Thus, BT and EE2 had a synergistic negative effect on GCT populations. However, we showed that removal of BT by anglers could enhance persistence of GCT and offset some of the negative effects of EE2. This case study demonstrates how mechanistic models can be used to link impacts of multiple stressors on individual survival, growth, and reproduction to consequences for populations and ecosystem service delivery. When coupled with ecosystem service valuation, the approach facilitates interpretation of traditional toxicity data in the context of realistic ecosystem conditions and provides quantitative information on risks to various - and sometimes competing - ecosystem services that people care about.

804 Risk analyses and risk management for invasive rodent eradication on islands using anticoagulants
K. Campbell, P. Castaño, Island Conservation; P. Fisher, Independent; G.R. Howald, Island Conservation
Invasive rodents on islands are a primary driver of extinctions. To prevent extinctions and restore island ecosystems more than 600 island-wide invasive rodent eradication have been conducted. Current methods for eradicating rodents from islands larger than a few football fields requires applications of anticoagulant rodenticide into every potential rodent home-range. These applications may impact individuals and populations of non-target species, including endemic species threatened with extinction. On inhabited islands, there is potential for people, domestic animals, and wild-harvested foods to be exposed to rodenticide as the result of bait application for rodent eradication. We have adopted a priori informed consent process that combines scientific, a priori ecological risk assessments and community engagement. The approach aims to assist island communities and the project in assessing risks against the benefits, identify needs for non-target mitigation and understand implicit uncertainty. Floreana Island in the Galapagos is one such case. Process components include food web analyses, assessing whether island taxa are evolutionarily significant units, categorizing primary and secondary risk of poisoning.
mortality, defining approximate population impacts and certainty of these. Where population level impacts may represent risks for a species or an evolutionarily significant unit, population viability assessments have been conducted to evaluate the impacts of combined potential risks and benefits. For decision making regarding wildlife, a workshop format has been adopted where wildlife managers, researchers, eradication practitioners and community members together assess potential impacts to each taxa and reach consensus on whether it is acceptable or not. Unacceptable risk to a taxa initiates assessment of mitigation options to effectively manage risk to an acceptable level. Risks to livestock, pets and people, through rodenticide bait, agricultural produce or wild-harvested foods are transparently communicated in one-on-one meetings or with families, concerns are noted and all the options to manage risk are identified. The preferred risk management option is then decided upon by the potentially affected parties in coordination with eradication practitioners. This process on Floreana Island has taken multiple years and is ongoing, and may be useful for other island restoration projects where the support of an island community is essential for success.

805 From Risk Assessment to Post-marketing monitoring. New developments in Europe with special focus on rodenticides

P. Berny, VETAGRO-SUP / Toxicology; O. Cardoso, ONCFS (National Game & Hunting Institute) / USF; M. Cœurdassier, University of Franche-Comté / UMR ChronoEnvironment; J. Chollet, ONCFS (National Game & Hunting Institute) / USF; A. Decors, ONCFS / SAGIR Network; M. Kammerer, ONIRIS / CAPAE-ouest

Plant Protection Products (PPPs) and Biocidal Products (BPs - including rodenticides for commensal rodent control) are currently marketed with an EU Marketing Authorization Dossier. As part of the registration requirements, any information regarding non-target poisoning should be made available (see for instance, SANCO-2012 Guidance Document for Birds and Mammal Risk Evaluation). Currently, RA covers human RA (workers, residents, by-standers), crop residues, environmental RA (soil surface and ground water, ecotoxicology). Safety factors are applied to cover for uncertainty and lab to field extrapolation. With respect to environmental risk assessment, more comprehensive evaluation on non-target arthropods and toxicokinetic/toxicodynamic models for aquatic organisms are being considered. In terrestrial RA, current revision of the Bird and Mammal SANCO guidance document is underway and should consider more realistic exposure models. Recent scientific opinion published by EFSA also suggest broadening the scope of this document to cover species not well protected by the current guidelines, such as amphibians, reptiles or bats. Furthermore, large scale landscape / systemic assessment of pesticide safety has not been considered and is still in its infancy but there is evidence that it could be used with great benefit to develop even more realistic exposure/effect models. ECHA evaluation of BPs follows very similar guidelines. Differences will be pointed out in the presentation. In 2014, France voted a new law to develop the “phytopharmacovigilance” or toxicovigilance of Plant Protection Products. This original program is intended to monitor non-target incidents occurring during the course of the field use of a PPP/BP and to include these data in the re-registration process as part of the risk/benefit ratio evaluation. In this process, risk mitigation measures (RMMs) may also be considered and retrospective and/or prospective analysis of monitoring data may help identify effective measures to reduce the frequency and/or severity of non-target incidents. Examples with rodenticides will be used to highlight the current RA procedure and potential changes.
Addressing Existing Challenges in Immunotoxicology: From Tool Development to Risk Assessment

**MP001 Optimization and validation of respiratory burst and phagocytic cell activity assays in the fathead minnow, an emerging immunotoxicity model**

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Respiratory burst (RB) and phagocytic cell activity (PCA) assays are utilized to evaluate the immunotoxic effects of environmental contaminants on cellular immune function in a variety of teleost species. Though several methods are available for assessing RB and PCA, plate-based assays may be preferred, as they do not require highly-specialized equipment. As such, the goal of this study was to adapt, optimize and validate a colorimetric plate-based RB assay and a fluorometric plate-based PCA assay for use in kidney cells from fathead minnows (Pimephales promelas), an emerging immunotoxicity model. To optimize the RB assay, the following experimental parameters were explored: stimulant (phorbol 12-myristate 13-acetate, PMA) concentration, incubation time, erythrocyte lysis and presence of superoxide dismutase (SOD). The performance of the RB assay was maximized when a PMA concentration of 0.5 µg/mL and an incubation time of one hour was used. Erythrocyte lysis and SOD did not enhance the performance of the RB assay. For PCA, incubation time and erythrocyte lysis were evaluated. The inclusion of multiple timepoints improved assay performance, and samples in which erythrocytes were lysed increased phagocytosis. It is recommended that measurements be made at multiple timepoints to evaluate PCA rate. Erythrocyte lysis will enhance PCA, but cell yield will be decreased and may cause other limitations. Overall, these results contribute to the standardization of cell-based assays for immunotoxicity assessments.

**MP002 A 15 year evaluation of toxicity monitoring for irrigated agriculture: how data linked to management practices has improved water quality**

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Beginning in 2004, the Central Valley Regional Water Quality Control Board (California, USA) required the Westside San Joaquin River Watershed Coalition (Coalition) to begin monitoring of runoff from agricultural lands during both the irrigation and stormwater seasons. The Coalition has been required to perform monthly monitoring at up to 20 sites for aquatic toxicity, as well as supporting analytical chemistry (e.g., pesticides). Toxicity tests included the 96-hr chronic Pseudokirchneriella subcapitata (formerly S. capricornutum), acute Ceriodaphnia dubia, and Pimephales promelas tests. Follow-up triggers based on the initial toxicity tests included dilution series testing if complete mortality was observed in the invertebrate or fish test, and Phase I Toxicity Identification Evaluations (TIEs) if a >=50% reduction in response was observed for any organisms compared to the associated laboratory control treatment. Early in the program, toxicity observations were relatively common, and more frequently observed for the P. subcapitata and C. dubia tests than for the P. promelas test. Non-polar organics were typically identified through TIEs as the class of contaminants most likely responsible for toxicity. Based on the outcome of toxicity testing and supporting chemical analyses, pesticides were identified as most likely responsible for the toxicity based on a concentration that exceeded effect thresholds in the literature. Pesticide use evaluation reports were then obtained from the Agriculture Commissioner and/or CA Department of Pesticide Evaluation and used to identify growers that applied the pesticide(s) of concern in months preceding the monitoring data. Use reports were then used to develop management plans to educate growers and certified pesticide applicators in the region so as to reduce the transport of the pesticide(s) into surface waters. This process has resulted in dramatic reductions in observed toxicity for the Coalition. However, continued monitoring allows for ongoing evaluations of any changes that may translate into toxicity observations in water samples.

**MP003 Building a bigger picture: Exploring effects of realistic resource and chemical environments on population-level ecotoxicology of D. magna**

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Traditional toxicity testing is used to assess adverse effects of chemicals on environments using tests of individual organisms. However, traditional toxicity tests largely fail to account for ecological factors such as predation and resource environment, as well as the effects of multiple chemical stressors. In this study, a binary mixture of two environmentally relevant chemicals was used to create a complex but realistic stressor environment. A pulse of pyraclostrobin, a fungicide, was applied to aquatic laboratory systems chronically stressed with high conductivity due to sodium chloride, which is common in aquatic systems from road de-icing activities. These compounds were selected due to their contrasting physiochemical attributes but also their likelihood to co-occur in many rural waterways. To first assess these stressors, we conducted a series of 48-hour acute studies with Daphnia magna exposed to various concentrations of sodium chloride and pyraclostrobin. The first study used the algae Raphidocelis subcapitata as a food source and the second study used homogenized waste from Lymnaea stagnalis, as a lower quality, but environmentally relevant, carbon source. Both food sources decreased toxicity of both chemicals and the mixture, but high-carbon quality R. subcapitata increased the LC50 significantly more, suggesting an important effect of resource quality. We then initiated a series of laboratory-population experiments with full factorial designs to evaluate the effects of both chemicals and food sources under more ecologically realistic conditions. Results for the laboratory-population experiment in which daphnia were fed algae showed that chloride delayed time to first reproduction and the addition of pyraclostrobin increased acute mortality in individuals that manifested at the population level. Average length of individuals increased after pyraclostrobin application due to size-specific toxicity but then plummeted as the population recovered. Interestingly, the acute data allowed for the estimation of outcomes from the population experiment with regard to the toxicity of the mixture. A similar population-level experiment is planned in which snail waste will be used as a carbon source. In conclusion, these increasingly complex ecological scenarios will provide ecologically relevant data, and can also be used to help inform and evaluate standard toxicity test designs.

**MP004 Climate Change Indices-Polycyclic Aromatic Hydrocarbons-Fisheries Nexus in Coastal Ecosystems and Vulnerable Economies: A Conceptual Framework**

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Coastal ecosystems are one of the most sensitive and vulnerable environments to both climate change and pollution. While coastal ecosystems contribute substantial benefits to people which include fisheries, recreational activities and transportation as well as serving as a major regulator of anthropogenic pollution, anthropogenic pollutants are affecting the ability of marine ecosystems to deliver such services. Climate change can exacerbate such impacts. A specific concern of such climate change pollutant interactions is polycyclic aromatic hydrocarbons (PAHs). Specifically, the increase in shipping activities, oil and gas exploration and industrialization in the Global South, where people are highly dependent on local living marine resources, lead to increasing levels of PAHs and their subsequent biological effects at all levels of biological quality, but environmentally relevant, carbon source. Both food sources decreased toxicity of both chemicals and the mixture, but high-carbon quality R. subcapitata increased the LC50 significantly more, suggesting an important effect of resource quality. We then initiated a series of laboratory-population experiments with full factorial designs to evaluate the effects of both chemicals and food sources under more ecologically realistic conditions. Results for the laboratory-population experiment in which daphnia were fed algae showed that chloride delayed time to first reproduction and the addition of pyraclostrobin increased acute mortality in individuals that manifested at the population level. Average length of individuals increased after pyraclostrobin application due to size-specific toxicity but then plummeted as the population recovered. Interestingly, the acute data allowed for the estimation of outcomes from the population experiment with regard to the toxicity of the mixture. A similar population-level experiment is planned in which snail waste will be used as a carbon source. In conclusion, these increasingly complex ecological scenarios will provide ecologically relevant data, and can also be used to help inform and evaluate standard toxicity test designs.
organization. However, the interactions of these stressors and their effects on the abundance and diversity of marine species have not been well studied. Here, we developed a conceptual framework for the potential interactions of these stressors, their effects on marine species abundance and diversity, fisheries and subsequent impacts on the sustainability of the society and economies. We provide a roadmap for integrated assessment models, empirical studies and policy needs. The implications of these effects for sustainable development of vulnerable economies and environments are critical to the United Nations Sustainable Development Goals 13 (i.e. urgent action to combat climate change and impacts) and 14 (life below water).

**MP005 Copper and zinc concentrations in seawater, sediment and gastropod, Burnupena spp. from the coast of the Cape Town, South Africa**

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Copper (Cu) and zinc (Zn) concentrations were measured in intertidal waters, sediment and marine gastropod Burnupena spp. (soft tissue and shells) by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Samples were collected once in the dry season (March) and wet season (September) in 2016 from eight sampling points in four sites along the coast of Cape Town. Mean concentration (mg/L) in water ranged from not detected (ND) to 0.0818±0.0494 for Cu and ND to 1.7679±0.6393 for Zn. Mean concentrations (mg/kg dry weight) in sediment were ND to 757.93±531.95 for Cu and 1.20±1.53 to 1340.78±1585.74 for Zn. Mean concentration (mg/kg dry weight) ranges in the soft tissue were 57.16±14.39 to 147.49±26.63 for Cu and 94.54±30.95 to 1010.79±93.79 for Zn, whereas that in shells were 0.48±1.08 to 15.32±1.02 for Cu and ND to 51.18±101.74 for Zn. Mean Cu and Zn concentrations in the soft tissue were significantly higher (p<0.05) than in the shells. The highest mean Cu and Zn concentrations were recorded in the sediment which may suggest that metal concentrations are from anthropogenic and lithogenic sources. Pollution Load Index (PLI) in sediment were in the range of 0.04 to 6.02 which showed that sediment was unpolluted to polluted and may have deleterious effects on marine biota. The results showed that several sampling points exceeded the environmental levels for Cu and Zn used in this study. Therefore, continuous monitoring of metals in all environmental compartment is needed.

**MP006 Effects of Wastewater Treatment Plant Effluent Exposure in Daphnia magna and Gambusia affinis**

E. Pocasangre, L.M. Jackson, University of Cincinnati / Biology

While the effects of effluent contamination have been tested and observed, there is scarcely any existing gradient exposure/effects to treated wastewater effluent that compares the effects of model invertebrate and vertebrate organisms. Treated effluent from wastewater treatment plants (WWTPs) is known to contain contaminants that may produce adverse effects on fish populations. Modern WWTPs are capable of filtering various contaminants such as heavy metals, organic compounds and solid wastes (also called biosolids), but certain synthetic organic compounds are still present in trace concentrations in the treated effluent. The aim of the present study is to investigate the possible consequences of short- and long-term exposures of different concentrations of treated effluent from a WWTP that services a large urban population on *Daphnia magna* and *Gambusia affinis*. An examination of 48 hours, 10 days, and one-month (multiple generations) experiments will examine exposure effects on *Daphnia magna*’s growth, survival, fecundity, and offspring survival. *Daphnia magna*,

**MP007 Effects-based monitoring of bioactive contaminants discharged to the Colorado River before and after upgrades to a wastewater treatment facility**


Recent monitoring of surface water from the Colorado River near the wastewater treatment plant (WWTP) outfall in Moab, UT, detected chemicals of emerging concern and estrogen-receptor (ER)-, glucocorticoid receptor (GR)-, and peroxisome proliferator activated receptor-gamma (PPARg)-mediated biological activities. In 2018, the Moab WWTP was modernized and upgraded to accommodate the increased influent associated with tourism in the area. The present, multi-year study aimed to determine whether the plant upgrade reduced bioactive contaminant loading and if so, over what geographic area relative to the discharge site. Water samples were collected bimonthly, pre- and post-upgrade, at 10 sites along the CO River, upstream and downstream of the Moab WWTP. Water samples were analyzed for in vitro biological activities (e.g., ER, GR, and PPARg). To evaluate the potential in vivo bioavailability of contaminants and potential impacts of the WWTP upgrade, adult fathead minnows were caged at five or six sites at various proximities to the WWTP pre- (2018) and post- (2019) upgrade. After four days of exposure, muscle, livers, gonads, and brains were collected for measurement of targeted gene expression. An autosampler was simultaneously deployed at each site to collect a composite water sample representative of the fish exposure. Composite water samples were analyzed for a suite of pharmaceuticals, pesticides, steroid hormones, wastewater indicators, and in vitro biological activities. Prior to the WWTP upgrade, in vitro ER, GR, and PPARg activities were associated with the surface water at the WWTP outfall site, but activities rapidly diminished with downstream dilution. Based on bioanalytical equivalents, estrone and estriol (38 and 66 ng/L) were the prominent drivers of in vitro ER activity at the WWTP site. No dramatic responses were observed in ER-, GR-, and PPAR-related gene expression in male livers of caged fish prior to the facility upgrade; however, 100% mortality was observed at the WWTP site, likely due to ammonia toxicity (0.91 mg NH3/L measured in the composite sample). No treatment-related mortalities were observed in the post-upgrade fish exposure. Results from 2018 and 2019 will be compared to evaluate effects of the upgrade on ER, GR, and PPAR-related bioactive contaminant loading. The contents of this abstract neither constitute nor reflect USEPA policy.

**MP008 Examining Effects of Agricultural Runoff on Daphnia at Individual and Population Levels to Better Understand Stressor Effects on Aquatic Ecosystems**

J. McNulty, University of Cincinnati; L.M. Jackson, University of Cincinnati / Biology

Multiple stressors, such as agricultural runoff, have the potential to greatly affect aquatic ecosystems, many times orders of magnitudes higher. Limited data on agricultural runoff poses challenges to identify clear stressor-response relationships between individuals and populations in the aquatic ecosystems affected. Also, the lack of data minimizes the knowledge and identification of the potential harmful effects of the runoff in our aquatic environment. This present study examines the effects of agricultural runoff in rural Ohio on *Daphnia magna*, a model toxicity test organism. Samples of runoff from a heavily farmed, agricultural area at multiple distances upstream and downstream of the point source of that
agricultural runoff will be taken and their effects on *D. magna* survival, growth, fecundity, and multi-generations will be observed. Acute (48 hour) and chronic (28 days) studies on individuals and populations of *D. magna* will be measured in response to the runoff exposure. The results from this study are being generated presently and will be presented at the SETAC North America 40th Annual Meeting in Toronto, Canada.

**MP009 Impacts and interaction effects of sediment contamination and ocean acidification on Eohaustorius estuarius**

*A.N. Parks*, D.J. Greenstein, S.M. Bay, Southern California Coastal Water Research Project / Toxicology

Contamination of aquatic and sediment habitats in southern California is widespread and a focus of multiple programs to monitor and restore sediment quality. Stressors associated with global climate change, including ocean acidification (OA), warming, and hypoxia, are of great concern in coastal waters, and these stressors have the potential to influence the impacts of environmental contamination. Although much research has been done to determine the toxicity of contaminants and OA in water column exposure conditions, little is known about their potential interactions in the benthic environment. Contaminated coastal sediments in upwelling zones are expected to be at greatest risk due to more frequent encroachment of corrosive waters. It is unknown how the dual stressor exposure will impact organism health. However, such information is essential to developing accurate vulnerability assessments and potential management actions to protect benthic communities and the many beneficial uses they support. The overall goal of this work is to investigate the effects of sediment contamination and OA conditions on widely-used sediment quality test species, *Eohaustorius estuarius*, using a multi-stressor approach. A 3x3 factorial design was implemented to evaluate the effects of ocean acidification and sediment contamination on the survival of *E. estuarius*. OA conditions, as a function of pCO2, encompassed a range of exposures found in local upwelling areas (400, 800, and 1200 ppm pCO2). Sediments were spiked with contaminants of concern in CA, either copper (0, 400, 800 mg/kg dry sediment) or cyfluthrin (0, 4.0, 7.5 µg/kg dry sediment), at concentrations expected to result in low to moderate toxicity during the 10-day survival test. A flow-through microprocessor-controlled exposure system was used to maintain desired pCO2pH, temperature, and dissolved oxygen levels throughout the exposure period. Results of this work will be evaluated to determine the presence/magnitude of an interaction between OA and contaminant exposure. Sediment quality objectives have already been adopted for California enclosed bays and estuaries, and this work will help inform whether such objectives will be protective of the coastal shelf sediments under current and expected OA conditions.

**MP010 Impacts of road runoff: A cocktail of multiple anthropogenic stressors and the subsequent response of macroinvertebrate communities**

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Globally, urbanization continues to increase and produce elevated levels of contaminants (e.g., metals, pesticides) in the air, soil, and water within and around urban centers. In particular, heavily trafficked roads are a major source of anthropogenic contaminants, including polycyclic aromatic hydrocarbons, heavy metals, tire dust, and road salt. This mixture, herein referred to as road runoff, represents one of the largest contributors of diffuse-source toxicants in urban areas, and yet is seldom studied as a contaminant mixture. Here we investigate how road runoff could impact ecosystem structure and function in urban stream ecosystems. Specifically, we (1) investigate contaminant fluctuations over the winter, a time of intense road salt application, (2) assess community-level invertebrate responses to contamination loads in urban streams, and (3) assess the effect of road runoff-associated chemicals to early life stage freshwater mussels. Preliminary results demonstrate that chloride concentrations in urban sites are an order of magnitude greater than rural sites. Additionally, the amount of chloride has a strong relationship with temperature, where chloride concentrations increase with air temperature during the winter season. Last, we detected differences in community composition of benthic macroinvertebrates between rural and urban sites. Future work will determine how early life stage freshwater mussels respond to environmentally relevant concentrations of each road runoff contaminant both singly and combined in a full factorial experiment. This will provide insight into potential stressors that can impact these and other sensitive species. Such work builds on our understanding of how multiple anthropogenic stressors impact stream communities as a mixture, and has the potential to help inform future policy and urban development decisions.

**MP011 Impacts of wastewater discharges on freshwater mussels in a watershed within Southern Ontario, Canada**

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Wastewater treatment lagoons serving communities across rural Canada were originally constructed to serve smaller populations. Growth and insufficient financial resources for upgrades have caused many communities to discharge treated wastewater that does not comply with current federal regulations for wastewater quality. Aquatic organisms in water bodies receiving wastewater are often negatively impacted by exposure to these discharges. Exposure to associated contaminants, including ammonia, chloride, metals, and contaminants of emerging concern (CECs) have been associated with effects on the health of freshwater mussels. The Grand River watershed located in southern Ontario, Canada supports one of the richest assemblages of freshwater mussels in Canada, including several Species at Risk. In previous studies, freshwater mussels exposed to wastewater have exhibited negative effects across multiple levels of biological organization; from sublethal responses to population alternations. In this study, caged adult freshwater mussels (Lasmigona costata) and passive samplers (POCIS) were deployed in Boston Creek, a tributary of the lower Grand River for a two-week period at locations both upstream and downstream of the seasonal discharge of a wastewater treatment lagoon serving the Mississaugas of the Credit First Nation. Although POCIS revealed that CECs were elevated 1km downstream of the lagoon, analysis of tissues for biomarkers of lipid peroxidation (i.e. HNE), as well as levels of metallothionein and vitellogenin-like proteins indicated that these parameters were not correlated with exposure to CEC microcontaminants and metals known to be discharged in wastewater. Pollution from other point and non-point sources, including runoff from roads, agriculture and pasture lands, as well as discharges from a gypsum plant may be contributing to poor water quality in Boston Creek and the observed biological impacts in caged freshwater mussels.

**MP012 Microplastics as vector for endocrine disrupting compounds in marine environment**

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The improper disposal of microplastics in the ocean coupled with insufficient wastewater treatment and coastal littering, have led to the presence of plastic debris in marine waters, sediment and in aquatic life through ingestion. Recent research suggests that microplastics could pose a risk to human health if transported via food chain. Therefore, laboratory experiments were carried out to estimate the concentrations of endocrine disrupting chemicals (EDCs) in weathered microplastics.
collected from Quayside Road along River Itchen. Following the extraction of EDCs, desorption experiments were conducted to estimate the amount of EDCs released from weathered microplastics under sea water conditions (pH = 7). Results showed that fairly amounts of phthalates were released in the solution after 24 hours; indicating the potential risk of the presence of microplastics in the marine water. Additionally, sorption and desorption isotherms were carried out to basically indicate the effect of the presence of multiple EDCs as mixture and their competitive sorption to pristine microplastics. Results showed that sorption of hormones and bisphenol was significant. However, in the desorption experiments, the release of phthalates was much higher compared to hormones and bisphenol compounds.

MP013 Physiological and biochemical comparison of Lake Chub in different reaches of the Ells River in the Athabasca Oil Sands Region

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The Fort McMurray deposit is part of the larger Athabasca Oil Sands formation found in northeastern Alberta, Canada. Exposed bitumen found in this region are rich in natural sources of polycyclic aromatic hydrocarbon (PAH) compounds. Numerous oil companies conduct surface mining in the areas around Fort McMurray and adjacent to the Athabasca River, extracting this naturally occurring bitumen for its petroleum. Thus, resident wild fish in the Athabasca and its tributaries may be exposed to either naturally occurring sources of bitumen or anthropogenically refined sources through surface mining. The Canadian and Alberta governments developed monitoring programs aimed to investigate fish health, of the lower Athabasca River and its tributaries in 2009. The Ells River serves as the predominant drinking water source for the community of Fort McKay. Although this research does not focus specifically on drinking water, investigating the health of forage fish provides information as to the health of the tributary. This work compares the physiological responses of 20 male and 20 female lake chub (Couesius plumbeus) from three different reaches of the Ells River across the years 2013, 2014, and 2015. The three reaches consist of a reference/baseline site (upper), a middle reach, which runs through natural bitumen deposit, and a lower reach, which may receive increased sources of contaminants associated with the refining of bitumen due to development and anthropogenic influences. Endpoints assessed in this study were age of fish, growth metrics (length at age, weight at age, condition factor, gonadosomatic index, and hepatosomatic index), and hepatic 7-ethoxyresorufin-O-deethylase (EROD) activity. Results suggest significant site differences in age, length and weight by age, and EROD differences in both male and female fish depending on site location for 2013 and 2015 sampling years. These site differences were not observed in 2014.

MP014 Role of agricultural intensities on sediment inputs and fish communities in the Upper Cache River Watershed, Arkansas

A.K. Atwell, Arkansas State University / Ecotoxicology Research Facility; J.L. Bouldin, Arkansas State University / Biological Sciences

Nearly 50% of all assessed streams in the United States are impaired for not meeting their designated use. The leading cause of impairment is non-point source pollution from agricultural land use. One common practice of streams draining agricultural lands is channelization, a process that involves widening and deepening stream channels to increase the hydraulic loading during flood events. This process can lead to increased stream sedimentation, reduced stream water quality, homogenization of the substrate, and negatively impact aquatic biota. The presence of intolerant fishes has been shown to decrease once agricultural land usage exceeds 30-50%. In the Cache River Watershed, located in northeast Arkansas, approximately 70% of the 230-km-long watershed is used for agricultural purposes. Nearly 150 river-km are channelized and over 200 river-km are listed as impaired for not supporting aquatic life, with sedimentation from agriculture the leading cause. The goal of the project is to monitor sediment contributions and water quality of the Cache River Watershed and determine if fish communities vary with increasing agricultural land use. Turbidity and total suspended solids (TSS) have been analyzed weekly since October 2017 in 12 spatially independent tributaries in the Upper Cache River Watershed while fish sampling took place June 2019. When grouped by agricultural intensity, there is a significant difference in turbidity between low intensity and moderate or high intensities. Results suggest that fish communities in the Cache River tributaries may be affected by intensity of agricultural land use and channel alteration which result in increased sediment contributions.

MP015 Temporal biological responses of caged yellow perch (Perca flavescens) environmentally exposed to a major urban effluent

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Municipal wastewater treatment plant (WWTP) effluents represent important sources of environmental contamination for a range of organic and inorganic pollutants. These complex chemical mixtures can affect the health of aquatic organisms residing in the receiving waters. High-throughput tools such as metabolomics can help identifying and understanding the interactions of contaminant mixtures and their exposure-related effects on aquatic organisms. The aim of this study was to examine the effects of in situ exposure of juvenile yellow perch (Perca flavescens) to a major WWTP effluent. Commercially purchased young-of-the-year perch were acclimated in the lab for two months prior to the study. Perch were then caged at a reference site and at a WWTP effluent-impacted site located downstream of the Montreal’s WWTP effluent point of discharge in the St. Lawrence River (Quebec, Canada). Responses at the gene transcription, metabolite, and protein levels were investigated as well as body condition of perch after 1, 3 and 6 weeks of exposure. Stable isotopes, flame retardants and metals were also analyzed in perch tissues. Body condition of perch caged downstream of the effluent increased after 3 and 6 weeks of exposure compared to that of fish exposed at the upstream reference site. Moreover, fish caged in the effluent plume had higher muscle δ13C and slightly depleted muscle δ15N after 3 and 6 weeks of exposure, suggesting possible diet differences between sites. Moreover, perch caged for 3 weeks downstream of the effluent had lower levels of metals in kidney than fish from the reference site. However, kidney Cd, Cu, Se, As, Zn and Fe were higher at the impacted site after 6 weeks of exposure, suggesting that metal accumulation could be time- and element-specific. Results indicated that glutathione reductase activity in gills increased with exposure time. Negative relationships between total kidney concentrations of non-essential metals and gill glutathione reductase activity were also observed, suggesting potential perturbation of these inorganic contaminants on oxidative stress responses in perch. Relationships between metal and flame retardant accumulation, transcription levels of stress-related genes and cellular metabolites will be discussed. The
of exposure of these herbicides to early life stages (ELS) of the African Catfish, Clarias gariepinus. Therefore, the effects of environmentally relevant concentrations Glyphosate (0.27 and 53 µg/L) and Paraquat (3.14 and 17.5 µg/L) on catfish ELS (Age: 2 wks, Length: 18-22 mm) were investigated following a 63 d exposure. The fishes were randomly sacrificed at 21, 42 and 63 d post exposure to analyse histopathological effects in the gills and liver, levels of the lipid peroxidation product, malondialdehyde-MDA and liver function enzymes; Aspartate aminotransferase-AST,Alanine aminotransferase-ALT and Alkaline phosphatase-ALP. The Micronucleus assay was also conducted to determine their genotoxic effects on their erythrocytes (ERT). The gill MDA levels, liver AST, ALT and ALP as well as micronuclei and bi nucleated cells in the ERT of exposed catfishes were significantly higher (P< 0.05) compared to control for both concentrations of the herbicides. Histopathological assessment revealed increasing incidence of shortening/blunting of secondary lamellae (SL), inflammation, mild lamellar necrosis, severe lamellar necrosis and destruction of both primary and SL. Only liver samples in those exposed to 53µg/l of Glyphosate showed fat vacuoles indicative of damage to some hepatocytes after 63 d. These findings call for cautious introduction of herbicides into farmlands especially in the face of global agro-intensification and quest for conservation of fisheries resources.

MP020 Tributary input effects on water quality and fish assemblages in the Strawberry River, Arkansas

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The Strawberry River is a tributary of the Black River within the White River basin in northern Arkansas. The river distance from source to mouth is about 177 km, and it is considered by the ADEQ as an extraordinary resource and ecologically sensitive waterway. In order to protect the water quality, it is important to determine which tributary is adding to the impairment due to siltation. Water quality in eight tributaries (Piney Fork, Mill Creek South Big Creek, North Big Creek, Clayton Creek, East Cooper Creek, Reeds Creek, Sleep Bank Creek, and Caney Creek) were collected, from October 2016 to September 2019, prior to the confluence with the Strawberry River. Water quality variables included total suspended solids (TSS), turbidity, pH, conductivity, dissolved oxygen, PO4, TP, TN, NO2, and NO3. Sites location and agricultural land use influences sedimentation and nutrients. Upstream sites had lower sedimentation values than downstream sites as the watershed transitions from the Ozark Highlands to the Delta Ecoregion. TN was significantly different among sites whereas TP was not. The major cause of the impairment is thought to be from excessive sedimentation due to agricultural runoff. A fish survey was also conducted in seven sites of the Strawberry River to assess population size and biodiversity at each site. This project will help us to monitor the water quality of this extraordinary resource, protecting over 100 species of fish and other indigenous species as they are being threatened by agriculture runoff.

MP021 Utilizing Transcriptomics to Evaluate Environmental Determinants of Oyster Health at an Implanted Bed in Newport Bay, CA

A. Russell, C.R. Whitcraft, E.B. Holland, California State University, Long Beach / Department of Biological Sciences

Estuarine ecosystems have historically faced severe degradation, and traditional restoration techniques using man-made structures have been scrutinized for ecological damage. Living shorelines, using objects such as oyster beds, reduce shoreline erosion and are supplements to man-made structures while also restoring ecological communities. Living shorelines were established in Upper Newport Bay (UNB, CA) in 2016 to restore native Olympia oysters, Ostrea lurida. One goal was to understand potentially important factors for optimal restoration conditions for O. lurida, including effects of plot design and sublethal concentrations of existing pollutants. Current methods to evaluate oyster health include recruitment and size; however, these metrics cannot anticipate sublethal stress effects prior to impacts on survival or fitness. Instead, high-throughput
transcriptomics techniques are powerful tools for assessing organismal health. This study will use whole transcriptome analysis and modeling to examine oyster health. Specifically, it will describe differential gene expression observed between (Aim 1) oysters recruited to beds in the presence or absence of neighboring eelgrass and (Aim 2) oysters with varying organic or inorganic pollutant burdens. I have already sampled gill tissue from oysters recruited to UNB shorelines and oysters maintained under clean conditions for three months as contaminant free controls. I have also gained preliminary results on pollutant burdens that may be present in UNB oyster tissue. This research will provide deeper understanding into the dynamic relationship between estuaries such as UNB and pollutants, and their influence on O. lurida conservation. Additionally, it will help inform future restoration strategies and support genomic analysis as a formidable tool for evaluating the health status of wild populations.

Mollusca Toxicology: An Ecological Important and Imperiled Phyla but Often Left Out

MP022 Adaptive Tolerance to Zinc in Freshwater Snails (Physa acuta) Across a Contamination Gradient
J.B. Belden, J. Hickey, S.T. McMurry, Oklahoma State University / Integrative Biology

The Tri-State-Mining district is an area of northeast Oklahoma, southwest Missouri, and southeast Kansas in which zinc and lead mines operated for over 100 years. Metal contamination from wastes left behind by these historic mining operations has polluted the Neosho and Spring Rivers, the Grand Lake o’ the Cherokees, and resulted in the EPA designating the Tar Creek Superfund site in 1983. The receiving watershed has a gradient of contamination from likely toxic concentrations to background concentrations. The purpose of this study was to determine if native populations of aquatic snails have developed tolerance to environmental metal concentrations and, if present, the extent of the metals tolerance across a downstream gradient from the metals-contaminated area. Freshwater snails (Physa acuta) were collected from sites representing the gradient of metals contamination and field sediment and water samples were analyzed for zinc. These populations were cultured in the lab and zinc toxicity tests were conducted with F1+ juveniles collected from those cultures. We found that snails cultured from populations collected from contaminated, upstream sites were more tolerant to zinc exposure than snails cultured from populations collected from clean, downstream sites. Additionally, zinc tolerance was found in snails collected from a site that represented a midpoint geographically, although environmental zinc levels were below levels likely to cause toxicity. Our results suggest that, despite past studies showing sediments from Grand Lake to be relatively nontoxic to sediment-dwelling organisms, aquatic organisms may still be experiencing selective pressures as a result of metals contamination and this may warrant further investigation.

MP023 Assessing the Impacts of Wastewater Effluent on the Growth of the Truncate Soft-Shelled Clam Mya truncata in Frobisher Bay, Nunavut
C. Schaefers, K. Jeffries, University of Manitoba / Biological Sciences; D. Deslauriers, Fisheries and Oceans Canada

Frobisher Bay, Nunavut, has historically had a large population of the soft-shelled clam Mya truncata, a popular food among locals. Lately, M. truncata’s populations are undergoing a steep decline throughout their circumboreal distribution. While climate change is a contributing factor, our study will focus on the interaction between climate change and wastewater effluent in this region. In Iqaluit, water and waste management have become increasingly complicated as the population continues to rise and the primary treatment system periodically gets overwhelmed leading to episodes of raw sewage pouring into the marine ecosystem. The input of wastewater effluent, whether raw or primarily treated, brings potential stressors of reduced salinity, increased temperature, low levels of dissolved oxygen, effluent toxicity, contamination of sediments, and increased nutrient loading leading to harmful algal blooms. These challenges bring an urgency to study the ability of M. truncata to physiologically cope with local conditions while addressing the concerns associated with contamination in a popular Arctic country-food. To address this, soft-shelled clams were sampled from several locations in Frobisher Bay that are exposed to varying levels of wastewater effluent, as well as from two nearby reference sites. We took a field study approach by investigating the relationship between periodic sewage effluent release and the effects on the bivalve’s annual shell growth and population-size structure. The widths of internal growth bands in the chondrophore were analyzed with the hypothesis that unregulated wastewater release would negatively impact the clams in terms of growth. Future research will endeavor to characterize the effluent release on the overall health of the truncate soft-shell clam. This work contributes to a baseline monitoring project for the protection and conservation of Canadian marine environments and investigates how chronic wastewater effluent exposure, alongside temperature increase, will negatively impact the soft-shell clam, Mya truncata.

MP024 Chronic toxicity from environmentally relevant concentrations of copper and zinc on freshwater mudsnail Potamopyrgus antipodarum
M. Subba, CAPIM, The University of Melbourne / Biosciences; M.J. Keough, The University of Melbourne / School of Biosciences; V.J. Pettigrove, RMIT University / Sciences; C. Kellar, Aquatic Pollution Prevention Partnership / RMIT University

Heavy metals are the most common pollutants in water around the world. Increasing concentration of these pollutants in aquatic environment has a serious threat to aquatic ecosystem because they are persistent, toxic, bioavailable and can biomagnify in food chain. Assessing the effect of common heavy metals on test species is important to get an understanding on the impact these metals can have on the aquatic species, and the aquatic environment. We modified OECD (2016) procedure and conducted a chronic (28 d) exposure of commonly detected heavy metals, copper (Cu) and zinc (Zn), and evaluated survivorship, growth and reproduction of freshwater mudsnail Potamopyrgus antipodarum under laboratory conditions. We selected this species because they are widely distributed, are used in ecotoxicology studies and are known to be a sensitive species. This mudsnail are ooperculate (has operculum) and undergoes asexual reproduction by parthenogenesis and ovoviviparity (produces live embryos). Adult snails (3.5 - 4 mm), were exposed to 4 concentrations of Cu (0, 0.002, 0.0125, and 0.025 mg/L) and Zn (0, 0.01, 0.05 and 0.4 mg/L) at concentrations detected in freshwater around the world. Each treatment had 3 replicates. This current test is valid because there was 100 % survival in the controls for both the metals. Both the metals had a negative impact on its mortality. A significant effect on the survival of P. antipodarum was observed at the top most concentration of Cu and Zn (p < 0.05). Both the metals had no significant effect on its growth (shell height). This species has a long-life cycle (> 2 y, personal observations) under laboratory conditions so it is expected it will not show a significant growth in 28 d. However, hormesis effect on its reproduction was observed at the lowest concentration of Zn (0.01 mg/L) with a significantly greater number (8.45 ± 1.09, mean ± standard error) of embryos than the control (5.75 ± 1.05, mean ± standard error) (p ≥ 0.05). The hormesis process explains lower concentration of toxicants having a positive effect while higher dose having an inhibitory effect. This result agrees with several previous findings. Our study demonstrates the effect from 2 common metals on an ecologically important species. Overall, our study found the endpoints sensitive and proposes to include these endpoints in risk assessment and in predicting effect of heavy metals in the aquatic environment.
MP025 Sensitivity of larval and juvenile mussels (Unionidae) to ammonia, chloride, copper, potassium, and selected binary chemical mixtures

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In aquatic environments, organisms such as freshwater mussels are likely exposed to complex contaminant mixtures related to industrial, agricultural, and urban activities. With growing interest in understanding the risk that chemical mixtures pose to mussels, this investigation focused on the effects of various waterborne contaminants (ammonia, chloride, copper, and potassium) and selected binary mixtures of these chemicals following a fixed-ratio design to *Villosa iris* glochidia and juvenile *Lampsilis fasciola*. In individual exposures, 48-h EC$_{50}$ values were determined for *V. iris* glochidia exposed to ammonia chloride (7.4 [95% confidence interval (CI) 6.6-8.2] mg N/L), ammonia sulfate (8.4 [7.6-9.1] mg N/L), copper sulfate (14.2 [12.9-15.4] μg Cu$^{2+}$/L), potassium sulfate (12.8 [11.9-13.7] mg K$^+$/L), potassium sulfate (10.1 [8.9-11.2] mg K$^+$/L), and sodium chloride (480.5 [435.5-525.5] mg Cl$^-$/L). The 7-d LC$_{50}$ values for juvenile *L. fasciola* were determined for potassium sulfate (45.0 [18.8-71.2] mg K$^+$/L), and sodium chloride (1738.2 [1418.6-2057.8] mg Cl$^-$/L). These waterborne contaminants have been reported to co-occur in the Canadian province of Ontario, with concentrations exceeding the EC$_{50}$ for both life stages at some locations. Data from binary mixture exposures for *V. iris* glochidia (ammonia-chlorine, chloride-copper, and copper-ammonia) and juvenile *L. fasciola* (chloride-potassium) were analyzed using a regression-based, dose-response mixture analysis modeling framework. Results from the mixture analysis were used to determine if an additive model for mixture toxicity [concentration addition or independent action] best described the toxicity of each mixture and if deviation towards dose-ratio or dose-level synergism/antagonism occurred. For all glochidia binary mixture exposures, concentration addition was the best fit model with dose-level deviation reported for the chloride-copper mixture and dose-ratio deviation reported for the copper-ammonia mixture. Using the model deviation ratio, the observed toxicity in all three glochidia mixture exposures were adequately described by both concentration addition (mean = 0.71) and independent action (mean = 0.97) whereas the juvenile mixture exposure was only adequately described by concentration addition (mean = 0.64; independent action mean = 0.05).

MP026 The effects of chloride on a freshwater mussel (Lasmigona costata): A non-targeted metabolomics study

B. Atkinson, University of Guelph

Acute and chronic exposure to roadside runoff poses concerns for populations of aquatic organisms. There is a need to investigate new screening tools for describing and measuring organism response in toxicological studies. These tools need to be able to assess stress sub- lethally, be cost effective, and reproducible. An analysis of circulatory fluid (hemolymph) from freshwater mussels offers a non-lethal sampling alternative that is simple to conduct, non-intrusive and provides reliable data. Metabolomics is a technique that provides insight into biochemical pathways being affected in response to the toxic stressor. This research will evaluate the effects of a 28-day exposure of chloride on the metabolism of the freshwater mussel Lasmigona costata (flutedshell). Sodium Chloride (known as rock salt) is commonly used as a deicing agent on roads and bridges and can be released in significant pulses after rainfall events. The study will explore the differences found on the metabolome of test animals at two environmentally relevant concentrations of chloride to a control group. The anticipated outcome of these results will confirm that examining hemolymph as a non-lethal sampling technique through metabolomics studies provides value added information for assessing risk and toxicity.

MP027 Environmental Concentration and Partitioning of Organic UV-filters in Seawater

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The organic UV filters contained in sunscreen products are under scrutiny regarding their environmental risk to aquatic organisms, especially sensitive coral. However, very limited or no information on the environmental concentrations of these chemicals in seawater and sediment around coral reefs is available, which is a critical component needed for environmental risk assessments. Furthermore, the partitioning of UV filters in seawater between dissolved and particulate phases has not been addressed and critical information in toxicological and environmental modelling assessments. To address these knowledge gaps, replicate surface seawater (dissolved and particulate fractions) and sediment samples were collected from multiple sites and State Parks (n=29) in Oahu, Hawaii including the popular tourist destinations of Hanauma Bay and Waikiki Beach. Surface seawater samples were filtered using glass fiber filters (GF/F) to result in dissolved and particulate fractions for analysis. All samples were analyzed for 13 UV filters using LC-ESI-MS/MS techniques. Up to nine UV filters were detected in both seawater and sediment and concentrations were very variable between sites, time of day and in some cases between replicates at a site. The highest detection frequencies and concentrations of UV filters in all matrices was homosale (HMS), octisalate (OS), BP-3 and octocrylene (OC). BP-3 was ubiquitous in surface seawater as it was detected at all sites with the highest concentrations found in the late afternoon samples from Hanauma Bay, Waikiki Beach and Ko’olina Beach Park, however, at 15 of the 29 sites, aqueous concentrations were less than 10 ng L$^{-1}$. However, BP-3 was only measurable in sediment samples at 16 out of 29 sites at < 4 ng g$^{-1}$ (dw). No quantifiable levels of EHMC were recorded for the seawater samples, although it was quantified in a few sediment samples (e.g. from Kaneohe Bay) at concentrations less than 13 ng g$^{-1}$ (dw). We also report on the ratio of the UV filter concentrations between the dissolved and particulate phases. This study provides insight as to the environmentally relevant concentrations in seawater and sediment in Hawaiian coral reef locations in addition to seawater partitioning data relevant to bioavailability and modelling for coral reef ecosystems. These data provide an important baseline for future risk assessments of the potential toxicological effects of UV-filters on coral reefs and other marine organisms in Oahu, Hawaii.

MP028 Occurrence and Partitioning of Emerging Ultraviolet Absorbers in the St. Lawrence River

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Ultraviolet absorbers (UVAs) are widely used as industrial additives because of their ability to reduce impacts of the natural light, such as UV-induced color change or photodegradation of commercial products. These compounds are therefore globally produced in large volumes and have been detected in the environment. Some UVAs have been shown to induce adverse effects such as hepatotoxicity and endocrine disruption in fish and mammals (e.g., rat), as well as coral bleaching, making these contaminants of emerging environmental concern. However, the fate of these contaminants, particularly their concentrations and partitioning behavior...
Environmental chemical contaminants have been of major concern as they can cause adverse health effects in single or multiple forms – even at trace levels. They are derived from different activities; and they include pesticides, personal care products, pharmaceuticals, and byproducts of various industrial processes. The contaminants often referred to as contaminants of emerging concern (CEC) are of growing awareness and concern because of their possibilities of interacting with biological systems to cause serious health issues. CEC are used daily and are continuously released into the environment via various waste streams. Galveston Bay and Clear Creek receive waters from several sources including runoffs which may contain a significant number/concentration of contaminants with a high possibility of human exposure. The potential adverse effects of the contaminants on humans, human environment, and the ecosystem can range from acute to chronic and are of significant importance. This study analyzed the presence of selected CEC: oxybenzone, sulfamethoxazole, and clofibrate in the water, sediment, and fish samples from the Galveston Bay and Clear Creek areas. Samples were collected from the identified locations, extracted using standard protocols, and analyzed using high-performance liquid chromatography coupled with an ultraviolet/visible detector. Results quantified, and bioaccumulation calculated. The results showed the presence of the contaminants in the samples analyzed. The concentration of oxybenzone in water and sediment samples was 1.85 ± 0.82 and 1.30 ± 1.55 ppm respectively. Oxybenzone in fish tissues/organs was 38.49 ± 14.64 ppm, this is 2,081% and 2,961% its concentration in water and sediment samples. Clofibrate was detected at a concentration of 0.45 ± 0.31 and 2.28 ± 3.76 ppm in water and sediment samples. Its concentration of 7.76 ± 2.46 ppm found in the fish tissues/organs is 17 and 3 times more than the levels in water and sediment. Sulfamethoxazole was below detection limits. Thus, the results revealed that oxybenzone and clofibrate are present in the locations analyzed and they bioaccumulate in fish tissues/organs with a high probability of biomagnification in higher animals. Oxybenzone has a higher bioaccumulative capacity and may produce more toxic interactions. The data from this research is an impetus for the continuous monitoring of the levels of CEC in the Galveston/Clear Creek areas bodies of water and the aquatic environment.

Photochemical reactions are a major degradation pathway for natural and xenobiotic organic chemicals in the coastal environment. These reactions are important in understanding the persistence and environmental compartmentalization of the parent compounds and/or their photochemical products, ultimately potentially changing their bioavailability and toxicology to resident organisms. Photochemical reactions may result in less or more toxic chemical products. To date, very limited information is available on the photochemical degradation of sunscreen organic UV-filters such as oxybenzone (benzophenone 3 or BP-3) and octocrylene in fresh and seawater. We used a custom-designed photodegradation system that is able to continuously photo-irradiate samples with simulated sunlight and quantify the changes in optical properties throughout 24h irradiation experiments. This system avoids inner filtering effects and starvation of oxygen, which have previously been limiting factors. Additionally, subsamples were collected during irradiation experiments at 5 different time points to determine the concentrations of the examined UV-filters using LC-qqq MS and to search for photo-products using non-targeted ultrahigh resolution mass spectrometry (FT-ICR MS). Results revealed accurate photochemical decay kinetics data of the two examined filters oxybenzone and octocrylene. A diverse suite of photo-products were found, which potentially has implications for risk assessment.
MP032 Are sunscreen UV filters polluting our beaches? A case study from consumer habits to recommendation for safe-by-design products

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Sunscreens are of emerging concern regarding both human and environmental health. Their regulation is constantly evolving largely due to the potential risks related to the ingredients contained. They typically consist of an oil-in-water emulsion in which the major active ingredients are UV filters, incorporated in high concentration, up to 25wt%. UV filters are of organic or mineral nature, in agreement with country regulations, and provide the desired solar protection factor. After leaving the skin either through bathing, the UV filters contained in the sunscreen can be released into the marine environment. This scenario is of particular interest since serious concern over the potential harm of UV filters to coral reefs is continuously being raised. Nevertheless, very few data are available to enable us to quantify the source of this pollution on field. In this work, we developed lab and field studies to give insights on (i) consumer sunscreen use on the seashore and its release into the water; (ii) the advantages and disadvantages of sunscreen mineral UV filters along the product lifecycle; and (iii) how to develop an eco-designed sunscreen. A field campaign was completed on three French beaches during summer recreational activities. A social survey on the sunscreen use by bathers was carried out in order to better understand the relation between the quantities and types of sunscreen used on the beach and the environmental concentrations of UV filters actually detected in the water at the same time. In a parallel lab approach, relevant sunscreens were formulated in-house in order to evaluate the benefits and costs of ingredients like nano-TiO2 UV filters and emulsifiers. Their roles in the sunscreen efficiency were evaluated, as well as their impacts on coral larvae survival. By considering each development stage of the sunscreen, from the choice of ingredients integrated into the cosmetic formulation, to the knowledge of the risk involved in this choice all along the product lifecycle, an eco-design approach can be proposed to minimize the risk. This work was cofunded by Labex Serenade Ecosun, Labex DRIHUM through OHM Lititoral, and IRCP-CRIOBE grant 2018.

MP033 Environmental release and fate of nanoparticulate titanium dioxide UV filters from sunscreen

D. Slomberg, R. Catalano, CEREGE/Aix-Marseille University; P. Hennebert, INERIS; A. Masion, CEREGE/Aix-Marseille University; J. Labille, CNRS

Although a strong focus has been placed on addressing the impact of mineral nanoparticulate UV filters in personal care products and sunscreens, their fate and behavior are not fully understood and resulting regulation is still under consideration due to their potential risk to consumers and the environment. For example, nanoparticulate titanium dioxide (nano-TiO2) UV filters in sunscreens may leave the skin either through swimming or everyday use and subsequent washing, thus being released into rivers, lakes, sea shores, and/or sewage treatment plants. Their fate and impact in these different aquatic systems are largely determined by the nanomaterial’s chemical properties (e.g., nanomaterial coating), lifetime, and aging. In this work, impacts on the direct aquatic environment were assessed by evaluating the release of two relevant nano-TiO2 UV filters with different surface coatings (i.e., silica and stearic acid) from sunscreens formulated in-house in a simulated laboratory aging procedure. The size distribution, surface charge, and degradation state of the by-products, as well as their nanomaterial concentration and colloidal behavior were determined in a variety of aqueous environments (e.g., sea water, fresh water). Our results demonstrate that TiO2 surface coating drives behavior and that aging of the passivation layer can result in photoactive by-products. Additionally, in an end-of-life scenario, we considered the potential release of these nano-TiO2 UV filters from sunscreen containers after disposal in a landfill. The hydrophilic, silica-coated nano-TiO2 was easily dispersed in the landfill leachate, followed by a rapid sedimentation while the majority of the hydrophobic, stearic-acid coated nano-TiO2 remained associated with the container after leachate exposure. These insights on nano-TiO2 UV filter environmental fate and behavior will help guide regulations, provide better information for consumers, and assist manufacturers in incorporating an eco-design approach in consumer product development. This work was funded by Labex Serenade.

MP034 In vivo benzophenone-3 exposure alters gene regulation in eastern mosquitofish

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The ultraviolet light screen chemical benzophenone-3 (BP3) has been the focus of sunscreen chemical bans (Hawaii, Key West in Florida, Palau) due to concern for environmental risk in aquatic systems, particularly in the marine environment. Monitoring data for marine environments indicate environmentally relevant BP3 concentrations (16 - 6073 ng/L) span from much lower to within the range of concentrations reported in the literature (2280 ng/L - 7544 μg/L) for effects upon growth, survival, and development. Since BP3 concentrations in waters are known to vary with the time of day coinciding with the number of bathers in the ocean, we exposed newly hatched eastern mosquitofish to diurnally varying, environmentally relevant BP3 concentrations for 8-weeks and conducted RNA sequencing in liver tissue to determine molecular response. Eastern mosquitofish were used for this study due to availability of genomic information for the species and its availability for the study. The average 24h BP3 concentration during the exposure was 545 ng/L, while the diurnal concentrations ranged from 45 - 3827 ng/L. Significant changes in gene regulation were observed, with the primary direction of change being down regulation. Pathway analysis identified cellular processes affected by the gene regulation changes. Generally, those processes grouped within several physiological functions including those of the renal, endocrine, digestive, nervous, muscle, and immune systems. Results of this study can be used to identify the physiological systems that should be monitored in whole organism studies involving BP3 either in the field or the laboratory.

MP035 Photo-Induced Toxicity of UVA Filters Under UVA Radiation

T. Walton, J.B. Belden, Oklahoma State University / Integrative Biology

As the use of personal cosmetic care products (PCCPs) with organic ultraviolet (UV) filters is increasing, so is the exposure risk of these compounds to aquatic ecosystems. In addition, environmental factors, such as UV radiation, have the potential to increase toxicity of these compounds. This study focuses on induced photo-toxicity of common UV filters found in PCCPs in the presence of UVA radiation. The freshwater microalga, Scenedesmus acutus, was exposed to individual UV filters during a 96-h period. Fluorescence of chlorophyll a was used as a measure of growth, and inhibition of growth was utilized as the endpoint. Homosolate and oxybenzone inhibited growth with increasing concentration under non UVA conditions with EC50s of 404 μg/L and 1940 μg/L, respectively. Avobenzone and octisalate did had no observed effect up to water solubility. Further testing will compare each of the UV filters under UVA and non-UVA conditions to see if UVA radiation increases toxicity.
MP036 Risk evaluation of commercial nano-rutile based UV filters used in sunscreen. Sea water environmental release and ecotoxicological impact

R. Catalano, CEREGE / Cerege; J. Labille, CNRS; D. Slomberg, CEREGE/Aix-Marseille University; A. Pinsino, A. Alijagic, IBIM CNR Palermo

Among cosmetics and personal care products, sunscreen products are of emerging concern regarding both environmental and human healths. While some organic UV blockers have been accused of undergoing rapid photodegradation, inducing allergenic skin reactions due to dermal penetration, or of causing deleterious effects on marine system, the fate of mineral UV blockers is still under consideration from a regulatory perspective. This is largely related to the potential impact of nanotechnology-based products on both environment and human health. The nano-TiO₂ UV-blockers typically used in sunscreen usually consist of rutile nanoparticles coated with a first mineral layer of silica or alumina aimed at blocking the photocatalytic character, and thus passivating the nanomaterial. In addition, the grafting of a second layer of organic coating is aimed at favoring the nanomaterial dispersion in the cream formulation. Once drained from the skin either through bathing activity or everyday usage and cleaning, the nanomaterials contained in the sunscreen can be released to the sea shore. Their behavior in this system is largely determined by this industrial coating and by their initial dispersion in the formulation. The release and the impact on the marine environment are mainly considered and studied using the following approaches. In order to estimate the environmental concentration of nanomaterials from sunscreen in sea water we carried a field campaign on three beaches of the southern french coast. The titanium concentration was measured in the sea water. The sampling were performed at 2 depths (40 cm and surface layer) and at three distances from the shoreline (2 m, 50 m, 200 m). More than 700 litres of sea water were collected and filtered in order to separate different size fractions (< 500 nm and > 500 nm) and to localise the UV filters. The impact on marine living organism was studied by toxicological tests on the Mediterranean sea urchin (Paracentrotus lividus) used as a biological model. In particular, the impact on the sea urchin embryos development was evaluated, exposing them to 4 commercial TiO₂-based sunscreen UV filters, using the same concentrations range as evaluated in the field campaign. The effect of the different nanoparticle coatings and of their dispersing medium in the formulation (oil or water) were studied. Acknowledgements. This work was funded by: Region PACA; European Commission; Labex SERENADE and Labex DRIIHM via OHM Littoral Mediterranean.

MP037 Environmental risk assessment of oxybenzone (benzophenone-3) and coral

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Several researchers recently identified the sunscreen active ingredient, oxybenzone (benzophenone-3), as a potential risk to reef-building coral using ad hoc toxicity test methods and exposure modeling or environmental monitoring. As a result, state and local legislators in the US have either enacted or are considering enacting bans on the sale of sunscreens containing oxybenzone. There is a tension between the potential benefit to coral by using this precautionary approach - which has thus far relied on highly uncertain data - and the expected adverse human health outcome due to a reduction in the sun protection factor (SPF) of sunscreen products lacking oxybenzone. To address this uncertainty, a comprehensive database of all relevant published data addressing environmental exposure and hazard of oxybenzone to coral species, plus newly generated oxybenzone toxicity data using adult coral nubbins, form the basis of this environmental risk assessment (ERA). The worldwide reasonable worst case exposure scenario was identified as the southeastern US during summer and is the focus of this evaluation. The ERA uses multiple regulatory paradigms from Europe and the US and the full aquatic toxicity database for oxybenzone with hard corals and surrogate species to characterize hazard potential. A combination of modeling using oxybenzone wash-off measurements from skin to which sunscreen was applied and environmental monitoring studies are used to characterize exposure potential. The ERA results are meant to inform legislative and regulatory efforts by identifying conditions under which there is any potential benefit expected to coral from restrictions on the sale of oxybenzone-containing sunscreens. This information is intended to assist decision-makers in balancing against the potential human health cost of any such restriction.

MP038 UV filters: can we estimate the risk to coral reef based on currently available effect and monitoring data?

V. Poulsen, L’Oréal / Environmental Safety; M. Leonard, L’Oréal / Environmental Research

Coral bleaching is a global environmental issue that we should address to ensure the preservation of this fragile ecosystem and source of biodiversity. It is recognised by experts that the cause of coral bleaching is multifactorial, mainly due to global warming, overfishing, and marine pollution. It is therefore important to take adapted mitigation measures to reduce the harmful impact of human activities. UV filters used in cosmetics are currently under scrutiny due to few published papers relating their toxicity towards coral and their potential impact on coral reef bleaching. This led to a ban of two compounds used in sunscreens in several states. The question is to understand what the real environmental benefits of these bans are. Chronic effects of UV filters can be measured using a specific test method developed by L’Oréal and the Scientific Center of Monaco. In addition, several compounds were recently monitored in marine environment in coral reef areas and reported in several publications. For a couple of compounds, based on these data, it is possible to conclude that they represent negligible to moderate risks to coral reefs. For others, the lack of data doesn’t allow to draw any conclusion. In order to take robust and efficient measures that induce a real benefit for the protection of coral, decision making should be risk based, taking into account real sunscreen contribution to measured concentrations, and therefore significantly reduce the ecological impact. Many uncertainties, as well as the lack of data, don’t allow to robustly conclude on this point, leading to potential useless bans. To improve the risk assessment, there is therefore a need for robust additional effect data, complementary monitoring studies, and adapted exposure models with representative scenarios.

MP039 Assessing the risks and identifying the knowledge gaps for UV filters in the freshwater environment

E.E. Burns, I. Davies, Personal Care Products Council / Science

There has been growing scientific, public and regulatory concern over the perceived risk of UV filters in the marine environment. The majority of these concerns focus on the potential detrimental impacts of UV filters on coral. Coral are present near popular marine aquatic recreational areas that could be an important environmental source of these compounds. In contrast, the freshwater environment has received less attention in terms of the risk organic UV filters may pose. UV filters can be found not only in sunscreen formulations but also in a wide range of personal care products that can enter the environment through domestic wash-off and eventual wastewater treatment plant (WWTP) effluent release. In the US, the majority of these effluent releases are to the freshwater environment. Additionally, UV filters can be directly released via bathing which is of particular importance to popular aquatic recreational areas, such as the Great Lakes. Therefore, we conducted a review of the literature and brought together existing exposure and hazard data to perform a freshwater risk assessment according to regulatory approaches used in the US. We assessed the reliability and relevance of current hazard and exposure data and identified knowledge gaps pertaining to how comprehensive these datasets are across UV filters used in the US. Clear knowledge gaps emerged that introduced significant uncertainty into our risk assessment approach. The exposure data is scarce and when available, was limited to the site and environmental conditions where it was measured. To address this, we ran the iSTREEM exposure model for the US. A variety of input
scenarios were applied representative of worst-case exposure through to more refined exposure estimates. The relevance of these exposure scenarios will become clearer as more monitoring, WWTP removal and partitioning data emerge. A probabilistic risk assessment was performed to identify the 95th percentile risk quotient for UV filters in the US freshwater environment. Our results suggest that chronic endpoints for freshwater species are more sensitive to organic UV filters than current ecotoxicological data for coral species. This work forms an important part of furthering our understanding of the risks posed by UV filters in the environment as a whole.

Advances in Ecotoxicology and Risk Assessment of Reptiles and Amphibians

**MP040 Development of an in vitro diagnostic method to determine the genotypic sex of Xenopus laevis**

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A genotypic sex determination assay provides accurate gender information of individuals with well-developed phenotypic characters as well as those with poorly developed or absent of phenotypic characters. Determination of genetic sex for *Xenopus laevis* can be used to validate the outcomes of Tier 2 amphibian assays, and is a requirement for conducting the larval amphibian growth and development assay (LAGDA), in the endocrine disruptor screening program (EDSP), test guidelines. The assay we developed uses a dual-labeled TaqMan probe-based real-time polymerase chain reaction (real-time PCR) method to determine the genotypic sex. The reliability of the assay was tested on 37 adult specimens of *X. laevis* collected from in-house cultures in Eurofins EAG Agroscience, Easton. The newly designed *X. laevis*-specific primer pair and probe targets the DM domain gene linked-chromosome W as a master female-determining gene. Accuracy of the molecular method was assessed by comparing with phenotypic sex, determined by necropsy and histological examination of gonads for all examined specimens. Genotypic sex assignments were strongly concordant with observed phenotypic sex, confirming that the 19 specimens were male and 18 were female. The results indicate that the TaqMan(R) assay could be practically used to determine the genetic sex of animals with poorly developed or no phenotypic sex characteristics with 100% precision. Therefore, the TaqMan(R) assay is confirmed as an efficient and feasible method, providing a diagnostic molecular sex determination approach to be used in the amphibian endocrine disrupting screening programs conducted by regulatory industries. The strength of an EDSP is dependent on a reliable method to determine genetic sex in order to identify reversals of phenotypic sex in animals exposed to endocrine active compounds.

**MP041 Evaluation of malformations induced by ibuprofen and naproxen in Xenopus laevis**

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Mexico is the second largest market in Latin America in the pharmaceutical industry, on the other hand, it has also been shown that this is one of the main ways of entry of medicines to water bodies, which in recent years has been demonstrated in reports of trace concentrations in different bodies of water around the world, which has gained significant relevance for eco-surveillance because it has also been shown that these are not eliminated in conventional wastewater treatment plants (WWTP) and that were designed to produce an effect on biological systems, represent a risk to the health of all organisms that come into contact with them in an ecosystem. On the other hand, several studies have reported that they cause different types of damage such as oxidative stress, cytogenotoxicity, kidney damage and in the reproduction of different aquatic organisms; and since by bioaccumulation processes or biomagnification, they could also represent a risk to the human being, its study is important. The objective of the present work was to evaluate the toxicity of two drugs widely used due to their analgesic and antiinflammatory properties, ibuprofen and naproxen, using the Frog embryo teratogenic assay - Xenopus (FETAX) in order to obtain its teratogenic index, the malformations generated and compare their toxicity. For this purpose oocytes in mid-blastula transition were exposed for 96 h to six different concentrations of naproxen and ibuprofen (1, 4, 8, 16, 32 and 62.5 mg/L), subsequently, the mean lethal concentration (LC50) effective concentration inducing 50% malformation (EC50), and the teratogenic index (TI) was obtained. Results indicates that lower concentrations of the two NSAIDs (ibuprofen and naproxen) induced slightly higher malformations and lethal effects in X. laevis, while the main alterations being microcephaly, cardiac and facial edema, malformations in the eye, notochord, tail, fin and intestine. The highest TI of ibuprofen indicates a higher probability that embryos exposed to this NSAID will be malformed in the absence of mortality compared to X. laevis exposed to naproxen, and therefore, can be considered more toxic for this species.

**MP043 Do Standard Toxicity Tests Reflect Ecologically Relevant Conditions? Xenopus laevis vs. Native Anuran Sensitivity to Chloride with Varied Resources**

*P. Ribeiro, Towson University / Environmental Science; C.J. Salice, F. Green, Towson University / Environmental Science & Studies; A. East, Towson University / Environmental Sciences*

Xenopus laevis (African clawed frog) is the standardized amphibian globally, making it the most common species in many ecotoxicology experiments. *X. laevis* is a relatively tolerant amphibian species in terms of chemical stressors and this raises the question of whether they can be used as reasonable representation of native amphibians that are potentially more sensitive to environmental stressors. An example of an increasingly important environmental stressor is the use of road-deicing salts near many North American amphibian breeding habitats. These salts, typically NaCl, runoff into freshwater ecosystems causing an increase in salinity; elevated salinity is a known stressor to freshwater aquatic organisms including amphibians. In this study a series 7-day toxicity studies were conducted using a range of chloride concentrations on *X. laevis* tadpoles and Lithobates sylvaticus tadpoles (an amphibian species native to North America). *X. laevis* larvae were exposed to Cl- concentrations of 2500, 3250, 4000, 4750 mg Cl-/L and *L. sylvaticus* was exposed to 2000, 2500, 3000, 3500 mg Cl-/L. Additionally, we explored the influence of food on Cl- toxicity. Standard protocols indicate that animals should not be fed but resources are always available in most habitats. Concentrations that caused 50% mortality (LC50) were obtained using exposure-response models in RStudio. *X. laevis* in fed treatments had an LC50 of 3475.29 mg Cl-/L (±460.5) and 3939.41 mg Cl-/L (±366.3) in unfed treatments. For *L. sylvaticus*, the LC50 in fed treatments was 2536.39 mg Cl-/L (±219.7) and 3148.98 mg Cl-/L (±169.7) in unfed treatments. We observed a statistically significant difference in survival between unfed and fed treatments as well as survival between the two species. Our data indicate a consistently higher LC50 values for *X. laevis* tadpoles when compared to *L. sylvaticus*. This suggests *X. laevis* does not necessarily provide an accurate representation for this amphibian species native to North America and potentially other, similar species native to this region. Additionally, the apparent increase in sensitivity to Cl- in fed animals was a surprising results and warrants additional attention as it also suggests that current test designs in which animals are not fed may underestimate toxicity. Further research is being conducted to determine how Cl- toxicity interacts with other environmentally relevant stressors such as, temperature variation and larval density.
MP044 Boreal chorus frog larval development in urban stormwater wetlands

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In Calgary, Alberta, approximately 90% of pre-settlement wetlands have been drained and filled in, or modified to perform storm water management functions. The potential for these urban wetlands to support biodiversity has not been assessed. Amphibians are valuable sentinels reflecting ecosystem health, particularly because they are exposed to potential pollutants via diet, and absorption through their skin. Frog development from tadpole to adult may be affected by undesirable conditions in wetlands and can indicate health risks to other vertebrate species. 59 city wetlands were surveyed by citizen scientists in the past 2 years, with boreal chorus frogs (Pseudacris maculata) being observed in 50% of the wetlands. Interestingly, frog presence does not appear to be associated with riparian health assessment scores or connectivity. Other factors, such as water quality may have more influence on frog presence. To assess which water characteristics in these urban wetlands predict successful frog development, we are conducting an in situ frog metamorphosis assay. We are rearing boreal chorus frog tadpoles in 4 selected wetlands, 2 with and 2 without frogs. In this pilot study, tadpoles are housed in fiberglass mesh enclosures with bamboo frames; 3 enclosures per wetland house 25 tadpoles each. Tadpoles are fed and closely observed until metamorphic climax. Throughout the study water quality is being assessed including nitrate, phosphate and metal concentrations. Related abiotic and habitat features are analysed in the context of developmental markers in tadpoles, survival, behaviour, time to metamorphosis, and physiological markers, such as thyroid hormone expression and body energy stores. Results will be presented. The aim of this pilot study is to identify wetland features that foster frog populations or exert adverse effects on frog development. The findings of this study will guide further field and laboratory studies and will directly inform storm water wetland management decisions.

MP045 Development and testing of a mesocosm design for conducting developmental toxicity tests using cricket frogs (Acris crepitans blanchardi)

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The potential for developmental effects of contaminants on the amphibians has received increasing attention, particularly regarding exposure to pesticides. Ideally, developmental toxicity tests with amphibians would be performed on species native to the area of concern. However, due to the dependence on both terrestrial and aquatic environments during development and a relatively long developmental stage, these tests are challenging. Consequently, standardized developmental testing thus far has focused primarily on aquatic species such as Xenopus spp., raising questions about geographic/life history representativeness. Thus, there is a current need to develop better approaches for developmental toxicity testing of native amphibians. We have developed and are conducting tests on a mesocosm design that allows for monitoring cricket frog growth and development from free-swimming tadpoles to sexually developed frogs over a 5 month period. The mesocosm includes a 20-l stainless steel vessel that allows for exposing larval amphibians to organic contaminants. The larger structure allows for a terrestrial environment that prevents escape, but facilitates augmented feeding and observation during the duration of the study. Mesocosms are located outdoors in a partially screened environment to allow for natural lighting and temperature patterns without overheating. Time to metamorphosis, size at metamorphosis, sex ratio, growth rate following metamorphosis, darkness of throat patch, and gross development of gonads are all being measured to generate background data on this species in our system. Successful development of the mesocosm will allow future studies evaluating the toxicity of organic compounds on the development of cricket frogs.

MP046 Identifying Amphibian Receptors of Concern for an Environmental Risk Assessment via eDNA Sampling: The Lower Seymour Conservation Area Study

J. Ward, AECOM / Impact Assessment & Permitting

Environmental DNA (eDNA) sampling and analysis is a cutting-edge tool that provides an efficient alternative to time-intensive field surveys. eDNA offers increased efficacy for detection of receptors of concern for an environmental risk assessment when target species are rare, endangered, or cryptic, and when those species are of social, economic, or cultural importance. In a recent application of eDNA sampling, the tool was used to inform and shape the environmental protection measures for site remediation work within Metro Vancouver’s Lower Seymour Conservation Reserve (LSCR). The LSCR is home to a diverse assemblage of amphibians, reptiles, fish, and mammals, many of which are protected in Canada federally through the Species at Risk Act (SARA). Among the species that potentially inhabit the remediation area are the SARA-listed Coastal Tailed Frog (Ascaphus truei), Red-Legged Frog (Rana aurora), and Pacific Water Shrew (Sorex bendirii). The author led a team that implemented an eDNA program, combined with a detailed site assessment, to determine whether the above species were present and, if so, the potential for site remediation works to adversely affect them. As eDNA analyses were non-detect for all target species, the assessment team avoided the need for an expensive and time-consuming amphibian salvage survey entailing attempted trapping of target species that were not present, while still adopting all appropriate mitigation measures to avoid harming other species. While eDNA sampling and analysis was applied following an environmental risk assessment in the study, this presentation will describe how the tool can be applied to inform conceptual-exposure models in ecological risk assessment, for environmental impact assessment, and prior to risk-based remediation of contaminated sites. This approach can increase confidence in the decision to include or exclude receptors of concern that are of rare, endangered, or cryptic, or species of social, economic, or cultural importance.

MP047 Dynamic screening of agricultural contaminants in fresh water ecosystems as part of amphibian biodiversity conservation

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In recent years the presence of agricultural contaminants such as pesticides, antimicrobial drugs, mycotoxins, coccidiostats, anthelmintics and heavy metals in the aquatic environment have gained more interest. Research has shown negative effects on fitness of aquatic amphibians. Because most amphibians reside in aquatic habitats during breeding season and because they have a highly permeable skin, these species tend to be more exposed to environmental toxins than other aquatic and terrestrial vertebrates. Furthermore, agricultural contaminants have a negative impact on zooplankton as part of the aquatic food web. These organisms are related with reduced chytrid infections in amphibians through the predation of chytrid spores. In this way agricultural contaminants have the ability to affect amphibians in a direct and indirect manner. The overall objective of this project was to assess the dynamic level of contamination of amphibian breeding ponds in relationship to the surrounding zooplankton and amphibian community. For this reason, 25 amphibian breeding ponds were selected across Flanders and sampled three times, at three different locations in the pond over a period of three months. Pesticides
mydas environment, their presence in plasma samples is evidence of recent pollutants like PCB and pesticides. Considering their persistence in the conclusion, Kemp’s Ridley population is exposed to persistent organic management of polychlorinated biphenyls (PCB) containing wastes. In 2015 and 2016 ΣCOP and atrazine median concentrations. Atrazine and atrazine [2015 (2.40 ng/ml); 2016 (39.26 ng/ml], α Endosulfan [2015 (1.55 using the Mann-Whitney U test. Results showed median concentrations of 2015 and 2016 nesting seasons. The POP quantification method in plasma samples from female turtles’ dorsal venous sinus during the 2015 and 2016 nesting seasons. The POP quantification method in plasma samples included focused ultrasound-assisted extraction and gas chromatography coupled to a mass detector with electron impact ionization. Nonparametric statistics were used to compare two independent samples using the Mann-Whitney U test. Results showed median concentrations of atrazine [2015 (2.40 ng/ml); 2016 (39.26 ng/ml], α Endosulfan [2015 (1.55 ng/ml); 2016 (1.55 ng/ml], ΣDDT [2015 (4.13 ng/ml); 2016 (3.45 ng/ml)], ΣPCB [2015 (7.57 ng/ml); 2016 (7.69 ng/ml)] and ΣCOP [2015 (30.42 ng/ml); 2016 (58.26 ng/ml)]. Significant differences were observed between 2015 and 2016 ΣCOP and atrazine median concentrations. Atrazine and endosulfan are two of the most widely used active ingredients in Mexico; on the other hand, there is also an environmental problem due to the poor management of polychlorinated biphenyls (PCB) containing wastes. In conclusion, Kemp’s Ridley population is exposed to persistent organic pollutants like PCB and pesticides. Considering their persistence in the environment, their presence in plasma samples is evidence of recent exposure; more interestingly, it is the fact that some of them are prohibited in Mexico and in the USA, where these turtles travel to eat. These results are the first data for Kemp’s Ridley population in Mexico, and are relevant for the protection and conservation of this endangered species.

MP048 Persistent organic pollutants in Kemp’s Ridley Turtles (Lepidochelys kempii) from Mexico
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Sea turtles are at the highest levels of the food chain, making them more vulnerable to exposure to contaminants, including persistent organic pollutants (POP). Kemp’s Ridley turtles (Lepidochelys kempii) are the most critically endangered species of sea turtles; they have a restricted distribution, mainly in the Gulf of Mexico, which has been disturbed by anthropogenic activities. Studies reporting contaminant concentrations in sea turtle are limited. This study objective was to evaluate POP concentrations in Kemp’s Ridley turtles from Rancho Nuevo, Tamaulipas, Mexico in order to generate a baseline for these chemicals. We collected 79 blood samples from female turtles’ dorsal venous sinus during the 2015 and 2016 nesting seasons. The POP quantification method in plasma samples included focused ultrasound-assisted extraction and gas chromatography coupled to a mass detector with electron impact ionization. Nonparametric statistics were used to compare two independent samples using the Mann-Whitney U test. Results showed median concentrations of atrazine [2015 (2.40 ng/ml); 2016 (39.26 ng/ml], α Endosulfan [2015 (1.55 ng/ml); 2016 (1.55 ng/ml], ΣDDT [2015 (4.13 ng/ml); 2016 (3.45 ng/ml)], ΣPCB [2015 (7.57 ng/ml); 2016 (7.69 ng/ml)] and ΣCOP [2015 (30.42 ng/ml); 2016 (58.26 ng/ml)]. Significant differences were observed between 2015 and 2016 ΣCOP and atrazine median concentrations. Atrazine and endosulfan are two of the most widely used active ingredients in Mexico; on the other hand, there is also an environmental problem due to the poor management of polychlorinated biphenyls (PCB) containing wastes. In conclusion, Kemp’s Ridley population is exposed to persistent organic pollutants like PCB and pesticides. Considering their persistence in the environment, their presence in plasma samples is evidence of recent exposure; more interestingly, it is the fact that some of them are prohibited in Mexico and in the USA, where these turtles travel to eat. These results are the first data for Kemp’s Ridley population in Mexico, and are relevant for the protection and conservation of this endangered species.

MP049 Alkoxyresorufin-O-dealkylase activity in multiple organs of the three predominant Gulf of Mexico sea turtle species
C.S. Calvin, C.M. Mello, Texas Tech University / Environmental Toxicology; B.M. Higgins, NOAA National Marine Fisheries Service; C.A. Godard, Texas Tech University / Environmental Toxicology/The Institute of Environmental and Human Health

The three predominant sea turtle species inhabiting the waters of the Gulf of Mexico are the Loggerhead (Caretta caretta), Green (Chelonia mydas) and Kemp’s Ridley (Lepidochelys kempii). They are classified as vulnerable, endangered, and critically endangered, respectively, by the International Union Conservation of Nature Red List. Sea turtles are considered a keystone species in the marine environment and the subject of global conservation efforts. Marine chemical pollution is an environmental hazard that increases overall risk for sea turtle health, but little is known about its potential adverse effects. Common marine contaminants, such as polycyclic aromatic hydrocarbons and polychlorinated biphenyls, have been detected in sea turtle organs, blood, and eggs. The induction of Cytochrome P450 1A (CYP1A) enzymatic activity is a well-established biomarker of exposure to aforementioned marine contaminants and other select chemicals. One aim of this project is to quantify baseline enzymatic activity of various organs in these sea turtle species using alkoxyresorufin-O-dealkylase (AROD) assays. A series of up to ten organs (bladder, gonad, heart, intestine, kidney, liver, lung, muscle, skin, and stomach) were collected at the NOAA Sea Turtle Facility in Galveston, Texas from loggerhead, green, and Kemp’s ridley sea turtles that failed rehabilitation due to swimming issues but were otherwise healthy. Samples were processed as S9 or microsomes at 4°C following previously published methodology. Protein concentrations were quantified using the Bradford assay and 40ug of sample protein was used for analysis. In mammals, it is established that induced CYP1A1 & CYP1A2 enzymatic activities are best measured by ethoxyresorufin O-deethylase (EROD) and methoxyresorufin O-demethylase (MROD) assays. Reptilian enzymatic activities related to CYP1A are not fully characterized but our preliminary data indicate that multiple alkoxyresorufin-O-dealkylase (AROD) activities are involved. Hence, we analyzed sample enzymatic activity using EROD and MROD, as well as benzyloxyresorufin O-debenzylase (BROD) and pentoxyresorufin O-depentylase (PORD) assays by spectrophotometry. Preliminary results in liver confirm multiple AROD activities. Further analyses on all organs will investigate correlations between organ types and differences between species. Lastly, this project is part of a larger study on sea turtle metabolism and toxicology that includes contaminant burden analysis.

MP050 Using plasma vitellogenin in loggerhead sea turtles to assess reproductive maturation and as a biomarker of estrogenic contaminant exposure
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Vitellogenin (VTG), a protein precursor to egg yolk, is normally expressed in adult oviparous females in response to estrogen; however, males and juveniles can produce VTG when exposed to estrogenic compounds, including environmental contaminants. This study sought to measure plasma VTG in threatened loggerhead sea turtles (Caretta caretta) to 1) further our understanding of their reproductive maturation, and 2) investigate VTG as a non-invasive biomarker of estrogenic contaminant exposure. Using a polyclonal antibody produced against VTG from the red-eared slider turtle (Trachemys scripta) in Western blots, we screened for the presence or absence of VTG in the plasma of 402 loggerhead sea turtles captured along the U.S. southeast coast which represented a wide range of size classes. VTG was detected in all 5 nesting females, in 90% of females captured offshore that were greater than 87 cm standard carapace length (SCL) (n=10), 73% percent of large juvenile females between 77 cm and 87 cm SCL (n=15), 2.3% of females less than 77 cm SCL (n=215), 5% of the turtles of unknown sex (n=60), and 1.0% of males (n=96). The VTG expression observed in the larger females (>77 cm SCL) is expected, but it is abnormal in the one male and could be considered precocious in the five smaller females with SCL of 52, 61, 64, 66, and 74 cm, especially the smallest of these. Organochlorine (OC) and polychlorinated biphenyl (PCB) concentrations were measured in whole blood and/or fat biopsies of >58 of these turtles using gas chromatography with electron capture detection and mass spectrometry. The nine precocious or abnormal juveniles had total PCB concentrations in their blood 65% higher than 49 juveniles that were not producing VTG, albeit not significantly different (p = 0.125). A fat biopsy taken from the smallest precocious female had the second highest total
PCB and 4,4’-dichlorodiphenyldichloroethylene (DDE) concentrations on a wet mass basis among 44 juveniles. These data suggest that loggerhead sea turtles inhabiting this region of the Atlantic Ocean begin reproductive maturation around 77 cm SCL and it is inconclusive whether these environmentally relevant concentrations of contaminants could disrupt their endocrine system.

**MP051 Biomarkers of oxidative stress and persistent organic pollutants in nesting Chelonia mydas from the southern Gulf of Mexico**

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The coast of Campeche on southern Gulf of Mexico is one of the world’s major breeding areas for green turtles, Chelonia mydas. Legendary pollutants such as organochlorine pesticides (OCPs) and polycyclic aromatic hydrocarbons (PAHs) have been periodically detected in this area. Although green turtles are regarded as species of conservation concern and are considered as sentinel organisms in marine biomonitoring, little is known about the relationship between exposure to OCPs and PAHs and biomarkers of oxidative stress in C. mydas. Since the alterations in antioxidant protection and oxidative damage have been used as reliable biomarkers for monitoring oxidative stress in aquatic organisms, the aim of this study was to assess oxidative stress in plasma in relation to pollutants concentrations in plasma and eggs. Blood samples were collected from 29 female green turtles (Chelonia mydas) nesting in three sites along the Campeche coast in the southern Gulf of Mexico, once the female laid her eggs, blood was collected on each female and was immediately centrifuged to obtain plasma and then frozen until analysis. One egg per female was also collected for pollutant analysis. Results indicated differences between sites in OCPs and PAHs concentrations in plasma and eggs. Total egg concentration of OCP were higher at Sabancuy site, and total PAH concentrations were lower in eggs collected from turtles at Carmen. Antioxidant response presented also significant differences between sampling sites. Samples from Carmen and Sabancuy were related to super oxide dismutase (SOD) glutathione-S-transferase (GST) and glutathione peroxidase (GP) activities and to the concentration of lipid hydroperoxides. These results could help to improve the understanding of antioxidant defense responses in C. mydas and their potential to be used as biomarkers.

**MP052 Exploring the effects of exposure from common perfluorooalkyl substances (PFASs) on Brown Anoles (Anolis sagrei)**

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Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants. Perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonic acid (PFHxS) are PFAS that have been key ingredients in aqueous film forming foams, which have been heavily used at military bases for fire suppression activities. As a result, PFOS and PFHxS are common environmental contaminants and there is concern about their potential toxicological impacts on humans and wildlife. While there has been some data generated on effects of these PFASs on the most common ecological receptors, there is no data available on the toxicity of PFOS or PFHxS to reptilian species. We used the brown anole as a model laboratory reptile species to help develop PFAS ecotoxicity data for reptiles. In total, three PFAS reptile toxicity studies were conducted: 2 PFOS studies (90-Day /35-day exposures) and one 63-day PFHxS dosing study. Here we report primarily the results from the 90-day PFOS study and compare to results from the other studies. All animals were dosed via pseudo-gavage. The 90-day PFOS dosing study was performed with fifty fully mature, male brown anole lizards separated into 5 dosing groups with 0, 0.05, 0.15, 0.45 or 1.35 mg/kg per day exposure concentrations. We collected mass and snout-vent length weight data weekly, organ weights and necropsy and also measured feeding rate. While analyses are ongoing, the preliminary analysis suggests that there were no strong effects of PFOS on the mass of exposed lizards nor the mass of organs. So far this suggests that PFOS is not toxic to mature male lizards at relatively high exposure levels. In comparison, the 35-Day PFOS study showed an apparent effect on the growth of younger, growing lizards at 2 mg PFOS/kg per day. In the PFHxS study male and female lizards were dosed with 0, 0.02, 0.2, or 2 mg/kg per day. The results of the PFHxS study showed no effects on body or organ size but there was an observed effect on the production of viable eggs by female lizards. Future studies will include PFOS+PFHxS mixture toxicity as these commonly co-occur. Collectively, these data are providing valuable insights into the effects of PFAS on reptilian species and should be useful for ecological risk assessment.

**MP053 Temporal trends in mercury tissue concentrations in the Brown watersnake (Nerodia taxispilota) from the Savannah River Site**

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Mercury (Hg) is a ubiquitous environmental contaminant that poses a significant threat to aquatic systems globally. Mercury can bioaccumulate and biomagnify in vertebrates, which may negatively impact a variety of health parameters (e.g., behavior, immune function, growth, reproduction, and overall survival). While studies that focus on Hg in snakes have increased in number in the last two decades, the paucity of data relative to other vertebrate taxa limits the inclusion of snakes in risk assessments. Brown watersnakes (Nerodia taxispilota) possess many traits that may make them susceptible to Hg bioaccumulation. These large-bodied snakes are long-lived (> 10 years), are entirely piscivorous, and are important predators in streams and rivers in the southeastern United States. The species is also common and easy to collect, making them potentially valuable for risk assessments. We compared Hg tissue concentrations in Brown watersnakes collected on the Savannah River Site, SC, during 1983-1986 and in 2019. Our objectives were to: 1) Quantify total Hg (THg) concentrations in blood, kidney, liver, muscle, and tail tips; 2) evaluate the ability to use tail tips and blood to approximate THg burdens in destructive tissue types (kidney, liver, and muscle); and 3) document changes in THg concentrations in Brown watersnakes over three decades. Mean THg values (in all tissues) in snakes sampled in the 1980s ranged from 0.570 - 50.4 mg/kg (dry weight). The highest value in our dataset represents the highest Hg measurement reported in a snake species to date. Preliminary data from snakes collected in 2019 suggest that historical tail THg values were > 4 times higher than contemporary THg concentrations. We will also present on predictive relationships among multiple tissue types. Our dataset presents a unique opportunity to not only provide critical Hg bioaccumulation data for use in risk assessments, but also to evaluate how the regulation of Hg in the United States has impacted Hg exposure in this snake species.
Emerging Contaminants? Emerging Tools: Effect-Based Surface Water Quality Assessment

**MP054 Endocrine disrupting chemicals (EDCs): Detection of the ‘estrogenic’ properties of water**

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Nine structurally diverse CECs that are known or suspected to be estrogenic and/or anti-androgenic were selected: 4-nonylphenol, atrazine, chlorpyrifos, dieldrin, bisphenol-A, estrone, metformin, triclocarban and triclosan. The two organisms were found to be sensitive to environmentally relevant concentrations (e.g., parts per trillion range, ppt) and a large number of significant alterations in gene expression were detected for all 9 CECs using QuantSeq. This study has clearly demonstrated the feasibility of the two organism bio-assay approach to identifying EDC activity in water and pathway analysis is currently underway to enable further development of the bio-assay as an EDC detection tool. The Detroit River receives a large number of contaminants from treated wastewater effluent, combined sewer overflows, urban and agricultural runoff, and landfill leachate. These contaminants include contaminants of emerging concern (CECs) that are not typically regulated and/or monitored by the governing agencies. Some CECs disrupt normal endocrine function and have been called Endocrine Disrupting Chemicals (EDCs). Feminized aquatic vertebrates have been reported all over the world (for e.g., reports of elevated levels of the yolk protein, vitellogenin [biomarker for estrogenicity] in male fish), particularly near areas where there is significant urban or agricultural impact on the environment, and this has been attributed to EDC activity. Our hypothesis is that a bio-assay system based on Daphnia pulex (waterflea) and Danio rerio (zebrafish) can be used for a molecular identification tool and can detect estrogenic and anti-androgenic activity in water using behavioral, morphological, and differential gene expression data.

**MP055 Application of an Integrative Zebrafish Embryo approaches on the Toxicity Assessment of Chemical Mixtures in Surface Waters**

Y. Peng, X. Zhang, Nanjing University / Environmental Science

p.pl {margin: 0.0px 0.0px 0.0px 0.0px; line-height: 19.0px; font: 13.0px ‘Helvetica Neue’} Wide variety of emerging organic pollutants (EOPs) frequently detected in surface waters, it will pose a great threat to human and ecological health. However, lack of understanding of chemical mixtures and cumulative exposures. Effect-based tools such as in vitro bioassays were used to monitoring chemical pollution of waters. However, there are limitations to the application of bioassays directly for water quality assessment, which often fail to identify pollutants of concern, since the defined priority and monitored pollutants often fail to explain the observed toxicity. A Full dose-response reduced zebrafish embryo transcriptome (RZT) method could prioritize potential biological end point and provide more sensitive biological molecular pathway profile compared to in vitro bioassays. In this study, for identifying multiple potential adverse effect of concern and prioritizing surface waters with the greatest potential adverse effects, an integrative zebrafish embryo toxicity approaches were used to systematic assess adverse effects of surface water from YRD area, which include high content imaging test (HCT), locomotor response test (LMR) and RZT method. Four types of surface samples and control samples (n = 9) were collected by large-volume SPE device (LVSEP), include waters from urban, aquaculture, farmland and wastewater treatment plants in chemical industry park (WWTP). Among all tested samples, HCT and LMR tests demonstrated that only water samples from WWTPs presented lethal effect to zebrafish embryo (LC50= 5.2 to 7.4 in REF). WWTP1 showed teratogenic effect (NOEC = 8 in REF) and neuroactivity (NOEC = 1 in REF); WWTP2 showed teratogenic effect (NOEC = 2 in REF) and neuroactivity (NOEC = 2 in REF); WWTP3 showed teratogenic effect (NOEC = 5 in REF). p.p1 [margin: 0.0px 0.0px 0.0px 0.0px; line-height: 19.0px; font: 13.0px ‘Helvetica Neue’] Further, based on the PODpath values calculated by biological molecular pathway analysis of RZT test, WWTP2 was the most potent sample (PODpath=0.078 in REF), the sensitive response genes, such as rps11, ppp4ha, mad2l1, snrpd1, raplaa, rps4x were related to the development and endocrine biological pathway (cell division, nervous system and organ development, cellular metabolism, signaling pathway and oocyte meiosis). These results were associated with teratogenic effect observed in individual level. As a result, the integrative zebrafish embryo testing technology can be applied to evaluate and prioritize chemicals mixtures in future water quality assessment.

**MP056 Recovery of wild fish in response to wastewater treatment plant upgrades**

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Municipal wastewater treatment plant (WWTP) effluent contains a variety of contaminants, including nutrients and pharmaceuticals, that are a concern for the health of aquatic ecosystems. The biological effects of effluent from two large WWTPs (Kitchener and Waterloo) which discharge into the Grand River in southern Ontario, have been reported in many previous studies. Wild rainbow darter (Etheostoma caeruleum) collected downstream of these discharges have demonstrated disruptions at multiple levels of biological organization, ranging from altered gene expression to tissue-level changes (i.e., intersex). The Region of Waterloo has recently invested in major treatment upgrades at both plants to improve effluent and river water quality by including additional nitrification and extended solids retention time. The initial facility upgrades came on line in 2012 at Kitchener but major additional changes are still ongoing. The major upgrades at the Waterloo WWTP came on line in late 2017. This has created a unique opportunity to investigate whether responses in rainbow darter previously associated with effluent exposure will resemble upstream reference levels following the upgrades. Analytical chemistry of effluent samples at both plants demonstrated that the upgrades resulted in an immediate reduction of many chemicals in the effluent including ammonia, selected pharmaceuticals (e.g. ibuprofen, naproxen) and estrogenicity. After the upgrades at Kitchener, stable isotope signatures of nitrogen in fish muscle tissue and in vitro sex steroid production of 11-ketotestosterone and testosterone in rainbow darter shifted to upstream reference conditions, and there was a significant reduction in intersex incidence and severity. The more recent upgrades at the Waterloo WWTP have resulted in similar recovery of both stable isotope signatures of nitrogen in muscle and steroid production in males. Histological assessment for intersex is ongoing. These major capital investments in WWTP
upgrades targeted at improving conventional effluent quality (e.g. Total Suspended Solids (TSS), ammonia, etc.) have the co-benefit of reducing or even eliminating key adverse biological responses in fish in the receiving environment.

**MP057 Effects-based analysis of agricultural runoff and environmental DNA biomonitoring in the Salinas Valley, California (USA)**

S. Stinson, University of California, Davis / VMAPC; X. Deng, California Department of Pesticide Regulation; S. Hasenbein, Technical University of Munich / Lehrstuhl für Aquatische Systembiologie; E.B. Holland, California State University, Long Beach / Department of Biological Sciences; S.P. Lawler, University of California, Davis / Entomology and Nematology; R.E. Connan, University of California, Davis / Anatomy, Physiology & Cell Biology, School of Veterinary Medicine

The Salinas River watershed is an important riparian corridor within the Central Coast region of California, and drains some of the most intensively farmed regions in the United States. Complex mixtures of agricultural pesticides are frequently and regularly detected within the watershed. To understand how these mixtures affect aquatic life, we collected water samples from six representative sites, analyzed pesticide concentrations, tested toxicity with model species *Daphnia magna*, *Hyalella azteca* and *Pimephales promelas*, and analyzed expression of selected genes involved in general stress responses. Recovery after an influx of pesticides is influenced by the regional pool of taxa (via drift and dispersal). To assess the recovery potential of invertebrate populations at impacted sites, we assessed biodiversity within the metacommunity, using environmental DNA (amplicon sequencing of CO1) and traditional kick-net sampling methods. Organisms were exposed to a geometric dilution series of field water in 96-hour, static renewal tests. Following exposures, we evaluated mortality and expression of genes involved in general stress responses, acetylcholine receptor, and ryanodine receptor pathways, which are expected to be impacted by emerging pesticides of concern that have been regularly detected at these sites, such as imidacloprid and chlorantraniliprole. There was significant *D. magna* and *H. azteca* mortality (100%) at three of the six sites. Gene expression data shows significant differential expression for several genes of interest including HSP90, RyR1, CYP1a and BCL-2, even at sites/concentrations without significant mortality. Biodiversity data indicates the presence of sensitive invertebrate taxa (*Ephemeroptera*, *Plecoptera*, *Trichoptera*) located upstream from chemically impacted sites. These data suggest that a) complex chemical mixtures impact aquatic life in the Salinas river watershed, even at sublethal exposure levels, and b) the surrounding metacommunity can potentially repopulate impacted sites, provided that sufficient connectivity and habitat exists. This research provides novel baseline biodiversity data for the Salinas watershed and will inform future bioassessment and monitoring efforts. As molecular bioassessment tools such as environmental DNA and gene expression assays become widespread, studies that link molecular data to ecological effects are increasingly necessary.

**MP059 Conclusions from Five Years of Chemical and Biological Effects Monitoring around the Great Lakes Basin**

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Under Action Plan I of the Great Lakes Restoration Initiative (GLRI), Federal and Academic partners investigated the presence, distribution, and potential impacts of chemicals of emerging concern (CECs) in Great Lakes tributaries. Over a span of five years, a range of CECs were monitored in surface waters, sediment, and in tissues of fish, invertebrates, and birds. Chemical monitoring was complemented with biological effects measurements in resident organisms, mussels and fish caged in situ, and in vitro assays. Detected chemical concentrations were compared with water quality benchmarks, literature-based screening values, and/or pathway-based biological potency estimates from high throughput screening data (e.g., ToxCast, Tox21). Concentrations of CECs exceeding water quality benchmarks or screening values were detected at multiple sites, with the most frequent exceedances detected for five PAHs, five pesticides, and the detergent metabolite 4-nonylphenol, as well as the pharmaceuticals, ibuprofen and venlafaxine. Consideration of ToxCast bioactivity screening data that are now available for thousands of chemicals nearly doubled the number of Great Lakes CECs for which a risk-based screening and prioritization approach could be employed. Overall, effects detected in resident and caged organisms were modest and sublethal. Nonetheless, considering multiple lines of evidence including biological effects and their statistical associations with measured exposure concentrations, PAHs were identified as an on-going threat to Great Lakes fish and wildlife that likely contributes to the persistence of beneficial use impairments in several tributaries of the Great Lakes Basin. Likewise, at least 10% of tributary streams surveyed were estimated to be at risk for estrogenic effects in vertebrates. These and other key findings of this five-year interagency research effort integrating chemical and biological effects monitoring are captured in a report scheduled for release in fall 2019. This presentation will highlight key findings, on-going challenges in the use of effect-based approaches, next steps for...
Fate and Effects of Metals: Mechanisms of Dietary Bioavailability and Toxicity

MP060 Ameliorative Effect Of Gallic Acid Against Sodium Fluoride-Induced Hypertension And Hepato-renal Complications In Wistar Rats

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Sodium fluoride (NaF) is used globally as an important element in the prevention of tooth decay, and it has proven its effectiveness in dental caries prevention when its low level is maintained in the oral cavity. However, detrimental effects associated with prolonged exposure to NaF include gastrointestinal disturbances, deranged cerebrovascular and cardio-renal integrity, initiation of anomalies in the chromosomes thus inducing genetic damage, muscular wasting, mineralization of myocardium as well as testicular necrosis. Gallic acid (GA) derivatives occur naturally in plants and has been reported to possess antioxidant properties against various disease conditions. Here, the ameliorative effect of GA on sodium fluoride (NaF)-induced hypertension and hepato-renal toxicity was studied. Four groups of seven rats each were used in this study. Group A received distilled water (control), group B received NaF (300 ppm), groups C and D received NaF + GA (60 mg/kg) and NaF + GA (120 mg/kg), respectively, through oral gavage, for 7 days. Blood pressure parameters were taken, the liver and kidney samples were harvested for markers of oxidative stress and histology using standard procedure. All data were expressed as mean ± standard deviation (SD). All results were analyzed using student’s t-test and one-way ANOVA followed by Tukey’s post-hoc test using Graph prism 6 and p-values < 0.05 considered to be statistically significant. The results showed that NaF alone significantly increased systolic, diastolic and mean arterial blood pressure. Administration of NaF also significantly raised both renal and hepatic hydrogen peroxide, malondialdehyde, protein carbonyl, serum myeloperoxidase and significantly decreased reduced glutathione, glutathione peroxidase, superoxide dismutase and glutathione-s-transferase when compared to the control and co-administered with GA. However, concomitant administration of Gallic acid with NaF reduced high blood pressure, markers of oxidative stress and improved antioxidant defence system. It also ameliorated structural changes in renal and hepatic tissues. Our findings thus suggest that Gallic acid is a potential drug candidate in the treatment of sodium fluoride induced hypertension and hepato-renal toxicity.

MP061 C. virginica physiological analysis after ingestion of Cu and Cd through Chlorella

G. Barrera Escorcia, UAMI / Hidrobiologia; F. Mares-Guzman, Metropolitan Autonomous University Iztapalapa / Hidrobiologia; X. Guzman-Garcia, Metropolitan Autonomous University Iztapalapa / Hidrobiologia; I. Hernandez-Calderas, Metropolitan Autonomous University / Hidrobiologia

Several human activities contribute to increase the load of metals in aquatic environments. The algae Chlorella is a primary link in the trophic chain. Being in direct contact with the environment, it can incorporate contaminants by absorption or adsorption. The organisms that feed on them, like the oyster Crassostrea virginica, can incorporate them and could present physiological problems. The objective of this work was to evaluate the possible damages derived from the trophic transfer of copper and cadmium, from Chlorella sp. to C. virginica. The algae were cultivated for 110 hours at a sublethal dose of 0.0254 mg/L of copper and 0.0493 mg/L of cadmium. Chlorella sp. in a concentration of 30 X 10^6 cells were proportionated to C. virginica daily. Relevant physiological parameters (filtration rate, feed intake, oxygen consumption, nitrogen excretion and O: N ratio) were analyzed during 21 days. The most notable physiological damages observed were: reduction of cell consumption, increase in the filtration rate as well as increase in the oxygen consumption. The biological responses associated with Cd exposure, could be observed in more than 50% of the organisms since day 11, while those associated to Cu exposure were deferred to day 16. Chlorella sp. is a algae resistant to Cu and Cd, but it was capable of transferring the metal to the oyster by trophic route. Despite Cu is an essential metal, its consumption generated physiological problems, however it was evident that Cd was able to enter quickly by the trophic via and it generated damages in a short time in C. virginica oyster, and compromised the health of the organisms.

MP062 Dietary Uptake of Metals from Periphyton into Midge (C. dilutes) and Mayfly (N. triangularis) Larvae

N. Faud, T. Vadas, University of Connecticut / Civil and Environmental Engineering

Healthy streams are vital components in healthy ecosystems. Metals can impair health of streams. USEPA sets regulatory limits for metals with the aquatic life criteria by testing toxicity of different organisms. Tools such as biotic ligand model are often used to modify acute concentration for some metals such as Cu. However, data is scarce for a family of organisms, insects, which is believed to have significant dietary uptake and bioaccumulation. Moreover, differences in metal speciation, caused by source water chemistry, or chronic exposure are yet to be fully accounted for in established toxicity assays. Hence, to protect stream health in chronic exposure cases, establishing different benchmarks and alternative means of assessment is necessary as opposed to setting daily average allowable concentrations. This requires a better understanding of metal speciation from different sources and biouptake via dietary pathways. Dietary uptake is known to be an important exposure pathway for macroinvertebrates. This study aimed at investigating uptake and assimilation of diet borne metals into midges (C. dilutes), a standard sediment toxicity test organism, and mayfly (N. triangularis) exposed to contaminated periphyton grown in different source waters. Uptake and elimination of metals into periphyton was also investigated in exposure experiments with 63Cu and 65Cu under different exposure conditions and durations. Collected stream water, wastewater treatment plant (WWTP) effluent and their mixtures were used as source waters. To investigate uptake into the macroinvertebrates, both the organisms and periphyton were exposed to reconstituted exposure water. Extracted organic matter (OM) from wastewater effluent and stormwater was used. Results showed Cu in periphyton equilibrated with environmentally relevant exposure water in about two days with ~ 90 µg/g internalized and similar surface bound Cu. Exchangeable Cu, weakly bound to OM, was identified as the most bioavailable fraction. Waterborne 65Cu uptake into midges from OM free water with 10 µg/L Cu was linear. Dietborne-only uptake was found to be slightly higher than waterborne uptake alone in 24 hours. Upon withdrawal of exposure conditions, Cu internalized into midges slowly dropped near initial in 44 hours. Ongoing experiments with varying metal concentrations in combined waterborne and dietborne uptake experiments are expected to show lower dietary uptake in experiments with effluent OM as a source.

MP063 Effect of environmental chloride concentration on copper and silver bioavailability and bio-reactivity in bluegill (Lepomis macrochirus) fish

M. Ibrahim, E. Bates, T. Black, M. Minghetti, Oklahoma State University / Integrative Biology

Chloride is an inorganic ligand that forms complexes with metals. In general, it is known that metal complexes are not bio-available, but
some recent studies have shown the potential of bio-availability of metal complexes in fish. Moreover, it was hypothesized that copper and silver may require a chloride dependent symporter mechanism to enter into cells. While several studies have investigated the effects of chloride on metal toxicity, very few have looked into its role in metal bio-availability and bio-reactivity in fish. In this study, we are investigating the effects of chloride in the exposure media on the bio-availability, and bio-reactivity of copper and silver in bluegill (Lepomis macrochirus) fish. Based on the USEPA freshwater formula for toxicity tests, we prepared three exposure media containing 0.05, 3 and 40 mM of chloride. Using a chemical equilibrium software, Visual MINTEQ, we calculated the speciation of copper and silver at a non-toxic concentration (300 nM) in each medium. The toxicity of the exposure media with and without metal were tested showing that the fish were able to tolerate the exposure conditions. The major Ag species formed in 0.05, 3, and 40 mM Cl media are Ag+ (90%), AgCl\(_2\) (69%), and AgCl\(_2\) (74%), respectively. For copper, in 0.05 and 3 mM Cl media, the dominant species were Cu\(^{2+}\) (~25%) and CuCO\(_3\) (~60%) whereas in 40 mM Cl medium, Cu\(^{2+}\) increased to ~35% and CuCO\(_3\) was reduced to ~50%. The bioavailability of silver and copper species will be determined by quantification of the gill, intestine and liver metal accumulation (by ICP-OES) in fish exposed for 48 hours. Metal bio-reactivity (i.e. induction of a metal-specific biological response) will be determined in the same set of samples by measuring metallothionine mRNA levels (by quantitative PCR). The outcomes from this experiment will shed light on the role of environmental chloride concentration on silver and copper bioavailability and bio-reactivity which is relevant for environmental risk assessment.

**MP064 Engineered nanoparticles alter insect emergence and result in flux of metals from aquatic to terrestrial food webs**

B. Perrotta, Baylor University; M. Simonin, Duke University / Biology; B. Castellon, Baylor University / Environmental Science Department; S.M. Anderson, Duke University / Biology; C.W. Matson, Baylor University / Environmental Science; E. Bernhardt, Duke University / Biology; R.S. King, Baylor University / Department of Biology

Freshwater ecosystems are exposed to engineered nanoparticles through discharge from wastewater and agricultural runoff. We conducted an experiment to examine the combined effects of chronic dosing of nanoparticles and nutrients on insect emergence. Three levels of nanoparticles (control, gold, copper) were crossed by two levels of nutrients (ambient vs. enriched nutrient dosing) in 18 outdoor wetland mesocosms. We estimated emergent insect abundance, community structure and flux of copper and gold nanoparticles from aquatic ecosystems to adjacent terrestrial environments, monthly over a nine-month experiment. We detected significant decrease in insect emergence after exposure to nanoparticles in some months and a flux of nanoparticles from treated mesocosms. These results have implications for terrestrial subsidies and contaminations in insectivorous terrestrial and riparian food webs.

**MP065 Heavy Metal Concentration Of Well Water In Ogolonto, Ikorodu Lagos, Lagos, Nigeria**

T. Folarin, University of Lagos, Akoko / Chemistry

The determination of heavy metal composition of Ogolonto, Ikorodu well water has been carried out using standard analytical procedure. This result of the heavy metal determination of Ogolonto, Ikorodu well water was reviewed that the concentration of Lead in the water is 2.2mg/L, Iron is 5.3mg/L, Zinc is 2.1mg/L, Copper is 0.1mg/L, Nickel is 0.2mg/L, Cadmium is 0.001mg/L, Manganese is 0.0130mg/L and Chromium is 0.02mg/L. the result of the analysis has shown that some of the heavy metal concentration in the well water is within the limit of WHO and SON. While some such as Lead and Iron is above the limit stated by WHO and SON. Adequate treatment measure must be carried out on the well water before using them so as to reduce the concentration of Lead and Iron in the water. Hence, with the result of the heavy water concentration of the well water, it has shown that the well water is not ideal for drinking, but it can be used for mixing concrete and washing.

**MP066 Interaction Effects of Dietary Nutrients Modulation And Cadmium Toxicity Against Algae And Daphnia**

O.M. Awoyemi, Texas Tech University / Environmental Toxicology; K. Thompson, Harvard School of Public Health / Biostatistics; A. Velazquez, Texas Tech University / Department of Environmental Toxicology; M.D. Hassan, A.L. Peace, Texas Tech University / Department of Mathematics and Statistics; G.D. Mayer, Texas Tech University / Department of Environmental Toxicology

Effective ecological risk assessment requires the understanding of complex ecological interactions, elemental cycling, and the interactive effect of natural stressors such as resource limitations and contaminants. The development of ecotoxicological models that incorporate such data would significantly contribute to interpreting how contaminants impact organisms and food webs in such a dynamic system. This study seeks to develop and analyze a series of empirically testable and robust mathematical models of population dynamics subject to stoichiometric nutrient modulation and contaminant stressors. Specific empirical measurements include: physiological traits (growth, survival, reproduction, respiration, heartrate), behavioral (distance moved, velocity), elemental-(C:P) and toxicant (Cadmium-Cd) uptake in primary producer, Algae (S. acutus) and primary consumer, Daphnia pulex. S. acutus and D. pulex were cultured in Cd-containing (25%, 50% and 100% of daphnia-exposed LC50 values) media with varying P-nutrient ratios [Low P (20% P) and COMBO (100% P as control)] media for acute (24 h and 96 h) and chronic (21 d) durations, according to USEPA methods. Acute toxicity results showed a concentration-dependent increase in the toxicity of Cd against S. acutus with higher in Low P media compared to the control. The survival of D. pulex reduced temporally with Cd exposure and Low P media further reduced the survival. Other toxicological endpoints (respiration, heartrate, growth, reproduction, and behavior) were also impacted by Cd exposure with enhanced impact in the Low P media, compared to control. Studies are currently underway to determine the effects of the stoichiometric modulation of the mineral nutrients (C:P:N) on the toxicities of Cd, Arsenic and Copper against S. acutus and D. pulex.

**MP067 Linking extracellular metal speciation to intracellular metal bioavailability and toxicity: An in vitro approach**

D. Oldham, M. Minghetti, Oklahoma State University / Integrative Biology

Ecotoxicology prediction models such as the Free Ionic Activity Model (FIAM) and Biotic Ligand Model (BLM) associate the free metal ion in solution as being the primary driver of toxicity. The FIAM and BLM assume that the metal is in equilibrium with all ligands and with the biotic ligand. However, studies have shown that free ions are not the only toxic species and that the cell can affect the equilibrium between metal and the biotic ligand. To evaluate the bioavailability and toxicity of neutral and charged metal complexes, as well as free metal ions, Visual Minteq, a chemical equilibrium model, was used to design different exposure media presenting a variety of metal species. Two non-essential (silver and cadmium) and two essential (copper and zinc) metals were selected. The rainbow trout (Oncorhynchus mykiss) gut cell line (RTgutGC) was used to investigate the bioavailability and toxicity of the different metal species. Dose response curves were calculated using a multiple endpoint cytotoxicity assay based on the dyes Alamar blue, CFDA-AM, and Neutral Red, which are indicators of metabolic activity, cell membrane and lysosomal integrity, respectively. Bioavailability of different metal species was measured by ICP-MS in cells exposed to an identical non-toxic dose of metal. Bioreactivity was measured by quantification of mRNA levels of genes that respond to metal intoxication, such as metallothioneins. Speciation calculations showed a wide range of metal species depending on anionic media composition. Silver and cadmium showed affinity for chloride, copper for phosphate, and zinc remained primarily in its free ionic form. Silver and copper, toxicity was not affected by extracellular change in metal speciation, whereas cadmium and zinc toxicity were reduced by chloride complexation and/or concentration. Bioavailability of the essential metals appeared to be tightly regulated as the metal.
concentrations remained constant throughout all media. The bioavailability of the non-essential metals was affected by the media composition. For silver, neutral chloride or cysteine complexation reduced bioavailability. Similarly, cadmium bioavailability was reduced by cysteine complexation but was also increased by the presence of bicarbonate in the media. This study demonstrates that speciation alone is not sufficient to explain metal bioavailability and toxicity, and that many factors play a role in metal-cell interactions.

**MP068 Sex-Specific Gene Expression Associated with Zinc Homeostasis in Squirrelfish**

D. Thompson, T. Riker, Northern Kentucky University / Biological Sciences; H. Veilleux, University of Alberta

Zinc (Zn) is a micronutrient required by all organisms for a range of essential processes. Studies of the reproductive physiology of squirrelfish (Holocentrus adscensionis) have shown that females preferentially increase Zn uptake during reproductively active periods, initially accumulate Zn in the liver, and ultimately redistribute this Zn to the ovary. This hyperaccumulation is likely caused by physiological differences between males and females, as it occurs when both are exposed to the same environmental Zn concentrations. An efficient uptake and shuttling system would be central to the ability of female squirrelfish to extract, accumulate, and utilize Zn from food and/or water. This project examined the hypothesis that the changes in maternal Zn homeostasis that occur during reproduction result from differential expression of Zn transporters between the sexes due to reproductive status. Male and female squirrelfish collected from the Florida Keys were compared for gonad size, liver and gonad Zn, and plasma sex steroids. Genetic analyses were conducted on RNA extracted from gill, anterior intestine, liver, and gonad samples. Female squirrelfish accumulated significantly more Zn in the liver and gonads compared to males. Females expressed higher levels of multiple Zn transporters, including the ZIP4 transporter that is known to play a pivotal role in intestinal Zn uptake. Furthermore, females that were reproductively active, as evidenced by gonad size and sex steroid levels, expressed ZIP4 to a greater extent than reproductively inactive females. The potential for hormonal regulation of Zn transporter expression in these animals warrants further investigation.

**MP069 Bioaccumulation and trophic transfer dynamics of heavy metals in food web assemblage in intertidal mangrove ecosystem, Sungai Puloh, Malaysia**

B.E. Udchukwu, Kampala International University- Western campus, Ishaka / Pharmacology/Toxology; A. Ismail, Universiti Pertanian Malaysia / Biology; S.Z. Zulkifli, H. Omar, University Putra Malaysia / Biology

In recent times the ever increasing anthropogenic activities associated with industrialization, population increase, and urbanization in developing countries which leave chemical footprints behind, pose risk to aquatic ecology. Among these chemical pollutants are heavy metals which are bioaccumulative, persistent and toxic. This consequently impacts aquatic organisms through bioaccumulation, trophic interactions, and dietary exposure. The aim of this research is to evaluate heavy metals (Cu, Ni, Pb, and Zn) and to assess their bioaccumulation patterns in surface sediments and some key ecological food chains in Sungai Puloh estuary. Also to characterize the trophic positions of samples viz: Periophthalmodon schlosseri, Osteoglossus militaris, Teleostei telescopium, Nerita lineata, Polymesoda coxans, Penaus monodon, Uca annulipes, Dotilla lineata, Polymesoda coxans, Penaus monodon, Uca annulipes, Dotilla lineata, and some key ecological food chains in Sungai Puloh estuary. The direct aqua regia method was employed for the metal level estimation. Samples were determined for heavy metal concentrations (u/g, dry weight) by using an Atomic absorption Spectrophotometer and Isotope Ratio Mass Spectrophotometer for the stable isotopes. The result revealed elevated Cu level in Penaus monodon, (47.19 ± 1.13) u/g and high levels of Pb (15.23 ± 1.93, 16.86 ± 0.52, 8.91 ± 1.06) μg in catfish (Osteoglossus militaris), Uca and Dotilla respectively. With the help of stable isotope ratios of δ13C and δ15N analysis, two distinct food chains and four trophic positions were determined, with catfish occupying the highest trophic level. By using catfish as a model for trophic web system, the result showed that the carbon source for catfish (-17.30 ± 0.91‰) is discretely from crabs (-17.93 ± 0.90‰, -18.03 ± 0.90‰) for Uca and Dotilla respectively with an enrichment of δ13C values of ~1.0‰, complementing the idea that crab found in the stomach content is its staple food. It is arguable that the major source of Pb in catfish comes from crab especially Dotilla and not from the surface sediment, since the biota sediment accumulation factor (BSAF:0.2) recorded a very low ratio compared to that of trophic transfer factor (TTF:1.7). We concluded that heavy metal contamination in Sungai Puloh estuary stems from the release of untreated or poorly/improperly treated effluents, and Pb in catfish is considered to be the element of much concern, and therefore should be strictly monitored.

**MP070 Using selenium: Mercury molar ratios to understand methylmercury toxicity in marine forage fish and their offspring**

X. Ye, N.S. Fisher, Stony Brook University / School of Marine and Atmospheric Sciences

The interaction between mercury (Hg) and selenium (Se) has been investigated for decades in mammals and aquatic organisms. The antagonistic effects have been commonly described as Se playing the protective role in Hg toxicity, with the Se/Hg molar ratio >1. We previously conducted a maternal transfer experiment to evaluate the impact of dietary methylmercury (MeHg) on marine fish reproduction and transgenerational effects on their offspring, but none of the reproductive endpoints were impaired and the larval fish displayed only a little hyperactivity. We hoped to use Se/Hg molar ratios to understand whether the fish were protected from Hg toxicity. Previously, the juvenile sheepshead minnow Cyprinodon variegatus were exposed to a control or MeHg diet from an age of 3-5 months. After the dosing period, female fish were paired with Hg-free male fish for spawning. Egg production, hatching success of embryos, time to hatch, the survival of larvae, growth and swimming behavior of larvae were assessed. We then examined Hg levels in the whole larvae and adult fish heads, intestines, ovaries, and muscles. Se levels were examined in the whole larvae and adult fish heads and muscles, then Se/Hg molar ratios were calculated. The Se/Hg molar ratios in the control treatment were all well above 1 while the Se/Hg molar ratios in Hg treatment were 0.31±0.08 in the female heads, 0.36±0.07 in female muscles. The Se/Hg molar ratio in larvae from Hg treatment were 4.48±2.0. It was difficult to use Se/Hg molar ratios to interpret the Hg effects on the sheepshead minnow which may be partially because we measured total Se levels while it was suggested that the antagonism between Se and Hg and their interactions also depend on the chemical species of both Hg and Se. Using Se/Hg molar ratio >1 might be insufficient to interpret whether fish experience more or less protective advantages of Se against Hg toxicity and more detailed studies should be conducted in the future.

**Environmental Considerations for the Risk Assessment of Polymers, Rubber and Macroplastics: State of the Science**

C.G. Eldridge, College of Charleston; B. Beckham, College of Charleston / Environmental Geosciences

Tire material has been studied for toxicity of leachates for decades, however there are still questions regarding fate and transport and the risks posed to aquatic life. This material carries potentially toxic chemicals resulting from production methods, but may also sorb them from the surrounding environment. PAHs are one class of hydrophobic organic contaminants that are associated with tire wear particles (TP) and crumb rubber (CR), and have the potential to exert narcotic, mutagenic and carcinogenic toxicity. This work determined crumb rubber (KCR-w) and tire wear particle (KTP-w) solid-water partitioning coefficients for PAHs that
were “native” (pre-existing on material) and spiked, and will assess bioaccessibility using single-point 24-hour TENAX extractions, an optimized method correlating to organism bioaccumulation. Sorption studies were conducted using a 3-phase mass balance approach with tire materials (63 – 150 micron size), polyethylene strips (PE, 76 micron thickness) and deionized water spiked with different levels of fluorene and 13C-pyrene and equilibrated for 7 – 21 d. PE serves as a passive sampler in the system, and extracted concentrations in PE are used to calculate K values. TENAX extracions follow established methods. 16 USEPA priority PAHs are analyzed by GC-MS with quantification by isotope dilution against 13C-PAH internal standards. Native PAH content of materials was determined following solvent-extraction by ultrasonication and clean-up by silica-gel column chromatography. Materials were further characterized for specific surface area and pore volume by a 40-pt N2 BET isotherm and composition (percent rubber, carbon black, and inorganic fillers) by thermogravimetry. Results with 1 representative end-of-life tire crumb rubber material showed Log KCR-w of PAHs, both spiked and native, were linearly correlated with Log KOW (R2=0.99). Fluorene sorption followed a linear isotherm (R2=0.999) over a 3-order of magnitude range in water concentration (CW at 14-d equilibrium, 0.1 to 217 µg/L), with an average Log KCR-w of 4.42 ± 0.15, which indicates that partitioning to the rubber fraction (60% material composition by mass) dominates sorption. Ongoing studies with additional crumb rubber and field-collected tire wear particles will expand upon this knowledge of sorption behavior and bioaccessibility, which can be applied to better understand contaminant fate and environmental risks from PAHs associated with tire materials. 

**MP072 Environmental Stewardship Program for Polymers Used in Cleaning Products—Polycarboxylate Polymers**

*P.C. DeLeo, Integral Consulting, Inc.; H. Summers, Integral Consulting Inc. / Institute of Environmental Toxicology and Chemistry; K. Stanton, American Cleaning Institute; M. Lam, Procter & Gamble / Global Product Stewardship; A. Carrao, Kao USA / R&D; N. Pechacek, Ecolab, Inc.*

Water-soluble polymers are important ingredients in cleaning products providing multiple functions and unique performance benefits. In some cases, polymers were developed as part of formulation changes needed to replace commodity chemistries for which environmental concerns were identified. Polymers historically were considered to pose de minimis environmental risks and, until recently, were exempted from regulatory actions globally. Registration of new polymers is now required in some countries (e.g., U.S., Canada, Australia, Japan, Korea). Polymers that are high volume, are estimated to have high consumer exposures, and contain reactive functional groups are expected to be prioritized for registration under REACh. Although data and assessments already exist for some polymeric materials, the cleaning products industry is generating more data to refine environmental risk assessments to support the safe use of polymers in its products. To that end, the American Cleaning Institute (ACI) is leading an environmental stewardship program for key polymers used by its members in the formulation of cleaning products. Through early efforts to understand key cleaning product polymer technologies and the landscape of data availability, the program was able to prioritize data generation needs to support environmental risk assessments, the results of which have been previously published. Currently, ACI leads ongoing efforts to support two categories of cleaning product polymers with widespread use in the U.S., polycarboxylates and polyquaterniums. Preliminary findings from sludge sorption studies on select variants of polyquaternium-10 will be shared here. ACI will also integrate data from other programs and projects including the European Chemical Industry Council’s (CEFIC) Long-Range Research Initiative’s (LRI) efforts evaluating the aquatic effects of cationic polymers into a robust risk assessment (presented during this meeting). ACI will also incorporate into its stewardship program an assessment to support the environmental safety of polycarboxylates that are widely used across the cleaning product industry (available during this meeting).

**MP073 Environmental stewardship program for polymers used in cleaning products**

*M. Lam, Procter & Gamble / Global Product Stewardship; A. Carrao, Kao USA / R&D; N. Pechacek, Ecolab, Inc.; K. Stanton, American Cleaning Institute*

Water-soluble polymers are important ingredients in cleaning products that have multiple functions and unique performance benefits. In some cases, polymers were developed as a components of formulation changes needed to replace commodity chemistries for which environmental concerns have been identified. Polymers historically were regarded to pose de minimis environmental risks and, until recently, exempted from regulatory actions globally. Registration of new polymers is now required in some countries (e.g., U.S., Canada, Australia, Japan, Korea). In Europe, polymers that are high volume, are estimated to have high consumer exposures, and contain reactive functional groups are expected to be prioritized for registration under REACh. Although data and assessments already exist for some polymeric materials, the cleaning products industry is generating more data to refine environmental risk assessments to support the safe use of polymers in its products. To that end, the American Cleaning Institute (ACI) is leading an environmental stewardship program for key polymers used by its members in the formulation of cleaning products. Through early efforts to understand key cleaning product polymer technologies and the landscape of data availability, the program was able to prioritize data generation needs to support environmental risk assessments, the results of which have been previously published. Currently, ACI leads ongoing efforts to support two categories of cleaning product polymers with widespread use in the U.S., polycarboxylates and polyquaterniums. Preliminary findings from sludge sorption studies on select variants of polyquaternium-10 will be shared here. ACI will also integrate data from other programs and projects including the European Chemical Industry Council’s (CEFIC) Long-Range Research Initiative’s (LRI) efforts evaluating the aquatic effects of cationic polymers into a robust risk assessment (presented during this meeting). ACI will also incorporate into its stewardship program an assessment to support the environmental safety of polycarboxylates that are widely used across the cleaning product industry (available during this meeting).

**MP074 Risk Assessments of Polymeric Substances on the Canadian Domestic Substances List**

*N. Sundin, W. Lin, D. Porter, D. Gutzman, Environment and Climate Change Canada / Ecological Assessment Division*

Following a prioritization activity known as categorization of Canada’s Domestic Substances List (DSL), approximately 4300 substances were identified as requiring screening assessment of their potential to cause harm to human health or the environment. Approximately six hundred of these substances are identified as polymers. Due to the complexity of polymeric substances, a novel approach to risk assessment of polymeric substance was developed. This poster will present the approach developed to assess polymers on the DSL, and discuss the various risk assessment methodologies used, which included polymer rapid screening approaches, as well as full-scale screening assessments that were used for six groups of polymers. Through the two polymer rapid screening processes, more than 550 substances were identified to be of low ecological and human health concern, and have been concluded as not meeting any of the criteria set out in section 64 of CEPA. Fifty-one substances were identified as requiring further assessment after the Second Phase of Polymer Rapid Screening due to potential concerns for the environment [29 substances], human health [19 substances] or both [3 substances]. The fifty-one substances were divided into six groups for screening assessments, which are regulatory assessments that can lead to development of measures to manage any risks identified. These groups include: Poly(bios) Group [five substances], Epoxy Resins Group [four substances], Poly(amine) Group [nine substances], Phenol-Formaldehyde Resins Group [eight substances], Poly(alkoxylates/ether) Group [21 substances], and Other Polymers Group
Building Bridges Between Lab-and Field-Derived Data: Methods for the Assessment of Complex Environmental Issues

MP075 An exploratory comparison of toxicity assessment instrument outputs compared to traditional laboratory assays using Daphnia magna

K. Reilly, S. Marshall, I. Lynch, University of Birmingham / Geography Earth Environmental Science

The Daphnia Toximeter (DT) is an instrument designed to be used with wastewater treatment work (WWTW) outflows as a tool to measure water quality, and currently there is very little literature available regarding the use of this instrument within research applications. The purpose of the DT is to trigger an alarm to initiate a response if the water quality is too poor and the daphnia’s behaviour/movement in the test chambers changes significantly from the controlled behaviour. This is designed to be used as a monitoring tool but in this study, we are comparing this output with the standard assays conducted in the lab to determine if there are any points during the 48-hour LC_{50} calculation that could prompt an earlier response, or if there was any notable difference between the DT outputs compared to laboratory observations. The exposures compared included the chemical Sodium Lauryl Sulphate (SLS) and gold nanomaterials (NMs) to assess for both survival and behaviour/movement. SLS has LC_{50} values ranging from 1.2-7.5 mg/l using the OECD 202 acute toxicity assay, while gold NMs (spheres and rods with cationic surfaces) have previously been shown to cause a change in the daphnia behaviour with regards to the carapace moult, suggesting that energy is diverted from moulting as the organism deals with oxidative stress arising from positively charged gold NMs. The study aims to see if the DT can detect this response, observed anecdotally as a jerky movement of the daphnids, to a dispersed NM in addition to a typical dissolved chemical. The hypothesis for this exploratory study is that the DT will be more sensitive to the chemical toxicity of the SLS, but less responsive to the sublethal behaviour changes arising from the gold NM. All tests were conducted using controlled laboratory conditions as far as possible. WWTW often don’t have the capacity to remove NMs and therefore NMs have the potential to be present in the outflow in varying concentrations, so it will be interesting to see the DT detection limits for the sublethal effects of this type of water contamination compared to a more simplistic chemical exposure.

MP076 Toxicity of selenium to a boreal lake food web: Direct and indirect organism responses

S. Graves, K. Liber, University of Saskatchewan / Toxicology Centre; V. Palace, IISD-Experimental Lakes Area; M. Hecker, University of Saskatchewan / School of the Environment & Sustainability and Toxicology Centre; L.E. Doig, University of Saskatchewan / Toxicology Centre; D.M. Janz, University of Saskatchewan / Veterinary Biomedical Sciences

Selenium (Se) is a contaminant of concern in Canada mainly due to its teratogenic effects on egg-laying vertebrates in aquatic ecosystems, with effects on invertebrates relatively under-studied. The objective of the present study was to assess the community-level effects of selenium on benthic macroinvertebrates and zooplankton following 63 d of exposure to Se using limnocorrals in Lake 239 at the International Institute for Sustainable Development - Experimental Lakes Area. From June 20 to August 22, 2018, limnocorrals were spiked with mean measured concentrations of 0.4, 0.8, 1.6, 3.1, 5.2 and 7.9 µg Se/L as selenite, with three untreated controls (background dissolved aqueous Se = 0.09 µg Se/L). Quantitative periphyton, phytoplankton, zooplankton and benthic macroinvertebrate samples were collected throughout and at the end of the 63 d exposure period. Zooplankton will be identified to family, counted and weighed. Taxa richness, density, and biomass will be determined for all invertebrates. Multivariate analysis of community-level impacts is in progress, but preliminary results show that density and biomass of Chironomidae decreased with increasing exposure concentrations, but Chironomidae were not affected by Se exposure. Phytoplankton and periphyton growth increased with elevated Se and were inversely correlated with invertebrate biomass. These results suggest that some invertebrates have greater sensitivity to Se than previously thought, and that Se can have both direct and indirect impacts on freshwater food webs.

MP077 A Review of Potential Impacts of Runoff from Refined Coal-Tar-Based Sealant Coating on Aquatic Organisms

S. Kane Driscoll, Exponent, Inc. / EcoSciences; K.J. Kulacki, Exponent / Ecological and Biological Sciences

Pavement sealants are widely used to improve the durability and appearance of asphalt parking lots and driveways. Concerns have been raised, however, regarding the potential for runoff from pavement sealant to cause adverse effects on aquatic organisms in urban and suburban streams. We performed a comprehensive literature review to summarize the potential for runoff from refined coal-tar-based sealants (RCTS) to impact aquatic organisms and evaluated the strengths and weaknesses of the lines of evidence presented in the literature. Several studies demonstrated that RCTS runoff can have detrimental impacts on aquatic organisms under controlled laboratory settings. The usefulness of laboratory data in predicting potential for effects in the field is limited, however, by lack of data on the influence of site conditions on the bioavailability of polycyclic aromatic hydrocarbons and other constituents of RCTS. Our review highlights the need for environmentally relevant study designs that demonstrate cause-effect relationships under field conditions.

MP078 Silver-selenium interaction and its effect on selenium metabolism studied using the Rainbow trout cell line- RTgutGC

D. Chanda, M. Minghetti, Oklahoma State University / Integrative Biology

Due to its anti-microbial properties, silver (Ag) has been used for medical and commercial purposes for several decades. With the increasing demand and use of silver containing products, its long-term adverse effects on human and environmental health is a concern. For instance, silver is known to be highly toxic to aquatic species. Moreover, recent research in mammalian cells has clearly indicated detrimental inhibitory effects on selenoenzymes. Selenoproteins are a group of proteins incorporating selenium (Se) as a structural and catalytic co-factor. Due to their role in removal of reactive oxygen species they are considered vital enzymes. Therefore, any disruption of selenoprotein function can be detrimental to organismal health. Our primary objective is to test the inhibitory effects of Ag exposure in the form of silver salt (AgNO3) and citrate coated silver nanoparticle (cit-AgNP) on selenoprotein function using a fish cell line derived from the Rainbow trout (Oncorhynchus mykiss) intestine (RTgutGC). Therefore, following exposure to non-toxic and toxic (EC50) concentrations of AgNO3 and cit-AgNP, selenoproteins (Glutathione peroxidase, thioredoxin reductase and selenoprotein P) function was evaluated by measuring their mRNA levels and enzyme activity.

In addition, oxidative stress was measured using the CM-H2DCFDA indicator assay. Intracellular accumulation of silver was measured by ICP-MS. From the results obtained, it was found that cells exposed to equimolar amounts of AgNO3 and AgNP accumulated the same amount of metal, however, AgNO3 was more toxic to the cells compared to...
cit-AgNP. Messenger RNA levels for the target selenoenzymes remained unchanged while that of Metallothionein increased indicating uptake of silver by cells but no effect on selenoproteins gene expression. An inhibition in activity of glutathione peroxidase was observed in cells exposed to toxic doses of AgNO3 when compared to un-exposed cells. Reactive oxygen species levels did not change after AgNO3 or cit-AgNP exposure. From the results obtained, we have concluded that AgNO3 is more toxic than AgNP when exposed to equivalent concentration. An inhibitory effect of Ag was observed at the post-translational level while no effects were observed at the transcription level. Moreover, an increase in the levels of Metallothionein was observed indicating the uptake of silver by the cells.

**MP079 Visualizing the transformation, transportation, and distribution of silver nanoparticles in Daphnia magna with a novel fluorescence technique**

N. Yan, W. Wang, The Hong Kong University of Science and Technology / Department of Ocean Science

While most current research focuses on the environmental behaviors such as dissolution and aggregation of silver nanoparticles (AgNPs), the fate of AgNPs and their correspondingionic counterparts in aquatic organisms has been rarely studied. In the present study, we employed a novel aggregation-induced emission (AIE) method by employing two AIEgens, namely, AIEgens coated AgNPs (AIE-AgNPs) and Ag+ sensor (tetrazole-functionalized tetraphenylethylene derivative 1, TET-TPE-1) for simultaneous detection of AgNPs and dissolved Ag+. We quantitatively monitored the time-dependent dissolution processes of AgNPs in Daphnia magna. When the bioaccumulation of AIE-AgNPs in Daphnia reached equilibrium, about 17.2% of AIE-AgNPs penetrated the gut membrane and was internalized, while 81.1% of AIE-AgNPs were excreted by daphnids into the surrounding environments, and 1.7% of AIE-AgNPs was dissolved to Ag+. Besides, the transformation process of AIE-AgNPs reached equilibrium at 48 h, and the concentration of Ag+ released reached 49.8-66.2 μg/g, which was 10.7% of AIE-AgNPs. These dissolved Ag+ ions were found to transport from gills to inner sides of Daphnia, in contrast to AIE-AgNPs, suggesting that Ag+ species was the major source of AgNPs toxicity. The present work lays the foundation for the elucidation of the use of AIE method as a non-invasive technique for simultaneous monitoring of transformation, transportation, and distribution of AgNPs in biological systems, addressing a critical technology gap in the field of nanotoxicology.

**MP080 Understanding Silver Nanoparticle Fate in Treatment Wetlands: Bioaccumulation dynamics by Daphnia magna**


Wetlands engineered for water purification are typically designed to allow for various physical and biological processes to reduce levels of organic contaminants, metals, bacteria, and suspended solids. In addition to the more common use of vegetation and associated microorganisms, recent studies have evaluated the utility of predation to remove these contaminants. Despite the various benefits of treatment wetlands, the reliability and efficiency of these systems can vary widely, and gaps in knowledge limit widespread application. Grazing by filter feeding zooplankton such as Daphnia magna, while less widely researched, can significantly contribute to treatment efficacy in wetlands through reduction of turbidity, removal of contaminants associated with particulate matter, and inactivation of microbial pollutants. Silver nanoparticles (AgNP) are widely used for their antimicrobial properties. Due to diverse application and increased production, the environmental concentrations of AgNPs are likely to increase, which is a concern as Ag is toxic to aquatic organisms. Developing a mechanistic understanding of the fate of AgNPs in treatment wetlands is thus necessary to improve treatment efficacy. Here we used isotopically labeled 109Ag to characterize the accumulation and elimination of AgNPs (20 nm polyvinylpyrrolidone coated) and AgNO3 in D. magna after environmentally relevant waterborne and dietborne exposures. Comparison of our rate constants to those from previous published studies that used different conditions (such as organism age, exposure concentration, duration, and sampling scheme) revealed differences, highlighting the conditional nature of bioaccumulation results. Future work with varying AgNP coating and size along with wetland mesocosm studies will be discussed.

**MP081 Uptake, transport and elimination of silver nanoparticles in oysters (Crassostrea hongkongensis) revealed by 110mAgNPs tracing**

Z. Shao, The Hong Kong University of Science and Technology; W. Wang, Hong Kong University Sci. Technol. / Department of Ocean Science

The prevalence of nanotechnology requires a comprehensive study on its biological impacts especially in marine and estuarine environments. Nevertheless, the background Ag concentration in the organisms may impede the accuracy of Ag determination when the accumulated Ag is extremely low. Here, a radio-synthesizing method was employed to trace the behavior of silver nanoparticles (AgNPs) with two sizes (15 nm and 60 nm) and two coatings (humic acid and citrate) in an estuarine oyster Crassostrea hongkongensis. Through biodynamic modelling, we demonstrated that AgNPs of smaller nominal size were more easily incorporated into the oysters, and humic acid capped AgNPs displayed higher biocompatibility than citrate capped AgNPs. Tissue distribution of Ag was also investigated at different time points of AgNPs exposure and depuration. Direct ingestion of nanoparticles dominated the uptake of 60 nm AgNPs, while dermal uptake and ingestion contributed equally to the uptake of 15 nm AgNPs. The digestive gland was the key detoxification organ of AgNPs with the greatest loss of Ag by the end of depuration. This highly sensitive radiotracing method serves as an effective tool to accurately quantify the bioaccumulation of AgNPs in aquatic organisms.

**MP082 Acute and chronic toxicity of citrate-coated silver nanoparticles to Hyalella azteca**

J. Kusi, K.J. Maier, Eastern Tennessee State University / Department of Environmental Health

The antimicrobial properties of silver nanoparticles (AgNPs) have increased their use in several consumer products. AgNPs are one of many emerging environmental contaminants, where the effects on biological systems are not fully understood, thus raising concerns about their release into the environment. Benthic invertebrates are likely to be affected by AgNPs exposure because they are highly sensitive to ionic silver. Hyalella azteca was used as a model species to evaluate the toxicity of AgNPs to benthic invertebrates due to their rapid response to contaminants. Test organisms (7-8 days old) were exposed to different concentrations of 10 nm citrate-coated AgNP with five replicate beakers for 10 and 28 days in a static-water-renewal system. Ten H. azteca were added to each replicate beaker containing 100 mL sand as a substrate. Aliquots of test solutions were centrifuged, digested, and analyzed using furnace atomic absorption spectrometer to measure dissolved Ag, which was used for all statistical analyses. One-way ANOVA and Dunnett’s test were used to determine effects of the citrate-coated AgNP on survival and growth of H. azteca. Median lethal concentration (LC50) for survival and median effective concentration (EC50) for growth were calculated using probit analysis and Toxicity Relationship Analysis Trap respectively. Citrate-coated AgNP significantly reduced growth (dry weight) from 0.15 to 0.07 mg at 10.8 μg/L (p < 0.05) for the 10-day acute exposure. For the 28-day chronic exposure, citrate-coated AgNP significantly reduced growth from 0.63 to 0.40 mg at 7.2 μg/L (p = 0.01). The LC50 (95% confidence interval) for survival in the acute exposure was 7.8 (7.2-8.4) µg/L and the EC50 (95% confidence interval) for growth was 3.4 (1.2-9.4) µg/L. The LC50 for survival in the chronic exposure was 4.1 (1.4-5.5) µg/L and the EC50 for growth was 1.0 (0.1-8.3) µg/L. Growth was more sensitive to citrate-coated AgNP compared to survival in both acute and chronic exposures. We conclude that citrate-coated AgNP poses a potential risk to survival and growth of freshwater H. azteca populations, thus there may be the need to monitor the release of AgNPs into aquatic systems.
MP083 The DeTER project: Detection, Toxicology, Environmental fate and Risk assessment of nanoparticles in the aquatic environment
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The DeTER project had three major aims to develop methods for the capture and detection of silver nanoparticles (AgNPs) in water, the determination of the toxicological effects of AgNPs in the aquatic environment and the development of risk assessment protocols which could be used to evaluate the environmental fate and likely risk from AgNPs through aquatic pathways. Milled activated charcoal was developed as a successful capture material for AgNPs from water samples. In order to quantify the captured silver a hydrochloric acid leaching procedure was developed which successfully removed the captured silver allowing the fraction captured by the charcoal to be quantified with an average of 94.8% recovery. To investigate the potential ecotoxicological impact of AgNPs on the aquatic environment a multi-trophic test battery which included three trophic levels was adopted to assess the ecotoxicity of AgNPs and AgNO3 to Pseudokirchneriella subcapitata, Daphnia sp. and Hydra attenuata. The standard media (Jaworski’s medium(JM)) and an EDTA-free media (Chu#10) were tested concurrently. An approximately 10-fold improvement in test sensitivity using EDTA-free media was observed overall. No significant difference between toxicities of AgNP and AgNO3 was observed. It was found that Daphnia pulex with its 24 hour IC₅₀ of 9.3 µg/L was less sensitive to AgNO₃ when compared to an IC₅₀ of 1.22 µg/L for Daphnia magna. When tested with AgNP, both species yielded similar results with an IC₅₀ for Daphnia magna of 7.85 µg/L and Daphnia pulex of 4.2 µg/L. As these IC₅₀ values were substantially higher than the PECs, sub-lethal endpoints were also investigated. Fecundity was assessed in Daphnia magna and showed that the number of offspring reduced by 50% after 14 days and 75% after 28 days when cultured in 100 ng/L AgNP. The risk assessment found that current environmental concentrations of AgNPs used in the model were at levels deemed unlikely to have toxicity concerns to aquatic organisms (mean levels in water of 4.34 µg/L). Therefore, at current predicted water concentrations, AgNPs are unlikely to present a toxic concern to the aquatic food chain. The potential human exposure through drinking water was also investigated. Risk to human health was calculated based on water consumption and potential exposure to residual AgNPs using the Hazard quotient (HQ). The predicted HQ indicated that there was no existing risk through consumption of drinking water.

MP084 Surface charge impact on nanoparticle biotransformation mechanisms in the environment
M. George, C.M. Sayes, Baylor University / Environmental Science

Nanoparticles are increasing in use in consumer products due to their high surface area, tailored surface functionalization, and ability to be excreted. Small particles of like surface charge are shown to display repulsive tendencies; but in the environment, these same particles form a double layer enabling particle stability. The electrostatic and magnetic forces are beneficial in the exploitation of homogenate and stable consumer products; however, when placed in biofluids or the environment, these forces are disturbed. When nanoparticles travel through the environment, they encounter many different aqueous environments which alters colloidal stability. We hypothesize that nanoparticles will become increasingly unstable as the matrix for which they are exposed becomes increasing complex. Specifically, the stability of the nanoparticles will be directly related to (1) the alteration in pH from pH 7.0, (2) the concentration of biomolecules, and (3) the ionic strength of the surrounding matrix. To test this hypothesis, we compared three different surface-functionalized silver nanoparticles coated with positive, negative, and neutral surface charge and characterized through electron microscopy and spectroscopic techniques. Each particle system was incubated in different environmental relevant matrices: strong ionic content, neutral biofluids, and basic surfactant fluid. The results indicate a mechanistic transformation where the surface charge significantly impacts nanoparticle transformation. The next step in this project is to simulate nanoparticle environmental fate to a combination of matrices sequentially. The information obtained from these studies will provide crucial insight into colloidal stability of consumer products, provide read-across comparisons between metal-based particles and the environment, and aid in filling the literature gap in colloidal stability effect on nanoparticle transformation, in situ.

MP085 Nano-CopperOxide Influences Rice (Oryza sativa japonica) Growth and Arsenic Uptake
J. Liu, M. Simms, Baylor University / Department of Environmental Science; K. Wolfe, Baylor University; B. Dhungana, Baylor University / Chemistry and Biochemistry; G.P. Cobb, Baylor University / Department of Environmental Science

Copper oxide nanoparticles (nCuO) may be used as a fungicide in agricultural systems, and has been shown to sequester arsenic (As) in remedial activities. These important features of nCuO led us to evaluate the ability of nCuO to mitigate phytotoxicity and accumulation of naturally occurring arsenic (As) in rice plants. A factorial study was conducted to evaluate the main effects of nCuO (0, 0.1, 1.0, 10, 50, and 100 mg/L) and As (0 and 10 mg/kg) and their interaction effects on the whole F0 life cycle and F1 germination of rice plants (Oryza sativa japonica). The Initial exposures were 131 d in length and were conducted in a greenhouse. After rice grain collection, Thereafter, germination of F1 seeds was tested for 18 d in an incubator. No significant effect was observed on the seed germination, in F0 or F1 generations. Both nCuO and As had a significant main effect on F0 fresh weights of rice straw (FW), the number of rice panicles (NRP), and various root growth parameters. A decrease in FW was observed in As alone treatment, while nCuO addition produced hormetic type effects. Importantly, increased concentrations on nCuO decreased As transport into rice grains. Intergenerational effects on root and shoot growth were observed for F1 seedlings that were repeatedly exposed to As and to high concentration nCuO in the same manner as were the F0 plants from which they were produced. In the higher nCuO treatments, arsenic concentrations were lowered below the WHO threshold for safe rice consumption. This has important implications for food safety in countries where rice is the primary staple grain.

MP086 Influence of organic ligands and environmental factors on metal sulfide nanoparticle precipitation
E. McKenzie, A. Donaghue, Temple University / Dept. of Civil and Environmental Engineering

In sediment porewaters, metal sulfides play an important role in the removal of many metals; however, understanding of the influence of environmental factors on multiple metal sulfide species released into aquatic waters is still needed. This study evaluates the competitive precipitation of metal sulfides as they are affected by organic ligands (cysteine, gallic acid, and Pahokee Peat humic acid), inorganics ligands (Cl⁻ and Cu²⁺), and oxidants. Centrifugation and ultrafiltration, coupled with inductively coupled plasma mass spectrometry (ICP-MS), was employed to characterize ZnS, PbS, CdS, and CuS particle size distributions (PSDs; i.e. 30, 60, and 100 nm) and differentiate between nanoparticle (NP) and dissolved concentrations (a component not typically examined when using TEM and light scattering techniques). The presence of the organic
ligand cysteine slows particle growth rates and limits bulk precipitation. Additionally, the presence of cysteine in 10-fold excess of initial metal/sulfide concentrations resulted in narrower PSDs (~3nm to 30 nm) for metals considered. However, for three-hour time scales, Pb and Zn sulfide particles demonstrate mixed trends with initial precipitation followed by subsequent dissolution even in the presence of excess organic ligands, which could be contributed to ligand promoted dissolution and/or chemical oxidation. This study illustrates that for multiple metal sulfide species in more complex aqueous matrices, several processes, including precipitation, dissolution, and chemical oxidation, can remain significant mechanisms in the lifetime of certain NPs even in the presence of excess capping agents.

### MP088 Revealing the Transformation and Fate of Black Phosphorus in Biological Environments

L. Zeng, G. Qu, G. Jiang, Research Center for Eco-Environmental Sciences / Chinese Academy of Sciences / State Key Laboratory of Environmental Chemistry and Ecotoxicology

Black phosphorus (BP) is a renewed 2D nanomaterial with excellent physicochemical properties, such as high electron mobility, tunable band structure and large anisotropy, which makes it advantageous in many fields. The widely potential applications of BP are likely to raise the exposure risks and health problems. Besides, BP is vulnerable to be oxidized in ambient environments due to the pair of lone electrons of each P atom. Thus, revealing the transformation, transport and fate of BP in biological environment is necessary to nano safety assessments and controllable designs of the environmentally unstable 2D materials. Here, we compared the time-dependent behaviors of BP with different sizes in biological environments from deionized water, salt solution with different pH/ion strengths to bovine serum albumin (BSA) solution systems. The morphology and defect of BP were revealed by atomic force microscopy (AFM), transmission electron microscopy (TEM), X-ray diffraction (XRD) and Raman spectroscopy, while the degradation products were identified by ion chromatography (IC) and nuclear magnetic resonance (NMR). Our results showed that degradation of BP in acid solution was faster than that in neutral and alkaline solutions. The existence of salt and BSA in solution had significant influence in degradation kinetics of BP. These results may have important toxicological relevance, and require further in vivo research in the future.

### MP089 Comparison of the effects of two different sized groups of metal oxide cobalt nanoparticles based on various biological activities

I. Kong, M. Kim, W. Wi, Yeungnam University / Environmental Engineering

The differences in the toxicity of cobalt metal oxide nanoparticles (Co-NPs) of two different sizes were evaluated in the context of bacterial bioluminescence activity, algal growth, plant activity (seed germination, root/shoot growth), xylene gene activity, enzymatic and biosynthetic activity of β-galactosidase, and bacterial gene mutation. Each size of Co-NP exhibited a different level of toxicity (sensitivity) in each bioassay. However, in all cases, the small Co-NPs showed statistically considerable higher toxicity than the large ones. However, in the case of gene mutation experiments, no revertant mutagenic ratio (greater than 2.0) of Salmonella typhimurium TA 98 was observed under the test conditions. Overall, the order of inhibitory effects has been roughly observed as follows: bacterial bioluminescence by xylene gene activity > bacterial bioluminescence by the growth activity > activity and biosynthesis of enzymes, bacterial gene mutation > algal growth, plant activity (seed germination, root/shoot growth). These findings demonstrate that particle size could be an important physical factor for evaluating the toxicity of NPs in environment. Moreover, combinations of results based on various biological activities, rather than just a single activity, would be better for the accurate assessment of NP toxicity in ecosystems.

### MP090 Aqueous instability of a complex metal oxide nanomaterial and adverse outcome pathway for its interaction with benthic organism Chironomus riparius

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A challenge for the field of nanotechnology is our understanding of how the chemical properties of engineered nanomaterials (ENMs) determine their fate in the environment and their subsequent interactions with organisms. Many ENMs are not stable in the aqueous environment and will aggregate and concentrate in the sediment, bringing them into direct contact with sediment-dwelling organisms at high concentrations. The goal of this study was to understand the aqueous stability of complex metal oxide ENM lithium cobalt oxide (LCO) and the molecular mechanism of its interactions with a model sediment-dwelling organism: Chironomus riparius. We show that transformations in aqueous media cause LCO to settle rapidly and concentrate at the bottom. Exposure to LCO causes significant, nano-specific effects on chironomid development, reducing larval size at 7 days and significantly delaying emergence of adult flies. Effects of LCO on other endpoints may point to the molecular mechanism underlying observed developmental impacts. Hemoglobin levels in larvae are significantly reduced by material exposure, and levels of genes involved in heme synthesis are also reduced, suggesting that LCO may negatively impact heme synthesis. Cobalt contained in LCO has previously been shown to disrupt the formation of Fe-S centers, which are cofactors in key regulatory and catalytic proteins, including the iron-responsive protein, which regulates the genes involved in heme metabolism. Transcriptomics experiments show disruption of expression of key Fe-S protein genes including those involved in Fe-S cluster formation as a result of LCO exposure, pointing to Fe-S cluster disruption as an important molecular mechanism of LCO impact. We propose an Adverse Outcome Pathway whereby LCO, by disrupting Fe-S centers of important enzymatic and regulatory proteins, may disrupt synthesis of heme, reduce synthesis of heme proteins, and affect synthesis of other key metabolites, which would result in disrupted animal metabolism and cause impacts on development like those we observe.
Across the treated groups, daphnid metabolomes were impacted on a dose-dependent manner. Compared to control, metabolomes of daphnids exposed to ions, 0.1 and 1.0 mg/l LCO nanoparticles exhibited 0, 2, and 182 metabolites, respectively, that were significantly different (p<0.05). The disproportionate impact on pathways seen between the ions and 1.0 mg/l LCO nanoparticles suggests a nano-specific impact. Analysis through partial least squares discriminant analysis revealed that metabolic profiles of daphnids exposed to 1.0 mg/l LCO were significantly different from both control and ion exposed profiles (p<0.05). Clustering of profiles from 0.1 mg/l LCO nanoparticle treated daphnids, while not statistically different from control, potentially indicate that differences observed in the 1.0 m/l profiles may be beginning to manifest.

**MP092 Mechanisms, Assessment, and Prediction of Toxicity of Multiple Engineered Nanoparticles to Aquatic Organisms**

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Ecotoxicological studies to characterize engineered nanoparticles (ENPs) hazards have just been unfolding in recent years. The validation and prediction of ecotoxicity of multicomponent ENPs mixtures are a significant part of the solution to the challenge of carrying out ecological risk assessments on multiple concomitant ENPs. On the basis of in-depth analysis of ecosystem levels and joint toxicity mechanism, developing a predictive toxicology model for ENPs mixtures is a crucial problem in science, which begs for solutions. This work will be based on the combination of in silico and experimental studies and will select metal oxide nanoparticles (MeO-NPs) as model compounds. This research seeks to: a) investigate the acute and chronic toxicity of single, binary, and multiple MeO-NPs mixtures to aquatic organisms of different trophic levels; b) estimate toxicity endpoint of aquatic organism population based on simple population model and concentration-response data; c) develop and validate quantitative prediction models for the toxicity of aquatic organism population to binary and multiple MeO-NPs based on joint toxicity mechanism, respectively. This research can not only provide theoretical and methodological foundations for the hazard identification and the risk assessment of ENPs, but also offer an important scientific basis for their healthy development and security application.

**MP093 Advancing tools for hazard assessment of ingested nanomaterials: an Adverse Outcome Pathway approach**

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Oral ingestion is one of the major routes of exposure for nanomaterials used in food products, and yet there are knowledge gaps on their potential to elicit health risks and mechanisms of toxicity. The overall objective of this study is to develop an adverse outcome pathway to predict the potential toxicity of dietary nanomaterials to gastrointestinal system. In this study, Caco-2 cell line exposed to incremental concentrations of food grade SiO2, TiO2 and silver particles was used to evaluate the molecular initiating events and key events that signify the early stages of adverse outcomes such as epithelial layer permeability changes, cell junction disruption, inflammatory responses and oxidative stress level. SiO2 and TiO2 particles didn't cause cytotoxic effects after 24 hours of exposure. However, nano-sized particles of SiO2 and TiO2 induced noticeable level of pro-inflammatory markers (IL-6, TNF-a) and intracellular H2O2 generation. Laser Scanning Confocal Microscopy analysis after immunofluorescence staining showed disruption in apical tight junction complex but not the basal adherens junction complex, thus maintaining the integrity of the intestinal epithelial layer. In contrast, silver nanoparticles induce significant cellular inflammatory responses and oxidative stress with the disruption of both tight junction and adherens junction, and subsequently cause leakiness and increased permeability of the epithelial layer. Results suggest nanomaterials could induce early signatures of adverse effects that may play a vital role towards the progression of diseases of relevance to gastrointestinal tract. The developed pathway could be used to perform hazard screening on other nanomaterials or novel chemicals for predictive hazard assessment and further risk assessment.

**MP094 Immunomodulatory Effects of Amine-capped Carbon dots on Murine Macrophages and Human Whole Blood Cell Cultures**

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Carbon dots (CDs) are nanoparticles used in various bio-applications such as drug delivery and bioimaging. Amine functionalization of carbon dots improve its use as nanosensors and also enhance the nanoparticles’ electrochemiluminescence. Few studies have evaluated the in vitro effects of these functionalized nanoparticles on the immune system. This study examined the in vitro effects of amine-capped carbon dots (a-CDs) on the immune system using the murine RAW264.7 macrophage cell line and human whole blood cell cultures. Effects of a-CDs on RAW cells were assessed under basal conditions and in the presence of the mitogen lipopolysaccharide (LPS). The whole blood cell cultures were exposed to a-CDs in the absence or presence of LPS and phytohaemagglutinin (PHA). Cell parameters such as cytotoxicity, inflammatory biomarkers, cytokines of the acquired immune system and a proteome profile analysis were monitored after a-CD exposure. The a-CDs were cytotoxic to RAW at concentrations ≥ 6.25 µg/mL and to whole blood cells at 500 µg/mL. Treatment of RAW cells with a-CDs under basal conditions did not affect nitric oxide (NO) and interleukin 6 (IL-6) synthesis, while a-CDs at concentrations ≥ 6.25 µg/mL decreased NO production by LPS stimulated RAW cells. Treatment of LPS stimulated RAW with a-CDs did not affect IL-6 synthesis. The a-CD did not affect cytokine production by whole blood cell cultures under basal conditions. Exposure of LPS stimulated whole blood cell cultures to a-CDs decreased IL-6 and macrophage inhibitory protein 1β (MIP-1β) significantly at concentrations ≥ 5 µg/mL and ≥ 50 µg/mL respectively. Exposure of PHA stimulated whole blood cell cultures to a-CDs decreased interleukin 10 (IL-10) and interferon gamma (IFNγ) significantly at concentrations ≥ 5 µg/mL and ≥ 50 µg/mL respectively. Proteome profile analysis of RAW cells under basal conditions at 25 µg/mL a-CDs indicated an upregulation of cytokines and chemokines associated with inflammation but no changes in the cytokine and chemokine production when in the presence of LPS when compared to their respective controls. Whole blood cell cultures exposed to 5 µg/mL a-CDs in the presence of LPS exhibit reduced inflammatory cytokines and chemokines compared to the LPS only control. This study clearly shows that a-CDs modulate various immune cell parameters in vivo and these should be investigated in more detail to evaluate potential adverse effects of these nanoparticles upon exposure in vivo.

**MP095 Low doses of multi-walled carbon nanotubes elicit hepatotoxicity in rats with markers of oxidative stress and induction of pro-inflammatory cytokines**

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The investigation into the potential health risks associated with the use of engineered nanomaterials is a major scientific interest in recent years. The present study elucidated the involvement of pro-inflammatory cytokines,
cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS) in carboxylated multi-walled carbon nanotubes (MWCNTs)-induced hepatotoxicity. Pubertal rats were exposed to purified MWCNTs at 0, 0.25, 0.5, 0.75 and 1.0 mg/kg for 5 consecutive days. Results indicated that exposure to MWCNTs caused liver damage evidenced by significant elevation in serum activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and gamma glutamyl transferase (GGT) when compared with control. Moreover, MWCNTs significantly decreased superoxide dismutase (SOD) and glutathione S-transferase (GST) activities as well as glutathione level whereas it significantly increased catalase (CAT) and glutathione peroxidase (GPx) activities in liver of the treated rats. Moreover, the dose-dependent increase in hepatic hydrogen peroxide (H2O2) and lipid peroxidation levels were accompanied by marked increase in micromole per gram (μmol/g) liver (MMP) content of catalase activity and MDA levels. 

Administration of MWCNTs significantly increased serum concentrations of pro-inflammatory cytokines namely interleukin-1b (IL-1b), interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-a) in the treated rats. Immunohistochemical analysis showed significantly increased COX-2 and iNOS protein expressions in the liver of MWCNTs-treated rats. In conclusion, carboxylated MWCNTs induces hepatic damage via disruption of antioxidant defense systems, such as gene expression and enzyme activity related to oxidative stress, consequently resulting in liver damage in rats.

The recent advances in engineered nanoparticles (ENPs) has propelled the production of thin-film liquid crystal displays (LCD) used in smart screens due to their small size, broad absorption and narrow emission spectra. If not properly recycled, under weathering conditions, ENPs have the potential to be released in the environment and interact with aquatic organisms and potentially cause toxic effects. The objective of this study is to use an aquatic test model (fish embryo test, FET, OECD TG 236) to assess the toxicity of cadmium-based ENPs (CdSe/ZnS/PEIEPoxy) used in LCD screen and released to liquid media through different treatments (not weathered, sonicated and sunlight simulator). Relevant outcomes will be measured in the embryos (cadmium uptake, viability, deformities, enzyme activity, and gene expression). This study has the potential to increase our understanding of the toxicity risks of cadmium-based ENPs in aquatic organisms under environmentally relevant exposure conditions.

**MP097** Impact of wastewater borne TiO2-ENP on plant uptake of heavy metals
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The presence of contaminants including, heavy metals, hormones, and PPCPs in Wastewater (WW), are harmful to the environment and human health. Engineered nanoparticles (ENPs) have also been detected recently in WW and could have interactions with contaminants in soil-water systems affecting contaminants translocation. Titanium dioxide (TiO2) could reduce their mobility and uptake of heavy metals by plants. Therefore, this research aimed to study the interaction between TiO2-ENPs, a type of nanoparticles commonly-used in industries and reported in effluents and heavy metals in wastewater. A field lysimeter study was conducted for two years (2017 and 2018) to investigate the impact of TiO2 on the mobility of heavy metals and emerging organic contaminants on potato plants in field lysimeters. Potatoes were grown in sandy soil under controlled conditions and irrigated with WW with/out NPs. The synthetic WW contained organic contaminants and heavy metals (Cd, Zn, Cu, Fe, Pb, and Cr). Potatoes were harvested and heavy metals in edible parts of the potato plant (flesh and peels) and root were determined using ICP-MS. In 2017, the concentration of Cd in potato flesh were WW- 1.5 μg/g, WW+NP- 0.45 μg/g, and in 2018 were WW- 5.3 μg/g, WW+NP- 3.04 μg/g. In 2017, the concentration of Cd in potato peel were WW- 7.84 μg/g, WW+NP- 1.5 μg/g, and in 2018 were WW- 59.3 μg/g, WW+NP- 21.29 μg/g. Similar trend was observed for the root; in 2017 the concentrations were WW- 121.1 μg/g, WW+NP- 64.7 μg/g, and in 2018 were WW- 204.31 μg/g, WW+NP- 106.99 μg/g. The results in two years were similar, and indicated that presence of TiO2 NPs at the levels of 100 mg/L significantly reduced (P<0.05) plant uptake of Cd, Cu, and Zn, but there was no significant effect of on Cr, Pb and, Fe.

**MP098** Characterizing the effects of engineered nanoparticles released from painted surfaces due to weathering, in zebrafish (Danio rerio)
K. Mittal, McGill University / Natural Resource Sciences; A. Rahim, McGill University / Civil Engineering; S. George, McGill University / Food Science and Agricultural Chemistry; S. Ghoshal, McGill University / Department of Civil Engineering; N. Basu, McGill University / Faculty of Agricultural and Environmental Sciences

Engineered nanoparticles (ENPs) are used in the manufacture of industrial and consumer products to enable or enhance specific functions. Titanium dioxide (nTiO2) and silver (nAg) are among the most common nanoparticles (nps) used in paint for their whitening and anti-microbial properties. Such nps from outdoor painted surfaces may be released to aquatic systems due to weathering processes, though little is known about the fate, exposure, and toxicity of the released particles. Recently, there has been great interest in ecotoxicology in the development of alternative testing systems to examine the toxicity of such emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants. The objective of this study is to use two alternative aquatic testing systems to examine the toxicity of emerging environmental contaminants.

**MP099** Interaction of dietary nanoparticles with human salivary proteins: Profiling protein corona and alteration in structure and function of vital enzymes
S. George, McGill University / Food Science and Agricultural Chemistry; D. Srinivasan, McGill University Faculty of Agricultural and Environmental Sciences / Food Science and Agricultural Chemistry

Nanotechnology offers unprecedented benefits in improving the organoleptic characteristics and safety of food. Consequently nanoparticles (NPs) are copied incorporated into different food products and food contact materials. While entry of NPs through oral route is inevitable, their interaction with salivary proteins and its potential influence on
structure and function of salivary enzymes are largely unknown. We studied the profile of salivary proteins found on the surface of saliva. Specific proteins such as food-grade silicon dioxide (SiO2), titanium dioxide (TiO2) and silver (Ag). Analysis of the protein corona composition was carried out by employing 1D gel electrophoresis and LC-MS/MS. Several proteins with vital functions in digestion and host protection were found to be enriched on the surface of particles. For instance, Lysozyme, Lactoferrin, Apolipoprotein B100 & E, and Annexin A2 were the most enriched proteins on NPs of SiO2. In order to verify if the binding of proteins have any effect on their function, we tested the amylase and lysozyme activities of saliva in the presence and absence of NPs of SiO2 and TiO2. The substrate affinity for α-amylase was found to be significantly reduced when they were interacted with NPs of SiO2. The SiO2 NP-α-amylase and SiO2 MP-α-amylase complex exhibited non-competitive and competitive type of inhibition, respectively. Far-UV Circular Dichroism studies and FTIR Spectroscopy revealed conformational changes in the 2D structure of proteins. Overall, our study, identified salivary proteins involved in the protein corona of dietary particles and showed that vital functions of saliva such as digestion and antimicrobial properties could be partially affected by protein-NP interactions in saliva.

MP100 UV-induced toxicity of nano-enabled azoxystrobin on zebrafish embryos and larvae

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The use of nanotechnology to enhance pesticide formulations holds the promise of reducing pesticide use, decreasing mobility in soils and overall improvements in agricultural practices while simultaneously maintaining yields. However, the toxicity of nano-enabled pesticides, including azoxystrobin, has not been well studied compared to their conventional formulation counterparts. This study investigates both lethal and sub-lethal endpoints in zebrafish embryos/larvae up to 120 hours post fertilization (hpf) under laboratory light or simulated UV light. The median lethal concentration (LC50) value of nano-enabled azoxystrobin was significantly lower than the conventional form counterparts and UV light significantly decreased LC50 values of both types of azoxystrobin. Malformations including pericardial edema, yolk sac edema, and spinal curvature were not observed during the exposure but the remaining yolk sac volume was significantly higher in both types of azoxystrobin at 120 hpf at both light conditions. This is partially in agreement with the metabolic result, which demonstrated co-exposure of nano-enabled azoxystrobin and UV light significantly decreased oxygen consumption rate. The co-exposure of conventional azoxystrobin at 100 μg L-1 and UV light significantly upregulated sodl, sod2 and gpx1b expression and both types of azoxystrobin significantly reduced gpx1a expression. Catalase enzyme activity was only increased by nano-enabled azoxystrobin at 100 μg L-1 while superoxide dismutase activity was significantly reduced by co-exposure of UV light and either type of azoxystrobin at a nominal concentration of 100 μg L-1. Lipid peroxidation was significantly increased in nano-enabled and conventional azoxystrobin at 100 μg L-1 under laboratory light and UV light induced a higher level of lipid peroxidation due to the generation of hydroxyl radical by UV light. This study will provide much-needed data of acute and medium-term hazards of nano-enabled and conventional azoxystrobin used in agriculture, demonstrate the importance of environmental factor (e.g. UV light) affecting the results of ecotoxicity study and help improving current regulatory guidelines on nano-enabled pesticides in more ecologically relevant conditions.

Contaminant Issues in Waste Streams

MP102 Chlorinated paraffins and organophosphorus flame retardants in automobile shredder residues from an end-of-life vehicle recycling facility in Japan

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Short-chain chlorinated paraffins (SCCPs) and certain brominated flame retardants (BFRs) were listed as Persistent Organic Pollutants (POPs) for elimination in the Stockholm Convention. Within Japan, domestic regulations on the production and import of the SCCPs and POP-BFRs entered into force in response to the convention and consequently the application of alternative medium-chain chlorinated paraffins (MCCPs) and organophosphorus flame retardants (OPFRs) in polymeric materials has increased. However, emerging concerns are being raised about overall persistence and long-range transport potential of certain MCCPs and OPFRs. In Japan, approximately three million of end-of-life vehicles (ELVs) have been collected and recycled properly every year since 2005 under the Law for the Recycling of End-Of-Life Vehicles. Automobile shredder residues (ASRs), which mainly consist of plastics, polyvinyl chlorides (PVCs), rubbers, polyurethane foams (PUF), fabrics and fibers, textiles, glasses, and metals remained after removing valuable rubber and metal fractions.
and reusable materials from ELVs, are required to be recycled instead of landfill due to shortage of final disposal sites. Information on levels and behaviors of CPs and FRs in ASRs is crucial to avoid indoor exposure and for planning appropriate measures for their emission control during ASR recycling. There is a report on levels and destruction behaviors of several BFRs in ASRs during their thermal treatment, nevertheless no definitive information exists for those of CPs and OPFRs in ASRs. We investigated the levels and behaviors of CPs and OPFRs in six ASR fractions after several sorting processes, such as air classification, magnetic separation, and float/sink separation in an ELV recycling facility in Japan. SCCPs were detected in the ASR samples with concentration ranges from 1.7 to 7.7 mg/kg. The levels of SCCPs in the ASR samples were lower than the Basel Convention provisional low POP content value of 100 or 10,000 mg/kg. MCCPs and OPFRs were also detected in the ASR samples with concentration ranges from 54 to 260 mg/kg and 14 to 870 mg/kg, respectively. The levels of MCCPs in the ASR samples were at least one order of magnitude higher than those of SCCPs. The highest concentrations of SCCPs and MCCPs were found in the heavy fraction containing mainly PVCs and rubbers, whereas those of OPFRs were found in the light fraction containing mainly PUFs.

MP103 Distribution of Bisphenol A (BPA) and 5 BPA Analogues in the Solid and Liquid Waste Streams of a Secondary Wastewater Treatment System
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The decision by various regulators to phase out certain uses of bisphenol A (BPA) has led to its gradual replacement with an increasing number of bisphenols. A number of these bisphenols are being detected in different components of the environment. Given that these bisphenols are often analogues of bisphenol A with small structural modifications, they also show estrogenic activity and some are more potent estrogens than BPA. In this study, a method for quantitative determination of BPA and five BPA analogues (BBP, BPE, BPF, BPS, and BPAF) was developed and applied for influent/effluent and biosolid samples from a secondary wastewater treatment plants (WWTP) in Canada. BPA and all five BPA analogues were detected in at least one of the three matrices studied. BPA and Bisphenol S (BPS) were detected in all the samples analyzed. BPE was mainly detected in effluent samples, whereas Bisphenol AF (BPAF) was predominantly detected in biosolid samples. Bisphenol F was detected in influent and effluent matrices but was not detected in biosolid samples. The highest concentration of bisphenol in the aqueous waste stream was detected for BPS (852 ng/L), followed by BPA (560 ng/L), BPE (365 ng/L), BPF (100 ng/L), and BBP (4.3 ng/L). In the solid waste stream, the highest concentration was detected for BPA (3,977 ng/g, BPS (852 ng/L), followed by BPA (560 ng/L), BPE (365 ng/L), BPF (100 ng/L), and BBP (4.3 ng/L). In the solid waste stream, the effect of sample storage on data quality will also be discussed in relation to the biodegradation of these analytes in WWTP samples.

MP104 Abatement of Amoxicillin, Ampicillin, and Chloramphenicol from Aqueous Solutions Using Activated Carbon Prepared from Grape Slurry
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Pharmaceuticals are widely used in human and veterinary health. Residues of pharmaceutical compounds have been reported to be present in biological samples and environmental matrices globally. The occurrence of pharmaceuticals has been linked to many global health and ecological issues. As much as 60-80% of the orally administered doses may remain un-metabolized, and are excreted through sweat, urine and faeces. They therefore reach water and other environmental compartments through releases from various sources including domestic, agricultural and industrial discharges. Water is essential to sustain life, but its deterioration in quality and quantity is increasing pressure on water resources globally. The need to explore possible wastewater reuse is now a necessity globally. The adsorption of amoxicillin (AMX), ampicillin (AMP), and chloramphenicol (CHLR) from simulated antibiotic-contaminated water using adsorbents prepared from grape slurry waste is studied. Batch adsorption experiments are carried out to evaluate the adsorption capacity of the adsorbents for AMX, AMP, and CHLR. Adsorption isotherms are described by the Langmuir and Freundlich isotherms, while the pseudo-second order kinetics describe the sorption processes. Negative values of the enthalpy change show that the sorption processes are exothermic, and the positive values of the Gibbs free energy change indicates non-spontaneous but feasible nature of the adsorption. The study shows that grape slurry waste could be a good precursor to prepare effective adsorbents for the remediation of antibiotic-contaminated wastewater.

Challenges in Characterizing Exposures to Organic Chemicals: Multiple Sources, Multiple Pathways and Multiple Scales

MP105 A new database and preliminary QSARs for environmentally relevant biodegradation half-lives
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Evaluating the thousands of chemicals in commerce at a global scale for their potential hazards and risks to humans and the environment presents many challenges. Environmental biodegradation half-lives are important parameters for performing chemical hazard and risk assessments. For instance, in Canada a chemical is considered “P” in water if its degradability half-life is in water is >182 days. Chemical half-lives in air, water, soil and sediment are also required input parameters for multimedia fate models, e.g., EUSES, RAIDAR, CalTox, ACC-Human, etc. which are routinely used for environmental fate and exposure and risk estimation. These models require reliable input parameters to give reliable calculations, which is a challenge because there is a paucity of environmental biodegradation half-lives for relevant chemicals in commerce. Quantitative Structure Activity Relationships (QSARs) for predicting environmental biodegradation half-lives from chemical structure are also quite limited. To help address these challenges, here we summarize the development of a new database of environmental biodegradation half-lives, focusing on water as a starting point, including information collected from publicly available sources. The database includes empirical estimates as well as professional expert judgment values. The half-lives in the database span about 5 orders of magnitude and represent a diverse range of chemical classes and structures. Using the database, preliminary QSARs are developed and tested following the “OECD guidelines on the Validation of (Q)SAR Models.” Recommendations for improving the database and QSARs are provided.

MP106 A robust, sensitive, and fast method to determine illicit drug and cannabis metabolites for wastewater based epidemiology studies
E. Aydin, AGAT Laboratories, Ltd / Ultra-trace Organics

In this study, we developed a robust measurement method to monitor cocaine metabolites (benzoylcegonine, and cocaethylene), heroine metabolites (morphine and 6-acetylmorphine), codeine, MDMA, methamphetamine, amphetamine, LSD and its metabolite (2-oxo-3-hydroxy-LSD), fentanyl and its metabolite (norfentanyl), and cannabis metabolite 11-nor-9-carboxy-A9-THC (THC-COOH) in wastewater for wastewater based epidemiology (WBE) studies. Among target compounds, the most challenging to measure was THC-COOH. High matrix effect brought elevated uncertainties from instrumental analysis (lower recovery, higher variation, and higher detection limits). This is a common problem for THC-COOH analysis in wastewater. Therefore, there is a demand for a robust measurement method of THC-COOH with lower...
For decades, Environment and Climate Change Canada (ECCC) has employed monitoring programs for known and potential chemicals of concern. Because of extensive data gaps on chemical use, release, fate and transport in the Great Lakes ecosystems, and exposures and potential risks to a myriad of ecological receptors (e.g., plants, invertebrates, fish and wildlife), it is not technically possible nor feasible to measure all of the anthropogenic chemicals released to the Great Lakes. Mass balance exposure and risk-based models can be used to estimate concentrations and the potential for deleterious effects to the Great Lakes ecosystems and humans. Furthermore, mass balance models can provide understandings for key processes affecting the concentrations in the environment and exposures to receptors, as well as provide estimates for times for recovery from unacceptable levels of contamination and guidance for source mitigation. In turn, models can be evaluated using monitoring data. Combined, these complementary data sources can identify and reduce potential risks to the health of the Great Lakes ecosystems. The Risk Assessment IDentification And Ranking (RAIDAR) model is a screening-level tool that combines user-supplied information on chemical emissions and chemical properties (e.g., partition coefficients, medium-specific half-lives) with a mechanistic description of chemical phase distribution, inter-media transport and degradation processes to calculate concentrations in air, water, soil and sediment of a default generic regional-scale (100,000 km²) environment. RAIDAR uses the predicted concentrations in the physical environment to calculate intake rates and exposure concentrations in a range of ecological receptors (e.g., plants, invertebrates, fish, birds and mammals) comprising aquatic and terrestrial food webs. The chemical intake rates and biological concentrations can then be compared with toxicity data, which can be entered included in the model, for screening-level risk estimates. In this project we parameterize and apply the RAIDAR model to demonstrate how it can be used to address data gaps and provide holistic exposure and risk-based information to aid decision-making for chemicals entering the Great Lakes ecosystems. The framework is applied here as a case study for polybrominated diphenyl ethers (PBDEs).

MP108 Biomonitoring, toxicological and stakeholders’ environmental risks knowledge evaluations at a sawmills-impacted site on the Lagos lagoon, Nigeria
T.O. Sogbamu, O. Faremii, University of Lagos / Department of Zoology

The Lagos Lagoon receives direct inputs from sawmills at the Okobaba hub among other anthropogenic influences. The study aim was to evaluate the potential effects of sawmill activities on species diversity and biomarkers in common macroinvertebrates and fish species at the Okobaba hub of the Lagos lagoon, Nigeria. Also, stakeholders’ environmental risk perception was investigated. Six (6) stations (3 stations each around the test (Okobaba) and reference (Beyond Third Mainland Bridge - BTMB)) sites were sampled. A cross-sectional questionnaire was administered to stakeholders from which data were gathered from 123 respondents. Most of the surface water physicochemical parameters at the test site were higher than the reference and Federal Ministry of Environment set limits. A total of 193 fishes (109 fishes at the reference and 84 fishes at the test site) comprising of 11 species were identified. 53 macrobenthos of 6 species were identified at the control site while none were found at the test site. Dominant fish species identified at the test and reference sites were Caranx hippos (Cravelle jack) and Sarotherodon melanotheron (Blackchin Tilapia) respectively. Histological evaluations showed mild lamellar necrosis and hepatic necrosis in the gill and liver of the dominant fish, C. hippos from the test site while the control was normal. The biochemical evaluations showed a significant difference (p<0.05) in malondialdehyde and reduced glutathione activities in C. hippos sampled from the test site compared to the reference site. The analysis of the questionnaires showed that the frequency of catarrh ranked first with 43.1% as the health symptoms common among the residents, 46.3% account for improper waste disposal as the major cause of the Okobaba waterbody pollution and 66.7% of the respondents agree that sawmill wastes are disposed off by burning while the residue run off into the lagoon. The results revealed the impacts of sawmilling wastes especially in fishes as well as its potential effects on the health of the residents of Okobaba environs. Further studies on human health risk assessment are recommended to enable evidence-informed decision making on the appropriate interventions to safeguard fisheries and human health.

MP109 Characteristics of giant-Miscanthus-biochar derived DOC extracted from methanol-water mixture and water
C. Kim, S. Hyun, Korea University / Department of Environmental Science and Ecological Engineering

When biochar is applied to soil, biochar-induced dissolved organic carbon (biochar-DOC) can affect the mobility of hydrophobic organic contaminants (HOCs). The sorption of biochar-DOC is related to its physico-chemical properties such as, hydrophobicity, functional groups. Organic solvent such as methanol can be introduced in aqueous solution, and affects DOC extraction. However, characteristics of biochar-DOC in these system are unknown. In this study, biochar-DOC was isolated from aqueous solution and cosolvent and analyzed for characteristics. Giant-Miscanthus derived biochars (GMBs) were produced by various pyrolysis temperature from 400, 500, 600 and 700 °C (GMB-400, GMB-500, GMB-600 and GMB-700 respectively). DOCs were extracted from GMBs and farm soil was extracted with 10mM CaCl2 and methanol volume fractions (f) of 0-0.6, and were quantified using a TOC analyzer. The functional group of biochar-DOC was analyzed by Fourier-transform infrared spectroscopy (FT-IR). The biochar-DOC concentrations in aqueous solution were higher than farm soil-DOC, except for GMB-700. Biochar-DOC concentration decreased with increasing pyrolysis temperature, that is related to degree of carbonization. High carbonization at high pyrolysis temperatures increase stabilized carbon, which causes a decrease in DOC concentration. For all samples, DOC concentrations in cosolvent system were lower than aqueous solution. As a result of FT-IR analysis, GMB-400 derived DOC observed carboxylic C in aqueous solution (1600-1660cm⁻¹) and aromatic ether in cosolvent system (1030-1070cm⁻¹), which means that hydrophobicity of cosolvent extractable biochar-DOC was more than water extractable biochar-DOC. This study
shows that 1) biochar-DOC concentration was related pyrolysis temperature and hydrophobicity of solvent, 2) functional group of biochar-DOC is determined by hydrophobicity of solvent. Therefore, the mobility of HOCs by cosolvent extractable biochar-DOC might be more than water extractable biochar-DOC.

**MP110 Comparative Potency Estimates of an Expanded List of PAHs from a Community and Facility Fenceline Air Sampling**

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There are few ambient air measurements of extended (beyond EPA Priority 16) lists of polycyclic aromatic hydrocarbons (PAHs), pollutants useful in source identification and significant contributors to cumulative inhalation cancer potency. We present the findings from comparative potency estimates from the results of a multi-year ambient air sampling study with a comparisons of mixed source, refinery, shingle manufacturers, and traffic. The cancer potency estimates were reported from both the straight 95% upper confidence limit of the mean and these results normalized by the percent of hours in the sampling period that the wind direction was from the source of interest. Below detection limit values were imputed based on regression on order statistics. Gas phase PAH concentrations were collected on XAD-4 and particulate phase collected as total suspended particulate on quartz fiber filters, and these results are based on the sum of the two physical phases. Potency was estimated for the entire suite of PAHs, the EPA-16, the EU-15, the EU-7 (ambient air), an estimate of potency from a scaling of Benzo[a]pyrene, and the IARC PAHS. Air concentrations were adjusted using Benzo[a]pyrene (BaP) equivalent relative cancer potency factors to estimate cancer potency equivalents. All cancer potency estimates were based on the WHO relative potency factors (check this) and the EPA IRIS inhalation unit risk factor. Benzo[c]fluorine (BeF) contributed the largest portion of the cumulative inhalation potency equivalence. Dibenzothiophene sulfone (DBTS) was a mass interferent in BeF measurement, and therefore included in the analyte list and is recommended for reporting BeF. Normalizing wind direction for risk estimates is one way of better understanding the impact of a cumulative PAH mixture from a specific source. We found a large impact of meteorological normalization for the traffic site and the refineries, but less informative for the refinery site and the mixed source sites, resulted in approximately half of the risk estimate than if BeF is included. The highest source types for BeF were traffic and the mixed source sites, and is recommended for reporting BeF.

**MP111 Determining Environmental and Individual Gestational Exposure Profiles of Healthy and Dysphagic Foals**

B.N. Rivera, Oregon State University / Environmental and Molecular Toxicology; K.R. Mullen, Littleton Equine Medical Center; L.G. Tidwell, Oregon State University / Environmental Molecular Toxicology; D.M. Ainsworth, Cornell University / Department of Clinical Sciences; S.C. Tilton, K.A. Anderson, Oregon State University / Environmental and Molecular Toxicology

Over the past two decades, there has been a rapid expansion in natural gas drilling in the United States. Shale gas made up 40% of U.S. gas production in 2012, compared to 2% in 2000, and is projected to grow fourfold by 2035. Exposure to natural gas drilling-related chemicals can occur through multiple exposure pathways, including water, soil, and air. A growing body of evidence suggests unconventional natural gas extraction emissions increases risk of adverse health effects in individuals who live less than 0.5 miles from an unconventional well. To assess for potential risks associated with this exposure, animals serve as ideal sentinels for humans since they are exposed continually and have shorter lifespans. In this study, foals at a location with an unconventional well within 0.25 miles, and another 5 within a 2.5 mile radius, had a high incidence of dysphagia (tracheal milk aspiration) compared to foals, bred by the same owner, in an area without active drilling, that never displayed signs of dysphagia. Consecutive sampling was conducted (Dec. 2014-Jul. 2016) to investigate an association between exposure profiles and health outcomes. Halter samplers applied to the dams, capturing individual exposure; and stationary well water and air samplers were used to identify potential routes of exposure associated with unconventional drilling. Analysis of well water samplers identified differences in polycyclic aromatic hydrocarbon (PAH) profiles between the two locations. PAHs with 3 or more rings were higher in the area with active drilling, and 2 ring PAHs were higher in the area not active in drilling (p<0.05). After the installation of a water treatment system at the active drilling location, a decrease in concentration of PAHs with 3 or more rings was reported. During this time, a significant decrease in incidence of dysphagia also occurred from 41% to 13% (p=0.04). Comprehensive foal health assessments identified duration of time the dam spent at the location near the unconventional drilling (odds ratio OR=1.41, 95% confidence interval CI 1.16, 1.71, p=0.0006 for each additional month of gestation spent at this location) and male gender (OR=5.47, 95% CI 1.22, 24.49, p=0.03) as risk factors for dysphagia. Future studies are needed to quantify PAHs and metabolites in biologic samples, identify a toxicopathological mechanism of dysphagia, and establish long term health risks for humans and animals living near active drilling.

**MP112 Developing AI forensics tools for chemical source tracking**

E. Dávila-Santiago, G.D. Jones, B.M. Medeghini, Oregon State University / Biological and Ecological Engineering

Water bodies are chemical data loggers that contain tens of thousands of chemicals that are derived throughout a watershed. While many compounds are widespread and are derived from multiple sources, we hypothesize the distribution of chemicals across the landscape is not random. Instead, different sources are expected to contain highly unique suites of chemicals or chemical ratios. Our aim is to extract non-polar organic compounds from both water samples at/near pollution sources, and then use high-resolution mass spectrometry (HRMS) data in conjunction with machine learning tools to identify the non-target chemicals that are diagnostic of each source. If these diagnostic chemicals, or chemical fingerprints, are detected in environmental samples, we can unequivocally identify their original sources. Grab samples were collected and analyzed in triplicate from different sources including headwater streams and run-off from urban, suburban, industrial surfaces, and agricultural sources. Preliminary data from artificial intelligence models indicate that each sample can be correctly identified with near perfect classification based on its chemical composition. These algorithms also show that highly similar water samples are readily distinguishable. In degraded ecosystems, where pollution sources are unknown or multiple sources exists for a given contaminant, this tool can help managers identify the most likely sources, which will help direct limited resources to projects that maximize water quality improvements.

**MP113 Developing and applying tools for high-throughput human health safety assessment**

J.A. Arnot, ARC Arnot Research & Consulting; L. Li, University of Toronto, Scarborough / Department of Environmental Sciences; F. Wanga, University of Toronto, Scarborough / Department of Physical and Environmental Sciences; R. Becker, American Chemistry Council

Humans are exposed to chemicals from various use scenarios and often multiple exposure pathways including near-field (direct applications and indoor fate) and far-field (via multimedia including food and water). Ratios of exposure and hazard data are required to assess the safety and potential risks of chemicals used in society. The exposure and hazard values should be aligned such that the values being compared are relevant,
appropriate and in equivalent units. The Threshold of Toxicological Concern (TTC) is an approach that has been used for exposure-based waiving and chemical safety assessment in various regulatory agencies such as Health Canada and the European Food Safety Agency. Current TTC data are expressed as an oral intake rate (e.g., mg/kg/d) corresponding to external exposure. However, for many chemicals aggregate exposure can occur from multiple portals of entry to the body; therefore, using such an external exposure TTC may not always be appropriate. Here we outline a new tiered approach for developing internal TTC (iTTC; µmol/L-blood) values that can be applied more broadly in chemical hazard and safety assessment. We apply the first tier of this method as a case study for 95 organic chemicals. Parameterizing and applying a physiologically-based toxicokinetic model, we convert the traditional oral intake TTCs for Cramer Class I, II and III and for acetylcholinesterase inhibition to unique steady-state blood concentrations. These blood concentrations are unique iTTCs for the individual chemicals. We then use a new holistic modeling framework, comprising a substance flow model (a modified version of CIP-CAFE) and chemical exposure models (RAIDAR and RAIDAR-ICE) to simulate the steady-state human blood concentrations resulting from aggregate exposures. The exposure modelling framework predicts human blood concentrations from only two parameters: chemical structure and production volume. The model predicted blood concentrations are shown to be in reasonable agreement with inferred blood concentrations derived from the US population (R2 = 0.5; 66/95 chemicals predicted < 1 order of magnitude of inferred blood concentrations). The modelling framework estimates margin of safety as ratios of chemical-specific iTTCs and predicted steady-state blood concentrations. Margins of safety estimates for the 95 case study chemicals span approximately 8 orders of magnitude demonstrating the capacity of the system for screening and prioritizing large numbers of chemicals for human health assessment. Merits and limitations are outlined to provide a path forward for further developing and applying the tools and data for chemical hazard and safety assessment.

MP114 Distribution and concentrations of pharmaceutical and personal care products (PPCPs) within cattails (Typha latifolia) as function of exposure time

D.J. Perez, INTA / Agronomy; M. Menone, Universidad Nacional Mar del Plata / Lab de Ecotoxicologia; W.J. Doucette, Utah State University / Utah Water Research Laboratory

The passive uptake of organic contaminants such as PPCP by plants is well documented. Uptake is often quantified and reported as concentration ratios between whole plants or specific plant compartments (e.g. roots, shoots, leaves, fruit) and the exposure media (e.g. soil, air water). The ratios may also be normalized to the amount water transpired by the plant or to lipid content of the plant tissue. However, there have been relatively few studies that have investigated the changes in concentrations among the various plant tissue compartments over time. Using hydroponically grown cattails (Typha latifolia) exposed to four PPCPs (carbamazepine, fluoxetine, gemfibrozil, triclosan) at environmentally relevant concentrations near 20 µg/L, the uptake and distribution of these compounds within the plants were evaluated at several time periods over a 42 day growing period. Thirty-six plants of uniform size were selected, eighteen exposed to the target PPCPs and eighteen untreated. Two unplanted, unexposed controls were also used. A nutrient solution containing the target compounds was used to replenish water lost to transpiration and maintain a consistent exposure environment (static exposure bioassay). Root zone samples were collected over time to determine the average exposure concentration. Whole plants were harvested at days 7, 14, 21, 28, 35 and 42 days. Concentrations of PPCPs in the exposure solution and various plant tissues were determined by direct injection LC-MSMS or after extraction, concentration and cleanup. Carbamazepine, fluoxetine, gemfibrozil and triclosan were detected in all underwater tissues (roots, rhizome, etc.) and above water tissues, except gemfibrozil which was not detected in shoots. Carbamazepine concentrations were highest in the upper leaves in the plants exposed for the longest time. Concentrations in the below water tissues were 30-40 times lower than the upper leaves and did not vary significantly with time. Above water tissue concentrations for fluoxetine were highest in the lower leaves and similar to the concentrations in the below water tissues. Triclosan concentrations were greatest in the roots and were about 50 higher than those found in the leaves. Overall, the results show that the root uptake, translocation and distribution within the plant tissues varies with the physical chemical properties of PPCP and longer exposures result in higher leaf concentrations for those compounds that are translocated from root to shoot. For compounds that are readily translocated from roots to shoots, the large differences in tissue concentrations could have important implications in risk assessment and biomonitoring applications.

MP115 Evaluating the RAIDAR-ICE model with monitoring and biomonitoring data from Europe

J.A. Arnott, ARC Arnott Research & Consulting; L. Li, University of Toronto, Scarborough / Department of Environmental Sciences; K. De Brouwere, VITO NV / Health; L. Geerts, VITO NV; M. Lamoree, VU University, Department Environment & Health / Department Environment & Health

Humans are exposed to a wide variety of chemicals that originate in “near-field” environments (i.e., indoors) as a part of building materials, consumer goods and articles, and products used daily, e.g., household products, personal care products. Measured data are emerging through various monitoring and biomonitoring projects and programs. For example, the Cefic-LRI SHINE project is conducting targeted and non-targeted analyses of dust and air samples in indoor environments coupled with a literature review for biomonitoring data for the target chemicals (e.g., flame retardants, pesticides, plasticizers). Mechanistic, mass-balance, multi-media models serve as powerful tools to understand important exposure pathways and to predict exposures in the absence of measured data for human health assessment. Such models that link external exposures with internal exposures can also be used to integrate monitoring data (air, dust, surface concentrations) with biomonitoring data (blood, urine). There is a need to test (evaluate) exposure models to foster confidence in their application in regulatory programs in both data rich and data poor contexts. The Risk Assessment IDentification And Ranking - Indoor and Consumer Exposure (RAIDAR-ICE) model combines an indoor fate model with a toxicokinetic model to simulate chemical exposures from direct (e.g., personal care products) and indirect (e.g., vaporization of chemicals from building materials) sources of chemicals. It simulates human exposure from the near-field environment through inhalation of indoor air, dermal absorption, non-dietary object-hand-mouth contact. Here we evaluate RAIDAR-ICE with monitoring and biomonitoring datasets from Europe for a range of chemicals, including new data obtained in the SHINE project. The case study chemicals comprise a broad range of use categories, partitioning properties, and biotransformation half-lives.

MP116 Evaluation of Metastatic Pathway Inhibition by Novel Ruthenium -based Metallodrugs using the Zebrafish Model

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Cancer progression into metastasis is an incredibly complex, multi-step process that is the major cause of cancer-related deaths. Targeting this cancer phenotype would result in decreased mortality. However, therapeutic efficacy is difficult to evaluate in vitro due to the complex nature of metastasis. The widely accepted model of testing metastasis is immunosuppressed nude mice, but the field agrees there are limitations
MP117 Identification and Quantification of Chemical Constituent Losses during Fine Particulate Matter Filter Extraction for Toxicology Research

C. Roper, Oregon State University / Department of Environmental and Molecular Toxicology; E. Weeks, Oregon State University / L.S. Trine, Oregon State University / Chemistry / Environmental and Molecular Toxicology; D. Barrett, Oregon State University / Department of Environmental and Molecular Toxicology; S. Simonich, Oregon State University / Dept of Chemistry and Environmental Molecular Toxicology; R.L. Tanguay, Oregon State University / Sinnhuber Aquatic Research Laboratory and the Environmental Molecular Toxicology

Fine particulate matter (PM2.5) exposures are complex mixtures that vary in concentration and composition resulting in differential human health effects. To better understand the known adverse health associations, toxicology studies are frequently conducted using filter collected PM2.5. However, the methods of filter extraction have significant impacts on both the chemical composition and subsequent toxicity of PM2.5 samples. We set out to optimize a previously used filter extraction method for PM2.5 toxicology research by quantifying chemical constituent losses throughout the steps of sample processing, including filter extraction and preparation for toxicology studies. For PM2.5 collected from different sources (n=3), Four different points during the sample processing were analyzed for polycyclic aromatic hydrocarbons (n=18) and elements (n=75) via gas chromatography-mass spectrometry and inductively coupled plasma optimal emission spectrometry, respectively; the points during extraction were following: sonication, concentration, drying, and re-suspension in a media amenable to toxicity testing (DMSO). Concentrations of chemical constituents at the various points in the sample preparation process were compared to constituent concentrations using standard extraction methods for characterization of ambient PM2.5. Significant differences were observed between the preparation steps in concentrations of PAH classes, individual compounds, and spiked surrogate compounds. Elemental data and differences based on the sources of PM2.5 are currently being analyzed to ultimately optimize sample processing of filter collected PM2.5 for toxicology studies.

MP118 Introducing a Nested Exposure Model for organic contaminantants (NEM): Part 1. The physical environment

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Persistent Organic Pollutants (POPs) and some other organic contaminantants have achieved global distribution. Yet, most empirical studies have a more restricted geographical scope (e.g. focus on a specific country or jurisdiction), and/or cover time-periods shorter than the contaminantants’ potential lifetime in the environment. This calls for regional modelling strategies that are global in context, yet dynamic, reflecting both the possible mobility and lifetime of relevant contaminantants in the physical environment. Our Nested Exposure Model (NEM) reflects the hypothesis that accurate predictions of organic contaminant exposure calls for increasing resolution with increasing proximity to a study region of interest. The description of contaminantate fate in the physical environment within NEM builds upon two existing dynamic (time-variant) fugacity-based multimedia models, BETR-Global and Co2Mo-POP 2, which describe organic contaminant fate in multiple compartments representing the physical environment. Unlike those models, NEM is a nested model. Through nesting up to five different model domains, NEM offers increasing resolution with increasing proximity (in space and time) to a study region of interest. Chemical transport between neighboring grid cells may occur by air, fresh water and seawater. Through sequential simulations, chemical inflow from the outside world into the next user-defined domain of NEM is based on model outputs stored from simulations of the preceding domain. We illustrate the utility of the model with a case study of the Nordic region, including remote Arctic areas such as Svalbard.

In order to expand the utility of the model beyond our study, the NEM model is developed such that any user-defined region may be targeted in a similar fashion. This is made possible as spatially and temporally variable environmental input data are derived from global data sets, processed and stored at a spatial resolution of 0.5°x0.5° (latitude/longitude). NEM thereby allows for the evaluation of the impact of variable spatial resolutions on predicted exposures in any region of interest across multiple scales. For example, NEM may offer insights on the merit and possible limitations of using regionalized models to simulate global organic contaminantants.

MP119 Introducing a Nested Exposure Model for organic contaminantants (NEM): Part 2. Bioaccumulation in Arctic Ecosystems

I. Krogseth, Norwegian Institute for Air Research / Environmental Chemistry Department; K. Breivik, NILU - Norwegian Institute for Air Research / Atmospheric and Climate Change Department; F. Wania, University of Toronto, Scarborough / Department of Physical and Environmental Sciences

Persistent Organic Pollutants (POPs) and some other organic contaminantants have achieved global distribution. Yet, most empirical studies have a more restricted geographical scope (e.g. focus on a specific country or jurisdiction), and/or cover time-periods shorter than the contaminantants’ potential lifetime in the environment. This calls for regional modelling strategies that are global in context, yet dynamic, reflecting both the possible mobility and lifetime of relevant contaminantants in the physical environment. Our Nested Exposure Model (NEM) reflects the hypothesis that accurate predictions of organic contaminant exposure calls for increasing resolution with increasing proximity to a study region of interest. The description of contaminant fate in the physical environment within NEM builds upon two existing dynamic (time-variant) fugacity-based multimedia models, BETR-Global and Co2Mo-POP 2, which describe organic contaminant fate in multiple compartments representing the physical environment. Unlike those models, NEM is a nested model. Through nesting up to five different model domains, NEM offers increasing resolution with increasing proximity (in space and time) to a study region of interest. Chemical transport between neighboring grid cells may occur by air, fresh water and seawater. Through sequential simulations, chemical inflow from the outside world into the next user-defined domain of NEM is based on model outputs stored from simulations of the preceding domain. We illustrate the utility of the model with a case study of the Nordic region, including remote Arctic areas such as Svalbard.

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and ringed seal, and is under development to be expanded to key seabird species. The bioaccumulation module was evaluated independently for predicted bioaccumulation of polychlorinated biphenyls (PCBs) across species and time by running the model based on measured or predicted PCB concentration in Arctic seawater and air. Predicted concentrations in biota were compared with available measurements in literature. The bioaccumulation module performed well in reproducing bioaccumulation of PCBs in a Svalbard food web. Predicted time-trends of ΣPCB6 and ΣPCB7 were also in good agreement with measurements from the Barents Sea for all fish species. The good model performance across trophic levels and time is promising for further expansion of the model to include (i) variation in space through connection with the physical module of NEM, and (ii) Arctic marine top-predators, the terrestrial environment, and human exposure. When finalized, we hope that the NEM model will be a useful tool for scientific and regulatory communities interested in understanding and protecting ecosystem and human health from legacy and emerging organic contaminants.

**MP120 Metabolic dysregulation by exposure of organochlorine pesticides mixture in obese zebrafish**

H. Lee, Gyeongsang National University / Marine Environmental Engineering; K. Kim, S. Lee, Seoul National University of Science and Technology / Environmental Engineering

Obesity and exposure to organochlorine pesticides (OCPs) are well-known physiological and chemical contributing factors of type 2 diabetes (T2D). Given that OCPs are lipophilic and well-accumulated in the adipose tissue, effect of exposure of OCPs on the incidence of T2D could be influenced by obesity. However, limited studies have been conducted to elucidate these trade-off roles. In this study, we investigated the different biological response related to T2D incidence on each condition of obesity and chemical exposure, and mixed scenarios in zebrafish. We exposed female zebrafish to 0 (solvent control, 0.1% DMSO) and 0.05 μg/L of OCPs mixture where non-monotonic dysregulation was observed at very low concentrations in our previous study, with dietary control. Obese zebrafish was provoked by feeding high-fat-diet (Gemma micro + chicken egg yolk) for energy imbalance and fat accumulation. After feeding amount and frequency were optimized, the experiment was lasted for 14 weeks in a flow-through system. After the exposure periods, zebrafish were sacrificed and body weight, length, blood glucose, fasting insulin, triglyceride and free fatty acid were measured. For identifying gene expression changes underlying molecular mechanism, the transcriptomic analysis (i.e., RNA-seq) was conducted in the liver tissue. Through this study, we demonstrate that metabolic dysregulation was caused by exposure of OCPs mixture in the obese condition, and we suggest the applicability of zebrafish model to study of metabolic diseases such as T2D or obesity under chemical exposure.

**MP121 Proteome-Wide Effects of Naphthalene-Derived Secondary Organic Aerosol Are Caused by Short-Lived Unsaturated Carbonyls**

J. Han, University of Toronto / Department of Chemistry; S. Wang, University of Toronto / Department of Chemical Engineering and Applied Chemistry; K. Yeung, University of Toronto / Chemistry; D. Yang, University of Toronto / School of the Environment; W. Gu, Chinese Center for Disease Control and Prevention; J. Sun, University of Toronto / Chemistry; A. Chan, University of Toronto / Department of Chemical Engineering and Applied Chemistry; H. Peng, University of Toronto / Department of Chemistry

It is widely recognized that naphthalene contributes largely to global organic aerosol (OA) burden, its adverse health effects is still poorly understood. Here we assessed the proteome effects of naphthalene derived secondary organic aerosol (NSOA) at 6 different aging stages on human airway epithelial cells (BEAS-2B) by quantitative proteomics. Compared with the precursor (C0), 125 proteins were significantly changed in C1 condition, whereas the number of proteins dramatically deceased along with aging (e.g., 12 changed proteins in C6 condition). This result indicated that proteome-wide effects of NSOA were caused by short-lived species produced during chamber reaction. While the majority of proteins were down-regulated by NSOA exposure (e.g., Rho pathways), two Nrf2-pathway proteins (i.e., Noq1, Txnrd1) were significantly upregulated in C1 condition, which was further confirmed by a Nrf2-ARE stably transfected reporter cell line. Consistent with quantitative proteomics results, Nrf2 responses induced by NSOA showed noteworthy elevation (6.38-fold) during the early atmospheric process, but subsequently decreased (66.51%) after a long term of aging. Pre-incubation of NSOA with cysteine significantly decreased the Nrf2 responses (49.98%), indicated that Michael addition to cysteinyi thiol is the major toxic pathway for NSOA. To further identify the exact chemicals responsible for the toxicities, non-targeted analysis was adopted to analyze the chemicals of NSOA lost and produced after incubations with cysteine. Among 151 detected chemical components, only 2 of them, including 1,2-naphthaquinone showed significant decrease. Consistent to this, 5 Michael addition adducts were detected and 4 of them were 1,2-naphthaquinone derived adducts. This study clearly indicated that short-lived unsaturated carbonyls are responsible for the proteome-wide effects of NSOA on BEAS-2B cells.

**MP122 Quantifying Polycyclic Aromatic Hydrocarbon (PAH) Losses During Sample Preparation Steps of Fine Particulate Matter (PM2.5) Filters**

E. Weeks, Oregon State University; C. Roper, Oregon State University / Department of Environmental and Molecular Toxicology; L. Trine, Oregon State University / Chemistry / Environmental and Molecular Toxicology; S. Simonich, Oregon State University / Depts of Chemistry and Environmental Molecular Toxicology

Fine particulate matter (PM2.5) has known adverse health effects in humans and is frequently comprised of compounds that are potential carcinogens, including polycyclic aromatic hydrocarbons (PAHs). Due to the known human health implications, toxicology research is routinely conducted on various types of PM2.5 to better understand the health impacts associated with these exposures. However, the actual chemical composition of PM2.5 in toxicology studies is rarely measured but there are known losses during filter extraction and preparation for toxicology research, resulting in samples not representative of the ambient exposures. Additionally, different research groups use differing methods for PM2.5 filter extraction, increasing the methods bias in this field. We set out to identify the steps during filter extraction that result in the highest losses of PAHs with a surrogate spike and recovery experiment on ambient collected PM2.5 filters. Surrogates represented five classes of PAHs including: Parent (n=7), Hydroxy (n=8), Oxy (n=2), Nitro (n=5), and High Molecular Weight (n=1) PAHs. Three different points in the sample preparation were tested: 1) Extraction - sonication of filter, 2) Concentration - fine blow down by N2 gas, and 3) Clean up - solid phase extraction of the sample prior to analysis using gas chromatography mass spectrometry (GC-MS). In this research the surrogate levels were compared between methods and between steps to target where the highest losses occurred. Preliminary results indicate that there is variability between PAHs and within classes of PAHs in surrogate recovery. Additionally, at all three points of sample preparation there were surrogate losses over 30% indicating the need for further investigation of these techniques. This research highlights the need for optimizing PM2.5 filter extraction methods to provide samples for toxicology research that are more representative of ambient exposures.

**MP123 Moving toward a spatially-resolved global surface water flow and aquatic exposure model for consumer-use down-the-drain ingredients: Japan case study**

S. A. Ciszar, Procter & Gamble Company / Global Product Stewardship; R. Yamshi, Waterborne Environmental, Inc.; M. Fan, K. McDonough, Procter & Gamble Company / Global Product Stewardship

Exposure assessment is a key factor in the environmental risk assessment (ERA) of consumer products that are disposed down-the-drain. The Procter & Gamble Company conducted research, resulting in samples not representative of the ambient exposures. Additionally, different research groups use differing methods for PM2.5 filter extraction, increasing the methods bias in this field. We set out to identify the steps during filter extraction that result in the highest losses of PAHs with a surrogate spike and recovery experiment on ambient collected PM2.5 filters. Surrogates represented five classes of PAHs including: Parent (n=7), Hydroxy (n=8), Oxy (n=2), Nitro (n=5), and High Molecular Weight (n=1) PAHs. Three different points in the sample preparation were tested: 1) Extraction - sonication of filter, 2) Concentration - fine blow down by N2 gas, and 3) Clean up - solid phase extraction of the sample prior to analysis using gas chromatography mass spectrometry (GC-MS). In this research the surrogate levels were compared between methods and between steps to target where the highest losses occurred. Preliminary results indicate that there is variability between PAHs and within classes of PAHs in surrogate recovery. Additionally, at all three points of sample preparation there were surrogate losses over 30% indicating the need for further investigation of these techniques. This research highlights the need for optimizing PM2.5 filter extraction methods to provide samples for toxicology research that are more representative of ambient exposures.

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 explicit aquatic exposure model for down-the-drain ingredients by leveraging the growing availability of computational methods and large spatial datasets. Current models often assume average conditions across a country/region in a deterministic calculation, while, in reality, there can be substantial spatial variation in input parameters (e.g., emissions, per capita water use, and waste water treatment) across a region. While spatial variability has been addressed by some models, they have focused on a single country/region; and there is a need for a user-friendly, global aquatic exposure model on a single platform with a consistent approach, using best available data. The iSTREEm(R) model (American Cleaning Institute) is a spatially-explicit aquatic exposure model parameterized and evaluated primarily for the United States. The model has also been extended to China and evaluation has indicated excellent agreement between modeled and measured river flow data. There was also excellent agreement between case study modeled and monitored chemical concentrations. This platform was leveraged and extended to cover Japan and follows a framework that uses global datasets to estimate river flow on a catchment level, route chemicals between catchments, and estimate catchment-specific concentrations. Each catchment is parameterized with a specific population, per capita water use, and waste water treatment plant (WWTP) information; and allows for spatial variation in emissions. For Japan, spatial locations of WWTPs were incorporated into the model and the resulting population served by WWTP treatment corresponds well with published reports of treatment levels. Direct discharge of grey water was included to represent current practice in some areas of Japan. Measured river flow data and case study chemicals with available monitoring data were used to evaluate the flow predictions and concentration distribution estimates by the model. Thus, this model framework provides a promising platform for expansion as a global aquatic exposure model for down-the-drain ingredients.

Multi-Pathway Exposure to Neonicotinoids and the Implications to Ecological and Public Health

MP124 Toxicity of neonicotinoids to non-target soil invertebrates
K. Pearson, Pennsylvania State University / Entomology; J. Tooker, The Pennsylvania State University / Department of Entomology

In conventional field corn production, it is common practice to coat seeds with neonicotinoid insecticides. These seed coats are designed to target below-ground and early season pests, however, up to 90% of neonicotinoids applied to seeds end up contaminating field soil. Non-target soil invertebrates are likely to come into contact with high doses of these insecticides, yet the risk of neonicotinoids to non-target soil invertebrates is largely unknown. While toxicological assays have been performed for handful of standard test species (e.g. Eisenia earthworms and Folsomia springtails), these species are unlikely to represent the diversity of soil invertebrates. To explore the risk of neonicotinoids to non-target soil invertebrates, we paired field-based pesticide residue analyses with acute toxicity assays. Rather than running assays on standard test species, we ran assays on a suite of ecologically and taxonomically diverse soil invertebrates from the local agroecosystem; species represented non-target herbivores (slugs), saprophages (millipedes and isopods), weed-seed predators (carabid beetles), and invertebrate predators (carabid beetles and wolf spiders). While basic, the results of these assays can be used to explore possible mechanisms behind insecticide-induced shifts in soil invertebrate populations and soil-based functional endpoints.

MP125 Neonicotinoid insecticides in common milkweed and soil next to agricultural fields in Ontario: Potential harmful effects to Monarch butterfly larvae
L. Collins, Trent University / Institute for Watershed Science; T. Sultana, Trent University / Environmental and Resource Studies; C.D. Metcalfe, Trent University / Water Quality Centre

The monarch butterfly (Danaus plexippus) is a species of special concern due to the restricted range of its overwintering habitat, and the negative impacts on population numbers from habitat destruction, climate change and exposure to pesticides. Southern Ontario is one of the most important breeding areas in Canada for the eastern monarch butterfly. This is also an area of intensive agriculture, especially for corn and soybean production. Exposure to neonicotinoid insecticides (NNIs) in intensive agricultural landscapes may play a role in reducing monarch numbers through contamination of the plant species that is favored by the larvae for forage, the common milkweed (Asclepias syriaca). Recent laboratory and field studies show that exposures of monarch larvae to low concentrations of the NNI, chloothionidin reduces larval size and condition. In this study, we sampled milkweed and soils at four field sites in two separate watersheds in southwestern Ontario to assess contamination with NNIs. Samples were prepared for analysis by liquid chromatography with tandem mass spectrometry (LC-MS/MS). The levels of chloothionidin and thiamethoxam in soil samples adjacent to agricultural fields at all sites were very low or below detection limits. Clothianidin and thiamethoxam were detected in the leaves of milkweed collected from sites in southwestern Ontario, but the concentrations were highly variable. The highest concentration of chloothionidin detected in milkweed leaves was 23.9 ng/g dry weight, which is above the reported threshold for sublethal effects in larvae of the monarch butterfly. No NNIs were detected in milkweed leaves collected from a non-agricultural reference site. These data indicate that exposures of larvae of the eastern monarch butterfly to NNIs may play a role in the reduced numbers of this species of special concern.

MP126 Transcriptional responses of yellow perch (Perca flavescens) exposed in vivo to individual neonicotinoid and diamide pesticides, and mixtures
M. Giraudou, L. Mercier, A.D. Gendron, M. Houde, Environment and Climate Change Canada / Aquatic Contaminants Research Division

Neonicotinoid pesticides, including clothianidin, are widely used in agriculture to fight pest insects. Given the upcoming restrictions on neonicotinoid use in Canada, new replacement compounds have been developed and some of them, such as the diamide chlorantraniliprole, are already in use. Despite the efforts put into evaluating the effects of these compounds on the environment, toxicity data on non-target aquatic organisms such as fish are scarce. The yellow perch (Perca flavescens) is an indigenous species of the St. Lawrence River inhabiting macrophyte beds and floodplains and therefore prone to pesticide exposure in agricultural areas. Concentrations reaching up to 100-200 ng/L of clothianidin and chlorantraniliprole have been measured in surface water samples from Lake St. Pierre, Quebec, Canada, where pesticide-treated soy and corn cultures are predominant. Juvenile perch are particularly vulnerable in this area and their exposure to pesticides could partially explain the low recruitment observed in this fluvial lake of the St. Lawrence River where the perch population has collapsed, leading to a fishing moratorium. The goal of this study was to evaluate the effects and modes of action of clothianidin and chlorantraniliprole in juvenile yellow perch chronically exposed in vivo (28 days) to environmental concentrations (200 ng/L) of the two pesticides alone and in a mixture. Hepatic transcriptional responses were measured by RNA-sequencing. Results showed that clothianidin did not affect gene transcription, while chlorantraniliprole deregulated the transcription of 38 genes. When the two compounds were combined, 251 genes were deregulated, which suggest synergistic effects of these two pesticides at environmental concentrations. Impacted molecular pathways and associated cellular responses will be discussed. Results will help identify biological processes affected by these compounds in fish and better understand their effects on this vulnerable developmental stage of yellow perch.
Neonicotinoids are rapidly-acting neuroactive pesticides with biological activity reported across many taxa. As a result of their rapid action and excretion, current approaches to detect exposure and effect in wild birds are limited. In order to identify new approaches, it is important to understand the biological mechanisms linking exposure to apical outcomes.

Although it is understood that these compounds act as reversible nicotinic acetylcholine receptor agonists, the way in which they exert their diverse set of effects has not been catalogued. Therefore, we report the results from an experiment in which the whole-transcriptome of chickens (Gallus gallus) in response to imidacloprid exposure was documented in a set of lethally and non-lethally collected tissues (liver, brain, and peripheral blood mononuclear cells (PBMCs)). Chickens were exposed orally over seven days to three treatment levels, based on known effects concentrations, and one control group, and tissues were collected via venipuncture or serial sacrifice. Isolated mRNA was sequenced via Illumina HiSeq 2500v4 (50 bp paired-end reads) producing from 8.02M to 17.42M reads per library. Data were analyzed for differential gene expression using RNAseq and edgeR pipelines. We found that although genes isolated from liver and brain were not highly responsive to exposure, genes in PBMCs were affected in a time and dose-dependent manner, suggesting potential immunological effects. In PBMCs, 29 out of 151 genes were significantly expressed at a logFC>5 fold change compared to baseline) and occurred less than 5 times or were expressed at a logFC>5 and occurred more than 5 times in the treatment groups. Twenty-five genes were down-regulated and only four were up-regulated. Our data provide an initial step towards discovering a means to non-lethally detect biological activity in response to IMI exposure in gallinaceous birds.

**MP128 Neurotoxicity Induced by Thiamethoxam and Clothianidin in SK-N-SH Cells**

X. Lu, J. Li, Q. Zhang, Y. Huang, B. Yu, Peking University

Thiamethoxam (TMX) and clothianidin (CLO) are two widely used neonicotinoid insecticides generally considered to have low toxicity to mammals. However, in recent years, there is a growing number of studies showing that neonicotinoid insecticides have potential hepatotoxicity, neurotoxicity, reproductive toxicity and developmental toxicity to mammals. In this study, human neuroblastoma cells (SK-N-SH cells) were used as models to explore the neurotoxicity of TMX and CLO. For each neonicotinoid, exposure experiments were set up at three levels: 0.01 mM, 0.1 mM and 1 mM. After exposure for 24 h, the cells were analyzed for oxidative phosphorylation levels, oxidative stress effect, activity of acetylcholinesterase, gene expressions of various subunits of nicotinic acetylcholine receptors (nAChR) and protein expression of nAChR α7 subunit. To further reveal the mechanism of CLO neurotoxicity, multi-omics analyses were performed. The results showed that exposure to TMX and CLO for 24 h had no significant effect on energy metabolism, but caused significant oxidative stress at 1 mM. For TMX, exposure at all three levels did not significantly change the gene expressions of nAChR subunits, the protein expression of nAChR α7 subunit, and the activity of acetylcholinesterase. However, for CLO, exposure at all three levels significantly increased the gene expression and protein expression of nAChR α7 subunit, and the increase positively correlated with the concentration of clothianidin. Exposure to CLO at 1 mM also significantly increased the gene expression of nAChR α3 subunit and decreased the activity of acetylcholinesterase. Multi-omics analyses revealed multiple differential genes, proteins and metabolites due to CLO exposure (0.1 and 1 mM), and the associated functions and pathways included oxidative stress and synaptic function-related pathways, as well as amino acid metabolism and other metabolic related pathways. This research provides a rich list of biomarkers for the study of neurotoxicity of neonicotinoid insecticides to human.
Mercury Fate, Biogeochemistry and Risk in a Changing Environment

MP131 Mercury speciation in gull guano samples and changes over a summer season on Brier Island, Nova Scotia

H. Geizer, N.J. O’Driscoll, S. Klapstein, Acadia University / Earth & Environmental Science

Birds are vectors for nutrient and pollutant movement between ecosystems which may influence habitat. Big Meadow Bog on Brier Island, Nova Scotia is home to >6000 herring gulls (Larus argentatus) and a few black-backed gulls (Larus marinus) each year during their nesting season (May - June). Previous research in this bog has shown that methylmercury and phosphate (PO₄) concentrations in surface groundwater are highest in gull nesting areas. This correlative finding suggested significant inputs from these avian biovectors. However, the concentrations of mercury and phosphate in guano samples was unknown. To address this knowledge gap, we collected guano samples in the most populated areas of the bog. In 2018 guano samples were collected from the ground using plastic scoops. Those results of total mercury are presented below. Initial results in 2018 had a wide range of total mercury concentrations (1.7 - 458.8 ng/g) with a mean of 64.5 ± 81.1 ng/g (n=97). In 2019 four plastic posts were installed for birds to perch and excrete on and samples collected ~bi-weekly from May to August to establish temporal patterns in Hg content. Samples were dried, homogenized and analyzed for total mercury, methyl mercury, and total phosphorous. These data are key for modelling environmental exposure and movement of Hg in these habitats. This poster will overview the most recent data collected in 2019 and temporal trends in Hg speciation and P data relative to gull life histories and visual inspections of guano.

MP132 Human activities enhance mercury methylation in soils and sediments

H. Zhang, P. Lei, W. Tang, Nanjing University

Recently, there are increasing concerns about human activity-impacted methylmercury (MeHg) production and bioaccumulation in aquatic and terrestrial systems. For instance, new hotspots of Hg methylation were reported in paddy soils and sediments in eutrophic lakes. It is thus necessary to better understand the effects of human activities on mercury methylation and the underlying mechanisms. Our recent studies focus on investigating the impacts of human activities (e.g., farming activities and eutrophication) on Hg methylation in soils and sediments. By conducting a national-scale survey in China (~70 paddy soils and 10 major lakes) together with mechanistic studies, we demonstrate that: (1) Input of plant-derived organic matter due to human activities (rice cultivation, straw return, and eutrophication and algal bloom) could mobilize refractory Hg in soils/sediments (e.g., HgS), or provide electron donors to microbial methylators, thus facilitating Hg methylation in soils and sediments. These may partly explain the enhanced MeHg levels in paddy soils and sediments in eutrophic lakes. (2) Sulfur fertilization in Hg-mining areas could impact Hg speciation in soils, e.g., by releasing mobile Hg species from HgS minerals, leading to enhanced MeHg levels in soils and crop grains. These recent findings demonstrate that human activities could be important factors, contributing to elevated risk of MeHg in both aquatic and terrestrial systems.

MP133 Temporal changes in dissolved elemental mercury at a coastal aquaculture site in the Grado Lagoon, northern Italy

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Mercury can be lost from ecosystems through the process of photoreduction to its volatile elemental form (Hg(0)) in natural waters which is primarily controlled by abiotic reactions with ultraviolet (UV) radiation. There is little mercury photoreduction research available for contaminated coastal marine systems. Grado lagoon, northern Italy, is an aquaculture area with high total mercury concentrations in sediment due to past cinnabar mining activities at Idrija (western Slovenia). Two sites (one highly Hg contaminated, VN1, and one with lower contamination, VN3) located within a lagoon fishfarm were analyzed for temporal changes in dissolved elemental mercury (Hg(0)aq) and its relationship with UV radiation in May of 2018. Solar radiation spectra were continuously quantified using an OceanOptics USB 4000 spectroradiometer and aqueous Hg(0) concentrations (Hg(0)aq) using a Lumex 915-RA with headspace analysis and an equilibrium partitioning model with temperature-corrected Henry’s law constant. It was found that the small pH changes observed were significantly correlated with Hg(0)aq concentrations at both sites however this was likely due to auto correlations with the daily cycle of microbial respiration and carboxylic acid concentrations. It was found that Hg(0)aq concentrations ranged between 237.6 - 401.5 pg L⁻¹ (mean = 331.4 pg L⁻¹; SD=42.94; n=13) at the more contaminated site, VN1, and showed a diurnal trend. Total dissolved mercury at this site ranged between 3.85 - 28.22 ng L⁻¹ (mean=7.7; SD=6.17 ng L⁻¹; n=13), which resulted in a % Hg(0) ranging between 0.84 - 8.24 %. At the lower mercury site, VN3, Hg(0)aq concentrations ranged between 200.3 - 321.52 pg L⁻¹ (mean=279.49 pg L⁻¹; SD=46.99; n=14). Total dissolved mercury at this site ranged between 2.86 - 9.13 ng L⁻¹ (mean=5.04; SD=2.06 ng L⁻¹; n=14), which resulted in a % Hg(0) ranging between 2.89 - 8.91 %. In both cases the Hg(0)aq concentrations in water were higher in the central part of the day and positively correlated with incoming UVB and UVA radiation measurements (Site VN1 Pearson r = 0.48, p=0.09, n=13; Site VN3 Pearson r=0.70, p=0.01 n=13). In conclusion, it was found that % Hg(0) relative to total mercury concentrations were similar at the contaminated coastal aquaculture site to other contaminated areas in previous work, but were substantially higher than those observed at other uncontaminated sites.

MP134 Water and sediment chemistry influences on mercury bioaccumulation in freshwater invertebrates from two lakes in Kejimkujik National Park, Nova Scotia

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Mercury is a trace metal and a toxic environmental pollutant that can be deposited in remote ecosystems and result in adverse effects on the heath of organisms. Elevated mercury levels at the bottom of the food web have implications for significant mercury (in the form of methylmercury (MeHg)) transfer to higher trophic organisms. Kejimkujik National Park (KNP), Nova Scotia is an area with a high landscape sensitivity to interactions with mercury. MeHg bioaccumulation in KNP lakes is of high concern in the area because elevated MeHg near the bottom of the food chain, such as near-sediment invertebrates, has implications for significant mercury transfer to higher trophic levels. Therefore, analysis of MeHg concentration in aquatic invertebrates and the relationship with water and sediment characteristics is required to understand food web bioaccumulation and relative bioaccumulation between invertebrates. Mayfly naïads, caddisfly larvae, lake water, and benthic sediments were collected from two lakes and one wetland catchment in KNP. Methylmercury (MeHg) was analyzed in all samples using gas chromatography-atomic fluorescence spectroscopy (AFS). MeHg concentrations in mayflies and caddisflies ranged from 14.28–427.78 ng/g (N=58), 0.05–0.46 ng/L (N=45) in water, and 0.02–28.94 ng/g (N=22) in sediment. Results indicated that mayfly MeHg concentration was positively correlated with water MeHg concentration (Spearman Rank correlation coefficient (rs)=0.43; P-value=0.02). Caddisflies may be more associated with sediment MeHg concentration than water MeHg (rs=0.45;0.07, respectively), although correlations were not significant. Most sediment and invertebrate samples and all water samples from the wetland catchment were significantly higher in MeHg concentration than the lake locations because wetlands are areas of efficient MeHg production. In conclusion, no significant relationships
were observed between MeHg concentration in caddisfly and mayfly and sediment MeHg. However, our data suggest that mayfly MeHg concentration is influenced by water characteristics (MeHg, pH). Analysis of MeHg bioaccumulation in aquatic invertebrates and the relationships with water and sediment characteristics are key. More research into MeHg bioaccumulation is necessary to better understand food web transfer.

**MP135 Assessing the mobilization potential of mercury during bog restoration**

*S. Klapanstein, Acadia University / Earth & Environmental Science; R. Cameron, Nova Scotia Provincial Government / Department of Environment; A. Walker, Acadia University / Biology Department; J. Murimboh, Acadia University / Chemistry; C. Hallett Saunders, Acadia University / Biology Department; N. O’Driscoll, Acadia University / Earth & Environmental Science*

Restored peat bog ecosystems create favourable conditions for methylation and therefore the formation of neurotoxic mercury that can bioaccumulate and biomagnify through food webs. A restoration project in a historically disturbed (ditched, drained, and then colonized by approximately 8000 herring gulls) bog ecosystem has raised the water table to pre-disturbance levels. This shift in hydrology has inundated peat that has experienced decades of drying and wetting cycles and consequently reiterative oxidation-reduction. To assess the potential for mercury mobilization and the formation of bioavailable methylmercury under post-restoration bog conditions, we extracted 10 cm diameter surface cores (0 - 20 cm, 20 - 40 cm, and 40 - 60 cm depth) from 3 sites: 2 sites within the disturbed Big Meadow Bog in southwestern Nova Scotia and 1 control site with no known disturbance. Cores were frozen and divided into 2 cm increments. Each subsample was then dried for up to 3 weeks at 20°C under low humidity mimicking an induced disturbance such as water table drawdown. Subsamples were then submerged in deionized water for 1 hour to rehydrate, gravity-drained for 15 minutes, and then flooded and leached for 1 hour. Leachates were analyzed for organic carbon, total mercury, and methylmercury. Field moisture, initial water holding capacity, varied more greatly in the control site (14-41%) than the ditched and nutrient sites (13-26% and 16-25%, respectively). Organic carbon concentrations of solid peat were consistent with depth across all sites (94-100%) and dissolved organic carbon concentrations in leachate decreased minutely with depth at all 3 sites and were very low (< 0.3 ppm). Total mercury in the leachate represented about 0.005% of the mercury in the solid peat whereas methylmercury in the leachate represented about 0.01% of the methylmercury in the solid peat. The disturbed sites had similar total mercury depth profiles in leachates with depth with more total mercury near the surface (10-15 cm), whereas the control site peaked in higher total mercury concentrations in the leachates from at 20-30 cm depth. Methylmercury concentrations in leachates tended to be higher near the surface (0 - 10 cm) across all sites. This experiment was conducted pre-restoration and indicates the potential for mercury mobilization and specifically methylmercury mobilization in the wetland outflows.

**MP136 Delineating sources of mercury and trace metals using epiphytic lichens in Nova Scotia, Canada**

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Mercury is a persistent pollutant present in all ecosystems. The prevalence and speciation of mercury will determine its movement in the atmosphere and potential to bioaccumulate and biomagnify through food webs. Monitoring of mercury and other trace metals can be costly, whereas the use of naturally occurring epiphytic lichens can be an effective tool for these types of studies. Nova Scotia, Canada is a hotspot for mercury and other trace metal accumulation in ecosystems, partially attributed to long-range transport of anthropogenic air pollution. The region also contains a number of historic gold mining sites that are known to have persistent high levels of mercury and arsenic in sediment. The relative contribution of local and national sources of mercury to local air is unknown. This work aimed to address which elements can be effectively monitored using lichens. Trace metals in lichens other than mercury may also help elucidate the potential sources of these elements: whether from geological, re-emission, or long-range transport. Almost 200 lichen (*Usnea spp.*) samples were collected across Nova Scotia and analyzed for total mercury (THg); a subset of these samples was analyzed for other trace metals, including arsenic, nickel, copper, cadmium, lead, and selenium (n=163). Significant variation in mercury content was observed across sampling sites and GIS analysis was used to display and model these regional trends. While broad spatial resolution was the initial focus for these collections, a few target areas (biological mercury hotspot Kejimkujik National Park and historic gold mining areas) were also sampled in more intensively to confirm spatial patterns and if these target areas deviated as expected from background concentrations of mercury and other trace metals. Similar to other monitoring studies of lichens and mosses as bioindicators of mercury deposition, this research provides an excellent baseline for a long-term monitoring program of mercury in Atlantic Canada with ongoing industrial activity and a changing climate.

**MP137 Assessment of the concentrations of mercury, selenium, and their molar ratios in traditional foods of the Bigstone Cree community in Alberta, Canada**

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Traditional foods provide nutritional, social, and economic benefits for Indigenous communities; however, anthropogenic activities have led to increasing concerns over the levels of mercury (Hg), especially methylmercury (MeHg), in these foods. This issue may be of particular concern for communities adjacent to large industrial activities, such as the Bigstone Cree near the Athabasca oil sands region of Alberta, Canada. In this community-led study, our main objective was to assess variation in THg and MeHg concentrations among traditional food types (plants or animals), species, and tissues (muscles or organs). We also assessed variation in concentrations of the micronutrient selenium (Se)—thought to protect against Hg toxicity—and in Se:THg ratios. Thirteen species of plants and animals were collected in 2015 by members of the Bigstone Cree community. From this, we quantified THg, Se, and Se:THg ratios in 65 plant and 111 animal samples and MeHg in 106 animal samples. For plants, the lichen, old man’s beard (*Usnea spp.*), showed the highest concentrations of THg and Se (0.11 ± 0.02 µg g⁻¹, wet weight (w.w.) and 0.08 ± 0.01 µg g⁻¹, w.w., respectively) and also had a low Se:THg molar ratio. Concentrations of THg, MeHg, and Se significantly differed among animal samples (mixed model, P < 0.01), showing variation among species and among tissues/organisms. Generally, concentrations of THg and MeHg were highest in aquatic animals including whitefish (*Coregoninae clupeiformis*) and mallard duck (*Anas platyrhynchos*), which also had relatively low Se:THg molar ratios. Overall, our results revealed substantial variation in the patterns of THg, MeHg, Se and Se:THg ratios across this comprehensive basket of traditional foods. Thus, measuring concentrations of THg alone, without considering MeHg and potential associations with Se, may not adequately convey the exposure to Hg in assessment studies of traditional foods.
MP138 Nutrient Stoichiometry (C:N:P) and Methylmercury Bioaccumulation in Arctic Freshwater Zooplankton

G.A. MacMillan, McGill University / Natural Resource Sciences; J. Chéretel, Environment and Climate Change Canada / National Wildlife Research Centre; M. Richardson, Carleton University / Geography and Environmental Studies; M. Amiot, University of Montreal / Biological Sciences

To predict long-term shifts in mercury dynamics with climate change, we need to better understand how aquatic productivity influences methylmercury (MeHg) bioaccumulation in freshwater food webs. Although studies have shown strong interactions between nutrient stoichiometry (C:N:P) and metal accumulation in the laboratory, relationships between these two variables have not been adequately tested in northern lakes. In this study, we sampled a gradient in ecosystem productivity in the eastern Canadian Arctic and measured MeHg bioaccumulation and carbon:nutrient ratios in seston and zooplankton from 47 lakes. Observations spanning 20° of latitude were used to compare MeHg bioaccumulation with water chemistry, food resource quality, growth rates, and food web structure. Contrary to previous findings at temperate latitudes, seston biomass, chlorophyll concentrations and seston nutritional quality (seston %P, and C:N, C:P ratios) were not good predictors of either seston or zooplankton MeHg concentrations. Rather, bulk zooplankton (57 ± 45 ng g-1) and Daphnia MeHg concentrations (101 ± 86 ng g-1) were positively correlated with water MeHg concentrations and only weakly negatively correlated to water nutrient concentrations (TN, TP). The highest zooplankton MeHg concentrations were found in lakes with high MeHg and low TN in surface waters. Overall, we found that indicators of lake productivity, seston nutritional quality and organism growth rates did not explain MeHg bioaccumulation, as predicted by biodilution theory. We suggest that aqueous MeHg exposure is the dominant factor controlling MeHg uptake at the base of these freshwater food webs, and that seston biomass and nutritional quality are not key drivers of MeHg bioaccumulation in these northern systems.

MP139 Use of Neural Network Models to Predict Ecosystem Response to Remediation in the Mercury-Impacted South River System

S. Thakali, AECOM / Remediation/Risk; D. Baldwin, AECOM; J. Collins, AECOM / DCS Remediation; N.R. Grosso, Corteva / Environmental Remediation

Historical mercury releases occurred at a textile manufacturing facility on the South River, Virginia, which led to increased mercury concentrations in biotic (fish tissue) and abiotic media (sediment and surface water). The mercury concentrations were expected to decline over the past forty years but remain higher than expected in these media. The current concept is that MeHg bioaccumulation in freshwater food webs, the cumulative impacts of MeHg from upstream to downstream, if mercury levels are affected by different harvesting intensities. To answer these questions three watersheds in New Brunswick, Canada were selected with different intensities of forest management with six sites each, each at a different harvesting intensity. The samples taken in fall 2018 from each site included water, seston, three food sources, five aquatic invertebrates representing different functional feeding groups, and slimy sculpin (Cottus cognatus) (n=2-10/sample type). To assess mercury bioaccumulation in a food web the food sources and invertebrates are being analyzed for MeHg and fish for total mercury (THg) while stable isotopes of carbon, nitrogen and hydrogen will be used to determine the food web structure. Water and seston samples have been analyzed using inductively coupled plasma mass spectrometry (ICP-MS) and MeHg levels varied from 0.0005 to 0.150 ng/L for water and 0.200 to 11.0 ng/g for seston across all sites. The average MeHg levels in water and seston for each watershed from the most intensively harvested to least harvested were 0.039 ng/L and 4.10 ng/g, 0.095 ng/L and 4.19 ng/g, and 0.027 ng/L and 2.28 ng/g. These findings start to fill a knowledge gap by giving a holistic understanding of MeHg in stream systems by investigating how it bioaccumulates in foodwebs, culminates in space and if MeHg levels change with harvesting intensity. This type of information can be used to focus efforts when improving best management practices for forest harvesting.

MP140 Does forest harvesting change methylmercury levels in New Brunswick stream systems and in aquatic food webs?

L. Negrazis, McMaster University; K.A. Kidd, McMaster University / Department of Biology and Canadian Rivers Institute

Forestry harvesting is one of the most important natural resource industries in Canada, yet it is also a major disturbance on forest ecosystems. Some of the impacts include increasing sediment loading, altering nutrient cycling and increasing mercury inputs into freshwater systems from run-off, and creating more aquatic environments that produce the neurotoxin, methylmercury (MeHg). Research on MeHg in fish, water, and zooplankton exists but mainly focuses on each component separately at a small scale within headwater streams and at high harvesting intensities. The objective of this thesis is to understand broader scale impacts of forestry on MeHg by looking at the bioaccumulation of MeHg in food webs, the cumulative impacts of MeHg from upstream to downstream, as well if mercury levels are affected by different harvesting intensities. To answer these questions three watersheds in New Brunswick, Canada were selected with different intensities of forest management with six sites each, each at a different harvesting intensity. The samples taken in fall 2018 from each site included water, seston, three food sources, five aquatic invertebrates representing different functional feeding groups, and slimy sculpin (Cottus cognatus) (n=2-10/sample type). To assess mercury bioaccumulation in a food web the food sources and invertebrates are being analyzed for MeHg and fish for total mercury (THg) while stable isotopes of carbon, nitrogen and hydrogen will be used to determine the food web structure. Water and seston samples have been analyzed using inductively coupled plasma mass spectrometry (ICP-MS) and MeHg levels varied from 0.0005 to 0.150 ng/L for water and 0.200 to 11.0 ng/g for seston across all sites. The average MeHg levels in water and seston for each watershed from the most intensively harvested to least harvested were 0.039 ng/L and 4.10 ng/g, 0.095 ng/L and 4.19 ng/g, and 0.027 ng/L and 2.28 ng/g. These findings start to fill a knowledge gap by giving a holistic understanding of MeHg in stream systems by investigating how it bioaccumulates in foodwebs, culminates in space and if MeHg levels change with harvesting intensity. This type of information can be used to focus efforts when improving best management practices for forest harvesting.

MP141 The influence of temperature on mercury methylation and demethylation potentials in high Arctic lake sediments

K. Hudelson, University of Windsor / Environmental Science; P. Drevnick, Alberta Environment and Parks / Environmental Monitoring and Science Division; F. Wang, D. Armstrong, University of Manitoba / Centre for Earth Observation Science, Department of Environment and Geography; A. Fisk, University of Windsor / Great Lakes Institute for Environmental Research

The fate of mercury (Hg) in Arctic environments is uncertain in the face of climate change disruptions to the cryosphere. Mercury methylation and demethylation are key factors that influence exposure and Hg concentrations in fish and humans, but these processes are poorly characterized in Arctic lakes. In lakes, most methylation occurs in the sediments, and the rate of the methylation reaction has been shown to be temperature dependent. We hypothesized that warmer lakes would exhibit higher methylation potential in the Arctic, and that warmer incubation temperatures would increase methylation potential in sediments. We also hypothesized that warming would have less of an effect on demethylation potential and that demethylation potential would not vary significantly among lakes. We collected littoral sediments from four well studied high Arctic lakes, to estimate methylation and demethylation potentials using
Hg stable isotope tracers at incubation temperatures of 4, 8, or 16 °C for 24 hrs. Overall, the magnitude of the methylation potential exceeded that of the demethylation potential, but this was not the case in all lakes. Methylation potential were greatest in sediments from the warmest lake and responded to increased temperatures in the warmest and in the coolest lakes. Demethylation potential was less affected by temperature but was more pronounced in sediments with greater [MeHg]. Overall, our results demonstrate significant lake-to-lake variation in methylation potential and evidence that both relatively warm and cold lakes can exhibit rapid increase in methylation potential due to warming.

**MP142 Trends in Atmospheric Mercury Fractions and Wet Mercury Deposition Across the United States**  
*C. Olson, Middle Tennessee State University / Civil and Environmental Engineering; H. Fakhraei, C.T. Driscoll, Syracuse University / Civil and Environmental Engineering*

The creation of long-term monitoring programs has proved invaluable in assessing the efficacy of environmental policies. Two such programs, the Atmospheric Mercury Network (AMNet) and the Mercury Deposition Network (MDN), have been used to characterize the magnitude and changes in concentrations of gaseous elemental mercury, particulate mercury and gaseous oxidized mercury, and wet mercury deposition across the United States. These networks provide information on the spatial and temporal responses of air quality management aimed at reducing mercury emissions. Recently, the United States Environmental Protection Agency (USEPA) has proposed to roll back Mercury Air Toxics Standards (MATS), raising questions about the effectiveness of such policies and how the environment will respond to their removal. Presented here is an analysis of the long-term trends in concentrations of atmospheric mercury fractions and mercury wet deposition across select MDN and AMNet sites, and their relationships to changes in mercury emissions. The results of these analyses show significant decreases in concentrations of all fractions of atmospheric mercury and wet mercury deposition across the United States, but particularly in the east, with only few sites showing significant increases. Also presented are short-term trends in mercury emissions from several states measured during the course of MATS’ enforcement. These results highlight the long-term effectiveness of air pollution control and underscore the importance of maintaining these policies and mercury monitoring programs.

**MP143 Total Mercury and Methylmercury Concentrations in Rice From Three Cities in Vietnam (Hanoi, Hue, and Ho Chi Minh City)**  
*V. Hoang, S. Rothenberg, Oregon State University / Environmental & Occupational Health*

Background: Vietnam is the third highest rice consuming country in the world (405 g rice/capita/day). However, there are no studies concerning total mercury (THg) and methylmercury (MeHg) in rice; yet, this is an important dietary source of mercury and other metals. The purpose of this study was to assess THg and MeHg levels in polished rice samples purchased in Vietnam. In addition, a comprehensive review of THg and MeHg concentrations in rice was completed for papers published since 2014, to update our previous review. Methods: In 2018, a convenience sample of 100 polished rice samples were purchased in three major cities in Vietnam, including Hanoi (n=46 rice samples, 9 stores), Hue (n=15 rice samples, 3 stores), and Ho Chi Minh City (n=39 rice samples, 3 store) (n=100 total, 15 stores). Rice THg and MeHg concentrations were determined using EPA 1631 and 1630, respectively. Using ISI Web of Science and U.S. National Institutes of Health PubMed, we searched papers in English using the terms “rice” and mercury,” which were published since 2014. Results: In Vietnam, the median values for THg and MeHg were 1.2 ng/g (range: 0.49-20 ng/g) and 0.41 ng/g (0.12-5.5 ng/g), respectively, and the median value for %MeHg (of THg) was 35% (range: 11-76%). There were no significant differences in THg, MeHg, and %MeHg (of THg) between the three Vietnamese cities (ANOVA, p-value range: 0.17-0.99). For the comprehensive review, 32 manuscripts reported rice THg and/or MeHg concentrations in nine countries since 2014. The median values for rice THg, MeHg and percent MeHg (of THg) for non-polluted sites were 4.7 ng/g, 2.4 ng/g, and 54%, respectively. For polluted sites, the median values for rice THg, MeHg and percent MeHg (of THg) were 69 ng/g, 14 ng/g, and 32%, respectively. All values for Vietnamese rice THg and MeHg concentrations fell within the ranges for non-polluted sites. Conclusions: In Vietnam, rice THg and MeHg levels were similar to rice cultivated in non-polluted areas, and were considered low-level. However, rice does not contain the same nutrients as fish, and thus the health impacts due to MeHg exposure are uncertain. Also, Vietnam has one of the highest rice ingestion rates globally, and thus MeHg exposure levels through rice ingestion may be elevated, and should be further investigated.

**MP144 Freshwater subsidies to insectivores: characterization of risks from methylmercury and benefits from omega-3 highly unsaturated fatty acids**  
*S.A. Dzielski, SUNY ESF / Department of Environmental and Forest Biology; C.W. Twining, University of Konstanz / Limnological Institute; L.B. Cleekner, Hobart and William Smith Colleges / Finger Lakes Institute; R. Rasuvi, SUNY ESF / Department of Environmental and Forest Biology*

Aquatic environments are sources of mercury (Hg) to insectivores such as birds. However, aquatic environments are also important sources of omega-3 highly unsaturated fatty acids (HUFAs), which are essential to meet nutritional requirements of nearly all organisms. HUFAs thus represent a benefit of consuming a dominantly aquatic diet while Hg represents a cost. Here we investigate aquatic subsidies of methylmercury (MeHg) and HUFAs to Eastern Phoebe (Sayornis phoebe) chicks. Stable isotopes of carbon, nitrogen and hydrogen were also used to estimate chick diet from aquatic versus terrestrial sources. We predicted that 1. Eastern Phoebe chicks whose diets contain more aquatic insects would have higher MeHg feather concentrations than chicks with more terrestrial diets and 2. aquatic insects contained more MeHg than terrestrial prey. Previous research showed that that aquatic insects were nearly as high in the HUFA eicosapentaenoic acid (EPA) compared to terrestrial prey, demonstrating the benefits of consuming emergent aquatic insects, and that Eastern Phoebe chick EPA d13C values were similar to those of aquatic insects, confirming that the source of their HUFA was from aquatic insects. Significant differences were found across sites in chick feather MeHg concentrations, and feather MeHg concentrations increased linearly with d13C. Preliminary data did not show a linear increase in Hg concentration with increasing proportion of aquatic diet. Further analyses of diet items will provide an assessment of the risks and benefits to wildlife of relying upon aquatic food sources contaminated by anthropogenic activities.

**Stockholm Convention on POPs: Progress in Monitoring, Research and Risk Assessment of Legacy and Emerging Chemicals**

**MP145 New measurements and consistency tests for physicochemical properties of phosphate flame retardants**  
*S. Endo, National Institute for Environmental Studies (NIES) / Center for Health and Environmental Risk Research; H. Karamochi, National Institute for Environmental Studies, Japan / Center for Material Cycles and Waste Management Research*

Phosphate flame retardants (PFRs) have increasingly been used as a result of restrictions of existing flame retardants. According to preliminary evaluations, some PFRs are suspected to have partitioning properties that are similar to those of existing POPs. Because of the absence of experimental data, such early evaluation typically uses predicted property values. Predictions tools could, however, generate errors by many orders of magnitude and thus need to be calibrated or validated.
against reliable experimental data, leading to a tautology problem. Hence, there is a steady need for accurate experimental property values with high accuracy for chemicals with diverse structures. In this presentation, we report new measurements of vapor pressure (P), aqueous solubility (Sw), and octanol-water partition coefficients (Kow) of triphenyl phosphate (TPHP), tri-m-cresyl phosphate (TmCP), and tri-p-cresyl phosphate (TpCP). P was measured with a gas saturation method, using PFR-coated beads packed in a stainless-steel column. P measurements around ambient temperature were conducted for the first time with these chemicals. Sw was measured with the conventional shake-flask method as well as an indirect method using the measured silicone/water partition coefficient and the solubility in silicone, and consistency of the results was evaluated. Kow was determined from the measured Sw and solubility in octanol as well as the measured silicone/water and silicone/octanol partition coefficients. Consistency was evaluated together with literature Kow measured by the established slow-stirring and generator column methods. All property values were compared to the existing values measured or predicted in the literature. We also predicted the values based on the COSMO-RS theory using COSMOtherm software. The first results indicate that P values measured around 25°C were much lower than previously reported estimations, while existing values for Kow and Sw are relatively accurate, suggesting that evaporation properties of PFRs need more intense experimental investigations.

**MP147 The concentration distribution and source of dioxin-like PCBs in air and soil in Republic of Korea**

D. Oh, Korea Environment Corporation

IntroductionPolychlorinated Biphenyls were used for transformers, capacitors’ insulating oils, lubricants, and plasticizers because of their excellent electrical insulation and thermal stability. PCBs are representative POPs along with dioxin and listed in annex A and C in the Stockholm Convention. Especially, among PCBs, dioxin-like PCBs (dl-PCBs) have a similar toxicity to dioxin. dl-PCBs which have a lot of chlorine is more easily adsorbed by airborne suspended dust or strongly adsorbed to soil. In addition, PCBs stay stable for longer periods of time in soil than other environmental media. This study was performed to see the differences how PFOA is distributed over in rivers and lakes in the Republic of Korea. This study describes PFCs are soluble in water, unlike general persistent organic pollutants, and drinking water has been pointed out as important human intake sources. PFOA has been listed as a persistent organic pollutant (Annex A) in the 2019 Stockholm Convention and is the only PFOA designated as a carcinogen by IARC under WHO. This study describes opportunities for inter-comparison modeling collaborations to possibly include but not be limited to: 1. Process oriented studies of POP/EC LRAT including joint analysis of modelling results and monitoring data (e.g. gas-particle partitioning, degradation, etc.) 2. Iterative integrated modeling (forward and inverse) to evaluate and assess qualified emission databases and uncertainties. 3. Modelling of Arctic pollution (and/or other regions/receptors) using emission scenarios and projections (e.g. thermal, shipping, waste combustion, etc.). 4. Model evaluation of trends in POP/EC deposition to the Arctic (and ecosystem receptors) including estimates of contribution of major groups of emission sources (e.g. based on HTAP, EDGAR, Stockholm Convention). 5. Sensitivity model simulations to evaluate effects of changes in meteorological conditions and atmospheric composition related to climate change. 6. Modeling with alternative parameterization the LRAT for SVOCs with high octanol-air partition coefficient. 7. Modelling how climate change influences the first and secondary emissions of POPs/ECs. 8. Understand the first and secondary fractionations under climate change conditions. Discussion at the conference will help refine and propose a concrete agenda for international collaboration serving the Stockholm Convention, LRTAP (e.g. HTAP) and AMAP and invite additional participants.

**MP148 POPS/EC Long Range Transport & Emission Uncertainties: Opportunities for Inter-comparison Modeling Collaborations**

P.W. Bartlett, Saint Peters University / Social Justice / Education; Y. Li, Harbin Institute of Technology; A. Gusev, Meteorological Synthesising Centre East; J. Ma, Peking University / College of Urban and Environmental Science; S. Tao, Peking University / Laboratory for Earth Surface Processes College of Urban and Environmental Sciences; C. Friedman, Maine Maritime Academy / Ocean Studies; R. Guardians, MARM; M. Muntean, European Commission Joint Research Centre / Energy, Transport and Climate Directorate; J. Kelly, Massachusetts Institute of Technology / Institute of Data, Systems, and Society; N.E. Selin, Massachusetts Institute of Technology / IDSS/EAES

There are many uncertainties of global emissions, Long Range Transport (LRT) and exposure of Persistent Organic Pollutants (POPs) and persistent Emerging Contaminants (ECs) for which modeling can be an effective tool to improve our understanding. This poster proposes and invites international research collaborations of inter-comparison modeling to better understand LRT from observations and incomplete emission estimates. Assessments by the Stockholm Convention, the Convention of Long Range Transport of Air Pollutants (e.g. Task Force on Hemispheric Transport of Air Pollutants, HTAP) and the Arctic Monitoring Assessment Programme (AMAP) identify key uncertainties and areas for which modeling can potentially be of great value. The global nature of the problem and extent of uncertainties call for an international collaborative modeling initiative. We focus on the Arctic since the unexpected discovery of many ECs in the Arctic call for a greater understanding of emissions and LRT. Specific ecosystem (e.g. biological effects), and food web receptors are also important to investigate. We suggest inter-comparison modeling collaborations to possibly include but not be limited to: 1. Process oriented studies of POP/EC LRAT including joint analysis of modelling results and monitoring data (e.g. gas-particle partitioning, degradation, etc.) 2. Iterative integrated modeling (forward and inverse) to evaluate and assess qualified emission databases and uncertainties. 3. Modelling of Arctic pollution (and/or other regions/receptors) using emission scenarios and projections (e.g. thermal, shipping, waste combustion, etc.). 4. Model evaluation of trends in POP/EC deposition to the Arctic (and ecosystem receptors) including estimates of contribution of major groups of emission sources (e.g. based on HTAP, EDGAR, Stockholm Convention). 5. Sensitivity model simulations to evaluate effects of changes in meteorological conditions and atmospheric composition related to climate change. 6. Modeling with alternative parameterization the LRAT for SVOCs with high octanol-air partition coefficient. 7. Modelling how climate change influences the first and secondary emissions of POPs/ECs. 8. Understand the first and secondary fractionations under climate change conditions. Discussion at the conference will help refine and propose a concrete agenda for international collaboration serving the Stockholm Convention, LRTAP (e.g. HTAP) and AMAP and invite additional participants.

**MP149 Distribution concentration for PFOA in water in Republic of Korea**

K. Son, S. Han, Korea Environment Corporation

IntroductionPFCs (perfluorinated compounds) is the fluorine-substituted structure of the basic skeleton of hydrocarbons and is used in the industry as a surfactant. PFCs are soluble in water, unlike general persistent organic pollutants, and drinking water has been pointed out as important human intake sources. PFOA has been listed as a persistent organic pollutant (Annex A) in the 2019 Stockholm Convention and is the only PFOA designated as a carcinogen by IARC under WHO. This study describes how PFOA is distributed over in rivers and lakes in the Republic of Korea.

Materials and methodsThe water samples were collected from Han River (8), Nak-Dong river (9), Geum river (5), Young-San river (4) and the others stream (10) from 2015 to 2016 (spring and autumn in each year) at a total of 36 sites. The water samples were taken using 500 mL polypropylene disposable screw-cap containers. The samples were purified by solid phase extraction (SPE) after removing the suspended material. The.
procedure is as follows. Activated the cartridge with 4 mL methanol and 4 mL distilled water and passed the sample. After the cartridge was washed with 20% methanol-distilled water, the remaining water was completely removed from the cartridge in the vacuum state and 5 mL of 0.1% ammonia-methanol solution was passed through the cartridge twice. The final samples were concentrated and analyzed using LC/MS/MS. Results and discussion POFA is detected at a relatively high concentration than PFOS. Some POFA was detected in the Nak-Dong River, Geum River, and other streams, but the Han River and Young-San River were below detection limits. Go-Ryung Bridge in the Nak-Dong River (123.615 ng/L in 2015, 16.056 ng/L in 2016) and the Geum-Gang Bridge (161.610 ng/L in 2015, 83.609 ng/L in 2016) and Geum-Gang estuary (201.876 ng/L in 2015, 152.012 ng/L in 2016) in the Geum River were relatively high. It is possible to affected by effluent which contains. There was no correlation between the concentrations in the season (spring and autumn), but all the annual mean concentrations of POFA in 2015 were decreased in 2016.

MP150 Nitrosamines analysis in drinking water using GC/MS/MS at ultra-trace levels


Nitrosamines, particularly NDMA, are a group of disinfection byproducts frequently detected in finished drinking water and of concern to environmental agencies. The USEPA Office of Groundwater and Drinking Water (OGWDW) developed Method 521 in 2004 to provide a procedure for trace level analysis of seven nitrosamines in finished drinking water by solid-phase extraction and chemical ionization tandem mass spectrometry (MS/MS). Ion Trap GC/MS is the approved technology, but the system is being obsoleted. Through an interlaboratory study, we show that migration to GC/MS/MS systems provided significant improvements in speed and sensitivity. This work demonstrates a GC/MS/MS method to allow for monitoring at levels below the current LCML (lowest concentration minimum reporting level) and detection limit set in Method 521. The GC/MS/MS method included the optimization of an additional nitrosamine, N-Nitrosomorpholine (NMOR). Three different laboratories collaborated to produce the LCML and performance data required for an Alternate Test Procedure method update. Results from these laboratories are compared to evaluate method feasibility and reproducibility. The method was validated by the three laboratories and written up for submission to the EPA for review. In 2008, the EPA issued a letter of equivalency deeming EEA-Agilent 521.1 for the analysis of nitrosamines in drinking water by GC/MS/MS as a method that provided equivalent performance to Method 521.

MP151 Assessment of steroid hormones and pharmaceuticals in South Florida surface waters by Liquid Chromatography-High Resolution Mass Spectrometry

N. Quinet, NC State University/Florida International University/SERC; K. Lugo, Florida International University; S. Maldonado, University of Puerto Rico; P.R. Gardinali, Florida International University/Chemistry & Biochemistry and SERC

Environmental exposure risk to different xenobiotics, which can alter the function of the endocrine system, remains a great threat to the health and safety of humans and aquatic species. Steroid hormones, pharmaceuticals, and personal care products (PCPs) have become recognized as relevant aquatic contaminants due to their widespread occurrence in surface waters and endocrine disrupting properties. Endocrine disruptors compounds (EDCs) are chemicals known to cause interferences in the reproduction system, developmental malformations, increased cancer risk, disturbances in the immune and nervous system at very low concentrations. Most previous studies in South Florida has been largely concentrated on assessing the relevance of the fate and transport of inorganic nutrients, heavy metals, and pesticides. Therefore, a significant gap exists in the occurrence and biological significance of human-related organic contaminants in surface waters. In this study, we have developed a fast and sensitive online solid phase extraction followed by liquid chromatography-high resolution mass spectrometry (SPE-LC-HRMS) method using a Q-Exactive for the determination of selected wastewater tracers, recalcitrant pharmaceuticals, PCPs, and steroid hormones in coastal ecosystems in South Florida in order to assess the water quality and potential health impacts to the aquatic system and humans. Seasonal and spatial variations of these contaminants have been monitored from 2017 to 2019. The presence of total coliforms and e-coli were also evaluated. Correlations between hormones and anthropogenic tracers will be explored to better elucidate the sources, pathways and exposure risks to these contaminants. Caffeine, sucralose, DEET and carbamazepine were frequently detected in the water samples, which is indicative of wastewater intrusion sources impacting the surface water. Estrone, estriol, β-estradiol, 17α-ethinylestradiol and diclofenac levels found in surface water raises concern of potential endocrine disruption effects in human and aquatic microbiomes.

MP152 Analysis of legacy & emerging per- and polyfluoroalkyl substances in water: Evaluation of current regulatory methods

T. Anumol, E. Parry, Agilent Technologies Inc.; H. Zhao, Agilent

Per and polyfluoroalkyl substances (PFAS) are chemicals widely used in consumer products and industry due to the unique and desirable chemical properties. Due to widespread usage and environmental persistence, legacy PFAS are ubiquitous in the environment and new fluoro-chemicals are being found in the environment frequently. Public interest has increased pressure to develop comprehensive methods for sensitive analysis in different types of water. EPA has released a revised drinking water analysis method (EPA 537.1) that includes new fluorochemicals and ASTM 7979 (draft SW-846 Method 8327 has the same sample prep procedure) can be employed for non-drinking water samples. We present data collected with these two methods with optimized analytical procedures that include all analytes listed in the methods plus several new emerging fluorochemicals. Method robustness, range, and detection levels will be presented. As the state and federal regulations continue to evolve in this field, robust analytical methods that can be adjusted to encompass new analytes will be important for confidence the public water supply.

MP153 Emissions of Fluorotelomer Alcohols from Municipal Sewage Treatment Plants: Is volatilization or effluent discharge a more relevant pathway?

C. Chen, Peking University/College of Environmental Sciences and Engineering; J. Wang, Peking University; L. Li, University of Toronto, Scarborough/Department of Environmental Sciences; W. Xu, J. Liu, Peking University

Municipal sewage treatment plants (STPs) are an important source to fluorotelomer alcohols (FTOHs), from which FTOHs can enter the aquatic environment through effluent discharge, the agricultural environment through sludge application, the atmosphere through diffusive volatilization. While several earlier studies have attempted to gauge the emissions of FTOHs from STPs, it remains unknown the emission strength per capita and the dominant portal of entry, and by extension, their seasonal variations. The lack of this information hinders our comprehensive understanding of the environmental risk of FTOHs. To this end, we conducted an on-site investigation on the multimedia emission of FTOHs from a typical STP in Beijing throughout a year. We derived the fluxes of FTOHs volatilizing to the atmosphere through measuring the gradient in air concentration above the STP, and those discharged into receiving water bodies through measuring concentrations in effluents and corresponding volumes. Our results indicate that effluent discharge is more relevant than diffusive volatilization to determine the total FTOH emissions in winter, because of the minimal volatilization at a low temperature, whereas their relative importance is reverse in other seasons. The long-chain 8.2 FTOH is still the major component, although the short-chain 6.2 FTOH becomes abundant due to the ongoing substitution of long-chain FTOH products. We extrapolated the results and concluded that ~7 kg FTOHs annually migrate from STPs to the air and aquatic environments in...
Beijing, equivalent to 0.32 mg/cap/year. Our results indicate that, to better understand the contribution of FTOH emission from STPs to environmental burdens, we should take into account the multimedia emissions through both volatilization and effluent discharge. This presentation fills in the knowledge gap of FTOH emission level via STPs for Beijing-like cities and highlights a method to improve future monitoring research for FTOHs in STPs.

**Recent Advances on the Analytical Chemistry, Fate and Mitigation of PFAS from Aqueous Film-Forming Foam (AFFF) Contamination**

**MP156 Evaluation of Current Use C6 AFFF: What do they really contain?**

R. Singh, Clarkson University / Department of Chemical and Biomolecular Engineering; T.M. Holsen, Clarkson University / Civil and Environmental Engineering; S. Mededovic Thagard, Clarkson University / Department of Chemical and Biomolecular Engineering

Aqueous film forming foam (AFFF) is a highly efficient fire suppressant agent used to extinguish flammable liquids that has been widely used at industrial and military sites. AFFF contains large concentrations of fluorinated surfactants including per- and polyfluoroalkyl substances (PFAS) which are persistent in the environment and associated with adverse health effects. In an effort to decrease their persistence and toxicity, current AFFF formulations are being advertised as containing only C6 and smaller perfluorinated surfactants and low molecular weight polymers. To evaluate this claim and better characterize currently available AFFF solutions, several AFFF samples were obtained and analyzed using mass spectroscopy before and after oxidation using the total oxidizable precursor assay (TOP). Measurable concentrations of >C6 acids were found including PFHpA, PFOA, PFNA, PFOS, PFDA, and PFDS. The TOP assay was only partially effective at oxidizing the precursors so increased doses and reaction times were needed. Even after doses of up to 240 mM persulfate and reaction times of 6 hours concentrations of PFAs and 6:2 FTS continued to increase indicating that higher doses and longer reaction times are needed to completely oxidize the precursors present. We are continuing these experiments and exploring other oxidation techniques and plasma destruction technologies for AFFF treatment.

**MP155 Estimating Total Concentrations of Polychlorinated Biphenyls in Fish Tissue using Congener Subsets**

G. Young, Advisian WorleyParsons Group / Aquatic Sciences; G. Ramesh, WorleyParsons Advisian

Polychlorinated biphenyls (PCB) are listed under the Stockholm convention, and signatories are obliged to phase out equipment containing PCBs and remediate contaminated materials by 2025. Meeting this target requires characterizing PCB concentrations in various environmental media, and developing clean disposal/destruction methods. Fish fillets from lakes near one of two facilities in Canada capable of incinerating PCB-contaminated material are sampled annually, and PCB content is analyzed according to EPA Method 1668C to assess potential human health risks. This analytical method measures concentrations of individual PCB congeners to provide accurate toxicity estimates for comparison with Canadian guidelines. However, analysis is costly and labour intensive, and the cost efficiency of environmental monitoring is an important consideration. The number of annual samples in the current monitoring program is limited and this also limits the power of statistical analyses used to track long-term trends in PCB concentrations and accumulation rates in fish from the lakes. Other monitoring programs throughout the world that collect many samples have used subsets of PCB congeners to estimate cost effectively the toxicity and total PCB concentration in biological tissue. This depends on close correlation between subset results and those for analysis of all congeners. Five PCB congener subsets were used to estimate total PCB concentrations in samples from 2013 to 2017. Estimated total PCB concentrations based on these subsets were compared with measured PCB concentrations based on all congeners using relative percent difference (RPD). The resulting RPD values were similar to those for duplicate analyses during the same time period suggesting that the accuracy of total PCB concentrations based on PCB congener subsets are within the analytical uncertainty of the more costly approach. It is crucial to maintain the reliability of analyses for health risk assessment, but our results indicate that analysis of PCB congener subsets could be a useful tool for characterizing total PCB concentrations in a greater number of samples thus improving program effectiveness.

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MP158 Identification and quantification of perfluorooctane sulfonamide isomers by liquid chromatography-tandem mass spectrometry in biological samples
G. Shan, L. Zhu, Nankai University

Characterization of perfluorooctane sulfonamide (PFOSA) isomers, a key intermediate of precursor transformation into perfluorooctane sulfonate (PFOS), is a prerequisite to understand the contribution of precursors to PFOS in the environment. However, the lack of commercial standards makes PFOSA isomers quantification in complex matrices a big challenge. For the first time, a liquid chromatography-tandem mass spectrometry (LC-MS/MS) method was established to identify and quantify PFOSA isomers. Improvement on chromatographic separation with monitoring by selective fragments allowed full resolution of six mono-, di-, and tri-methyl branched isomers of PFOSA. The isomers were identified using a series of characteristic daughter ions and the specific ions were assigned to quantify isomers: m/z 78 (n-), m/z 169 (iso-), m/z 419 (1m-), m/z 164 (2m-), m/z 259 (3m-), m/z 269 (4m-) and m/z 219 (5m-PFOSA). With the aid of 31P isotope, a stepwise tandem mass spectrometry technique, one technical product served as standard, and was used to quantify PFOSA isomers in other technical products and fish blood samples. The results indicated that the developed method displayed strong application prospect for measuring trace level of PFOSA isomers in environmental samples. The method detection limits for all isomers were in the range of 0.1 to 0.6 pg/g ww for blood samples.

MP159 Use of high-resolution mass spectrometry to assess phytoremediation of PFAS at the former Loring Air Force Base
S.L. Nason, Connecticut Agricultural Experiment Station / Environmental Science; C. Stanley, Unaffiliated; N. Zuverza-Mena, Connecticut Agricultural Experiment Station / Analytical Chemistry

The use of Aqueous Film-Forming Foams (AFFFs) has caused widespread contamination with per- and polyfluoroalkyl substances (PFAS) in areas that have been used for fire-fighter training. Such is the case at the Burn House site of the former Loring Airforce Base in northern Maine, USA, where the land now belongs to the Aroostook band of the Micmac nation. A group of concerned citizens is growing industrial hemp on the land in an attempt to reduce the contamination levels, and scientists at the Connecticut Agricultural Experiment Station (CAES) are assisting them with assessing the effectiveness of their efforts. At CAES, we are developing methods to evaluate levels of AFFF related PFAS in soil and hemp tissue using liquid chromatography coupled with quadrupole-orbitrap mass spectrometry. This tandem, high resolution mass spectrometry method has the advantage that we can both screen for a wide range of compounds and develop sensitive quantification methods for a more limited number of contaminants. Our preliminary results tentatively identified 41 PFAS in soil from the Burn House site, including both cationic and anionic compounds. Hemp will be grown on the site for the first time in summer 2019, and we will use our analysis methods to compare the amounts and distribution of PFAS in the soil and plant tissue. Our presentation will focus on the design of this collaborative project, as well as on our initial results.

MP160 Creation of an AFFF Reference Material
J. Reiner, B. Place, National Institute of Standards and Technology / Chemical Sciences Division

The National Institute of Standards and Technology (NIST) provides a wide range of reference materials for the quality assurance and quality control (QA/QC) of chemical measurements. NIST reference materials are produced to be homogenous and stable with SI-traceable, qualitative values for individual compounds or mixtures. As a unique class of organic contaminants, per- and polyfluoroalkyl substances (PFAS) present measurement challenges to the environmental analytical community that can affect the accuracy and precision of quantitative measurements. Currently, NIST has ten different reference materials with concentration values of PFAS on them; however, there are relevant gaps in the NIST library of reference materials. A major gap is a reference material of technical mixtures, specifically an aqueous film-forming foam (AFFF) material. NIST currently has four AFFF materials in-house and has botiled these materials for an interlaboratory study to determine the usability of the materials. This presentation will discuss the current efforts at NIST to produce an AFFF reference material.

MP161 Occurrence of AFFF-derived perfluoroalkyl and polyfluoroalkyl substances in the Bohai Bay, China
H. Chen, Nankai University / College of Environmental Science and Engineering; G. Munoz, S. Yo Duy, University of Montreal / Chemistry; L. Zhang, Y. Yao, L. Yi, Nankai University / College of Environmental Science and Engineering; M. Liu, McGill University / Civil Engineering; H. Sun, Nankai University / College of Environmental Science and Engineering; J. Liu, McGill University / Civil Engineering; S. Sauvé, University of Montreal / Chemistry

Limited data are available regarding the occurrence and distribution of aqueous film-forming foam (AFFF) related PFASs in urban environments in China. In the present study, 53 PFASs were quantitatively monitored in surface river water, groundwater, seawater, and sediment samples collected around the Bohai Bay, China. Perfluorooctanoic acid, perfluorooctane sulfonic acid, and 6:2 chlorinated fluoropolyfluorinated ether sulfonic acid (6:2 CF-PFESA) were the predominant PFASs in all environmental matrices. AFFF-related PFASs such as 6:2 fluorotelomer sulfonamide alkylbetaine (6:2 FTAB) and perfluorooctane sulfonamidoal kyl amine (PFOSA) were also widely detected. To our knowledge, this constitutes the first report of zwitterionic and cationic PFASs in coastal seawater and sediment. Field-derived sediment-water partitioning coefficients confirm that cationic and zwitterionic PFASs tend to be strongly associated with the sediment. Fifteen classes of infrequently reported PFASs were qualitatively identified through suspect screening using high-resolution Orbitrap mass spectrometry. In particular, n,2 CF-PFESA, hydrogen-substituted fluorokelyther homologs, and p-perfluorooctane nonoxynbenzensulfonate (OBS) were identified across all environmental matrices. Fluorotelomer-based PFASs, including n,2 FTAB and n,2 fluorotelomer sulfonamide amine homologs, were present in the water and sediment samples. Most of these emerging PFASs were reported at high concentration levels. Monitoring efforts were initiated to document the spatial distribution of perfluoroalkyl acids (PFAs) in urban areas.
in samples collected near the south and central portions of the river, compared to those collected near the north shore. The marked spatial trends of PFECHS within the different water masses could indicate the prevalence of upstream sources (e.g., Laurentian Great Lakes), as was observed for some other pollutants targeted in this survey.

**MP163 Spatial trends of legacy and novel perfluoroalkyl substances in tap water in Québec, Canada**

S. Vo Duy, G. Munoz, University of Montreal / Chemistry; J. Liu, McGill University / Civil Engineering; S. Sauvé, University of Montreal / Chemistry

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) have been reported in the St. Lawrence watershed, but limited monitoring data are available regarding their occurrence in drinking water produced from the river, tributaries, and groundwater. The present survey set out to investigate the occurrence of perfluoroalkyl acids, some of their anionic, cationic, and zwitterionic precursors, and ether-PFASs in drinking water. The analytical procedure involved off-line solid-phase extraction and UHPLC-HRMS analysis with new mobile phase modifiers to improve retention and sensitivity of short-chain PFASs. Method quantification limits in the sub-part-per-trillion range were obtained for all compounds with accuracy and precision compliant with acceptability criteria. The method was applied to drinking water samples collected in 2018 at a large spatial scale from public tap water supplies in Quebec, Canada. Overall, 99% of the tap water samples were positive to at least one PFAS. Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) were the most recurrently detected (88% and 80%, respectively). Regardless of the particular treatment technology, PFOS levels were generally higher in tap water produced from the St. Lawrence River compared to other sources (other rivers or groundwater). The 6:2 fluorotelomer sulfonate (6:2 FTSA) was detected in 21% of samples, while 8:2 FTSA and 6:2 fluorotelomer sulfonamidoalkyl betaine (6:2 FTAB) were less frequent. Our study also confirms results from an earlier survey indicating the potential widespread exposure to short-chain perfluoroalkyl sulfonamides, especially the C4 and C6 homologs, while a cyclic perfluoroalkyl acid was also recurrently detected in tap water.

**MP164 Bioaccumulation potential of novel fluoroalkyl substances in soil to earthworm microcosms**

G. Munoz, University of Montreal / Chemistry; M. Desroisiers, Center of Expertise in Environmental Analysis of Quebec; S. Vo Duy, University of Montreal / Chemistry; J. Jarjour, J. Liu, McGill University / Civil Engineering; S. Sauvé, University of Montreal / Chemistry

Various classes of per- and polyfluoroalkyl substances (PFASs) were recently discovered in aqueous film-forming foams (AFFFs) and environmental samples impacted by AFFF activities. However, critical knowledge gaps remain regarding their environmental fate and effects, including assessment of their bioaccumulation potential. Here, we performed a comprehensive assessment of the bioaccumulation of legacy and newly-identified PFASs, using earthworms (Eisenia fetida) as model organisms. Extraction procedures were first validated for improved recoveries of fluorotelomer sulfonamidoalkyl betaines (FTAB) and fluorotelomer betaines (FtB) from soil and earthworm matrix. This allowed a more accurate assessment of bioaccumulation factors (BSAF) for compounds without authentic standards. In the first step of this study, earthworms were exposed to soils amended with AFFFs (Ansol, Arctic Foam) or pure standards, as well as to a field-collected soil impacted by fire-equipment testing activities. The 6:2 FTAB bioaccumulated in earthworms but showed a substantially lower BSAF compared to that of perfluorooctane sulfonate. In earthworms exposed to Ansolite amended soil, the BSAF exhibited certain chain length dependence for n:3 FtB and n:1.2 FtB. In the second step of this study, earthworms were collected in situ from an active firefighting training area and submitted to UHPLC-HRMS analysis. Fluorotelomer sulfonates were detected at elevated levels in field-collected earthworms, especially the 6:2 and 8:2 homologs. Several major PFAS classes are also reported for the first time in terrestrial organisms, including FTAB, FtB, fluorotelomer thioether amidosulfonates, and presumed biotransformation intermediates.

**MP165 In situ and laboratory assessment of PFAS effects using the in situ Toxicity Diagnostic System (iToDS)**

E.C. Cervi, University of Michigan / SEAS; G.A. Burton, University of Michigan / School for Environment and Sustainability; E. Verhamme, T. Dekker, J. Daley, LimnoTech; C.P. Higgins, Colorado School of Mines / Department of Civil and Environmental Engineering; N. Fitzgerald, University of Minnesota

An in situ Toxicity Diagnostic System (iToDS) was developed to better establish stressor exposure-causality. Recently, we evaluated its use for detecting per- and polyfluoroalkyl substances (PFASs) exposures and adverse biological effects. ToDS deployment was conducted in the Clinton River, Michigan; previously identified as a PFAS hotspot. The iToDS units were acid cleaned (12% hydrochloric acid) prior to deployment. Each unit was connected to a 500 mL polypropylene collection bottle via silicone tubing with an additional check valve to prevent backflow into the bottles. Commercially available resins were preweighed (3-5 g each, dry) and preconditioned with deionized water or methanol. Resins chosen for deployment included activated carbon (AC), Oasis HLB, Oasis WAX, and glass wool. AC, HLB, and WAX were chosen as active resins while glass wool represented a control (no chemical removal). Daphnia magna were placed in exposure chambers to assess acute (in situ) and chronic toxicity (post-exposure reproduction) of water processed by each resin chamber. The iToDS units pumped at 25 mL h⁻¹ for a 24 h exposure. PFAS concentrations were analyzed by ultra-performance liquid chromatography - tandem mass spectrometry (UPLC-MS/MS). Concurrent comparisons in the laboratory consisted of a chemtainer (50 L) containing site water and using similar sorption and exposure conditions. The comparisons showed each approach provided different outcomes with different advantages and limitations. PFOS concentrations of over 600 ng L⁻¹ in situ failed to produce toxicity. Spiking studies in the laboratory confirmed D. magna was not sensitive at environmentally-relevant concentrations. The iToDS technology required half the resource time as the lab TIE, and again proved to be robust, reliable, and easy to use in the field. It also has shown to be more sensitive at detecting ambient toxicity than the traditional lab-based protocols. A primary limitation of the iToDS is also its strength - it must be deployed in situ which increases accuracy and realism; but, can present logistical challenges. This innovative system is providing benefits by allowing for more accurate assessments of ecological risk at PFAS contaminated sites.

**MP166 Estimating Human Accumulation Potential of Per- and Polyfluoralkyl Substances: A Novel Density Functional Theory Approach**

B. Yan, J. Liu, McGill University / Civil Engineering

The extremely stable carbon-fluorine bonds make per- and polyfluoroalkyl substances (PFASs) ideal for widespread industrial uses, but also result in highly persistent and globally distributed contaminants. Humans are exposed to PFAS via ingesting contaminated food, dust or drinking water, while PFAS exposure has been reported to associate with series human diseases such as bladder cancer and prostate cancer. Close to 97% population in North America has detectable levels of PFASs, particularly, perfluorooctanoic carboxylate (PFOA) and sulfonate (PFOS). Binding to proteins is one of the routes by which PFASs accumulate in the human body; PFASs are mainly distributed in serum, kidney, and liver, with liver concentrations being several times higher than serum concentrations. However, the binding of protein and PFAS is not fully understood. A novel Density Functional Theory (DFT) based approach that combines molecular docking, molecular dynamics simulation, and quantum calculation was developed to estimate the binding affinity of three human proteins (i.e., serum protein, -lipoprotein, and liver-type fatty acid binding protein) with PFASs commonly detected in soil, groundwater and drinking water. The PFASs under examination include PFOA, PFOS,
florotolomer sulfonates, 6:2 florotolomer sulfonamidoalkyl betaine, perfluorohexanoic sulfonate and sulfonamide, and perfluoro-4-ethylcyclohexanesulfonate. The estimated values of binding energy demonstrated a good correlation with the experimental data obtained from three different studies. The strong binding affinity was primarily contributed by hydrogen-bonding, electrostatic attraction, and hydrophobic interaction. The strength of binding was enhanced with the increase in the perfluoroalkyl chain length. The DFT based computational method shows a great promise to allow estimating and evaluating the human accumulation potential of PFASs in organisms.

**MP167 The bioaccumulation of polyfluoroalkyl and perfluoroalkyl substances (PFASs) in earthworms (Eisenia fetida) from sorbent amended soil**

J. Jarjour, McGill University; G. Munoz, University of Montreal / Chemistry; M. Desrosiers, Center of Expertise in Environmental Analysis of Quebec; S. Sauvé, University of Montreal / Chemistry; J. Liu, McGill University / Civil Engineering

The use of aqueous film forming foams (AFFFs) for putting out flammable liquid fires has introduced polyfluoroalkyl and perfluoroalkyl substances (PFASs) into different environmental media, including soil. In situ soil stabilization using sorbent amendment has demonstrated potential in reducing PFAS leaching from contaminated soil and bioavailability. However, the behaviors of PFASs following the amendments have to be further evaluated to validate this approach. The uptake by earthworms (Eisenia fetida) following amendment will be studied as it is a widely used means to assess bioavailability in soil. Two different amendments will be used for this study: coal based activated carbon (F-400) and a new clay-based adsorbent (Fluorosorb® 100). A surface soil was collected in Montreal to which the sorbents will be amended at different concentrations (0-4%). A mixture of representative PFASs including 4 perfluorokyl sulfonates (PFsAs), 6 perfluorocarboxylates (PFCAs), 3 (n:2) florotelomer sulfonic acids, and 6:2 florotelomer sulfonamidoalkyl betaine (6:2 FTAB) will be used to spike the soils at relevant concentrations. Spiked soils will be amended with the sorbents to which the earthworms will be exposed to for an uptake phase test until steady-state is reached. This study will examine and discuss the relationship between the different factors that contribute to the reduction of bioaccumulation of PFASs. The reduction in bioaccumulation will be compared with the data generated using the USEPA Method 1311 (TCLP test) to allow the determination of appropriate amendments for different soil types and PFAS, and establish cost-effective materials for stabilizing PFAS in the soil.

**MP168 The relationship between PFAS and microbial communities at a legacy firefighting training area**

D. O’Carroll, M. Lee, S. Le, A. Yeung, M. Manefield, University of New South Wales / Civil and Environmental Engineering; S.J. Wallace, Institut National de la Recherche Scientifique / Centre Eau Terre Environnement; N. Battye, Royal Military College of Canada / Chemistry and Chemical Engineering; K.P. Weber, Royal Military College / Chemistry and Chemical Engineering

We evaluated the relationship between microbial communities and PFAS distributions in the subsurface at a firefighting training area (FFTA). Aqueous film forming foam (AFFF) was applied to the FFTA for over 50 years, a time period which spans many different AFFF manufacturer formulations. A suite of PFAS encompassing those with Canadian guidance values (C4-C12, carboxylates, sulfonates) and those found in newer formulations (8:2 and 6:2 telomers) were profiled in 40+ wells over a two year period yielding over 80 samples total. Microbial communities from these same samples were also characterized using next generation sequencing and this data analyzed in conjunction with PFAS profiles, available site data (e.g., subsurface stratigraphy), monitoring well data (e.g., pH, ORP, inorganic species) and soil data (e.g., soil type, organic carbon). Our data indicates and supports current hypotheses that PFAS telomer transformations occur onsite. Additionally, we found several correlations indicating positive, negative, and sometimes threshold inhibition relationships between certain PFAS and specific microbial genera.

**MP169 Sorption of PFAS to Rock**

S. Saucé, University of Montreal / Chemistry; J. Liu, McGill University / Civil Engineering

Despite the widespread occurrence of PFAS contamination in bedrock formations, the fate and transport of these contaminants in fractured bedrock remains unexplored. Fractured bedrock formations are complex, dominated by flow through fractures and exhibit much different characteristics than soils and sediments. It is currently unclear whether distribution coefficients, retardation factors and sorption mechanisms of PFAS to soils and sediments are applicable to fractured bedrock formations. To address this knowledge gap, a series of laboratory experiments was conducted to study the sorption of a suite of PFAS to rock. Crushed and re-wetted Lockport Dolostone was used to evaluate sorption kinetics, mechanisms, and competition for a suite of 13 PFAS (C4-C12) with varying functional head groups (carboxylates, sulfonates and sulfonamide). For long chain PFAS (C8-C12 for carboxylated or C6-C12 for sulfonated) sorption increased with increasing chain length, suggesting hydrophobic-like interactions to be the predominant sorption mechanism. For short chain PFAS (C4-C7 for carboxylated or C4-C5 for sulfonated) sorption was not correlated to chain length, potentially due to competition between short and long chain compounds for available sites. This phenomenon has not been observed in previous sorption studies conducted using soils and sediments, suggesting that PFAS fate and transport in fractured bedrock formations is likely different than in soils and sediments. Additionally, sorption of long chain length compounds exhibited two different behaviors depending on chain length, suggesting that long chain length compounds should be subdivided into intermediate chain length compounds and long chain length compounds (C10-C12). Sorption of sulfonated PFAS was found to be greater than sorption of carboxylate or sulfonamide analogs with the same carbon chain length, suggesting that electrostatic forces also play a role in sorption to these rock samples. This is the first data for sorption of PFAS to rock and thus represent the first step towards evaluating PFAS fate and transport in fractured bedrock aquifers.

**MP170 Degradation of PFAS in a nuclear reactor: Determining an underlying and universal degradation mechanism**

J. Rook, Department of National Defence; E. Corcoran, Royal Military College of Canada / Chemistry and Chemical Engineering; K.P. Weber, Royal Military College / Chemistry and Chemical Engineering

Degradation of PFAS is challenging by any means. We put a selection of 13 PFAS (C4-C12) with varying functional head groups (sulfonates, carboxylates, sulfonamide), in various water chemistries, inside a nuclear reactor core for over 1 hour. We did not see complete degradation of any of the PFAS (3-90% over the range of conditions). We were however able to see varying degradation efficiencies based on PFAS length, functional head group, and water chemistry. Through a rigorous, numerical model assisted, dose and fluence characterization we were able to discern the likely degradation mechanism involved in a reasonably realistic ground-water scenario. Reduction, specifically and solely based on aqueous electrons, was shown to be effective and therefore holds promise as a universal degradation mechanism. The information learned here can be universally applied to the development of remediation technologies for both water and soil.
MP171 Development of an experimental and modeling framework to evaluate the remediation of PFAS by colloidal activated carbon
S. Gilak Hakimabadi, University of Waterloo / Civil and Environmental Engineering; G. Carey, Porewater Solutions; A. Pham, University of Waterloo / Civil and Environmental Engineering

The remediation of sites contaminated with poly- and perfluoroalkyl substances (PFAS) using colloidal activated carbon (CAC) was investigated in this study. CAC are micron-sized particles that can readily migrate through pore spaces in transmissive sand zones. Following injection into the subsurface, CAC will attach to soil grains, creating a stationary barrier zone that will adsorb PFAS compounds in situ and substantially reduce contaminant transport downstream of the barrier. As with any sorption-based technology, the sorption sites on CAC will eventually become saturated, resulting in a breakthrough of PFAS. The overall objective of this research was to gain insights into the factors influencing the adsorption of PFAS by CAC, the knowledge of which will allow the development of a reactive transport model capable of predicting the longevity of CAC barriers. To this end, a series of batch adsorption experiments were conducted to investigate how the solution composition as well as various water chemistry parameters affected the adsorption of 15 perfluoroalkyl acids and 3 PFAS precursors on CAC. The adsorption isotherm parameters obtained from these experiments were then employed in a reactive transport model to predict the concentrations of PFAS in the CAC barrier and downgradient under various scenarios of source zone PFAS mass discharge, and the concentration of CAC in the barrier. Modeling of a conceptual aqueous film-forming foam (AFFF)-impacted site indicated that the longevity of CAC barriers could be on order of decades for longer-chain compounds such as PFOA, PFOS and PFHxS, because these compounds have a high affinity to CAC. Shorter chain compounds (e.g., PFBS and PFBA) generally had lower adsorption affinity, especially in the presence of longer-chain compounds that competed with the shorter-chain ones for the CAC surface. Although the breakthrough of the shorter-chain compounds may occur within a shorter timeframe, these compounds are less toxic and have higher groundwater action levels if they are regulated in a jurisdiction. Further research will focus on evaluating the efficacy of this technology for shorter-chain PFAS and designing of more robust modeling tools to support remedial predictions.

MP172 PFAS Destruction in Soil through Smouldering Combustion (STAR)
A. Duchesne, Western University / Civil and Environmental Engineering; D. Patch, Royal Military College of Canada / Chemistry and Chemical Engineering; J. Gerhard, J. Brown, Western University / Civil and Environmental Engineering; G. Grant, Savron Solutions; K.P. Weber, Royal Military College / Chemistry and Chemical Engineering; D. Major, Savron Solutions

Smouldering is a flameless, exothermic oxidation reaction; charcoal in a BBQ is a typical example. Once initiated the smouldering reaction is self-sustaining and will propagate through the contaminated porous media without any additional external energy input. This makes smouldering a less costly and more cost-effective process than other thermal treatments. STAR can destroy a variety of recalcitrant organic compounds with removal efficiencies typically in excess of 99%. The tests used either GAC loaded with PFAS combined with sand to produce a smoulderable mixture, or a soil contaminated with PFAS and mixed with uncontaminated GAC to create a smoulderable mixture. In all tests, the PFAS-contaminated mixtures were subject to smouldering (STAR) tests in 60 cm high, 16 cm diameter steel columns instrumented with thermocouples. Results reveal that the smouldering front propagated in a self-sustained manner through the PFAS-impacted mixtures, destroying all the GAC and organic carbon and generating temperatures in excess of 900°C, which is expected to be sufficient to thermally destroy PFAS compounds. Post-treatment concentrations of PFAS in the remaining sand, soil, and ash were below detection limits (0.05 µg/kg). Initial emission analysis indicated that over 82% of the available fluorine was captured as HF with only small amounts of PFAS emitted which could be subsequently captured by activated carbon and treated. Results to date are promising, suggesting STAR may provide an effective remediation technique for PFAS-impacted soils.

MP173 Scale-up and destruction of per- and polyfluoroalkyl substances in soil via ball milling
N. Battye, Royal Military College of Canada / Chemistry and Chemical Engineering; L. Turner, Queen’s University / Department of Civil Engineering; O. El-Sharnouby, GeoSyntec Consultants, Inc.; D. Patch, Royal Military College of Canada / Chemistry and Chemical Engineering; K. Juansalu, NATO; B. Kueper, Queen’s University / Department of Civil Engineering; K.P. Weber, Royal Military College / Chemistry and Chemical Engineering

We have demonstrated that ball milling can destroy per- and polyfluoroalkyl substances (PFAS) in contaminated soil. PFAS impacted soil from a 50+ year old firefighting training area (FFTA), as well as PFAS-spiked Ottawa sand, were used in all trials. Three different sized ball mills were used to evaluate and demonstrate scalability. A suite of 13 PFAS compounds spanning and extending beyond those with Canadian guidance values were tracked in all cases. Our results demonstrate up to 97% of the PFAS is destroyed within minutes in two types of soil, sand, and clay, and that no identifiable PFAS products are produced. Conventional remediation technologies are not effective for the destruction of PFAS; this methodology of onsite PFAS-contaminated soil remediation is cost-effective and will be scaled on-site to develop detailed operational requirements.

Environmental Occurrence, Bioaccumulation, Fate and Transport of Poly- and Perfluoroalkyl Substances (PFAS)

MP174 Environmental Degradation of a Novel Polyfluorinated Surfactant: Aerobic Biodegradation and Atmospheric Oxidation
S. Jouad, University of Toronto / Chemistry; J.J. Orlando, G.S. Tyndall, National Center for Atmospheric Research / Atmospheric Chemistry, Observations & Modeling; T.C. Furlani, York University / Chemistry; C. Young, York University / Department of Chemistry; S. Mabury, University of Toronto / Chemistry

As many per- and polyfluoroalkyl substances have been legislated or phased-out, newer chemistries are being developed. Ideally, the replacement chemicals will be intelligently designed to degrade to non-bioaccumulative components under ambient environmental conditions. One new commercially available fluorinated surfactant has an active ingredient with the chemical structure \([R_2-O-CHF-CF_2-S-CH_2-O-C=O]_2\). To investigate if this surfactant will in fact degrade, we incubated it with wastewater treatment plant sludge under aerobic conditions. Preliminary experiments with 0.5%, 2% and 10% sludge resulted in the degradation of about 70%, 84% and 92% of the surfactant over eight days. Using positive chemical ionization GC-MS, we observed the formation of an alcohol, \(R_2-O-CHF-CF_2-S-CH_2-OH\), and using negative electrospray ionization UPLC-MS/MS, we observed the formation of a carboxylic acid \(R_2-O-CHF-CF_2-S-CH_2-C(=O)OH\). Further degradation products are being investigated using a longer biodegradation experiment with 0.5% sludge, which will be completed in time for this meeting. The alcohol is a starting material for the synthesis of the surfactant, and we have shown that it also forms as a degradation product. Since it is semi-volatile, we investigated its atmospheric fate via laboratory oxidation experiments with Cl and OH radicals. Preliminary results report reaction kinetics faster than the fluorotelomer alcohols (FTOHs) which are synthetic intermediates and degradation products of many phased out or current use products. The atmospheric lifetime of this alcohol is about 1-3 days with respect to reaction with OH.
including COF₂, SO₂ and a prominent acyl fluoride (R₁-O-CH₂C(=O)F). Offline product experiments were also performed under various atmospheric conditions, and offline samples were collected in a bubbler and analyzed for acid degradation products. Two larger acids were identified as primary degradation products [R₁-O-CHF-CF₂-S-CH₂CH₂-C(=O)OH; R₁-O-CHF-CF₂-SO₂H], and two smaller acids that appear to be terminal degradation products, one of which is perfluoropropanoic acid. These two studies will assess the formation of degradation products under various environmental conditions to determine if this replacement surfactant is less persistent than other fluorinated surfactants.

**MP175 Waste Incineration of Polytetrafluoroethylene (PTFE) to Evaluate Potential Formation of Per- and Poly-fluorinated Substances (PFAS) in Flue Gas**

D. Pigeon, W.L. Gore & Associates; H. Gehrmann, Karlsruhe Institute of Technology KIT / Institut für Technische Chemie (ITC); K. Aleksandrov, Karlsruhe Institute of Technology KIT; M. Wexler, H. Mätzinger, Karlsruher Institut für Technologie; M. Hauser, Karlsruher Institut für Technologie (KIT); D. Staff, Karlsruher Institut für Technologie

In recent years, concerns over some per- and polyfluorinated alkyl substances (PFAS) have grown steadily. PFAS are a large group of chemical substances with widely differing properties. While one class of PFAS, fluoro polymers, have been demonstrated to meet the OECD criteria for polymers of low concern during the in-use phase of their lifecycle, questions remain regarding waste handling at the end of useful life for products containing fluoro polymers. To show that polytetrafluoroethylene (PTFE) can be almost fully transformed into fluorne (F) (as hydrofluoric acid (HF)) and to study the possible generation of low molecular weight per- and polyfluorinated alkyl substances (PFAS), PTFE combustion under typical waste incineration conditions at the BREnda (German acronym for "Brennkammer mit Dampfkessel") pilot plant at Karlsruhe Institute of Technology (KIT) was investigated. Results indicate that, within procedural quantitation limits, no statistically significant evidence was found that the PFAS studied were created during the incineration of PTFE. Therefore, municipal incineration of PTFE using best available waste treatment technologies (BAT) is not a significant source of the studied PFAS and should be considered an acceptable form of waste treatment.

**MP176 Heterogeneous reaction of perfluoropropanoic acid (PFPrA) with aerosol proxies: Implications for aerosol-mediated long-range transport**

E. Gaona Colmán, Universidad Nacional de Córdoba / Chemistry; T. Vandendoor, York University / Department of Chemistry; J. Wentzell, J. Liggio, Environment and Climate Change Canada / Air Quality Research Division; C. Young, York University / Department of Chemistry

Perfluoropropanoic acid (PFPrA) is a short chain aliphatic carboxylic acid part of the poly- and perfluoralkyl substances (PFASs) family. PFASs are highly demanded substances due to their stability and properties surfactant properties leading to industrial applications such as textiles, cookware, and firefighting foams. Therefore, due to their extensive industrial use and their high persistence, these substances are ubiquitously distributed in the environment even in remote locations such as the Arctic. In the atmosphere, short chain PFASs can be emitted directly from sources or formed from reactions of longer chain precursors (e.g. fluorotelomers) with atmospheric oxidants (e.g. hydroxyl radicals). Despite the well-known atmospheric formation of short chain fluorinated acids, there is still a gap of knowledge regarding their transport to remote locations, where aerosols could contribute to this transport. In this study we present the uptake of gas phase PFPrA onto aerosol proxies, including carbonate salts as proxies of inorganic mineral dust. The experiments were performed in a flow tube reactor at 298 K and atmospheric pressure in zero air carrier gas coupled to a chemical ionization mass spectrometer (CIMS) detection system using acetate reagent ion. Gas phase PFPrA was obtained from the acid displacement reaction of HCl(g) over a salt bed of sodium perfluoropropanoate. The monitored ions were acetate (m/z=59), acetate dimer (m/z=119), PFPrA ion (m/z=163), nitrate (m/z=62) and chloride (m/z=35). To our knowledge, this work is the first determination of the reactive uptake coefficients of gas phase PFAS onto aerosol proxies. Reactive uptake coefficients will be presented and the implications for PFAS long-range transport will be discussed.

**MP177 Precipitation Dominates Atmospheric Deposition of PFASs to the Great Lakes**

Y. Wu, Indiana University, Bloomington / O’Neill School of Public and Environmental Affairs; A. Salamova, Indiana University / SPEA; R.A. Hites, Indiana University / School of Public Environmental Affairs; M. Venier, Indiana University / SPEA

In this study, we collected vapor and particle phase samples as well as precipitation in Bloomington, Indiana (n = 10 each) with the goal of determining which phase contributed the most to atmospheric deposition. We also compared two sampling methods for precipitation, one employing a stainless steel funnel and one a polypropylene funnel. Our results clearly indicate that polypropylene should be used for PFASs precipitation sampling due to sorption of ionic PFASs to stainless steel. In Bloomington, ΣPFAS median concentrations were 99.6 pg/m³ in the vapor phase, 4.02 pg/m³ in the particle phase, and 2000 pg/L in precipitation. We also collected precipitation samples at two sites (n = 3 each) located in the Great Lakes basin, which are part of the Integrated Deposition Atmospheric Network (IADN), one urban (Cleveland, Ohio) and one remote (Sleeping Bear Dunes, Michigan). Median ΣPFAS concentrations were 9000 and 817 pg/L at Cleveland and Sleeping Bear Dunes, respectively. Median wet deposition fluxes for ΣPFASs in Cleveland were 7810 ng y⁻¹ m⁻², significantly higher than in Bloomington at 1730 ng y⁻¹ m⁻². Wet deposition fluxes for PFASs were also about 15 times higher than those for total PCBs and total organochlorine pesticides at about 500 ng y⁻¹ m⁻². Based on the relatively low vapor and dry deposition fluxes (2.39 and 254 ng y⁻¹ m⁻², respectively) measured in Bloomington, we suggest that precipitation is the most important atmospheric phase to monitor.

**MP178 Air concentrations of per- and polyfluoroalkyl substances (PFAS) in North Carolina**

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While per- and polyfluoroalkyl substances (PFAS), especially legacy compounds, have been measured in ambient air in urban and rural areas in several locations around the world, concentrations, source contributions and atmospheric transformations of legacy and emerging PFAS remain poorly characterized. North Carolina (NC) is a logical place to study these, given the existence of a PFAS manufacturing plant (Chemours), military bases and other users of fire-fighting foams, and urban waste streams, all of which are sources. The potential for human exposure to these compounds (directly through inhalation and indirectly as a result of atmospheric deposition) is a source of concern for stakeholders in NC and beyond. For these reasons, we initiated an on-going sampling campaign that includes 6-day integrated sampling of particle and gas-phase PFAS using quartz filters and polyurethane foam (PUF) plugs, respectively. Samples are being collected weekly for one year at 5 locations: Fayetteville, Wilmington, Research Triangle Park, Charlotte, and Greenville, NC. Seasonally-compomised samples are analyzed using an optimized (targeted) method via AB SCIEX Triple Quad(TM) 6500 LC/MS/MS. Detection limits for targeted PFAS are 0.05-1 ppb in
Poly- and perfluoroalkyl substances (PFAS) and volatile methyl siloxanes (VMS) are high production volume chemicals and are persistent, hence show long-range transport in the environment. Among PFAS, perfluorooctane sulfonate (PFOS), its salts and precursor compound (perfluorooctane sulfonyl fluoride), were added to the Stockholm Convention (SC) on persistent organic pollutants (POPs) in 2009. Very recently in 2019, perfluorooctanoic acid (PFOA), its salts and related compounds have also been listed in SC, given their potential toxic effects of human health and environment. As such, their continuous monitoring is required to assess the effectiveness of these regulations. PFAS and VMS are globally being monitored at 20 sites under Global Atmospheric Passive Sampling (GAPS) Network for the past decade. In 2017, GAPS expanded the monitoring of these chemicals at over 40 sites across the globe including polar, background, agricultural and urban sites. Sorbent impregnated polyurethane foam disks (SIPs) were deployed at ~45 GAPS sites in double-dome sampling chambers. Sampling was conducted from April to June 2017 and samples were stored below -10°C until analysis. Samples are being analysed for 18 perfluoroalkyl acids, 7 neutral-PFAS (nPFAS) and 7 linear and cyclic VMS. Preliminary results are presented here for n-PFAS at 8 sites in the United Nations region of ‘Western Europe and Others Group’ (WEOG) monitored under GAPS network. These include 2 polar, 5 background and 1 urban sites. Levels of Σ7nPFAS were 2.4-12, 0.2-16 and 50 pg/m³ at polar, background and urban sites, respectively. Among nPFAS, 8:2TOT, 10:2 FTOH and Me-FOSA were most widely detected at these sites. Upcoming analysis will report new information on levels of all PFAS and VMS on larger spatial scale across the globe.

MP182 Multimedia fate modelling of per- and polyfluoroalkyl substances near industrial point sources

A.M. Lampic, J. Parnis, D. Mackay, Trent University / Chemistry

Per- and polyfluoroalkyl substances (PFASs) are man-made chemicals widely used in a variety of industries. Once introduced to the environment, PFASs are resistant to degradation which increases their bioaccumulation potential and exposure to the surrounding environment. Fluorochemical manufacturing parks (FMPs) are important point sources of PFASs into surrounding environments. Understanding the environmental fate of emitted PFASs from FMPs is important to mitigate exposure and aid in environmental remediation. We will report on the status and progress in the creation of a fugacity-based multimedia model to accurately describe the fate and transport of 25 PFASs in urban and agricultural environments that surround FMPs. We will report and critically review predictions of physicochemical properties of PFASs made by application of property estimation programs. Fugacity-based multimedia
models will be created using a similar theoretical framework as described in Mackay (2001). Three fugacity-based multimedia models with increasing complexity will be created (Mackay Level I, Level II, and Level III). The quality of the models will be assessed by the degree of agreement between the predicted and experimentally measured PFAS levels in the various environmental compartments of the system, with the experimental data coming from the work by Chen et al. (2018) in Fuxin, China. This research will shed light on the important processes that control the fate and distribution of these compounds and will provide a supportive framework for regulatory control and environmental remediation. The developed models will also provide insight and understanding into the processes and important factors that govern PFAS fate in the environment. The primary sinks for PFAS will also be highlighted under the defined environmental conditions.

MP183 PFAS Fate and Transport During Wastewater and Indirect Potable Reuse Treatment: A Utility’s Perspective on the Importance of Source Control

D. Gonzalez, Hampton Roads Sanitation District; J. Heisig-Mitchell, Hampton Roads Sanitation District / Water Technology and Research

While there are several potential sources of PFAS in wastewater influent, one of the most concentrated sources can be aqueous film forming foam (AFFF) when it is accepted by treatment plants in industrial waste streams. Research going back to the 1970s using different versions of AFFF has indicated that fluxes of these chemicals into treatment plants in southeastern Virginia has the potential to inhibit effective treatment of wastewater. While initial source control implementation at the utility stemmed from potential impacts to wastewater treatment, recent source control efforts also consider limiting PFAS content for indirect potable reuse and advanced water treatment. In this talk we will review impacts of various types of AFFF using a holistic view of both wastewater and drinking water quality at a utility in southeastern Virginia. Impacts on biological nutrient removal (BNR) using sequencing batch reactor (SBR) studies will be presented. In this work, three different wastewater treatment configurations (fully nitrifying, Modified Ludzack-Ettinger (MLE), and 5-stage Bardenpho) were considered to investigate impacts on nitrification, denitrification, and biological phosphorus removal. In addition, the fate and transport of AFFF-associated PFAS during wastewater treatment will be discussed. The importance of source control in minimizing pass-through to water reuse activities cannot be understated. Here, we will present results from an indirect potable reuse project that employs an advanced treatment train using coagulation, flocculation, sedimentation, ozonation, biofiltration, granular activated carbon (GAC), and UV disinfection. The main mode of PFAS removal in this train is via adsorption on GAC. Large swings in influent PFAS content to this carbon-based train are avoided primarily by a comprehensive pretreatment program that does not allow AFFF into the waste stream. We will present data showing that finished indirect potable reuse water has low PFAS levels when the lowest possible quantitation limits are employed.

MP184 Per- and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate, Municipal Wastewater and Occurrence in Drinking Water Sources

J. Thelusmond, M. Barlaz, North Carolina State University / Civil Constr and Env Eng

Per- and polyfluoroalkyl substances (PFASs) are used in a variety of consumer products which, at the end of their life cycle, are disposed in landfills. It is not surprising that PFASs have been detected in leachate percolating from landfills that receive municipal solid waste (MSW). This is cause for concern because leachate from MSW is generally treated together with domestic wastewater in publicly owned wastewater treatment plants (POTWs) which were not originally designed to remove such contaminants. Therefore, POTWs have the potential to act as point sources for PFAS surface water contamination. Other potential water contamination sources include construction and demolition landfills, which are typically unlined, and therefore release their leachate untreated to both groundwater and surface water. The aim of this research is to estimate the mass of PFASs released from North Carolina (NC) domestic wastewater and landfill leachate to POTWs, and in turn, from POTWs to surface water. We collected leachate samples from 13 MSW landfills and 4 construction and demolition sites. We also collected flow-proportional, 24 h composite samples of raw influent and final effluent from 24 POTWs throughout NC. To account for PFAS temporal variability, two of the 24 POTWs were sampled weekly for 4 weeks. All samples were kept on ice until their arrival in the laboratory where they were frozen until PFAS extraction by solid phase extraction. The samples have been extracted and their analysis by liquid chromatography high-resolution mass spectrometry is in progress. PFAS concentrations will be quantified or estimated depending on whether adequate standards are available. PFAS concentration data will be used to estimate the mass of individual PFAS as well as total PFAS entering POTWs. We will also estimate the mass of PFASs discharged from NC POTWs.

MP185 Occurrence of per- and polyfluoroalkyl substances (PFAS) in North Carolina drinking water sources

N. DeStefano, North Carolina State University; Z. Hopkins, NC State University / Department of Civil, Construction, and Environmental Engineering; A. Joyce, Duke University / Civil and Environmental Engineering; Y. Han, M. Sun, University of North Carolina at Charlotte / Civil and Environmental Engineering; L. Ferguson, Duke University / Civil and Environmental Engineering; D. Knappe, North Carolina State University / Civil, Construction and Environmental Engineering

Per- and polyfluoroalkyl substances (PFAS) are a group of man-made compounds produced and used commercially for their nonstick and heat resistant properties. They are commonly used in food containers, house- hold products, electronics manufacturing, and firefighting foam. Several PFAS, such as perfluorooctanoic acid (PFOA), are ubiquitous globally and can harm human health through commercial and environmental exposure. In addition to the suite of known compounds, thousands of new PFAS are being produced and released into environmental matrices, limiting our ability to reliably assess true human exposure potential. For example, the compound known as “GenX” was recently discovered in high concentrations in the Cape Fear River in North Carolina (NC) downstream of a fluorochemical manufacturing plant. GenX and related compounds passed through drinking water treatment plants unaffected into finished water taps, and the resulting impacts on human health are largely unknown. As a result of the discovery of GenX and related fluoroethers, residents in other NC communities are wondering whether poorly understood PFAS are present in their drinking water. Therefore, the overarching aim of this study is to gain a better understanding of PFAS occurrence in North Carolina drinking water sources. A combination of targeted and non-targeted workflows is being performed to comprehensively identify PFAS in raw drinking water from public water systems throughout NC. Also, adsorbable organic fluorine (AOF) is being quantified in each water sample by combustion ion chromatography to understand the total burden of fluorinated compounds. Known PFAS compounds are quantified using available authentic standards and compared to AOF data to determine the proportion of PFAS that remains uncharacterized. Non-targeted PFAS identification is being performed by spectral library interrogation, isotope rationalization, in situ fragmentation, generation of fragmentation trees, and comprehensive literature and patent review.

MP186 Monitoring of perfluorinated compounds (PFCs) in private drinking well water in the Tama area of Tokyo, Japan

T. Yamazaki, T. Kinoshita, Tokyo Metropolitan Institute of Public Health; T. Suzuki, Tokyo Metropolitan Institute of Public Health; T. Suzuki, Tokyo Metropolitan Institute of Public Health; T. Nishimura, Teikyo Heisei University / Faculty of Pharmaceutical Sciences

Perfluorinated compounds (PFCs) are used widely as a water repellent, fire extinguishing agent, coating agent, etc. PFCs have many kinds of
congeners, and their properties differ depending on their carbon chain length. In particular, perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), both having a straight chain composed of 8 carbon atoms (C8), are well known. They are persistent in the environment and bioaccumulative in wildlife and humans. Therefore, they have been internationally regulated. PFOS has been listed in Annex B (Restriction) of the Stockholm Convention on Persistent Organic Pollutants, which restricts its production, use, import, and export, since 2009. On the other hand, PFOA was recently recommended for listing in Annex A (Elimination) of the convention in the 14th meeting of the Persistent Organic Pollutants Review Committee. In Japan, as well, manufacture and importation of PFOA have basically been prohibited, and production and import results for PFOA must be reported. In this study, we investigated the contamination levels of PFCs in well waters in the year 2018 and compared these results to the monitoring results in 2007-2011. The monitored PFCs were PFPeA(C5), PFHxS(C6), PFHpA(C7), PFOA, PFNA(C9), PFDA(C10), PFUdA(C11), PFDoA(C12), PTrA(C13), PFtA(C14), PFBS(C4), PFHxS(C6), PFHpS(C7), PFOS, and PFDS(C10). A 500 mL water sample was concentrated to 0.5 mL by a solid-phase extraction method (OASIS HLB, elution with methanol) and the resulting sample was analyzed by ultra-high performance liquid chromatography-tandem mass spectrometry. In 2007-2011 (n = 276), the average of the detected concentration (maximum) was 42.6 (1118.3) ng/L for PFOS and 9.6 (199.7) ng/L for PFOA. On the other hand, in 2018 (n = 58), the average (maximum) of the detected concentration was 34.3 (776.1) ng/L for PFOA and 8.3 (83.7) ng/L for PFOA. Comparing the average values in 2007-2011 with those in 2018, it is apparent that both concentrations of PFOS and PFOA have decreased. In addition, we performed a cluster analysis of all the PFCs detected in 2007-2011 and 2018. In both monitoring periods, a correlation was found between PFOS and PFHxS, and this correlation was more pronounced in 2018. Furthermore, the average concentration of PFHxS in 2018 (39.3 ng/L) was larger than that in 2007-2011 (25.5 ng/L). It is suggested that the use of PFHxS may have increased because of its use as an alternative to PFOS.

**MP187 Tissue-specific distribution of emerging per- and polyfluoroalkyl substances (PFASs) in Atlantic seabirds**

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Long-chain per- and polyfluoroalkyl substances (PFASs) demonstrate remarkable environmental persistence, bioaccumulative capacity, and have been found globally in surface water and biota, including birds from diverse habitats. Public health concerns and regulatory attention have caused a shift in PFAS production, causing industry to move away from longer-chain perfluorinated structures towards short-chain analogues or structurally diverse compounds with variable functional groups or fluorination patterns. Seabirds are ideal sentinels to assess the occurrence of both legacy and emerging PFASs in food webs, as their upper trophic level position allows them to assimilate resources and related biological, physical, and chemical conditions across multiple ecosystems and temporal scales. Here, PFASs were measured in multiple tissues from juvenile Atlantic seabirds collected in 2017 and 2018. Species sampled included deceased immature or juvenile herring gulls, great shearwaters, terns, and pelicans from Narragansett Bay in Rhode Island, Massachusetts Bay off the coast of Massachusetts, and the Cape Fear River Estuary (CFRE) in southeastern North Carolina. Samples were analyzed for legacy and emerging PFASs using liquid chromatography/high resolution mass spectrometry, employing both targeted and suspect screening methods. Tissues screened included heart, brain, kidney, lungs, uropygial gland, adipose fat, liver, muscle, blood, and feces. PFOS dominated all liver samples across all individuals and habitats. Emerging compounds previously found in the CFRE system were variably detected in tissues from CFRE chicks, with high inter-individual variability. Emerging compound Nafion byproduct-2 was detected at concentrations similar to or exceeding legacy PFOS in brain and muscular tissues, driven largely by low PFOS concentrations in these matrices in conjunction with significant Nafion byproduct-2 concentrations. Concentrations of emerging compounds decreased significantly in chicks collected from the CFRE system in 2018, suggesting a rapid food web response to cessation of upstream sources.

**MP188 Uptake and effects of per- and polyfluoroalkyl substances in fish exposed to contaminated environments**


Exposure to per- and polyfluoroalkyl substances (PFASs) has been associated with many negative human health effects including immunotoxicity and metabolic disruption. Aqueous film-forming foams (AFFFs) containing PFASs are effective at extinguishing hydrocarbon fires but can be a large source of contamination to the surrounding environment. To date, there is still limited knowledge of risks posed by AFFF-impacted ecosystems to humans and wildlife, including toxicological data for exposed aquatic organisms. This project aims to fill some of these gaps by investigating whether PFAS exposures are associated with bio-uptake and expression of metagenomic indicators of adverse effects in exposed fish. We experimentally measured PFAS accumulation in model freshwater fish exposed to groundwater pumped from a contaminant plume on Cape Cod, Massachusetts, that was formed by historical use of AFFF. Near the source, the groundwater contains up to 17 individual PFAS compounds, with perfluorooctanesulfonic acid (PFOS) and perfluorohexanesulfonic acid (PFHxS) being the most abundant. We used a mobile laboratory to control chronic exposure scenarios. Fathead minnows were exposed on-site over a 21-day period under flow-through conditions to both groundwater from a reference area (minimally impacted by PFAS contamination) and groundwater from the vicinity of a historical fire-training area with known high concentrations of PFAS. PFAS uptake and whole-body burden were evaluated using an ion-pairing extraction and liquid chromatography tandem mass spectrometry method. Preliminary results show that PFASs with longer carbon chain length and sulfonate head groups preferentially accumulate in fish, with increases in body burden over the 21-day period. The most abundant PFASs detected in the fish include PFHxS and PFOS, with significant contributions from the branched isomers, and perfluorohexane sulfonamide (FHxSA). We find significant variability in PFAS concentrations between individuals. Female and male fathead minnows differ in the temporal patterns of PFAS accumulation, and some evidence of PFAS elimination was noted for female fish after the first week of exposure. We will present results of our analysis assessing differential uptake of aqueous PFASs by fish.

**MP189 Health Goals for Perfluoroalkyl Substances (PFAS)—Phase I**

K. Schulz, M. Silva, University of Wisconsin, Milwaukee; R. Klapaer, University of Wisconsin, Milwaukee / School of Freshwater Sciences

Perfluoroalkyl substances, or PFAS, are a class of persistent organic pollutants that have become a major concern in recent years due to their associated health effects and near-ubiquitous presence in the environment and biota, including humans. Recent attention has led to a call for regulation and a quickly widening body of research relating to PFAS, especially the two most prominent compounds, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). This project seeks to summarize available information about the health effects, environmental transport, contamination sources, and available detection and remediation technologies for this class of chemicals using Wisconsin as a case study. In order to achieve this goal, the project consists of five main steps: (1) a review of available literature on PFAS, focusing on transport, exposure, and health effects; (2) identification of known and unknown but likely sources and areas of contamination in Wisconsin; (3) contact and survey of companies...
MP190 First Report on in vivo Pharmacokinetics and Biotransformation of Novel Chlorinated Polyfluoroalkyl Substances in Rainbow Trout
S. Yi, Nankai University / Environmental Science and Engineering
Juvenile rainbow trout received 30-day dietary exposure to perfluorooctane sulfonate (PFOS), chlorinated perfluorooctane sulfonate (CI-PFOS), and 6:2 and 8:2 chlorinated polyfluoralkyl ether sulfonates (CI-PFESAs), respectively, followed by a 34-day depuration phase fed with clean food. Qualification and quantification of target compounds in fish tissues were achieved via UPLC-MS/MS analysis. The four test chemicals shared certain similarities in bioaccumulation potential and partitioning preference among tissues, but differences exhibited dependent on their structural rigidity and molecular size. To be specific, PFOS and CI-PFOS displayed comparable bioaccumulative potencies and similar distribution patterns in the tissues (blood > liver > kidneys), regardless of a terminal chlorine in CI-PFOS molecule. The CI-PFESAs, especially 8:2 CI-PFESA, were predominantly assimilated by liver and kidneys from the bloodstream and resisted elimination. The longer half-lives in liver and kidneys of CI-PFESAs stressed their heavier biological burdens and posed risks as alternatives to legacy PFOS. For the first time, in vivo transformation of 6:2 and 8:2 CI-PFESAs was reported, with 6:2 and 8:2 H-PFESA identified as the sole metabolites, respectively, providing the first line of evidence on the transformation susceptibility of CI-PFESAs distinct from their environmental persistence. In contrast to the liver-mediated oxidation of legacy per- and polyfluoralkyl precursors in biota, dechlorination of CI-PFESAs implies the involvement of reductases in catalyzing this process.

MP191 Metabolism of fluorotelomer alcohols (FTOHs) to perfluorocarboxylic acids (PFCAs) in rat microsomes
D. Daramola, Carleton University / Chemistry
Fluorotelomer alcohols (FTOHs) are a group of flame resistant and lipophobic compounds that consist of a long non-polar fluorinated tail attached to an ethanol head group. They are denoted by the nomenclature x-y FTOH, with “x” and “y” representing the number of fluorinated and hydrogenated carbons, respectively. Several studies on the widely used 8:2 FTOH congener have shown significant metabolism, in humans and animals, to the environmentally persistent perfluorooctanoic acid (PFOA). However, there are limited investigations on the metabolism and enzymology of the shorter chain length FTOHs like the 6:2 and 4:2 analogues. This research aims to understand the metabolism of 6:2 FTOH to the respective C6 PFOA analogue, perfluorohexanoic acid (PFHxA), in a biotic environment. In vitro enzymatic assays, performed with rat and human liver microsomes, seek to identify the primary enzyme responsible for the metabolism of the 6:2 FTOH. We hypothesize that the conversion of 6:2 FTOH to PFHxA starts with the phase I metabolism by a cytochrome P450 (CYP) to a fluorinated aldehyde. The aldehyde is further metabolised through oxidative reactions to form PFHx A. Given the enzymes responsible for metabolizing 8:2 FTOH, CYP 2E1 and CYP 2C19 are currently hypothesized as the CYPs responsible for the phase I metabolism. Enzyme kinetic constants were obtained by monitoring decreases in the 6:2 FTOH levels in active microsomes using GC-MS. A series of inhibition assays were then performed using selective CYP 2E1 and CYP 2C19 inhibitors to determine the CYP responsible for 6:2 FTOH metabolism. Further enzymatic trials will be performed to quantify the difference in the metabolic kinetic constants between human and rat in vitro assays. The environmental regulation of PFOA precursors such as 8:2 FTOH in consumer products was achieved through several investigative analyses of the metabolic pathways. A similar series of analysis for its shorter chain industrial replacements, 6:2 and 4:2, is of utmost importance to determine their significance in the production of the persistent and potentially toxic C-6 and C-4 PFOA analogues and other bioactive fluorinated metabolites.

MP192 Body distribution and placental transfer of per- and polyfluorinated substances (PFASs) in marine mammals
Y. Jeong, Hanyang University / Marine Sciences and Convergence Engineering; S. Mok, Hanyang University / Marine Sciences and Convergence Technology; Y. An, Cetacea Research Institute (CRI), NFRDI; H. Moon, Hanyang University / Marine Sciences and Convergence Engineering
Limited studies have conducted on placental transfer of per- and polyfluorinated substances (PFASs) in marine mammals. In this study, a total of 62 samples were collected including blubber, kidney, stomach, liver, ovary, heart, lung, intestine, and brain, and umbilical cord from mothers and/or their fetuses, to assess the placental transfer of PFASs using the mother-fetus pair samples of finless porpoises. For mothers, the PFOS concentration was the highest in all tissues, ranging from 3.7 to 648 ng/g, followed by PFUnDA (0.44-54 ng/g) and PFTDA (0.35-31 ng/g). The concentrations of F-53B ranged from 0.14 to 48 ng/g, which has a similar range with long-chained carboxylates. Among the maternal organs, the liver (413 ng/g) showed the highest concentration, followed by kidney (122 ng/g), pancreas (99 ng/g), ovary (92 ng/g), and heart (79 ng/g). FOSA and F-53B are also found as higher concentration in liver, pancreas, heart, and kidney than other tissues. Similar to mothers, the fetal concentration of PFOS (28.3-470 ng/g) was the highest, followed by PFUnDA (11-69 ng/g) and PFTDA (7.3-55 ng/g). In fetuses, the concentrations of PFASs increased with gestational age and the PFAS concentrations in older fetuses were higher than those measured for their mothers. Body distribution of PFASs in fetus was homogenous among organs. A high umbilical cord to placenta ratio was found for longer-chained carboxylates, suggesting the compound-specific placental transfer. Placental transfer rate was estimated using the body burden of mother-fetus pairs. The estimated placental transfer rate of PFASs, FOSA, and F-53B was 58%, 2.7%, and 74%, respectively, which were higher than those reported for lipophilic compounds (0.7-5.5%). This is the first study on placental transfer of precursors and alternatives of PFASs in marine mammals.

MP193 Biotransformation of 8:2 monosubstituted polyfluoralkyl phosphate in rat liver and intestinal S9 fractions
S. Fok, T. Harris, A.A. Rand, Carleton University / Chemistry
Polyfluoralkyl phosphates have been used in a variety of commercial and industrial applications owing to their thermal stability and surfactant properties. However, these chemicals are precursors to metabolically labile fluorotelomer alcohols and bioaccumulative and persistent perfluoralkyl carboxylic acids, making them a concern to humans and the environment. A previous study investigated 8:2 monosubstituted polyfluoralkyl phosphate (8:2 monoPAP) transformation in rats, observing an absence of 8:2 monoPAPs in blood. This suggested the monoPAPs are hydrolyzed in the gut, followed by the sorption of fluorotelomer alcohols into the blood stream. To further establish the mechanistic fate of polyfluoralkyl phosphates, this present work focuses on the biotransformation of 8:2 monoPAPs in rat via in vitro incubations with liver and intestinal S9 fractions. The hydrolysis product of 8:2 monoPAP, the 8:2 fluorotelomer alcohol, was monitored by GC-MS in EI mode. The maximum velocity (Vmax) for 8:2 monoPAP was 1.1×10-1 ± 2.1×10-2 nmol/min/mg, and the Michaelis constant (Km) was 4.0×103 ± 1.5×103 nM. The calculated intrinsic clearance rate (Clint) was determined to be 2.8±10-2 mL/min/mg protein. These results show that esterase activity in the liver is minimal. We hypothesize that the phosphate ester hydrolysis activity towards 8:2 monoPAPs is greater in the intestine compared to the liver due to the intestine being the first site of 8:2 monoPAP biotransformation before uptake into various parts of the body. Work to characterize esterase
activity in the gut is ongoing. The current study attempts to demonstrate the gut intestine as a major contributor for environmental toxicant metabolism via phosphate ester hydrolysis activity.

**MP194 In Vivo Biotransformation of a New Commercial Polyfluorinated Surfactant**

A. Folkerson, S. Joudan, S. Mabury, J.C. D’eon, University of Toronto / Chemistry

Fluorinated surfactants are a class of widely used compounds that are found in a range of products ranging from wetting and leveling agents in coating industries to window cleaning formulations. These fluorinated compounds are especially proficient at reducing the surface tension between two interfaces, however tend to also be more persistent than other surfactants. A new commercially available fluorosurfactant, whose active ingredient has the general structure of [R₂-O-CHF-CF₂-S-CH₂CH₂-O-(C=O)]₂C₆H₅SO₃⁻, has been designed with environmental degradation in mind. This study looks to characterize the fate of the surfactant in biological systems using both in vitro and in vivo experiments. We have shown that the ester linkages within the compound undergo hydrolysis and further oxidation to a carboxylic acid (R₂-O-CHF-CF₂-S-CH₂-COOH). In vitro assays using rat liver S9 fractions demonstrated this expected biological transformation; however in small quantities. In vivo studies in Sprague-Dawley rats dosed by oral gavage showed a lack of bioavailability of the fluorinated surfactant but significant biotransformation suggesting significant first pass metabolism. Additionally, the parent surfactant and its acid metabolite could not be detected by 3 days post-dose. Tissue distribution and a comprehensive degradation pathway will be discussed.

**MP195 In situ determination of cross-species protein binding affinities with chemical proteomics: FABP-PFCs as a case study**

J. Fu, Queens University / Department of Chemistry

Experimental determinations of protein binding affinities across species are challenging for current methodologies. In this study, we proposed a chemical proteomics platform for in situ determination of cross-species protein binding affinities without the need for laborious biochemical methods. The interactions between perfluorinated compounds (PFCs) and fatty acid-binding proteins (FABPs) are used as a case study since the FABP proteins are one of the primary factors to account for bioaccumulation of PFCs in organisms. The chemical proteomics method, Target-Identification by Ligand Stabilization (TILS) is tested for this project. Human FABP1 protein was purified in E. coli and optimized for TILS. A large melting temperature shift was observed when FABP1 was complexed with perfluorooctanesulfonic acid (PFOS), the most abundant PFC detected in organisms. The melting temperature of FABP1 shifted from ~65 °C to ~75 °C with good reproducibility. The method was further validated by crude E. coli lysates containing polyhistidine-tagged FABP1 proteins, and a clear melting temperature shift was observed by western blotting. This indicated that the interaction between PFOS and FABP1 could be determined by TILS even with complex lysate samples containing thousands of proteins. The method was further applied to human HepG2 cell line and rat liver samples and a shift of FABP1 was observed when the samples were spiked with PFOS. The chemical proteomics methods developed in this study will provide an effective opportunity to investigate inter-species protein binding affinities for PFCs, as well as other pollutants of concern.

**MP196 USEPA CompTox Chemicals Dashboard - a web-based database and information hub for over five thousand per- and polyfluoroalkyl chemical substances**

A.J. Williams, C. Grulke, G. Patlewicz, A. Richard, US Environmental Protection Agency / National Center for Computational Toxicology

The USEPA's CompTox Chemicals Dashboard (https://comptox.epa.gov/dashboard) is a publicly accessible website providing access to data for ~875,000 chemical substances, the majority of these represented as chemical structures. The web application delivers a wide array of computed and measured physicochemical properties, in vitro high-throughput screening data and in vivo toxicity data, product use information extracted from safety data sheets, and integrated chemical linkages to a growing list of literature, toxicology, and analytical chemistry websites. The application provides access to segregated lists of chemicals that are of specific interest to relevant stakeholders, including per- and polyfluoroalkyl substances (PFAS) containing thousands of chemicals. A procured testing library of hundreds of PFAS chemicals annotated into chemical categories has also been integrated into the dashboard with a number of resulting benefits: a searchable database of chemical properties, with hazard and exposure predictions, and links to the open literature. Several specific search types have been developed to directly support the mass spectrometry non-targeted screening community, enabling cohesive workflows to support data generation for the detection and assessment of environmental exposures to chemicals contained within the database. This presentation will provide an overview of the dashboard, the ongoing expansion of the PFAS chemical library, with associated categorization, and new physicochemical property and environmental fate and transport QSAR prediction models developed for these chemicals. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

**MP197 Moving beyond monitoring legacy per and polyfluoroalkyl substances (PFAS): Screening strategies for the growing list**


Per/Polyfluoroalkyl substances (PFAS), are compounds that have uniquely desirable properties for use in various industries. However, their wide-ranging use leads to emission into the environment, and as PFAS are persistent and bioaccumulate in the environment and wildlife, they are contaminants of concern. Monitoring PFAS precursors present in an environmental sample may impact decisions in treatment processes at remediation sites and help deduce possible degradation products that could exist in the environment. Consequently, scientists are contributing newly identified PFAS structures and spectra to various publicly available databases: growing the list of precursors and degradation by-products, some listing thousands of PFAS. Traditionally, methods such as USEPA 537 and ASTM 7979 and other self-tested targeted methods are designed to monitor a small and discrete number of PFAS compounds, thought to be end-products of degradation processes occurring in environmental systems. LC-MS/MS technology is usually employed to quantify commonly monitored PFAS end-products. Without standards, adding target compounds to an LC-MS/MS method is restrictive and it would be logistically difficult to monitor all possible PFAS without knowing them and having standards. LC-QTOF technology allows the simultaneous quantification of commonly monitored PFAS whilst acquiring untargeted data that can be screened for suspected PFAS precursors. The non-target nature of the data acquired also allows for retrospective detection of new PFAS as the scientific community learns more about these emerging contaminants. The total fluorinated compounds in a sample may be underestimated by not monitoring the precursor compounds of which these compounds are formed from. Sample preparation techniques such as the Total Oxidizable Precursor (TOP) Assay attempt to measure the total fluorinated compounds by forcing degradation of precursors into measurable end-products. This technique is time consuming and may not degrade all precursors into measurable end-products. Additionally, some countries decided to phase out specific classes of PFAS manufacturing and use, which has led manufactures to find alternative classes of PFAS, leading to new precursors and degradation products being found in environmental samples. This study uses a simple dilution (with MeOH) and acidification extraction of non-potable water samples to quantify ~20 commonly monitored PFAS and determines the accuracy, recovery and estimated limits of detection on an LC-QTOF. Further, the ability to collect non-targeted data
allowed us to screen against a user-created database of PFAS compounds to identify additional PFAS that were not in our original target list without the need for standards or re-injection of the sample.

MP198 Toward Comprehensive PFAS Annotation using a Novel Software FluoroMatch for LC-HRMS/MS Data
J.A. Bowden, University of Florida; J. Koelmel, Yale University / School of Public Health Environmental Health Sciences YSPH Global Health Concentration; E.Z. Lin, Yale University / Environmental Health Sciences; K.J. Jobst, McMaster University / Department of Chemistry and Chemical Biology; N. DeStefano, North Carolina State University; K. Pollitt, Yale University / Environmental Health Sciences

Per- and polyfluoroalkyl substances (PFAS) are a growing class of chemicals of increasing concern. Despite the reduction of use for the more commonly known PFAS, a new generation of replacement PFAS have now been introduced, with a limited understanding of how these chemicals impact both environmental and human health. Over 5000 PFAS chemicals are compiled in the USEPA’s CompTox Chemistry Dashboard (“The PFAS Master List”), and yet most analyses only cover a select few PFAS. One major bottleneck in the expansion of PFAS analyses is the lack of tools to adequately characterize unknown or lesser known PFAS species. Liquid chromatography (LC) high-resolution tandem mass spectrometry (HRMS/MS) is an effective approach for non-targeted analyses, which is well-suited for the comprehensive characterization PFAS content, and yet, to date, no software exists to effectively mine the wealth of information provided by this technique. For the first time, we present FluoroMatch for annotation of PFAS in LC-HRMS/MS experiments. Our expertise in developing informatics tools for lipodics (e.g., LipidMatch, IE-Omics, LipidPioneer) will be directly applied to the development of this PFAS annotation software, as lipids and PFAS, from an informatics standpoint, are similar (both contain differing “head groups” which can be combined with various carbon chains, resulting in predicted structures with predictable MS/MS spectra based on head group and carbon chain characteristics). We have generated in-silico PFAS libraries by combining various fluorinated carbon chains and functional groups and then searched against experimental data. We also applied iterative exclusion and intelligent data-acquisition algorithms developed in our laboratory to increase MS/MS coverage and hence the annotation of less abundant and intelligent data-acquisition algorithms developed in our laboratory to increase MS/MS coverage and hence the annotation of less abundant data. FluoroMatch was constructed and validated using a large set of perfluorinated standards and mixtures directly from companies. We have applied FluoroMatch to the LC-HRMS/MS analyses of various PFAS-containing products. We have determined tentative novel PFAS species, as well as major differences in the diversity of PFAS depending on the PFAS-containing product analyzed.

MP199 New Mass Spectrometry Analysis for short chain perfluorocarboxylic acids
J. Clouthier, C. Young, York University / Department of Chemistry

Perfluoroalkyl substances (PFAS) are widely used in many consumer and industrial products including stain repellents, non-stick food paper or pans, and fire fighting foams. Perfluoroalkyl carboxylic acids (PFCAs) are resistant to degradation and have adverse effects to the environment and human health. The long lifetimes of these compounds in the environment is due to the chemical and thermal stability of the carbon-fluorine bond. Long chain PFCAs are known to be toxic in the environment, bioaccumulate, and magnify in the food chain. Short-chain PFCAs (scPFCAs) are PFCAs with four or fewer carbons and are less studied with their toxicity poorly known; they have been observed to accumulate in different plant tissues, including crops. While the toxicity of scPFCAs are not well known, their long lifetimes and persistence in the environment indicate a risk to long term exposure that would adversely affect environmental and human health. PFASs have been observed in the High Arctic indicating that they participate in long-range atmospheric transportation. An additional major source for PFCAs is from the Montreal Protocol-mandated chlorofluorocarbon (CFC) replacements that have known degradation pathways to scPFCAs. Atmospheric scPFCAs have not been widely measured and is an area of research that is lacking; they are difficult to retain on analytical columns and there are currently no real time or quasi-real time measurements of scPFCAs. Therefore, I am developing new analytical methods to measure scPFCAs using ion chromatography mass spectrometry (IC-MS) and a new derivatization method to improve scPFC retention using gas chromatography mass spectrometry (GC-MS).

MP200 Untargeted Annotation of PFAS using a novel software for gas chromatography positive chemical ionization high resolution tandem mass spectrometry
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Poly- and Perfluoroalkyl Substances (PFAS) have a diverse range of structures due to impurities, the production of highly complex technical mixtures, and degradation and transformation in the environment. For example, the Simons Electrochemical Fluorination process has been the major manufacturing process in China of PFAS compounds, yielding highly isomerically impure PFAS mixtures. International regulation of long chain PFAS has led to thousands of replacement compounds. The environmental and health impacts of these alternatives are not well understood. This is in part attributable to challenges in characterizing unknown PFAS species; unidentified organofluorine chemicals account for 50 to 99% of organofluorine content in environmental samples. While gas chromatography (GC) high-resolution tandem mass spectrometry can provide a wealth of data revealing PFAS structural information, software to mine this data and automate the compound annotation process is needed. We present a novel untargeted PFAS annotation software for GC-MS data, FluoroMatch GC. It has been shown that positive chemical ionization (PCI) gives high quality data for certain volatile perfluorinated compounds, including perfluoro- ethanol, ethyl acrylate, and ethylene species with varying degrees of fluorination and carbon chain lengths without the need for derivatization. FluoroMatch GC in-silico PCI high resolution tandem mass spectrometry (HRMS/MS) libraries are generated by combining various functional groups with carbon chains differing in length, branching, degrees of unsaturation, and degrees of fluorination. The resulting PCI HRMS/MS spectra is predicted for each generated PFAS structure. GC-PCI-HRMS/MS data was obtained on a GC Q-Exactive mass spectrometer acquiring high resolution MS/MS via HCD for more accurate annotation using both targeted and data-dependent acquisition. GC-EL data was also acquired for targeted search against experimental and predicted PFAS data. FluoroMatch algorithms were validated using over 40 internal standards and various standard reference materials. We applied FluoroMatch to GC-PCI-HRMS/MS analysis of various PFAS products. Demonstration of this software in environmental and biological samples will also be presented.

MP201 Sorption of per- and polyfluoroalkyl substances onto anion exchange passive samplers
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Per- and polyfluoroalkyl substances (PFASs) have been widely used in diverse products, including fire-fighting foams, insecticides, stain-resistant fabric, and food contact paper and packaging for several decades. Due to the chemical and thermal stability of the C-F bond, PFASs have been frequently detected in different environmental compartments, aquatic organisms, and even humans after using. The distinctive environmental behavior and subsequently potential health impacts have raised increased attentions on effective management of these special chemicals. To date, research in the temporal and spatial concentration...
distribution of a wide range of PFASs in the environment is still limited, which is partially due to the lack of effective passive samplers. Although sorption of some PFAS onto different anion exchange materials has been observed in previous studies, the application of anion exchange materials as potential passive samplers has not been carefully explored yet. In this study, we investigated the sorption of 12 chemically-diverse PFASs (e.g., perfluorooalkyl carboxylates, perfluorooalkyl sulfonates, fluorotelomer sulfonates, and perfluorooctane sulfonamides) into three different anion exchange materials (i.e., FAP-450 and FAS-50 anion exchange membranes (Fumatech) and the Mion AK-22 anion exchange fibers (Imatek&K)). The batch sorption tests were conducted in both clean (e.g., 10 mM NaCl) and real water (e.g., groundwater) matrices and the aqueous- and sampler-phase PFAS concentrations at equilibrium was assessed by multiple isotherms (e.g., Langmuir isoherm and Freundlich isotherm) to determine the selectivity coefficient for a PFAS anion over typical environmental anion (e.g., Cl\(^-\)). The concentrations of PFAS and inorganic anions were measured by liquid chromatography tandem mass spectrometry and ion chromatography, respectively. The deployment time required for ion exchange-based samplers to achieve equilibrium with PFAS-contaminated water was identified (e.g., 70 h in an ultrapure water matrix) and the relative trends in PFAS update by molecular properties was further investigated. Overall, our results highlighted the possibility of using the anion exchange membranes and fibers as passive samplers for the chemically diverse PFASs.

Great Expectations: Recovery after Remediation at Contaminated Sediment Sites

MP202 Baseline sampling at the Portland Harbor Superfund Site: How much natural recovery is occurring?

K.E. Vickstrom, CDM Smith / Environmental and Technology Group; J. Kern, Kern Statistical Services Inc; S. Sheldrake, USEPA

The Portland Harbor Superfund Site is a 10-mile reach of the lower Willamette River in Portland, Oregon that has contaminated sediment, water, and biota for which a Record of Decision (ROP) was signed in 2017. Patterns of deposition, erosion, and contaminant distributions are heterogeneous leading to complexities in understanding spatial and temporal change at various scales. Baseline sampling in 2018 and 2019 collected an unbiased dataset of 483 surface sediment grab samples in the site and upstream along with 7 surface water transects, 135 smallmouth bass specimens, and a bathymetry survey. These data were collected to assess pre-construction conditions and serve as a benchmark for post-remediation monitoring. Additionally, temporal change between the baseline and previous Remedial Investigation samples can be approximated with statistical methods that de-bias the different study designs. These data and analyses suggest that the areas selected in the ROD for monitored natural recovery, which comprise just over 80% of the total site area, are predominantly depositional over time and drive site-wide decreases in the different media. However, at smaller spatial scales, the areas of elevated sediment contamination (approximately 20% of total site area) are majority dynamic, have not experienced decreases in sediment concentrations, and continue to serve as sources to surface water and biota. Natural recovery is occurring at Portland Harbor but is limited to less dynamic areas where contaminant concentrations are already lower. Active remediation is therefore needed to accelerate this process and should result in more rapid declines across multiple spatial scales. Before, during and following construction, future unbiased sampling efforts are expected to give a more precise estimate of MNR rates which will help determine timeframes for achievement of cleanup levels post-construction.

MP203 Design, Installation and Quality Control for Organoclay-based Contaminated Sediment Cap at the East Branch of the Grand Calumet River


Background. The East Branch of the Grand Calumet River (EBGCR) is a heavily impacted section of river that enters the southern end of Lake Michigan via the Indiana Harbor Ship Channel. The river has been impacted by legacy industrial activity and primary contaminants consist of PAHs and metals. The east branch project segment consisted of an approximately 1.8 mile long reach just east of the confluence of the east and west branches of the river. The design for the project called for an active cap consisting of organoclay materials having certain minimum sorptive properties (partition coefficients - K\(_\text{d}\) values) for two target dissolved phase PAH contaminants. Based on modeling and design performed by Tetra Tech, organoclay was selected as the reactive/adsorptive material for the cap. J.F. Brennan placed the materials with their proprietary broadcast spreader system. Natural Resource Technology (NRT) performed monitoring and quality control during subaqueous installation of the cap materials in accordance with project specifications. After installation of the active layer, NRT collected additional samples of as-placed cap materials. SAO Environmental Consulting was engaged to oversee laboratory sorption testing to evaluate the relative sorption characteristics of both manufactured and as-placed product samples. Approach/Objectives. This presentation will provide an overview of placement and on-site quality control activities surrounding placement of the EBGCR active cap. In addition, the approach, methodology, and results for laboratory sorption testing of the active capping product will also be provided. The objective of the additional laboratory-based work in this study was to determine possible detrimental impacts that either the manufacturing process (incorporating CETCO’s organoclay powder material into a coated particle) or the act of placing the product in the river may have had on the organoclay sorption capability. Results/Summary. Data demonstrates that the project approach for delivering active-treatment materials to the sediments provided a result that supports the modeling assumptions which were incorporated into the EBGCR remedial design and enables full-scale application of active capping materials in a manner that allows verification of both the quantity and post-placement material properties.

MP204 Historical synthesis and evaluation of long-term recovery of pulpmill-impacted sediments in Alberni Inlet, British Columbia

R. Stevenson, M. Davies, C. Sanchez, R. Philibert, Hatfield Consultants

The pulp and paper mill at Port Alberni, BC has produced a variety of pulp and paper products since 1947. Historically, mill effluent was a significant source of biological oxygen demand (BOD) and suspended organic matter to Alberni Inlet, which led to localized severe sediment anoxia and a thick fibre mat on the sea floor near the mill, with significant associated impacts on the benthic invertebrate community. Substantial improvements in effluent quality in the early 1990s created conditions for natural sediment recovery including long-term burial and microbial degradation of the fibre mat. The study presented here involved a synthesis and evaluation of Federal Environmental Effects Monitoring (EEM) studies conducted since 1994 (immediately following effluent improvements) to examine long-term recovery and to attribute any persisting sediment effects and biological responses to current effluent discharges or legacy sediment conditions (related to historical effluent discharges). The evaluation applied trend analyses for stressors and biological responses, biological effect-size modelling, and community structure assessments to determine support for these alternative impact hypotheses (i.e., current effluent vs. legacy impacts). Sediment conditions near the mill have improved considerably with corresponding improvements in benthic invertebrate density and richness; invertebrate community structure also has transitioned from dominance by opportunistic, pollution-tolerant species to a structure more representative of reference conditions, with numerous taxa and feeding guilds represented. Ongoing benthic
invertebrate community impairment immediately adjacent to the effluent outfall appears to be associated with legacy impacts, requiring a longer recovery period than other stations due to more severe historical impacts. The correspondence between sediment improvements and benthic recovery implicated legacy sediment conditions (which are recovering) as opposed to current effluent discharge as the main mill-related stressor in the marine receiving environment. The length of this study (>25 years) informs the timeframe over which natural recovery occurs in a severely impacted marine environment.

**MP205 Long-term monitoring of a thin-layer sand cap in Peninsula Harbour Area of Concern**

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Peninsula Harbour is located in Lake Superior and is identified as an Area of Concern due to historical inputs from the pulp mill and chlor-alkali plant, and historical log booming. Over time these activities resulted in impaired fish and benthic communities, as well as elevated levels of contaminants in sediment and biota - specifically mercury (Hg), methylmercury (MeHg), and polychlorinated biphenyls (PCBs). To reduce the risks posed by the contaminants, thin-layer capping was the selected sediment management option for the contaminant hot spot located adjacent to the mill. In 2012, a 15-20 cm sand cap was placed over sediment exceeding the remedial target of 3 µg/g total Hg. In 2017, five-years post-cap, the first long-term monitoring assessment was completed with the goals of assessing progress towards targets for cap stability, cap effectiveness, and ecological recovery. The large grain size of the sand cap presented some challenges, requiring divers and the use of novel technologies to collect samples. Cap stability was monitored through sediment grab samples and underwater video. The effectiveness of the cap in meeting the remedial target was assessed with surficial sediment data and porewater data from passive samplers inserted in the cap to measure movement of Hg through the cap. Ecological recovery was assessed by the collection of benthic invertebrates, measurements of submerged aquatic vegetation coverage, and the collection of sport fish tissue. Results showed that the cap is stable and has essentially eliminated the vertical transport of Hg from the native sediment to the water-sediment interface. Natural sedimentation on the cap has occurred since cap construction, and the spatially weighted area average concentration of Hg in the overlying sediment was 0.37 µg/g, almost ten times less than the remedial target. As expected, concentrations of PCBs and MeHg also decreased in the sediment. Biological surveys indicated that the cap has been colonized with benthic invertebrates and submerged aquatic vegetation; abundance is low but is expected to increase over time. Concentrations of Hg and PCBs in fish tissue have declined since cap placement. Overall the cap is functioning as intended and is accelerating the recovery of the Area of Concern.

**MP206 Long-term performance of in situ treatment of sediment with AC at Grasse River, NY**

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We present here the first long-term (10-year) monitoring data from a pilot-study conducted in a river to demonstrate the feasibility of in situ remediation with the amendment of activated carbon (AC) into sediments. In 2006 the first pilot-scale demonstration of PCB bioavailability reduction in sediments with AC amendment was implemented in Grasse River, NY. The study initially documented the performance of the AC amendment over the first three years and showed that AC was stable in the river sediments. AC applied at a dose similar to the native organic carbon of sediment reduced PCB bioaccumulation in worms by 69-99% and porewater concentrations by more than 93% for three years after treatment. In 2016, we performed a 10-year post remedy assessment of the pilot study to evaluate the long-term stability of AC and performance of the treatment. Sediment core samples were collected form the AC-treated and background sites in Grasse River. The core samples were sectioned to determine the present location of AC and the persistence of the AC in the field. AC was stable in the sediments after 10 years and was buried under nearly 20 cm of new sediments confirming a sediment deposition rate of about 2 cm/year. AC recovery was at or above the target dose in the two treatment sites: one where the AC was applied as a thin layer on sediments, and the other where the AC was mechanically mixed into the top layer of sediments. Natural attenuation due to clean sediment deposition is high at Grasse River that has resulted in a nearly one order of magnitude reduction in surface sediment PCB concentration over 10 years. The porewater concentration in the two AC-treated sites has remained reduced by nearly 2-orders of magnitude over the 10 year period post treatment. AC amended to sediments continue to reduce bioaccumulation in worms within the zone of application. Initial mechanical mixing in one plot resulted in a more diffuse layer of AC with time as additional natural mixing spread out the AC through the depth. This finding suggests that the initial mechanical mixing is not necessary for sites where natural mixing can be anticipated. The long-term efficacy and permanence of remedies is one of the nine National Contingency Plan criteria that are used in evaluating and selecting remedies. We show here that in situ treatment with AC is effective in reducing PCB bioavailability in sediments for the long-term.

**MP207 Long-Term Sediment PCB Monitoring Data Influence Reassessment of Remedial Action Decisions**

L. Richman, Ministry of the Environment, Conservation and Parks / Environmental Monitoring and Reporting Branch; D.J. Milani, L.C. Grapentine, Environment and Climate Change Canada / Water Science and Technology Directorate

Monitored Natural Recovery (MoNR) was the management option for PCB contaminated sediment in Lyons Creek East (ON, Canada). The Remedial Action Objective was to reduce PCB exposure to biota (e.g., eastern belted kingfisher and mink) by achieving target concentrations of PCB in sediment that were based on an ERA from 2005. As deposition rates were low, recovery was expected to be slow. Sediment total PCB concentration protective of the kingfisher and mink were estimated at 3.4 µg/g and 1.0 µg/g respectively. The creek was sub-divided into seven Zones based on historical PCB contamination, habitat types, and the home ranges of the receptors. The upstream area, Zones 1-3, was the only identified source of PCBs to the downstream areas. To assess recovery in a step-wise fashion, short and long-term targets for surface sediment (top 0-3 cm and 0-10 cm segments) PCB concentrations were identified. Ninety-six cores were collected from the creek. Samples were analysed for PCB congeners, total organic carbon and particle size. Young of the
Contaminated sediment has been identified as one of the major impediments to remediation in many Great Lakes Areas of Concern (AOCs), including the Toronto and Region AOC. Designated in 1986, a formal Remedial Action Plan (RAP) was established in 1994 to implement numerous restoration actions aimed at the original 11 Beneficial Use Impairments (BUIs) identified. This led to significant improvements in sediment quality, and re-designation of the Degradation of Benthos Beneficial Use Impairment (BUI) as “not impaired” in 2013. The current study applied a sediment quality tetrad (SQtet) in a weight-of-evidence assessment to evaluate current sediment condition within the AOC after the re-designation of the Benthos BUI. The SQtet includes assessment of four lines of evidence (LOE): sediment chemistry, bioaccumulation, toxicity, and benthic community structure. Samples were collected in 2015 from 5 stations within the AOC and compared to 7 nearshore reference stations historically monitored by the Ontario Ministry of Environment, Conservation and Parks. Sediment chemistry indicated no beneficial use impairment.
MP211 Remediation and Restoration of Great Lakes Areas of Concern via Maintenance Dredging of Navigable Waterways and Beneficial Use of Dredged Material


The U.S. Army Corps of Engineers’ dredging program has contributed to the restoration of Great Lakes Areas of Concern (AOCs) in two main ways--historically through the removal of legacy contamination, and more recently through the beneficial use of dredged material. The Corps of Engineers operates and maintains the U.S. portion of the Great Lakes Navigation System, consisting of 140 harbors, 3 lock complexes, 104 miles of navigation structures, and over 600 miles of navigation channels stretching through all 5 Great Lakes and connecting channels. This navigation system supports recreational navigation and waterborne commerce—the most energy efficient and safest form of transportation of bulk commodities. Each year, the Corps of Engineers dredges 3 to 5 million cubic yards of sediment from 20 to 40 harbors in the Great Lakes. This includes federally-maintained navigation channels present in 29 of the Great Lakes’ 43 AOCs. Before the 1970s, virtually all dredged material from the Great Lakes was placed in established open-lake placement areas. In 1970, Section 123 of the Rivers and Harbors Act authorized construction of confined disposal facilities (CDFs) in the Great Lakes. In 2003 it was estimated that the 45 CDFs constructed by the Corps of Engineers had facilitated the removal of over 70 million cubic yards of contaminated sediments from AOCs. More recently, CDFs have served as economical and safe disposal facilities for contaminated sediments removed from outside of navigation channels under the auspices of the Great Lakes Legacy Act as part of active AOC remediation. Additional strategic navigation dredging contributes to remediation within federal channels that otherwise are not currently maintained. The removal of sediment contaminants provided by the CDF program represents a substantial contribution to the goals of Remedial Action Plans and Lakewide Management Plans. Material dredged from many federal navigation channels now contains sufficiently low concentrations of legacy contaminants such that it is suitable for use as fill material in habitat restoration and brownfield remediation projects. These projects include beach nourishment, storm protection, improvements to benthic, fish, and wildlife habitat, remediation of contaminated sediment, and reduction in bioaccumulation of PCBs and other contaminants. Beneficial use of dredged material has thereby further contributed to AOC restoration and removal of beneficial use impairments at some harbors.

MP212 Remedy effectiveness following early actions at the Lower Duwamish Waterway Superfund Site: Implications to long-term effectiveness

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Early remedial actions have been completed in the Lower Duwamish Waterway (LDW) Superfund site in Seattle, Washington, and remedial design has started for the full sediment remedy. Baseline sampling occurred in 2017-18 to serve as a foundation for assessing trends from before the early actions, and future trends as the full sediment remedy is implemented. This talk presents the site-wide baseline water, sediment, and tissue sampling results for the four human health risk drivers—polychlorinated biphenyls (PCBs), cariocgenic polycyclic aromatic hydrocarbons (pPAHs), dioxins/furans, and arsenic—relative to Remedial Investigation/Feasibility Study (RI/FS) data, predicted concentrations, ARARs, sediment cleanup levels, and tissue target levels. Baseline results are generally consistent with FS modeling predictions following early remedial actions. Post-remedy predictions are discussed relative to site-wide cleanup levels that are not predicted to be met in this complex urban waterway. Predicted outcomes and implications are discussed.

MP213 Remedy Effectiveness: Lessons Learned from 12 Case Studies

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In a recent collaborative workshop, we reviewed case studies of 12 large contaminated sediment sites to ascertain lessons learned regarding remedy effectiveness. The sites were located in the Pacific Northwest, Upper Midwest, and Northeast regions of the United States. Remedies were completed between 3 and 30 years ago and remedial approaches included dredging, capping, cover, and monitored natural recovery. Common contaminants of concern included PCBs, PAHs (including NAPL), mercury, and creosote constituents. Post-remediation monitoring generally focused on chemical concentrations in sediment, surface water, fish, and shellfish as well as porewater and cap integrity in the case of capping remedies. Each site was reviewed with respect to remedial objectives and risk drivers, a summary of early or completed remedy, significant remedy scope or schedule deviations, timing and effectiveness of source control, primary pre- and post-remedy monitoring elements, achievement of short- and long-term remediation objectives for surface sediment, if the remedy is on track to achieve long-term remediation objectives for water and/or biota, and key take home messages. Several themes were apparent. Source control was of primary importance and early or interim actions often resulted in significant progress toward meeting remedial objectives. At several sites, adaptive management in various forms was an effective way to deal with an evolving conceptual site model or changing site conditions. Remediation was found to be, in large part, effective at reducing contaminant concentrations in sediment. Remedy effectiveness with respect to reductions in contaminant concentrations in biota was mixed with some sites showing reductions consistent with expectations while others did not. The latter was generally attributed to an incomplete understanding of what controls contaminant concentrations in biota, particularly the link between sediment and tissue concentrations. In some cases, ongoing sources to surface water (e.g., stormwater runoff transporting PCBs derived from old building materials in areas subject to redevelopment) were considered responsible for maintaining tissue concentrations above remedial goals. This in-depth evaluation of remedy effectiveness is the first in a series of retrospective reviews and provides important information for site managers seeking to optimize the success of sediment remediation.
MP214 Toxicity evaluations of sediments in coastal area closing to a million cities in Japan using fish embryos

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Fukuoka and Kitakyushu cities, where are a million cities, locating on the north part of Kyushu Island, Japan. In Kitakyushu, a large industrial area spreads around the Dokai Bay. Because the sewage had been discharged and the industrial soot had been deposited, the bay is one of most seriously polluted coastal area in Japan, even though the regulations such as the effluent standard was established until now. The Dokai Bay is closed, long narrow terrain, and low frequency of water exchange, and, therefore, the improvement from pollutions progress slowly. The Hakata Bay has been thriving as an international port, and many vessels pass frequently. Additionally, because the bay is closed to Fukuoka, whose population is increasing yearly, the pollutants continue. On the other hand, a large number of species of biota inhabit in the bay, because that has geographical features such as the intertidal flats, seaweed beds, and neritic provinces. A part of pollutants has been possibly residue even in sediments, and expect to affect aquatic biota such as benthic organisms. However, the effects of sediments on the aquatic biota in the aquatic environment are not known well. We have been continuously evaluating the toxicities of sediment, collected from the coastal area in Japan, using the fish embryos, and can find that sediments collected even from the rural coastal area possibly affect the biota. In the present study, we evaluated the toxicities of sediments collected from 11 sites closed to Fukuoka and Kitakyushu cities using the embryos of Java medaka (Oryzias javanicus), which inhabits in the sea water area. Ten embryos were embedded in half of them on each sediments including the slight pore water, which is laid at a glass petri dish, and were developed on the sediment for 12 days post-fertilization.

In the period, the rearing water was not added on the sediments. An embryo was then individually transferred in a hole of 48-well microplates containing sea water, and kept until 3 days after hatching. The mortalities of embryos exposed to sediments collected from 3 sites of the Hakata Bay were from 46.7 to 93.3%. Additionally, 20 to 63% of those exposed to sediments of 4 sites in the Dokai Bay were killed. We could also observe to hatch larvae with some malformations of up to 27% after the exposures of sediments collected from the Hakata and Dokai Bays. These results suggest that both bays polluted as possibly affecting the aquatic biota.

MP215 Utility of conductive soil particles in enhanced direct interspecies electron transfer (DIET) for methanogenic organic acid degradation

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Anaerobic digestion (AD) is an attractive bioprocess for organic waste treatment as it proffers a clean source for energy generation and environmental remediation. However, the process over the years has suffered from limited applicability due to the prolonged lag phase, high susceptibility to environmental changes and substrate-induced inhibition. Several studies are ongoing for AD process optimization. Direct interspecies electron transfer (DIET) is a syntrophic association characterised by electron transfer between two microbial species in contact with each other. Enhancing DIET efficiency between acetogens and methanogens invariably enhances methane generation and the overall process efficiency of AD. Several conductive particles such as graphite, activated charcoal and haematite have been used in the past with great success to “hardwire” microbes for DIET. However, there are no reports on the use of soil particles for DIET, being that they are ubiquitous, cheap and silicon (semiconductor) derivatives. To this end, this study aimed at investigating the potentials of using soil particles for enhancing DIET. Out of 5 different soil types studied, clay soil with conductive clayey particles (CCP) having a conductivity of 77.33 ± 1.12 uS/m was chosen for DIET enhancing ability. Experimental setups with activated charcoal and without any additive were the positive and negative controls respectively. The setup (40 g/l of clay soil) with CCP of 77.33 ± 1.12 uS/m gave the highest methane yield (3496.60 ± 105.10 ml/g) with a production rate of 223.11 ± 7.00 ml/g/d and this corresponds to an enhancement of 44.7% and 38.5% respectively when compared to the negative control. The linear regression equation for production using 40 g/l clayey particle was modelled to y = 0.0325x + 232.45, while the negative control was y = -3.3859x + 188.18. Comparing their gradients suggests a sustained stability and delayed decline in production rate of the clayey setup. Hence, CCP, a representative of clayey soil, has the potential to enhance DIET for anaerobic digestion. The hypothesis is that this soil particle size was just adequate for attachment of the micro-organisms which resulted in sustained or enhanced production. There is a need for further studies to substantiate the actual mechanism of DIET enhancement by CCP.

MP216 Evaluation of Mercury Leaching From the Bank and Ability of the Stabilization Efforts on Mercury Fate and Transport

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The effectiveness of bank stabilization using biochar on controlling pore water mercury concentration was studied in the South River Waynesboro VA. Historical releases from a textile manufacturing facility resulted in increased mercury concentrations in biota and in sediment and surface water. In 2015, a sampling event was conducted to evaluate pore water total mercury and methylmercury concentration at baseline flow and during drainage conditions after flooding events. The results showed that significant amount of mercury could be releasing from the bank area during drainage conditions. Mercury measurements were conducted using diffusion gradient in thin film devices (DGTs). Bank stabilization efforts were conducted in 2016 and a cap layer of biochar was placed on a contaminated area as part of the mercury remedial action. The stabilization efforts were primarily designed to eliminate any erosion of the mercury contaminated bank soils but, with the biochar, offered control for the leaching of mercury to porewaters. After the bank stabilization, sampling results in August 2017 during baseline conditions showed significant decreases in pore water total mercury concentration; Additionally, sampling was conducted during drainage conditions after a flood event in October 2018 and showed modest increases in pore water mercury but still well below concentrations that were observed prior to bank management. High resolution passive profilers (HRPP) were also used to assess seepage velocities and fluxes of mercury from the bank. The work demonstrated the effective use of DGTs and HRPP to evaluate the impact of flooding and drainage cycles on contaminant release from contaminated banks as well as the effectiveness of bank stabilization and capping efforts in controlling the release.

MP217 In Situ Passive Sampling to Measure Remedial Effectiveness at the Pacific Sound Resources Superfund Site

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During the 1998 remedial investigation for the Pacific Sound Resources (PSR) Superfund Site, dissolved-phase groundwater contamination and “fingers” of creosote-related Dense Non-Aqueous Phase Liquid (DNAPL) was observed to extend from the upland containment wall area towards the Marine Sediments Unit (MSU) within PSR. Following the investigation sub-tidal sediments were capped with borrow materials at depths of 7 feet (near shore) to 3.5 feet (offshore). In 2018, sampling was conducted to evaluate whether the cap contains polyaromatic hydrocarbon (PAH) contaminants that might suggest migration of the underlying cap materials. In 2011 in situ passive sampling for 16 PAHs and Dibenzofuran (DBF)
was deployed at 24 locations, at a depth of up to 34 inches below the cap surface in locations most likely influenced by contaminated groundwater discharge. PAHs were detected in nearly all depth intervals, but no clear vertical concentration gradients could be linked to the underlying contaminants. In 2018, Texas Tech University performed identical in situ passive sampling with the addition of a 25th location for the same 16 priority PAHs and DBF at the PSR site. Porewater concentrations remained low throughout the site (total PAHs < 1 μg/L). ΣPAH concentrations to the northwest portion of the site decreased to 100-200 ng/L in 2018 compared to 500-800 ng/L found in the 2011 sampling. Porewater ΣPAH concentrations in the NE sampling location exhibited a range of 32 ng/L to 879 ng/L with a majority of the observed porewater concentrations in the 500-600 ng/L range. Within the NE locations 11 out of 12 sampling sites showed modest increases in porewater concentrations from the 2011 analysis but no suggestion of substantial PAH penetration of the cap materials or breakthrough of underlying contaminants. Summed porewater concentrations of total PAHs are compared to the higher molecular weight PAHs (3+ ring PAHs) to identify mechanisms and the influence of hydrophobicity of the contaminants on mobility and cap integrity. There were limited effects of hydrophobicity indicating the limited sorption within the cap.

MP218 Sources of Polychlorinated Biphenyls to Upper Hudson River Sediment Post-Dredging

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The Upper Hudson River (UHR) has been contaminated with polychlorinated biphenyls (PCBs) since the 1940s due to the manufacture of capacitors at two plants near Hudson Falls and Fort Edward, NY by General Electric (GE). Dredging of portions of the UHR was conducted from 2009-2015 as a partial remedy for this contamination. In 2017, the New York State Department of Environmental Conservation undertook a comprehensive post-dredging survey of sediment contamination in the UHR. Thousands of samples were collected, and 130 of these were analyzed for PCBs using EPA method 1668A, allowing a fingerprinting analysis to determine the main sources of PCBs to the UHR sediment post-dredging. This data set was analyzed using Positive Matrix Factorization. Six factors were observed. One resembled the original Aroclors 1016 and 1242 used by GE. Dredging of portions of the UHR was conducted from 2009-2015 as a partial remedy for this contamination. In 2017, the New York State Department of Environmental Conservation undertook a comprehensive post-dredging survey of sediment contamination in the UHR. Thousands of samples were collected, and 130 of these were analyzed for PCBs using EPA method 1668A, allowing a fingerprinting analysis to determine the main sources of PCBs to the UHR sediment post-dredging. This data set was analyzed using Positive Matrix Factorization. Six factors were observed. One resembled the original Aroclors 1016 and 1242 used by GE. Three represented different pathways and/or extents of microbial dechlorination. One factor resembled a dechlorinated version of Aroclor 1254, which was also used by GE. There was another factor that can be described as a mixture of four different Aroclors and its spatial distribution suggests that it is not directly attributable to the GE activities at the Fort Edward and Hudson Falls plants. It explains about 2% of the PCB mass in the sediment of the UHR.

Soil Contaminants: Fate, Bioavailability, Environmental Toxicology in Ecological and Human Health Risk Assessment

MP219 Assessment Of Bacterial Isolates Of Soil From Houston Area Watersheds

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Assessing the Houston area watershed soil for bacterial levels is essential since some water bodies are prone to bacterial contamination from wastewater treatment plants, industrial facilities, and feces from animals. Houston has a complex watershed, which makes the city prone to flooding like the 2017 Hurricane Harvey. As a result, a comparative study between soil samples collected during the 2018 summer (July) and 2018 winter (November) was carried out. The Houston area bayous characterized for bacterial burden were: Dickinson, Horsepen, Mustang, Cypress Spring, and Clear Lake. Quantification of bacterial loads was done using selective and differential media as well as a broad-based medium for enteric and total counts, respectively. Biolog identification System was used to confirm the biochemical tests of the isolated colonies. It was observed that bayous closer to the densely populated urban center, such as Dickinson and Horsepen, had significantly higher enteric and total bacterial loads during the winter when compared to summer samples, perhaps due to their closeness to wastewater treatment plants, recreational activities, temperature change inhibiting the growth of some bacteria and also due to the redistribution of flow of water from upstream to downstream. Future studies will aim to identify isolated colonies (using biochemical and DNA sequencing approaches) and evaluate their growth kinetics, biofilm formation, and responses to oxidative stress.

MP220 The change of microbial diversity and community composition in the process of pig feces returning to the field in Jiuzhou River Basin, GuangXi

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In recent years, breeding industry has development in China following the rise of the economy. The development of breeding industry brings not only economic development but also huge environmental problems. Fecal contamination is a major concern because of its direct pathogenesis. Feces can be used in fertilizer to return the soil after treatment, and now, many farms used fermentation to treat feces before using. But lots of microorganisms remained in the treated feces and they may cause harm to people’s health. In this study, we used MiSeq sequencing to explain the change of composition of microorganisms in the feces return to soil. We chose feces (MA), waster water (WA), farmland soil (FS), yard soil (YS), and sewage sludge (SS) as our research objects and selected 18 farms in Jiuzhou River basin as sampling place. We got 369950 high quality microbial sequences for analysis. According to the analysis, the composition of microorganisms in the MA group changed dramatically after fermentation and lots of microorganisms including pathogens were decreased. Badly, we found many pathogens in WA and soil samples. Some high content pathogens exist in MA and we can find them in soil samples. We think WA may contribute to the pathogens in the soil. The content of pathogenic bacteria in the soil is low, but the harm should not be underestimated. We should improve the methods to remove pathogens in the WA. This paper confirmed with a large amount of data that fermentation can indeed change the microbial structure in feces, but new pathogens contamination may be introduced in the fecal treatment process.

MP221 The Combined effect of Mix biochar and Compost on Potato Plant uptake of Heavy metals

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Freshwater shortage, coupled with need of increasing food production for the growing population, has become a challenge for irrigated agriculture. Increased utilization of freshwater due to industrial development and urbanization has resulted in the production of massive volumes of wastewater posing its disposal problem. Wastewater use for irrigation could partly fulfill water demand and solve disposal problem. In several developing countries, knowingly or unknowingly, partially treated and/or untreated wastewater is used to irrigate food crops. However, the presence of contaminants, including heavy metals in wastewater, could pose a risk for human health and aquatic life. Therefore, low-cost simple treatment methods are needed to reduce contaminant transmission to crops. A field lysimeter experiment was conducted for two years (2017/18) to investigate the effect of mixing barley straw biochar and compost in soil on the mobility of heavy metals from wastewater to potatoes. Potatoes were planted in sandy soil and irrigated with synthetic wastewater containing organic contaminants and heavy metals (Cd, Zn, Cu, Fe, Pb, and Cr).
Four treatments 1- wastewater irrigation to non-amended soil (WW), 2- wastewater irrigation to soil amended with 7% compost (C-WW), 3- wastewater irrigation to soil amended with 1% biochar (B-WW), and 4- wastewater irrigation to soil amended with Mix 7% compost and 1% biochar (CB-WW), in triplicate. After eight irrigations potatoes were harvested. The edible parts of the potato plant (flesh and peels) and root were analyzed to determine heavy metals using ICP-MS. In 2017, Cd concentration in potatoes flesh were WW 1.51 μg/g, BC 1.07 μg/g, and BC+ Compost 0.63 μg/g. In 2018, these were WW 5.3 μg/g, BC 4.46 μg/g, and BC+ Compost 2.19 μg/g. Similarly, in 2017 the concentrations in the root were WW 121.1 μg/g, BC 95.7 μg/g, and BC+ Compost 43.2 μg/g, and in 2018 were WW 2.43 μg/g, BC 223.7 μg/g, and BC+ Compost 76.8 μg/g. These results in two years indicated that there was a significant reduction (P<0.05) in plant uptake of (Cu, Cd, and Zn) for Mix BC+ Compost as compared to WW Control, Compost and BC 1%. The immobilization effect in BC-WW treatment was attributed to changes in the soil physicochemical properties such as higher pH, increased soil organic matter, cation exchange capacity, and dissolved organic carbon in the soil.

MP222 Assessment of risk to hoary squash bees (Peponapis pruinosa) and other ground-nesting bees from systemic insecticides in agricultural soil
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Using the hoary squash bee (Peponapis pruinosa) as a model, we provide the first probabilistic risk assessment of exposure to systemic insecticides in soil for ground-nesting bees. To assess risk in acute and chronic exposure scenarios in Cucurbita and field crops, concentrations of clothianidin, thiamethoxam and imidacloprid (neonicotinoids) and chlorantraniliprole (an anthranilamide) were measured in soil samples. The probability of exceedance of several exposure endpoints (LC50s) was compared to an acceptable risk threshold (5%). In Cucurbita crops, under acute exposure, risk to hoary squash bees was below 5% for honey bee LC50s for all residues evaluated but exceeded 5% for clothianidin and imidacloprid using a solitary bee LC50. For Cucurbita crops in the chronic exposure scenario, exposure risks for clothianidin and imidacloprid exceeded 5% for all endpoints, and exposure risk for chlorantraniliprole was below 5% for all endpoints. In field crops, risk to ground-nesting bees was high from clothianidin in all exposure scenarios and high for thiamethoxam and imidacloprid under chronic exposure scenarios. Risk assessments for ground-nesting bees should include exposure impacts from soil and could use the hoary squash bee as an ecotoxicology model.

MP223 Impact of metals in sewage sludge on soils and plants stress response including DNA damage and expression of genes encoding metal transporters
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The recent increase in soil supplementation with sewage sludge (SS), is gaining a lot of interest, and the proper evaluation of its safety is critically needed. Heavy metals (HMs), that are often seen in sewage sludge, such as lead and cadmium pose a threat to all members of the food chain and are considered to be the most crucial inorganic soil contaminants. Still, our understanding of the specific effects of metals on plants physiology and metal uptake are strictly limited. Simultaneously, the disposal of sewage sludge poses a severe threat to the environment, and today there is an increasing pressure to minimize landfilling of SS which leaves two possible ways of its disposal: incineration or application to land, which is considered to be a beneficial method because it allows for nutrient recycling. Thus, a better understanding of interactions between contamination and mechanisms by which plants respond to such exposure is a prime objective in plant research. In this study, S. alba was exposed to degraded but not contaminated soil, characterized by a severe lack of organic matter due to overexploitation. In order to research the safety of SS application to soil and plants physiological response to such actions, the soil was supplemented with 4 different types of sewage sludges. Two out of four of those sludges contained trace amounts of heavy metals, but still manage to pass the norms for HM contamination. The measurement endpoints were: biomass, roots length, metal accumulation in plants shoots, activity of peroxidase, expression of The ATP-binding cassette transporters (ABCs) genes by real-time quantitative PCR and the level of DNA damage via comet assay. Overall the expression was elevated in samples with municipal sewage sludges after 7 days of exposure and continued to increase through the timepoints. Moreover, we observed a increase in plants oxidative stress and DNA damage. Therefore, the supplementation of soil with sewage sludge containing even trace amounts of HMs causes an adverse impact on plant physiology and hence, the use of more sensitive biomarkers that take into consideration plants metabolic pathways of dealing with such stress is needed to thoroughly test the safety of selected waste product to be applied to land. Hence, we propose that the measurement of DNA damage and ABCs expression could be potentially used in such safety evaluation process as an early indicator of metal stress - before any visible signs of toxicity will occur.

MP224 Influence of stereochemistry on the partitioning of selected ortho and non-ortho polychlorinated biphenyls between aqueous solution and soil system
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The influence of sorbate characteristics such as stereochemistry on the partitioning of selected non-ortho and ortho-substituted polychlorinated biphenyls (PCBs) between aqueous solution and soil collected along the river course of uMgeni River of KwaZulu-Natal, South Africa located in sub-Saharan Africa was investigated in this study. Specifically, PCB 77 and PCB 52 were selected in this study to represent the non-ortho and ortho-substituted system. These congeners were chosen due to their historical environmental problems and varying degree of hydrophobicity characters despite their equal numbers of chlorine atoms. Soil physicochemical characteristics were quantified such as soil organic matter, cation exchange capacity, surface area, pore volume distribution, and pore diameter as well as various functional groups present in the soil humic materials using Walkley Black, BET adsorption-desorption, and FTIR methods respectively. Batch adsorption experiments were used for the sorption studies. The results of the investigation revealed that non-ortho substituted congener was found to show more preference for soil compared to its di-ortho substituted counterpart congener of the same homolog. The effect of initial concentrations on both revealed that low initial PCB concentrations were mostly favoured for the sorption while sorption was generally low for ortho-substituted PCBs at high concentration. This could be due to the soil interlayer pore blockage which may be influenced by the position of the chlorine. Also, non-ortho PCB 77 was said to be more hydrophobic due to the orientation of chlorine atoms which allows for the free rotation of chlorine atoms between the phenyl rings and practically impossible in PCB 52 thereby making it more susceptible to aqueous solubility. Due to the susceptibility of ortho-substituted congeners to aqueous solubility, it is, therefore, more likely for this pollutant to re-suspended back to surface water or leach to the groundwater more easily when sorbed by soil and may possibly pose more risk to the aquatic ecosystem relative to its non-ortho substituted congener of the same homolog. However, PCB 77 are more likely to result in steady sorption by soil and become less available to the aquatic life which may then become more available to filter feeder organisms who source their food from surface sediment.
**MP225 Environmental Impacts of Spent Oil Lubricants on Soil Properties and Environmental Segments in Orji Mechanic Workshop, Imo State Nigeria**

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The study investigated the effects of spent oil lubricants on soil physical and chemical properties. Twelve (12) different soil samples were collected from the auto-mechanic villages and from the Federal University of Owerri (FUTO) university agricultural land that served as the control. Two (2) samples were collected from these three points 50.31.114N 7002.703E, 5031.165 N 70.2670E and 5023.35N6059.176E at profile of 0-15cm and 15-30cm. Twenty three (23) different parameters were analyzed for the soils such as pH, bulk density, total organic carbon, particle size distribution, heavy metals of Ni, Cu, Zn, Ar, Cd, Hg and Pb. Standard methods were employed in the course of the analysis. All the parameters tested was in good condition except for the soil pH and concentrations of heavy metals which were more significant as pH of the auto-mechanic soils were acidic in the range of 4.3 - 5.0 in comparison with the control with mean value 5.6. Heavy metals were higher and richer in auto mechanic soils than in the control and their concentration decreases in this trend Cu 0.940 > Hg 0.211 > Ni 0.093 > Zn 0.051 > Pb 0.021 > Cd 0.015 > Ar 0.003; Hg 1.385 > Cu 0.853 > Ni 0.079 > Zn 0.041 > Cd 0.04 > Pb 0.034 > Ar 0.004 for the soil auto-mechanic soil 1 and 2. Ar had zero values in the soils of the control. Pearson Correlation coefficient was computed in testing the hypothesis using SPSS v. 20 where significant positive correlations were obtained at values 0.957 and 0.99. P value 0.000; 0.874 and 0.999, P 0.000; 0.997 and 0.912, P 0.000; 0.997 and 0.918 P 0.000 all at 0.01 level of significance. The null hypothesis was rejected on the basis of the significant correlations for relationships between the use of lubricants and physico chemical variables, physico chemical variables and depths of the soil across the profile, use of oil lubricants and soil particle size distribution, use and disposal of oil lubricants and soil texture. Recommendations were made like adherence to proper disposal of auto mechanic wastes, use and enforcement of Environmental Management Plan in auto-mechanic workshop villages and remediation measures to correct the concentration of parameters as identified using phyto-remediation for a sustainable soil and environmental management in the vicinities of the workshop.

**MP226 Extraction approach to analyze organoaarsenic species such as dimethylmonothioarsinic acid (DMMTAV) and dimethyldithioarsinic acid (DMDTAV) in soil**

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Various arsenic species are present in the environments and these species can be transformed according to the environmental conditions. Among the arsenic species, it was reported that the inorganic arsenics have higher toxicity than organic arsenics. However, some organic arsenics such as dimethylmonothioarsinic acid (DMMTAV) and dimethyldithioarsinic acid (DMDTAV) have relatively high toxicity. These species can be transformed from low toxic arsenic species such as dimethylarsinic acid (DMAV) under sulfidic condition. In our previous studies, it was confirmed that the DMAV can be thiolated to DMMTAV and DMDTAV according to environmental conditions. This transformation can occur in actual environments and the strong candidates are landfill and mine site. In these sites, DMMTAV and DMDTAV can be present as an adsorbed form onto soil, and consequently the toxic organoaarsenic can be exposed to the plants, animals, and human. However, the analysis method of DMMTAV and DMDTAV extracted from soil was not reported. Therefore, the aim of this study is to find the extraction method of DMMTAV and DMDTAV adsorbed from the soils. The experiment was carried out using the clay minerals because it reduces interference by soil factors such as sulfide and iron. These factors can be significantly influenced to adsorption and extraction reaction of organoaarsenic species. The soil experiments will be attempted after this clay mineral experiment. First of all, we made DMMTAV and DMDTAV be adsorbed on the clay minerals. And the various extracting solutions, including methanol/water mixture, inorganic acid, and organic acid, are employed to extract DMMTAV and DMDTAV from clay minerals. For extraction, solid and solution was appropriately mixed and sonicated. After then, the mixture was centrifuged and filtered to separate the supernatant and solid. The separated supernatant was analysis using HPLC-ICP-MS to compare the extraction efficiency of DMMTAV and DMDTAV. Through this study, we infer the potential on extraction of DMMTAV and DMDTAV. In addition, it can be investigated which one is the most effective to extract DMMTAV and DMDTAV from clay minerals, and simultaneously this result can be basis on the application of actual soil environment. This research was supported by a grant from the Korean Basic Science Institute (Project No. C39707).

**MP227 Source Identification and Human Health Assessment of Heavy Metal Contamination by Multivariate and Hazard Index Analyses**

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Petroleum contamination is a significant contributor of elevated level of toxic heavy metals, which are of great concern to human health, due to their non-biodegradable nature. Agaye community has experienced frequent gasoline spills due to pipeline vandalism, resulting in the contamination of soil and water sources. The concentrations of metals (Cd, Cr, Cu, Mn, Ni, Pb, V and Zn) in groundwater, surface-water and soil were determined from a total of 216 samples acquired bi-monthly for two years by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) to evaluate the impact of oil spills. Multivariate analyses using principal component analysis (PCA) and cluster analysis (CA) were also used to study the interactions between metals and identify the possible sources of contamination. The concentrations of heavy metals in soil and water samples (surface and groundwater) were in decreasing order of Mn > Ni > Zn > Cu > V > Cr > Pb > Cd and Ni > Zn > V > Cu > Mn > Pb > Cr > Cd respectively. Ni concentration ranged from 0.42-8.05 mg kg-1 and 0.10-2.85 mg L-1 for soil and groundwater respectively. Ni and V were more enhanced (P < 0.05) in soil samples. This study showed that there was significant relationship between elevated levels of Cr, Cu, Ni and Zn and oil spillage, due to petroleum spills and that residents were vulnerable to and at greater risk of non-carcinogenic hazards if they consumed groundwater. Multivariate analyses showed significant anthropogenic intrusions of two diagnostic heavy metals (Ni and V) for petroleum contamination in the soils and water sources.

**MP228 Toxic Effect Concentrations of Rare Earth Elements by Total and CaCl2 Extraction Including Comparison of Bioaccessibility to OECD Soil**

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Rare earth elements (REEs) are a group of 17 elements including the lanthanide series, yttrium and scandium. They co-occur naturally in mineral deposits, have similar properties, and are being used increasingly in new technologies. At low REE concentrations in soils, plant growth can be stimulated; at higher concentrations, toxicity has been identified for some REEs. Through 14 day growth studies, toxicity thresholds (shoot/root length) for radish, tomato and durum wheat to three REEs: cerium, neodymium, and europium, were determined. A hormetic response was not observed for any of the data, however many endpoints displayed thresholds. Bioaccessible REE concentrations determined by CaCl2 extraction were very low - less than 0.05% - for each REE. The range of observed toxicity thresholds (EC 25900-7600 mg/kg) was greater than that reported...
in previous studies, likely due to the low bioaccessibility of REEs in the highly organic soil used in the present study. Internal tissue concentrations may better relate to the dose at the site of toxicity.

MP229 Quantification of nano-zero-valent iron in soil for toxicity testing of soil invertebrates

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Nano zero-valent iron (nZVI) has been used for several years in the remediation of contaminated groundwater and has more recently been proposed as a method for soil remediation. It can reduce the toxicity of contaminants such as polycyclic aromatic hydrocarbons, pesticides, and heavy metals that are resistant to microbial degradation and weathering (degradation and immobilization). Before nZVI can be widely used in soil remediation efforts, toxicity testing must be done to compare the toxicity of the existing contaminants to potential toxicity of the nZVI. Some literature exists on the toxicity of nZVI to soil biota, but these studies report nominal concentrations or reduction in bioactivity of a contaminant rather than measured concentration of nZVI, which undermines confidence in the data. The purpose of this research is to adapt a method of nZVI quantification from groundwater research that uses indigo disulfonate as a specific chemical redox probe. A standard curve was developed by reacting indigo disulfonate with known concentrations of nZVI in water to produce a colour change measured by ultraviolet-visible spectroscopy. This curve was then used to quantify nZVI in soil pore water extracted from nZVI amended soils. Toxicity to the soil invertebrates Folsomia candida and Eisenia andrei was then assessed using the endpoints of avoidance, lethality, and reproduction. These endpoints were combined with the method of measuring nZVI to express toxicity thresholds in terms of the realized dose in the soil. This allows for better extrapolation to field exposure scenarios and development of guidelines for the use of nZVI in soil remediation.

MP230 Use of QSAR models in Environmental Management Information System for soil pollution

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Assessment and regulation of environmental impacts of organic pollutants in soils and groundwater can be costly and time-consuming. These problems are compensated by different Environmental Management Information Systems (EMIS) that accelerate the decision-making process by tracking pollution, monitoring impacts and environmental fate, describing background soil conditions, choosing of alternative compounds for better practices, etc. In all these cases, the adsorption of pollutants in soil organic matter (logKoc) is a key parameter. In this sense, several QSAR models (QSARs) to predict logKoc from empirical data measured under laboratory conditions had been published and proposed for regulation. However, differences between laboratory and field conditions imply uncertainty about the applicability of QSARs with this focus. This work proposes an QSAR-based approach to environmental management by connecting QSARs and EMIS through a quality improvement methodology. The method divides the process of creation and application of QSARs on four steps, based on PDCA cycle: (i) Plan, including the data mining and generation of datasets; (ii) Do, where datasets are classified according to an objective, such as assessment of potential risk, and the QSARs are created. In this step, the mathematical complexity of model (linear or non-linear) is based on the system complexity, i.e. relationship between the initial descriptors pool and the variability of endpoint data; (iii) Check, using different chemometric tool for the statistical validation of QSARs, such as cross-validation, external validation, bootstrapping, and adding an empirical validation consisting of generate and analyze empirical data in situ, considering environmental conditions such as pedogenetic, climate, soil-water potential, temperature, among others. Finally, (iv) Act, where the results of empirical validation are used to redefine and/or improve the applicability domain and mechanistic explanation of QSARs. In addition, the experimental data can be used as input to a new and more accurate QSARs, while the fails on predictivity can help to propose new descriptors that include the unexplained variability of the current model. The use of Baseline Environmental Assessment as empirical data is also a way to connect scientific and political work, and the applicability of QSARs in local contexts allows a greater commitment among citizen, regulators and scientists.

MP231 Risk assessment and toxicological evaluation of the impact of lead-mining activities in Agalegu, Ebonyi State, Nigeria

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In this study, we examined the levels of contamination of some vegetable crops, soil and water arising from the mining activities in Agalegu in Ebonyi State. Toxicity of water samples were tested using the “ostracod (Heterocypris incongruens) toxicity assay kit” and that of soil using earthworms as test organism. Results show that the concentrations the various vegetables, soil and water samples decreased as distances progressed from the mining site. There was no observed mortality of earthworms after 72hours of exposure to the various lead-soil samples. However, 10% mortality of earthworms (after 7 days) and 22.2% mortality (after 14 days) were observed in lead-soil samples collected 0.05km away from the mining site, while 10% mortality was observed (after 14 days) in lead-soil sample collected 2km away from the mining site. Percentage mortality of ostracod crustaceans exposed to lead-water samples decreased as distances progressed from the mining site, but remained constant after distance of 4km. In Agalegu community, Ebonyi State, Nigeria the total THQ values of adults and children through consumption of vegetables and water intake were 4.12 and 5.41, respectively, suggesting that the residents may be facing health risks due to vegetable consumption and that children in particular were vulnerable to the adverse effects of heavy metal ingestion.

MP232 Arsenic Contamination and its Impact on Cellular Functions in Wound Healing

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Arsenic (As) is a naturally occurring element found in the environment and is harmful to humans at elevated concentrations. Erosion of natural arsenic mineral deposits can lead to contaminated water wells that communities use for bathing, drinking and agriculture. Following human exposure, As has been shown to negatively impact major organs, cellular functions, and gene expression, potentially increasing the risk for developing pathologies. The cellular and molecular underpinnings of As effects on these disease states are similar to those seen during wound healing, suggesting that arsenic exposure impacts normal cell function in wound healing. In these studies, human fibroblast (hDF) skin cells were exposed to environmentally relevant concentrations of As (sodium arsenite). Fibroblasts are critical for many aspects of wound healing and can be cultured in a monolayer to study contaminated wounds. Cellular migration, metabolic activity and viability of hDF cells exposed to As were evaluated using three independent in vitro assays. In a scratch cellular migration assay, treatment of hDF with As for 24 hours prior to scratch reduces the effective As dose 20-fold (from 10 μM to 0.5 μM) compared to treating at time of scratch (p< 0.05). In the cell metabolic activity and viability assays, pretreatment (24-72 hours) of hDF with As decreases metabolic rate at 1 μM, reduces proliferation at 2 μM, and is lethal to both metabolic rate and viability at 5 μM and 10 μM (p< 0.05). These results suggest that As may deleteriously affect wound healing, which may directly translate to future in vivo studies.
MP233 Environmental contamination: The toxic legacy of a Native American tribe continues
K. Fetecie, O.N. Avenbuan, New York University School of Medicine / Environmental Medicine; D. DeFreesee, Ramapough Lenape Nation / New Jersey; M. Zhong, J.L. Bloom, J. Zelikoff, New York University School of Medicine / Environmental Medicine

Beginning in the early 1960s through the late 1970s, Ford Motor Co. dumped paint sludge and other toxic metals from its Mahwah plant into the local suburbs, including Ringwood, NJ. As a result, Ringwood became riddled with contaminated soil and water, placing a large environmental health burden on the very people who have lived on this land for generations - the Ramapough Tribal Nation. Upon community request, soil samples were collected from chemically-impacted areas of Ringwood by citizen scientists and NYU graduate assistants in order to evaluate soil metal concentrations. Samples were collected by digging 3-5 inches deep into the soil with a plastic trowel. Once dried, samples were crushed and homogenized and digested by adding 2 ml of nitric and 1ml of hydrochloric acid to 1 g of soil. The soil digest was then diluted with water and filtered using a 0.45mm filter to capture any particulate matter. Using ICP-MS, 36 metals were identified and their levels compared to New Jersey Direct Contact Soil Standards for dermal, ingestion, and inhalation exposure. Vanadium (V), a transition metal readily taken up by plants, was found in several soil samples at levels that exceeded the NJ soil standard of 78 mg V/kg. At high concentrations, ingestion of Vanadium has been correlated with adverse health effects in the human gastrointestinal, cardiovascular and renal systems and its cancer-causing potential is still being debated. Given the elevated V concentrations in the soil samples of this region, residents consuming plants grown in this area or recreating in the area could be at increased risk for adverse health effects. Supported by NIEHS Core Center Pilot Grant.

MP234 Application of Box-Bennken design in the optimization of organic amendments during the bioremediation of kerosene polluted soils
M.O. Chukwu, University of Nigeria, Nsukka / Microbiology

Nigeria is one of the major oil-producing countries and as a result, is faced with various forms pollution emanating from crude oil exploration, transport and utilization. This has hampered the agricultural activities and endangered most aquatic organisms owing to the toxicity associated with the pollutants. To this end, the current study was undertaken to optimize the composting materials during the bioremediation of the polluted soil. The optimization of the organic amendments was performed using the Box-Behnken statistical experimental design. This design consisted of 15 runs of 3 factors (poultry droppings, sawdust and grass trimmings) at 3 levels which included three central points to analyze the model robustness. The rate of total petroleum hydrocarbon removal, lipase and dehydrogenase activities were considered as the experimental responses for monitoring of the effectiveness of the biodegradation. The statistical design suggested that a mixture of grass trimmings (158.2 g), poultry droppings (50g) and sawdust (602.7g) resulted in best total hydrocarbon removal rates (R2 =0.9776). The dehydrogenase and lipase activities of the soil microbes were effective biomonitoring tools during the remediation. This study clearly shows that cheap organic amendments are indispensable in the removal of pollutants from the environment.

Natural and Ambient Soil Background Studies and Their Utility in Risk Assessment

MP235 Analytical Investigation of Physicochemical Properties of Soil and Water From Coal Mining Environment of Enugu State, Nigeria
O. Francis, University of Nigeria Nsukka

Underground coal mining are likely to disturb the underground water and soil in terms of quality. Added to this is the problem of leachates from the large number of industrial waste and overburden dumps that are in abundance in mining areas. It was observed that pH level of Ngwo soil compared to that of Udi and Akwuke soil which is below W.H.O standard may be attributed to anthropogenic sources. The specific gravity and bulk density of soil from, Ngwo, Udi and Akwuke were below the WHO allowable limit. The anion levels, NO3, PO4, SO4 and Cl levels in soil from the three communities studied were within permissible limit (EPA, 2012), though PO4, SO4 and Cl2 level of Udi soil were significantly higher than the values in the communities. The decrease in pH of well water from Udi and Akwuke, 4.80±0.01 and 5.54±0.01 respectively was an indication of acidity of the well water. These values are above W.H.O standard level (6.5) for portable water. The conductivity levels of well water from the three communities investigated were within the EPA permissible level (5-50µhos/cm3) for drinking water. The observed levels of total solid, total dissolved solid and total suspended solid of well water from the three communities were within the WHO permissible limit for drinking water, except chloride level (916.00±1.00) in Udi well water which was above W.H.O permissible limit (250mg/l) for chloride.

MP236 QSAR models to predict pesticide sorption in soils:
Application in environmental decision-making
A. Neira-Albornoz, University of Chile; L. Caceres-Jensen, J. Rodriguez-Becerra, Metropolitan University of Educational Sciences; M. Escudey, University of Santiago de Chile

Soil and water pollution by pesticides is an issue of global concern because of its multiple impacts and complex fate pathways, principally dependent on adsorption. In this sense, QSAR models (QSARs) to predict sorption of pesticides in soils are usually used as screening tools to evaluate environmental and health risks. The OECD propose the use of logKoc as endpoint, assuming that sorption is hydrophobic and occurs only in organic matter (OM). Moreover, only one logKoc value per pesticide is used, resulting from the average of sorption coefficients among different soils. However, this procedure hides the variations in sorption mechanisms among different soil orders due to environmental and physicochemical soil properties. This reduce the accuracy and relevance of QSARs in specific scenarios, affecting their use in environmental decision-making. Considering the sorption mechanisms in pesticide-soil systems as a source of uncertainty for QSARs, the current study analyzes the sorption mechanisms from a molecular view, focused on soil and solution properties using a bibliometric approach that involved a total of 1488 articles. First, sorption data was separated by kind of molecule and sorbent, then sorption mechanisms for all the combinations were studied and finally, logKoc values were compared with QSARs validated by the OECD, considering if (i) logKoc is representative of sorption mechanisms and (ii) prediction of QSARs is connected to the mechanistic assumptions. The results showed differences inter-soil and inter-pesticide related to the speciation of both, particularly between ionizable and non-ionizable pesticides, or between variable and permanent charge soils. The most frequent sorption mechanism is hydrophobic in OM, however, we found some prediction errors in OECD QSARs, associated to the functional groups and humification degree of OM and clay-humus complexes. On the other hand, the most uncommon sorption mechanisms occur in variable charge soils, including sorption of anions, cation-pi interactions and sorption pH-dependent for ionizable and non-ionizable pesticides, with inapplicability of OECD QSARs. These results are useful to contextualize the endpoint to the specific soil properties and sorption mechanisms, improve the applicability domain of QSARs, support a decision-making soil by soil and facilitate the comparison of sorption trends and future soil policies among OECD countries.
Mining Environments in a Changing Climate

MP237 Assessment of pollution levels and some heavy metal in the coal mining environment of Ngwo, Akwuke and Udi communities of Enugu State

Q. Francis, University of Nigeria Nsukka; C. K. Urama, Enugu State University of Science and Technology / Biochemistry

Soil and water in the coal mining communities of Enugu State were investigated for the presence of heavy metals in the soil and water. Three of the communities are coal mining impacted areas, though coal mining has been stopped for over 20 years now in these communities. The heavy metal and water from these areas were investigated, using Atomic Absorption Spectrophotometer (AAS). The result of Heavy metal levels in soil of the three communities are within the permissible limit which could be attributed to anthropogenic and mining activities that took place in the area, and the used of fertilizer. The heavy metal levels in well water followed the same trend as observed in soil. However Mn, Cr and Pb level in well water from the three communities were above W.H.O. (2005) permissible limit of 0.05 mg/l, 0.05 mg/l, and 0.01 for Mn, Cr, and Pb respectively. The high level of these metals in well water could be attributed to anthropogenic source as well as underground water pollution due to leaching of these metals in the soil to underground water. It was observed that pH level of Ngwo soil compared to that of Udi and Akwuke soil which is below W.H.O standard may be attributed to anthropogenic sources. The specific gravity and bulk density of soil from Ngwo, Udi and Akwuke were below the WHO allowble limit. The anion levels, NO3, PO4, SO4 and CI2 levels in soil from the three communities studied were within permissible limit (EPA, 2012), though PO4, SO4 and CI2 level of Udi soil were significantly higher than the values in the communities. The decrease in pH of well water from Udi and Akwuke, 4.80±0.01 and 5.54±0.01 respectively was an indication of acidity of the well water. These values are above W.H.O standard level (6.5) for portable water. The conductivity levels of well water from the three communities investigated were within the EPA permissible level (5-50 μhos/cm) for drinking water. The observed levels of total solid, total dissolved solid and total suspended solid of well water from the three communities were within the WHO permissible limit for drinking water, except chloride level (916.00±1.00) in Udi well water which was above W.H.O permissible limit (250 mg/l) for chloride.

MP238 Climate-related changes to arsenic cycling in northern lakes: Implications for future environmental monitoring of mine sites

C. Miller, Queen’s University / Department of Geological Sciences and Geological Engineering; M. Parsons, Natural Resources Canada, Bedford Institute of Oceangraphy; H. Jamieson, Queen’s University / Department of Geological Sciences and Geological Engineering; G. Ardakani, Natural Resources Canada, Geological Survey of Canada; G. Swindles, University of Leeds / School of Geography; B. Gregory, N. Nasser, T. Patterson, Carleton University / Ottawa–Carleton Geoscience Centre and Department of Earth Sciences; J. Galloway, Natural Resources Canada, Geological Survey of Canada/Aarhus Institute of Advanced Studies, Aarhus University

Continued climate warming may affect the cycling of naturally occurring metal(loids) and the long-term stability of mining-derived contaminants in lakes. In sub-Arctic environments, it is not known how the cumulative effects of resource extraction and climate warming will influence geochemical baselines or the cycling of arsenic (As) that can be naturally elevated in mineralized bedrock or as a result of legacy mining activities. This study integrates As geochemistry, mineralogy, organic petrography, multivariate analysis of paleoclimate proxies, and radiometric dating to determine the influence of climate on the concentration and cycling of As in lake sediments during the late Holocene (ca. 5,000 yrs. cal BP). Analyses of sediment cores collected from two lakes in the central Northwest Territories, Canada, document increases in sediment and porewater As coincident with changes in the source and composition of total organic matter. In both lakes, detrital As-bearing minerals (e.g., arsenopyrite and scorodite) are present. However, sediments also contain abundant As-bearing minerals (e.g., framboidal pyrite and Fe-(oxy)hydroxides) formed in situ and mixed porewater oxidation states, suggesting that remobilization of As occurred in lakes where labile organic matter, such as algal-derived lipids and cell walls, increased relative to generally inert terrestrially-derived organic matter. These findings provide evidence that past climate warming has influenced the cycling of As in these lakes through its effect on aquatic primary productivity, terrestrial organic matter composition, and catchment weathering. This study demonstrates the value of studying long sediment cores from different lakes in a catchment to determine natural variations in background metal concentrations. New geoscience knowledge produced from this study can be used to predict future climate-driven variations in metal(loid) cycling in lakes and help guide the interpretation of environmental monitoring results at northern metal mines.

MP239 Customized reactive capping blend for enhancing natural recovery of wetlands impacted by contaminated legacy gold mine tailings

E. Chapman, Saint Marys University; C. E. Moore, Intrinsik Corp.; L.M. Campbell, Saint Marys University / Department of Environmental Science

Gold mine tailings generated in the late 1800’s still contains elevated concentrations of mercury (Hg) due to the amalgamation process used to extract the gold, and arsenic (As) due to the naturally high levels of arsenopyrite present in gold-bearing rock. At that time, before environmental legislation, tailings were simply discarded into nearby lakes, wetlands or rivers without treatment. More than a century later, multi-generational exposure to tailings has occurred, potentially impairing ecosystem function and impeding biological recovery. Innovative, non-intrusive, low-cost approaches are urgently needed to manage risks associated with legacy tailings in sensitive aquatic habitats. The purpose of this project was to complete proof of concept testing of customized capping blends for limiting the mobility, bioaccumulation and toxicity of Hg and As in wetland sediment impacted by legacy tailings. Sediment was collected from two wetlands in historical gold mining districts. A clean control sediment was also prepared mimicking the texture of the contaminated sediments. Capping applications were assessed in terms of success in limiting the toxicity and bioaccumulation of contaminants in invertebrates exposed to the sediments, as well as the ability of the capping blends to reduce mobility of contaminants from the sediment to the water column. Due to the extremely high concentrations of Hg and As, invertebrates exposed to untreated contaminated sediment exhibited high mortality, growth impacts, and high bioaccumulation of both contaminants. The capping application that showed best results in limiting these impacts was a blend of fine silica sand, two different clays, and zeolite-supported nanoscale zerovalent iron slurry. This capping blend dramatically improved the survival of Hyalella azteca and Daphnia magna to levels observed in clean control sediments, and significantly reduced the bioaccumulation of Hg and As. Sediment concentrations of Hg and As were reduced by 88% and 99% respectively. Our proof of concept bench top testing with this capping blend shows potential. However, before the capping blend can be used in the field to reduce risks it is necessary to complete testing using more environmentally realistic mesocosms.

MP240 Effects of tailings dust on surface water chemistry

A. Cleaver, H. Jamieson, Queen’s University / Department of Geological Sciences and Geological Engineering; P. Huntsman, CanmetMINING, Natural Resources Canada; C. Rickwood, Natural Resources Canada

Canada’s climate is warming and reductions in summer rainfall are projected for parts of southern Canada. The resulting increased risk of water supply shortages in summer months means that dry tailings are more likely to blow into nearby surface waters. However, dust as a source of metal contamination to surface waters has not been evaluated. This
research aims to address this knowledge gap by investigating the effects of metal-bearing mine dust on surface water chemistry and how climate change may influence these effects. During this study, two abandoned mine sites in Nova Scotia, Canada with apparent aerial erosion and nearby water bodies were investigated; Stirling mine and Goldenville. To ensure representative samples and to evaluate different dust sampling methods, a variety of sampling methods were used. These methods included passive air samplers, high volume air sampler, and sieved tailings samples (as a proxy for windblown dust). Dust filter sampling was completed seasonally, occurring approximately every three months since December 2017. Seasonal sampling allows for a better understanding of seasonal trends and correlation to climatic conditions. Bulk geochemistry and mineralogy of the sieved tailings and filters were analyzed to determine metal concentrations and the primary and secondary metal-bearing phases. This is important due to differing solubilities associated with each mineral phase. Additionally, shaker flask tests were conducted to investigate the dust’s behavior in water. This information combined with dust deposition rates will help evaluate the potential risk tailings dust poses to surface water chemistry in the field. These results will be related to climate change scenarios by comparing observed seasonal trends in dust generation and dust composition to local climate change models.

MP241 Evaluation of chemical and physical variables as a predictors of sediment toxicity to C. Dilutus and H. Azteca

K. Batchelor, P. Stecko, Minnow Environmental, Inc.; C. Hughes, Mount Polley Mining Corporation

A foundational failure of the perimeter embankment of the Mount Polley Tailings Storage Facility on August 4th 2014 resulted in a breach that released approximately 25 million cubic meters of debris. Toxicity testing has been used as one tool in monitoring breach-affected sediments from deep areas of lakes impacted by the event (areas which represent locations of sediment accumulation/fate). Previous toxicity testing of sediments from one of the impacted lakes has indicated adverse effects to the growth of Chironomus dilutus and Hyalella azteca, with more limited effects on survival. Breach-affected sediments are characterized by low total organic carbon (TOC) and high concentrations of some metals (copper in particular). Prior evaluations have been unable to separate chemical (i.e., copper) and physical (i.e., TOC) variables as potential predictors of the adverse growth responses to breach-affected sediment. In this study, a number of endpoints were evaluated to further evaluate potential drivers of the growth responses that continue to be observed. These included overlying water chemistry, porewater chemistry, and labile metal concentrations (measured using Diffusive Gradients in Thin-Film) assessed in the field and laboratory, in addition to sediment chemistry. To create a gradient of exposure concentrations for this assessment, sediment was collected from two impacted areas and one reference area, and from field locations with intermediate sediment metal concentrations. Intermediate samples were also created by mixing exposed and reference sediment in the laboratory. Physical and chemical endpoints were assessed across this sample gradient to determine which best predicted the growth responses to breach-affected sediment for both C. dilutus and H. azteca.

MP242 Human Health and Ecological Risk Assessment in Support of the Canadian Environmental Assessment Process

M.J. Denyes, Wood Environment & Infrastructure

A Human Health and Ecological Risk Assessment (HHERA) was completed to define and quantify potential risks to human health and ecological receptors as a result of exposure to chemicals in the existing environment as well as predicted chemical concentrations as a result of mining activities during all phases (construction through abandonment) of the proposed Goliath Gold Project (Project). The Project is in the late stages of achieving approval under the Canadian Environmental Assessment Act, 2012. The HHERA assessed potential risk at three study areas where human and ecological receptors would experience the highest magnitude, frequency, and duration of chemical concentrations for baseline conditions, the Project alone, and the combination of baseline conditions and Project as per current Environmental Assessment guidance. The Project is located in Northwestern Ontario, within an area where traditional land and resource use is currently practiced. Therefore, the detailed human health risk assessment considered ingestion country foods and inhalation of criteria air contaminants including nitrogen dioxide and particulate matter within the property boundary where traditional land use is practiced. Inclusion of all Project phases, study areas and assessment scenarios, resulted in 21 unique human health and ecological conceptual site models. To support the interpretation of this large data set, data were organized into an HHERA model specifically designed for the Project. The development of a Project-specific HHERA model, allowed for efficient incorporation of new data including effluent and water quality predictions as a result of ongoing improvements to the engineering design of the Project related to climate forecasts and the long-term viability of a wet cover for the tailings storage facility. The results of the HHERA are being used by the Proponent to develop mitigation measures, monitoring programs and aid in on-going consultation activities. This presentation will detail the methodology for the development of the conceptual site models and HHERA model including rationale for all operable exposure pathways from environmental media (air, soil and surface water) and project-specific media (tailings, waste rock, pit-lake water), and offer insight into the regulatory expectations for approval in Canada.

MP243 Paleolimnology tracks the impacts of metal smelting on biota of Phantom Lake, Flin Flon (MB): Implications to mercury concentrations in northern pike

B. Simmatis, K.M. Rühlund, Queen’s University / Department of Biology; M. Evans, Environment and Climate Change Canada / Water, Science and Technology Directorate; J.L. Kirk, S. Roberts, X. Wang, Environment and Climate Change Canada / Aquatic Contaminants Research Division; C. Meyer-Jacob, J.P. Smol, Queen’s University / Department of Biology

Information stored in lake sediments can provide long-term context to past environmental conditions prior to active monitoring. At its peak, the Cu-Zn smelter in Flin Flon, Manitoba, was one of the largest Hg emission sources in Canada. Despite this, northern pike in nearby lakes appeared healthy, with low liver and fillet Hg concentrations (< 0.1 µg/g), possibly because high metal concentrations in lake sediments inhibited mercury methylation. To investigate metal toxicity trends, we used a 210-Pb dated sedimentary record from Phantom Lake, located ~5 km south of the Flin Flon smelting operations, to examine long-term trends in metals, diatoms, and invertebrates to track the environmental history of the region over the past ~200 years. This work examined (1) whether Phantom Lake acidified in light of high sulphur loading, (2) how metal concentrations and fluxes changed in response to increased smelting activity, operational improvements, and closure of the smelter in 2010, and (3) whether biological assemblages responded to smelting and other environmental changes. Metal concentrations were determined using ICP-MS. Diatoms and invertebrate assemblages were used to examine direct and indirect industrial effects. There was no evidence of acidification with the increased sulfur loading; the lake has a moderately high conductivity (184 uS/cm) and hence a strong buffering capacity. Metal concentrations in lake sediments increased with smelter operation expansion and then decreased with technological improvements and eventual smelter closure. Several metals were above CCME probable effects guidelines for sediments and remain so suggesting that toxicity was likely. Although the magnitude of change was variable, changes in all proxies (especially diatoms) were consistent with those expected in response to high levels of metal toxicity during active smelting. Despite reductions in metal concentrations, biological proxies did not return to their pre-smelting states. Post~2000 biological proxies suggest modest declines in metal toxicity, but climate change may also be affecting recent changes. These results support the hypothesis that lake biota, including methylating bacteria, have and continue to experience the effects of sediment toxicity. This could impair mercury methylation and may explain why mercury concentrations in northern pike have remained low and not responded to changes in smelting activities.
MP244 Point source atmospheric metal(loid) pollution history from Thompson Manitoba Smelter in Canada using lake sediment cores
S. Roberts, J.L. Kirk, D.C. Muir, Environment and Climate Change Canada / Aquatic Contaminants Research Division; J. Wiklund, University of Waterloo; A. Gleason, G. Lawson, F. Yang, Environment and Climate Change Canada; J. Keating, Environment and Climate Change Canada / Water and Science Technology Directorate; M. Evans, Environment and Climate Change Canada / Water, Science and Technology Directorate

The Thompson Manitoba nickel (Ni) and copper (Cu) smelter was constructed in 1961 CE, following a decade of mining exploration in the region. The smelter was a major producer of Ni globally, and the Thompson region is unique to focus on, due to the scarcity of regional temporal metal(loid) deposition studies. Thus, this study reconstructs high-resolution atmospheric anthropogenic metal(loid) deposition over the last c. 100 years using $^{210}$Pb dated lake sediment cores collected from 9 lakes located at varying distances and directions from the Thompson smelter, in order to explore the local point-source deposition history. Thompson lake sediments were moderately enriched (average enrichment factor 2 - 5) in antimony (Sb) > Hg > lead (Pb) > cadmium (Cd) > Ni, and slightly enriched (average enrichment factor < 2) in arsenic (As) > strontium (Sr) > bismuth (Bi) > Cu > zinc (Zn) > uranium (U). Deposition decreases with distance from the Thompson smelter for 6 of 11 enriched metal(loid)s (As, Bi, Cd, Cu, Ni, Sr), whereas the remaining enriched metal(loid)s (Hg, Pb, Sb, Zn, U) appear to be largely sourced from long range atmospheric deposition rather than predominately local pollution from the Thompson smelter. Ni and Sr deposition in Thompson area lakes are higher (up to 100-fold and 4-fold respectively) compared to Flin Flon area lakes. For the other enriched metal(loid)s (As, Bi, Cu, Cd, Hg, Pb, Sb, Zn) in the Thompson lake sediments, deposition is higher in the Flin Flon area lakes in comparison to the Thompson area lakes. Anthropogenic fluxes for all the enriched metal(loid)s have been declining over the recent 9-year period between 2005 to 2014 CE, in alignment with the reported emissions from the Thompson smelter. Whereas Hg anthropogenic fluxes are continuing to increase post-2005 CE despite the reported Hg emission declines. One likely explanation for this discrepancy is catchment soil saturation, with historically deposited Hg being remobilised and leached into the Thompson area lakes, from climate-driven permafrost thaw in the Manitoba region. Thus, the catchment areas of the Thompson area lakes could be a major source of legacy Hg into the lakes with the rising regional temperatures, resulting in the continued ongoing fluxes of Hg into the lakes.

MP245 Tracking dust under a changing climate: Investigating the environmental fate and effect of dust-bound metals from abandoned mine sites
C. Rickwood, Natural Resources Canada; P. Huntsman, S. DeSisto, CanmetMINING Natural Resources Canada; A. Cleaver, H. Jamieson, Queen’s University / Department of Geological Sciences and Geological Engineering

Changes in average temperatures, precipitation and extreme weather events at mine sites across Canada are altering the environment and increasing the challenges for mine waste and water management. Climate models suggest that many southern regions in Canada (i.e. south of 60 degrees parallel) will become warmer and drier during the summer months. With this change in climate there is a risk of increased dust generation with greater impacts on the surrounding environment. Dust pollution from extreme droughts is a serious concern to both environmental and human health. Recent studies in some mine sites have shown a significant contribution of metals associated with particulate matter entering watersheds due to localised wind erosion of waste piles, dust from roads and atmospheric deposition during snow/rain fall events. The metals associated with these dust particles have the potential for remobilization in the environment leading to impacts on ecosystems. CanmetMINING and Queens University are investigating the fate and effect of metals associated with dust particles from abandoned mine tailings. This presentation outlines the results of sampling at two abandoned mine sites in Nova Scotia, the Stirling Zn/Cu/Pb mine and the Goldenville Au mine. Results from a number of field and lab techniques will be presented including sediment and water analysis and toxicity assessments. Results from this work will fill knowledge gaps with respect to our understanding of the impacts of climate change on resource development in addition to improving our understanding of the cumulative effects of dust impacts away from the immediate bounds of mine sites.

MP246 Tracking water quality in a changing climate
C. Miller, Queen’s University / Department of Geological Sciences and Geological Engineering; P. Huntsman, CanmetMINING, Natural Resources Canada; R. Bouwhuis, Environment and Climate Change Canada / Ecological Assessment Division; C. Rickwood, Natural Resources Canada

Both the quality and quantity of water in watersheds is expected to be altered due to climate change. However, there is insufficient scientific knowledge to predict how these changes are likely to be manifested. One approach is to look at long-term trends in past data to evaluate changes over time and space (e.g. watershed and regional variability). CanmetMINING, in collaboration with Environment and Climate Change Canada are compiling national and provincial water quality data in areas located close to active and abandoned mine sites. By compiling and examining water quality data over the past couple of decades we aim to determine if baseline water quality is changing over time, which could reflect climate change impacts. This work will help us to identify a number of important observations: 1) Identify indicators - are there specific metals or water quality parameters that show consistent responses to climate change that could be used as ‘indicators’ for future projections. 2) Hot spots - are there specific areas in Canada that are more sensitive to changes in climate? By collaborating with provinces and the federal family this project provides an opportunity to establish a national database that could track and monitor water quality in a changing climate, which would be of use to research organizations, governments as well as offering potential for citizen science applications.

MP247 Use of biomonitoring and remote sensing to track mine dust in a changing climate
P. Huntsman, CanmetMINING, Natural Resources Canada; H. White, Canada Centre for Mapping and Earth Observation / Natural Resources Canada; J. Percival, Geological Survey of Canada / Natural Resources Canada; C. Rickwood, Natural Resources Canada; A. Cleaver, Queen’s University / Geological Sciences and Geological Engineering

Many active and abandoned mining areas across Canada are vulnerable to weather extremes from a changing climate. Increases in snowfall and rate of snowmelt will cause surface runoff, followed potentially by drier summer periods, allowing for aerial deposition of dust from dry tailings into nearby surface waters. Two abandoned mine sites in Nova Scotia, Canada, with visible aerial erosion and nearby water bodies, were investigated during this project. To supplement the more traditional dust monitoring methods, including high-volume and passive air samplers, lichen was collected at each site and assessed for metal content/uptake. Patterns of metal dust deposition on passive air samplers were compared to metal content in the lichen at both sites. In addition, optical (spectral) satellite imagery was added to the suite of tools to monitor dust and identify land cover types that trap dust in the environment, with ground-truthing by hand-held VNIR-SWIR spectrometers. The spectral signature of the waste rock dust was evaluated for detection in the imagery, with the aim to identify land cover types that capture dust (either down wind or downstream). This project is assessing tools to monitor dust distribution from tailings areas and improve our ability to predict and mitigate the cumulative impacts of climate change on metal mines across Canada.
Challenges and Strategies for Linking Adverse Effects to Endocrine Modes of Action

**MP248 Evaluation of the effects of bisphenols on TM3 Leydig cells in vitro**

_T. Jambor, H. Grejfova, A. Kovacik, N. Lukac, Slovak University of Agriculture in Nitra / Department of Animal Physiology; P. Massanyi, Slovak University of Agriculture in Nitra_

In the last decades, many epidemiological studies have focused on the potentially hazardous effects of a wide range of chemicals present in the environment. Nowadays, we recognize many chemicals with endocrine disruptive properties and one of the most studied is bisphenol A (BPA). Overleaf, many BPA alternatives such as bisphenol S, F or B have been found in agrochemicals, personal care products epoxy resins or in the plastics packaging. Due to their wide usage, a large number of bisphenols are discharged into the ecosystem and evokes a public health risk. A significant body of evidence based upon laboratory experiments indicates that exposure to bisphenols is associated with male reproductive malfunctions, impairment of spermatogenesis followed by irreversible changes in steroidogenesis. The purpose of the present in vitro study was to elucidate the hazardous effects of bisphenols on TM3 Leydig cell line through the evaluation of steroid hormone production, mitochondrial activity and membrane integrity of exposed cells. Mice Leydig cells were cultured for 24 h with addition of 0.2-25 µg/mL of bisphenol A, B, S or F and compared to the non-treated cells. The level of steroid hormones in cell culture media was determined by enzyme linked immunosorbent (ELISA) assay, while the quantification of mitochondrial activity and membrane integrity was assessed using alamarBlue and CFDA-AM assay. The results showed that testosterone production was significantly (P< 0.001) reduced at 10 and 25 µg/mL of bisphenol A and bisphenol B. The same experimental doses of bisphenol S and bisphenol F initiated a successive decrease; however, the differences were not significant. Obtained data clearly demonstrated that the higher experimental concentrations (10 and 25 µg/mL) significantly (P< 0.001; P< 0.01) decreased mitochondrial activity. Furthermore, a significant (P< 0.001; P< 0.01) loss of cell membrane integrity was recorded at 10 and 25 µg/mL of bisphenol S and bisphenol B. Overleaf, only highest dose of bisphenol A and bisphenol F reduce membrane integrity significantly (P< 0.001). Taken together, the results of our study help to determine bisphenols effects on TM3 Leydig cells and increase the understanding of molecular mechanisms responsible for the adverse effects of selected bisphenols on the male reproductive system. This work was supported by the Slovak Research and Development Agency under the contract No. APVV-16-0289 and VEGA 1/0539/18.

**MP249 Human and Xenopus laevis type 3 iodothyronine deiodinase enzyme cross-species sensitivity to inhibition by ToxCast chemicals**


Deiodinase enzymes are critical components of the thyroid system that activate or inactivate thyroid hormones when and where needed in vertebrate development, as well as in amphibian metamorphosis. From a screening study of the ToxCast Phase 1, Phase 2 and e1k chemical libraries for inhibitory activity toward human Type 3 iodothyronine deiodinase (DIO3) enzyme we identified a subset of 357 chemicals to test for amphibian (Xenopus laevis) DIO3 inhibition. Recombinant X. laevis DIO3 enzyme was produced in cell culture and used in 96-well plate screening assays at a single test chemical concentration (200 uM). Our goals were to further determine specific chemical inhibitors of DIO3 and cross-species sensitivity. From the initial single concentration screening results with X. laevis DIO3, 80 chemicals were tested in concentration response mode to compare inhibitory activity between the two species. Results showed a general relationship between LogP (octanol:water) and Hill slope. Fourteen of the most potent chemicals with IC50 of 30 uM or less, 10 with LogP < 4.5, had Hill slopes near -1 and were not significantly different between species. These 14 chemicals, 11 of which are used as pesticides, may be specific inhibitors of DIO3 for both species, likely due to conservation of the enzyme active site amino acids between these species. Of the 43 chemicals with a LogP > 4.5, 33 had steep Hill slopes (much less than -1) for one or both species, with the X. laevis DIO3 more likely to have a higher IC50; for 19 of these chemicals the IC50 for either species was also > 90 uM. Other chemicals with steep Hill slopes for both species but with LogP < 4.5 include 4 PFAS compounds, other surfactants, and chemicals that did not reach complete inhibition at 200 uM. In general, our results indicate that human DIO3 responses to the ToxCast chemicals tested can be predictive of X. laevis DIO3 sensitivity to those chemicals.

**MP250 Species Extrapolation of a Quantitative AOP Describing Inhibition of Aromatase in Fishes: The Importance of Reproductive Traits**


Quantitative adverse outcome pathways (qAOPs) include descriptions of quantitative response-response relationships between key biological processes that facilitate prediction of the probability or severity of an apical-level toxicity for a given magnitude of chemical interaction with a target biomolecule. Quantitative response-response relationships in a qAOP are intended to represent generalized patterns of responses to produce models with the broadest taxonomic applicability. However, this applicability is often tested. As an example, response-response relationships were developed using data from the fathead minnow for a qAOP linking inhibition of aromatase to decreased fecundity. The extent to which these relationships could be applied to other fishes with asynchronous oocyte development in common with fathead minnow (e.g. Japanese medaka, zebrafish) was unknown, let alone how applicable they would be to fishes with group-synchronous oocyte development (e.g. mosquitofish). To address this question, zebrafish, Japanese medaka, and mosquitofish were exposed to the model aromatase inhibitor, fadrozole, for 21 days. Empirical results were compared with predictions based on the fathead minnow-based qAOP. The qAOP simulated responses measured in zebrafish exposed to fadrozole with comparable accuracy as for fathead minnow but did not simulate responses measured in Japanese medaka. Basal levels of plasma 17β-estradiol, plasma vitellogenin, and fecundity were comparable between fathead minnow and zebrafish, but were different in Japanese medaka. However, after normalizing for differences in basal production, the qAOP accurately predicted responses of Japanese medaka to fadrozole. This suggests that quantitative response-response relationships are conserved across these three asynchronous fishes when considering relative change rather than absolute measurements. In contrast, mosquitofish have complex reproductive profiles and compensatory responses which are distinct from those of asynchronous fishes.
Therefore, although responses to fadrozole were qualitatively similar between mosquitofish and fathead minnow, the current qAOP could not quantitatively predict responses in this group-synchronous fish. Overall, this study illustrates the importance of reproductive traits, including oocyte development and basal production of biomolecules, in the species extrapolation of certain quantitative response–response relationships described in qAOPs.

MP251 Bioactivity models as tools for predicting endocrine-mediated adversity - regulatory significance

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The World Health Organization (WHO) definition of an endocrine disrupting chemical (EDC) requires that the chemical 1) shows an adverse effect in an organism or its progeny, 2) has an endocrine mode of action (MoA), and 3) the adverse effect is a consequence of the endocrine MoA. The endocrine MoA leg of the WHO definition relies on the understanding that for a chemical to be considered an EDC, endocrine activity must occur at a molecular level (initiating effect) and trigger downstream key events. As part of the determination for whether a chemical has the potential to interact with the endocrine system, regulatory authorities have developed standard tests for generating key in vitro and in vivo mechanistic evidence. While there is considerable publicly available in vitro evidence to provide indications of potential endocrine activity of a plethora of substances, in vivo mechanistic data is understandably sparse in comparison. Thus, considerable in vivo studies utilizing a large number of animals would need to be conducted to meet sufficient evidence for determining endocrine activity of chemicals. In response, bioactivity models, which take into account both potency and efficacy, were developed utilizing existing mechanistic evidence, and validated utilizing a large pool of reference substances, to predict whether an adverse outcome is probable, relative to the mechanistic activity. These models are highly beneficial in terms of reductions in cost and time of testing, reductions in animal use and utilization of robust scientific basis for decision making. One such model, the ToxCast ER (estrogen receptor) Bioactivity Model, was notably indicated by US and EU authorities as providing sufficient evidence to support a conclusion of not endocrine active for the estrogen pathway. Here, we examine the significance, appropriateness and implementation of this and other bioactivity models for use in regulatory decision-making on endocrine disruption.

MP252 Transcriptomics: A Tool for Identification of Endocrine Active Chemicals in Fish

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The fish short-term reproduction assay (FSTRA) is often required by international regulatory bodies such as the United States Environmental Protection Agency (USEPA) and the European Food Safety Authority (EFSA) for assessing a chemical for potential endocrine activity in fish. The study is costly, time consuming, requires a lot of test material, creates a large volume of effluent waste, and requires a large number of test organisms. Smaller scale in vivo tests examining biomarkers such as vitellogenin induction may assist in evaluating the potential for endocrine activity but their sensitivity and ability to identify all modes of action (MoAs) may be limited. Transcriptomic analysis has greatly improved the ability to detect and understand mechanisms of action and may be a useful tool for rapid and less costly identification of endocrine active chemicals if gene expression profiles for the various MoAs can be characterized. Ovary, testis and liver tissue were taken from fathead minnows exposed to a variety of endocrine disruptor positive control chemicals (estrogen/androgen agonist/antagonist, aromatase inhibitor) for 2 and 21 days. RNA-sequencing was conducted and transcriptome sequences aligned to the fathead minnow whole genome. Here we discuss the gene expression profiles that were generated, the effectiveness of this approach for identification of chemicals that may have endocrine activity in fish and its utility as a tool for prioritization of chemicals for testing in the FSTRA.

Environmental DNA (eDNA) Approaches to Enhance Biodiversity Monitoring and Risk Assessments

MP253 Evolution of a high-throughput environmental DNA (eDNA) sampling platform

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With the rise of environmental DNA as a surveillance tool for aquatic species, a need has also arisen for professionally engineered research tools specifically designed for eDNA applications. We created the first portable, purpose-built eDNA sampling stream in the form of a backpack smart-pump filtration apparatus and custom made eDNA filter packs for each sample. The eDNA-Sampler (previously ANDe) enables both point-location sampling and mobile sampling over a spatial distance, with the ability to standardize filtration parameters (e.g. flow rate, pressure, water volume, etc.). In this presentation we will describe the evolution of the eDNA sampling backpack and associated components, each designed to help streamline the eDNA sampling process and increase sampling efficiency. We have optimized the platform for mobile sampling by integrating GPS and data logging capabilities, in addition to modifying the chemistry of the eDNA filter packets to minimize the effort required for sample preservation. Results will be presented from a series of pilot studies in which the eDNA-Sampler capabilities were evaluated. Combined, the innovations described herein should help remove barriers to entry for potential eDNA practitioners and also improve overall eDNA data quality.

MP254 Benchmarking water eDNA metabarcoding for biomonitoring of Canadian Freshwater Fishes

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Earlier studies have supported the use of eDNA metabarcoding of fishes to provide reliable biomonitoring information and were comparable with traditional capture methods. However, multiple factors from field sampling to wet lab procedures to bioinformatics pipelines can influence the final data matrix. Comprehensive studies are required to benchmark the eDNA metabarcoding pipeline for fish monitoring. Here, we benchmarked eDNA metabarcoding for Canadian freshwater fish monitoring from sampling effort, eDNA extraction methods, metabarcoding primers, sequencing effort, and bioinformatics pipelines against mock communities and fish surveys of rivers and lakes. Based on the benchmarking, module-based eDNA pipelines for fish monitoring were developed and can be customized for different end-users or scenarios. This work will enhance the capability of eDNA metabarcoding and boost the application of eDNA metabarcoding for Canadian freshwater fish monitoring. A framework of benchmarking/standardization eDNA metabarcoding should be considered before its wider application.
Aquatic multicellular organisms continually shed cellular and extracellular DNA into their environment, and by sampling their habitat for this environmental DNA (eDNA) it is possible to detect and monitor them. This sensitive and non-invasive tool allows for species in low numbers to be detected in the environment. However, the novelty of this tool leaves areas of uncertainty with regards to best practices and potential biases in the methodology. The objective of this study was to understand the influence of stream bed disturbances on eDNA recovery, thereby identifying and reducing areas of uncertainty in eDNA methodology in lotic systems. DNA is known to adsorb to sediment in aquatic systems, therefore when the stream bed is disturbed, and sediments are mobilized there is the potential for an artificial inflation of eDNA concentration, leading to biases and/or inaccurate conclusions. This study was completed in Washington Creek, a first order stream in the Grand River watershed in Southern Ontario, Canada, with a characterized brook trout (Salvelinus fontinalis) population. Water samples from the stream were collected before and after disturbance events in stream areas upstream (reference undisturbed) and downstream, at several time intervals, then filtered, extracted, and brook trout DNA was amplified via quantitative polymerase chain reaction. In addition, the effects of physical disturbance were assessed on a set of field positive controls that contained a known amount of brook trout biomass, exposed to disturbed and undisturbed water for 90 minutes. Disturbed water exhibited decreased eDNA recovery due to inhibitors present in turbid water preventing DNA amplification, resulting in lower eDNA yield. Immediately after a stream bed disturbance, eDNA signal was lost completely, then returned to baseline after 30 minutes. Positive control methodology was validated, and a correlation between brook trout biomass and eDNA amplification was observed. Next steps for inhibitor evaluation and removal have been identified. Once biases and knowledge gaps in eDNA practices are addressed it can become a powerful tool for monitoring aquatic organisms, including species at risk.

The collection of environmental DNA (eDNA) is an affordable and non-invasive technique for aquatic species monitoring. eDNA can be utilized as a natural tracer linking the fields of hydrology, ecology, and biology as its detection depends on the hydrologic characteristics of the system, including zones of transient storage and water quality. Certain areas of a stream, such as the streambed or pools, may result in greater accumulation of eDNA. eDNA allows one to track species diversity and distribution, however, there remain several knowledge gaps in terms of eDNA transport and storage due to the complexity of eDNA’s interactions with its surrounding environment. For instance, the hydrologic conditions during a storm, such as increased flow and turbidity, may bias eDNA amplification and its downstream interpretation. Under such conditions, eDNA may experience increased resuspension and/or sorption to suspended sediments. Existing literature shows eDNA does not behave as a conservative tracer in the environment as it exists as a complex mixture of particles with different properties. However, some components of eDNA may behave similarly to free DNA (fDNA), extracellular DNA, through a fluvial system, therefore having a potential to be treated as a surrogate to understand eDNA movement. Although fDNA has been used as a tracer in freshwater systems its environmental transport and fate is poorly understood. Washington Creek, in southern Ontario, is a headwater stream that has been the focus of several studies on brook trout (Salvelinus fontinalis) and the distribution of eDNA. This study investigates the behaviour of synthetic fDNAs injected into the creek during different hydrologic conditions (e.g., high flow, high turbidity versus baseflow) and it compares them to a conventional tracer (e.g., salt). Following the injection of fDNA and salt, water samples were collected at various time points and distances downstream of the source. The samples were filtered, and the fDNA mixture was extracted and further amplified using a quantitative polymerase chain reaction (qPCR) targeting the fDNA sequences. This study assesses transport of fDNA to better understand how it can be used as a tracer through aquatic stream systems. These tracers are nontoxic, sensitive and allow for multiple tracers to be applied simultaneously in a single system. Therefore can be used to better understand movement and degradation of components of eDNA.

Environmental DNA (eDNA) is a complex mixture of genetic DNA derived from various organisms inhabiting a specific environment. Despite its relatively low concentration and fast degradation, it is possible to isolate it from various samples (i.e., water, soil, air) and use to indirectly identify single or multiple taxa in a given sample. In this study a species-specific eDNA approach was used to identify brook trout (Salvelinus fontinalis) fish species and to monitor their population dynamics in a headwater stream in the Grand River sub-watershed (Ontario) and compare its sensitivity to traditional methods. Intense urbanization and agricultural activities in this part of Canada, that is also facing dramatic climate change, are overall threatening the cold habitats that these fish currently thrive in. This species and many others that prefer these rare habitats are of great concern for many ecologists and water managers in this area. eDNA offers a sensitive methodology that provides reliable results in a timely manner and at relatively low cost for monitoring species presence and their seasonal and spatial distribution. Beside its qualitative aspects it is important to further explore eDNA as a quantitative tool, that is, relating the amount of eDNA to fish abundance. The experimental design that was employed in this study used stream water sampling for brook trout DNA coupled with electrofishing that was conducted on monthly bases from April to December in a headwater stream of this sub-basin. The initial results suggest that the greater brook trout abundance and biomass in the summer months correspond to significantly higher detection of brook trout eDNA, supporting earlier literature findings of positive correlation between eDNA amount and species biomass/density. Considering the lack of standardized procedures in this new, still developing field, the experimental design of repetitive and consistent sampling with a set of field positive controls and sample inhibitor testing (with a foreign species) developed for this study, reduces error artifacts and increases the reliability of eDNA interpretation. This is extremely important since this technique is gaining on attractiveness and it is becoming a key component for bioassessment. Results from this and similar studies should fill in the knowledge gaps that currently exist and should allow eventual integration of the quantitative eDNA aspect within the fisheries management plans.
**MP258 Comparing electrofishing observations to environmental DNA metabarcoding detections along Bauman Creek, a tributary of Ontario’s Grand River**  
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Environmental DNA (eDNA) is the assorted genetic material shed by resident organisms into their surroundings. eDNA can be isolated from various environmental matrices including water. Metabarcoding is a high-throughput technique that can assign taxonomic identity to DNA barcodes generated from environmental samples. eDNA metabarcoding of water samples is an emerging ecological survey technique that can non-invasively provide biodiversity information on the fish and amphibians inhabiting a waterway. To date, little research has examined the potential of eDNA metabarcoding to monitor fish and amphibians in tributaries of Ontario’s Grand River. Comparisons of eDNA metabarcoding to locally implemented survey techniques such as electrofishing are critical for local end-users when assessing the utility of eDNA metabarcoding. Our research aims to compare the detection rates of fish and amphibians obtained via environmental DNA metabarcoding to the detection rates obtained through conventional 3-pass electrofishing surveys, allowing for head to head comparisons of the two methods. Here, we present the results from a pilot study conducted in Bauman Creek, a 1.8 km long tributary to the Grand River (Ontario, Canada). Water samples for eDNA metabarcoding were taken from multiple locations along Bauman Creek. eDNA sampling was immediately followed by 3-pass electrofishing surveys. Water samples were filtered prior to eDNA extraction using commercially available kits. Before application, primers were validated in silico to predict species detection and production of unique amplicons, in vitro to confirm predicted species detections, and in situ to confirm amplicon production. Prior to sequencing, eDNA was quality checked for inhibitors through use of an internal positive control and for integrity by measuring intact plant DNA in the sample. Samples were sequenced, and the data was quality checked before assigning taxonomic identities to sequence reads. Metabarcoding reads were then compared to the communities observed during electrofishing. This allowed an examination of the utility of both sampling methods in detecting the species communities present at each sampling site. Ultimately, the validation of eDNA metabarcoding will facilitate monitoring and conservation of fish and amphibians in the Grand River watershed.

**MP259 Taking environmental DNA (eDNA) to the field: Methods, applications, and lessons**  
C. Naumann, S. Kalyn, L. Dilley, Dillon Consulting Limited / Natural Resources Management; C. Kwok, Dillon Consulting Limited

Environmental DNA (eDNA) refers to DNA that is shed by a species into the environment through its life history processes. These eDNA materials can be collected and analyzed using quantitative PCR techniques to identify the targeted species. In the last decade, research on eDNA has also been collected and analyzed using quantitative PCR techniques to identify the targeted species. In the last decade, research on eDNA has grown significantly, as evident by the number of peer-reviewed publications that have accumulated. The technology of analyzing eDNA is now more accessible and available at a commercial scale. However, the use of eDNA as a means to detect species can be limited by lack of acceptance by regulators, lack of qualified practitioners to appropriately collect and process eDNA samples, and general lack of awareness on what eDNA can be used for. This presentation is a case study of two projects in BC where eDNA was used in addition to traditional sampling methods to enhance detectability of several conspicuous species. We will discuss the applicability of eDNA on projects of varying scales and how eDNA can be incorporated into the field of environmental consulting.

**MP260 STREAM: Sequencing The Rivers for Environmental Assessment and Monitoring**  
C.P. Robinson, University of Guelph / Biodiversity Institute of Ontario; D.J. Baird, Environment Canada / Canadian Rivers Institute; K. Hartwig, Living Lakes Canada; E. Hendriks, WWF-Canada; L. Maclean, Environment Canada; R. Mallinson, Living Lakes Canada; W. Monk, S. Pappas, Environment Canada; C. Paquette, WWF-Canada; K. Trainor, Environment Canada; M. Hajibabaei, University of Guelph / Biodiversity Institute of Ontario

Globally, freshwater systems are essential for human and wildlife survival. Despite their importance, many freshwater ecosystems are under threat and currently there is lack of an effective technique to monitor the status of these ecosystems. In Canada, freshwater systems are vast and often inaccessible, rendering them difficult to monitor, which results in data deficiencies. Additionally, current methods of freshwater biomonitoring involving visual identification of benthic macroinvertebrate communities are costly, time-consuming and often lack species resolution. To address these issues, STREAM (Sequencing The Rivers for Environmental Assessment and Monitoring) aims to validate and implement DNA metabarcoding as a mainstream approach, to be utilised by ECCC (Environment and Climate Change Canada), WWF-Canada and LLC (Living Lakes Canada) for generating freshwater biodiversity data through community-based monitoring (CBM). STREAM combines the standard CABIN (Canadian Aquatic Biomonitoring Network) sample collection approach with DNA metabarcoding to assess macroinvertebrate community assemblages across a wide range of Canadian watersheds. Implementing this approach, STREAM expects to 1) educate and train communities of citizen scientists to expand geographic coverage of freshwater biomonitoring; 2) provide a timely capacity improvement for data generation and reporting (2 months as opposed to current 8-12 months) and 3) improve the taxonomic resolution and ecological diagnostic power via metabarcoding data. The unique combination of academic, government organisations and NGOs (non-government organisations) in conjunction with CBM, enables the STREAM project model to be applied across the whole of Canada and beyond to facilitate the generation of a clearer picture of the health of rivers for freshwater stewardship and conservation.

**Environmental Risk Assessment**

**MP261 Spatial and probabilistic risk assessment associated with drinking groundwater in Pingtung Plain of Taiwan**  
C. Liang, Fooyin University / Department of Nursing; J. Chen, National Central University / Graduate Institute of Applied Geology

Despite that the average of percentage of tap water served by Taiwan Water Corporation in Taiwan is above 90%, only approximately half of households in the Pingtung Plain have access to the public water distribution system. Residents without access to tap water supply thus extract groundwater to meet their household water demand because this area has abundant groundwater resource. A long-term groundwater quality survey in the Pingtung Plain has reported obvious groundwater contamination with the occurrence of chemicals such as arsenic, nitrate, manganese and iron in some of the monitoring wells. Health risk assessment associated with the drinking of contaminated groundwater is required for protecting and managing human health. Measurement data of water quality items clearly indicated considerable spatial variability in concentration levels, implying that the human health risk through the drinking of the groundwater will also vary from region to region corresponding to variations in the concentration levels of the contaminants in the groundwater. This study carries out a spatial health risk assessment associated with the drinking of groundwater in the Pingtung Plain. First, the spatial concentration of the groundwater quality items on each cell are calculated using a geostatistical approach. Subsequently, the spatial patterns of the Hazard Quotient (HQ) and target risk (TR) are computed based on the spatial concentration distributions of groundwater quality items on each cell.
To illustrate significant variability of the drinking water consumption rate and body weight of each individual person, health risk assessments on each cells are probabilistically conducted by using a Monte Carlo simulation by treating daily water intake rate and body weight as probability distributions. Ultimately, a maps showing the spatial distribution of occurrence percentage of high HQs and TR is demarcated. The results can provide a basis for improving the decision-making process for managing health risk associated with drinking groundwater.

**MP262 Ions and trace elements in groundwater in the city of Porto Velho-RO/Brazil**

_C. Ceolin Baia, W.R. Bastos, T.F. Vargas, V. Azevedo, W. Aleixo, Federal University of Rondônia_

Groundwater are heavily exploited for various uses, including human consumption. The main form of extraction of the same is by wells, which can be tubular or excavated. In the Amazon region, the use of excavated wells, commonly known as the “amazonas” well, is common. These wells, depending on their structure, can be an entry channel for various biological and inorganic contaminants. Inorganic contamination is by means of cationic and anionic ions (nitrate, sulfate, ammonium, etc.) and trace elements (arsenic, aluminum, zinc, cadmium, etc.), which depending on the concentration in the water and if this water is destined for human consumption and other uses of indirect ingestion (hygiene, preparation of food, domestic activities), can cause risks to the health of the one who ingests it. Therefore, it is necessary that these waters comply with the standards of potability established by the competent bodies. In this study, samples of 50 points (36 excavated wells and 14 tubular wells) were analyzed from the urban perimeter of the city of Porto Velho - RO / Brazil. Cation and anion determinations were made by ion chromatography and trace element determinations were made by induced plasma optical emission spectrometry. The levels for sodium, ammonium, potassium, calcium, magnesium, fluoride, chloride and sulfate ions did not exceed the limits established by Brazilian legislation for water intended for human consumption. The nitrate ion, whose water limit is 10 mg L⁻¹, presented a mean for excavated and tubular wells of 21.2 and 14.1 mg L⁻¹, respectively. This is indicative of the effect of anthropic activities, in particular, the lack of basic sanitation in the city, where waste water is released into the environment without any kind of treatment. In relation to trace elements, aluminum, copper, manganese, strontium and zinc were below established standards. Only the zinc element had higher concentrations in the tubular wells (mean for excavated wells = 0.019 mg L⁻¹ and average for tubular wells 0.042 mg L⁻¹), reflecting the mobility of this element and the leaching action. In view of the presented results, nitrate levels in the groundwater of the city of Porto Velho are the most worrisome, because nitrate is harmful to human health when there is exposure to high levels of this contaminant.

**MP263 Effects-driven site specific risk assessment of a complex operating site**

_R. Peters, Federated Co-operatives, Ltd. / Sustainability; K. Bradshaw, Federated Co-operatives Limited; S. Siciliano, University of Saskatchewan / Department of Soil Science_

Our project focused on a pesticide manufacturing and packaging facility located in Western Canada. This facility has operated for more than 60 years, and handled a wide range of compounds over that time. Historic operational practices and various accidental releases over the operating lifespan have left soil and groundwater contaminated with a complex mixture of parent and daughter compounds of both pesticides and solvents, including hydrocarbons. An initial site assessment determined that compound migration to aquatic waterbodies and indoor vapour inhalation of volatile compounds are the exposure pathways of potential concern to human and ecological receptors. Completing a traditional risk assessment at the site is difficult since many of the compounds present in the environment are unknown or have no toxicological information. Additionally, the impacts are present in a complex mixture and interactions between compounds are unknown. Research began to determine the effects of impacted soil and groundwater from the site on human and ecological receptors using in vivo and in vitro assays, including human cell lines, aquatic studies, and full animal exposure. In addition to site soil and groundwater exposure, we will expose cell lines to 20 different pesticides in 5 effect categories to assist in deriving a site specific estimate of risk. Following exposure studies, we will complete a site-specific risk assessment to inform safe work practices for construction activities on-site, as well as determine end of site life liability for facility partners.

**MP264 Establishment of data selection criteria for integrated risk assessment of phthalates**

_W. Jeon, M. Seo, S. Baek, S. Lee, M. Hwang, Y. Koo, Ministry of Food and Drug Safety / National Institute of Food and Drug Safety Evaluation_

In Korea, National Institute of Food and Drug Safety Evaluation (NIFDS) has launched human integrated risk assessment of 60 hazard chemicals such as heavy metal, dioxin, formaldehyde, nonylphenol or phthalates in consumer products and food from 2018. Phthalates are plasticizer widely used in consumer products as solvents, additives, and cosmetics. Some phthalates are known as an endocrine disrupter in human. In this study, seven phthalates (DEHP, DBP, BBP, DNOP, DINP and DIDP) were selected for evaluation. In order to improve the reliability of evaluation, we developed data selection criteria. Based on an extensive literature review and criteria, we selected data for phthalate levels in food and compared exposure levels of phthalate between domestic and international data. This data selection criteria will provide information about evaluation of external exposure for integrated risk assessment.

**MP265 Occurrence and risk assessment of pharmaceuticals in the water environment in Japan**

_H. Isda, Y. Kosugi, K. Watanahe, T. Suzuki, Tokyo Metropolitan Institute of Public Health / Environmental Chemistry; T. Nishimura, Teikyo Heisei University / Faculty of Pharmaceutical Sciences_

Used pharmaceuticals that are discharged into the aquatic environment mainly via sewage treatment have become a public concern because they might have adverse impacts on aquatic organisms. Thus, the Ministry of Health, Labor and Welfare of Japan issued “Guidance on environmental risk assessment (ERA) in new pharmaceutical development” in 2016. To evaluate the validity of phase 1 of Japan’s ERA guideline, we monitored the measured environmental concentration (MEC) of already approved pharmaceuticals in rivers flowing through urban areas and urban sewage treatment plants (STPs) in Japan and compared the MEC with the predicted environmental concentration (PEC). The calculation of PEC was based on the ERA of Japan (MHLW), the United States (USEPA), and Europe (EMEA). We collected water samples from seven rivers (2015-2016) and three STPs (2016-2017) in urban areas of Japan in each season and analyzed 54 kinds of pharmaceuticals by LC/MS/MS after concentrating by solid phase extraction to determine MEC values. Among the highest MECs in the river water, the concentrations of sulfadiazine, crotamiton, acetaminophen, and olmesartan were 500-1000 ng/L, and those of valsartan, DEET, azithromycin, clarithromycin, bezafibrate, epinastine, cefmetazole, erythromycin, irbesartan, ketoprofen, losartan, and candesartan were 100-500 ng/L. In the survey at the STPs, pharmaceuticals were higher in influent than in effluent. In the comparison between MEC and the PEC obtained from each ERA method, some pharmaceuticals exceeded 1 when MEC was divided by PEC in the case of default values. The possible reasons why PEC was underestimated follow: (1) the dilution factor (DF) was not suitable to the actual river condition, (2) the result for lorazepam, which is a psychotropic agent, might have been affected by deviation according to each region of use, and (3) the results for ketoprofen and epinastine might have been affected by underestimation of the quantity of consumption (production) in Japan. These results suggest that it is necessary to set DF = 2 as the worst case when calculating the PEC of a new pharmaceutical and to know the accurate quantity of production for already approved pharmaceuticals.
MP266 Correlating Water Quality Data to Assess Potential Risks to Human Health in the White River, AR
J. Chester; J.L. Bouldin, Arkansas State University / Biological Sciences

Pollution of streams and rivers in the United States is damaging the environment and risking the health of humans in recreational areas. Fecal coliform bacteria are an indicator bacteria for dangerous diseases such as Escherichia. Coli, hepatitis, and salmonella. The most common way to contract these diseases via polluted water is by oral ingestion or through breaks in the skin. Assessing and correlating water quality for fecal coliform bacteria can pinpoint locations where humans are at risk for contracting harmful diseases. Northern Arkansas is a major hotspot for recreational fishing, which can be a risk to human health if fishing in polluted waters. Fifteen tributary sites of the White River in Arkansas were tested twice a month to assess water quality parameters such as temperature, pH, dissolved oxygen, conductivity, turbidity, total suspended solids, total nitrogen, total phosphorus, and fecal coliform bacteria. Additionally, three of those sites where fishing is common were also chosen for a study to swab fish for fecal coliform bacteria on the skin of the fish. Statistical analyses were performed to determine the correlation between water quality parameters and fecal coliform bacteria. Geographical analyses were also performed to determine if land use was correlated to the aequous fecal coliform counts in the stream.

MP267 Oregon's Tiered Approach to Toxic Air Contaminant Health Risk Assessments
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The State of Oregon recently adopted a program called Cleaner Air Oregon to regulate toxic air contaminants from industrial sources. This is a risk-based approach, requiring industry to assess risks from air emissions to nearby populations. Incorporating elements from other states, the rules include a tiered approach to risk assessment. This allows industry to tailor the risk assessment effort to match the complexity of their site. All levels of risk assessment involve calculating annual and daily air concentrations at exposure locations, and comparing air concentrations with appropriate Risk-Based Concentrations (RBCs). RBCs were developed assuming a one-in-one-million excess cancer risk for carcinogens, and a hazard quotient of 1 for noncarcinogens. This comparison allows a facility to readily calculate risk, and compare the summed excess cancer risks and hazard indices with Risk Action Levels. A simple Level 1 assessment involves choosing dispersion factors from a table based on site-specific information. This includes stack height and distances to various exposure locations for stack emissions, and building height, dimensions, and distances to exposure locations for fugitive emissions. Facilities have the option to use a conservative, default dispersion factor. To screen emissions, facilities multiply each toxic air contaminant emission rate by the dispersion factor to calculate an air concentration for comparison with an RBC. Facilities can use site-specific information and perform modeling in the next two risk assessment levels. In Level 2, they can use U.S. Environmental Protection Agency’s EERSCREEN model or AERMOD model in screening mode, and in Level 3, they can perform complex modeling using AERMOD. In both levels, calculated air concentrations are compared with RBCs. As an option, facilities can directly model risk, rather than concentrations, thereby saving considerable effort in post-modeling calculations. The most comprehensive Level 4 risk assessment uses the same air dispersion modeling conducted in Level 3. In addition, facilities can consider factors to refine the exposure assessment. These factors include modified exposure assumptions, relative bioavailability, or multipathway considerations not covered by the values used to develop RBCs. The intent of a tiered approach is to let facilities optimize resources by selecting a risk assessment level appropriate to their emissions.

MP268 Anthropogenic threats associated with floods in precarious neighborhoods of coastal areas in the Río de La Plata river (Buenos Aires, Argentina)
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The urbanized coastal areas of the Río de la Plata have large portions of their territory in low areas, so they have high risks of flooding caused by floods of the Río de la Plata (Sudestada) and abundant rainfall that produce overflowing streams. The objective of the study was to identify anthropogenic threats in post-flood scenarios in precarious neighborhood of coastal settlements of the Río de La Plata river, to assess modifiable risk factors in order to develop proposals for improving inhabitants life quality. Health, climate, natural and socioeconomic aspects were analyzed. UBN was evaluated from facilities (i.e. tap water availability, sewages and pluvial drains, etc.). Coastal urban areas vulnerable to flooding were selected in the counties of Quilmes and Punta Lara, selecting slums and precarious neighborhoods as study sites. The study methodology included: visits to the different neighborhood and the visual assess of habitatility, state of the dwellings and the green and built public spaces. Neighbors were surveyed searching information about frequency and duration of floods, the damages caused by floods, health problems and questions to assess risk perception of floods; the actions taken before, during and after events were also surveyed. Water samples were taken after flood events to measure physicochemical and microbiological parameters. Normalized data were analyzed using XLSTAT, PCA were performed exploratory. Significant differences were observed between the districts studied, where anthropic threats have been identified that increase the risks of natural hazards, these varied among the study sites, highlighting: the presence of dumps and dumping points, incineration of solid waste in the space public, proliferation of pests, presence of unlined ditches on public roads. Since these received black and gray waters without treatment and they overflow in flood events, these had become a route of exposure to pollutants for the population. Post-flood periods are characterized by an increase of exposure to contaminated water, lack of tap-water, power cuts and lack of communication ways. Bacteriological analysis of the samples revealed a high level of pathogens in stagnant waters (E. coli, salmonellas, pseudomonas, etc.), which correlated with higher incidences of health problems such as skin, respiratory, urinary and gastrointestinal affections. Regarding the perception of risk, inhabitants take preventive measures, such as listening to alerts, protecting their homes and self-evacuation, but are not aware of the link between floods and sanitary problems. We concluded that the risks of floods have multiple anthropogenic threats modifiable in the different studied sites. Therefore, health risks could be diminished by in-tubing ditches, in the short term and implementing health education to modify behaviors in order to improve the environmental quality of the neighborhoods.

MP269 Emission of PAHs from roasting of animals’ furs with used tyres; implication for schools in the vicinity of an abattoir in Nigeria
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Roasting of slaughtered cows, goats and sheep/rams in many abattoirs in Nigeria has become an everyday practice and this has been viewed to have an economic advantage in terms of cost and “recycling.” However, it has become obvious that this practice releases particulate matter, volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) especially polycyclic aromatic hydrocarbons (PAHs) into the environment. Research has shown that these PAHs could trigger some health
problems ranging from respiratory irritation, cough, dermatitis, depressed immune system and a decrease in lung function. This study was aimed at evaluating the risk of exposure of primary school children whose schools are located in close proximity to these abattoirs. The study sought to determine the concentrations of some selected EPA priority PAHs, particulate matter in ambient air and around the school environment, concentrations of some PAH metabolites and some heavy metals in post-shift urine of selected primary school children and control subjects. Lung function, cytogenetic evaluation of DNA damage in buccal exfoliates and urinary phenol of subjects were undertaken. Some of the results show that the concentrations of 1-Hydroxypyrene (l-OPyr) (µg/molCret), a PAH metabolite, in the post-shift urine samples of the 85% of the children were 0.52±0.13 µg/molCret vs 0.20±0.07 µg/molCret while urinary phenol concentrations were 14.26 ± 1.19 mg/L vs. 4.44 ± 1.12 mg/L respectively in exposed children when compared with the control (children in primary schools far away from the abattoir). The buccal epithelial exfoliates showed that karyorrhexis and condensed chromatin bodies were significantly higher in the exposed children than in the control. The implications of these results for the exposed children are discussed in the light of the statement that “health is wealth.”

**MP270 Community risk assessment of ethylene oxide emissions near a sterilization facility in the Denver, Colorado, USA metropolitan area**

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In August 2018, the USEPA released an updated version of the National Air Toxics Assessment (NATA) that indicated a potential increased risk of cancer in the area surrounding a sterilization facility near Denver, Colorado, USA. The previous NATA indicated a much lower cancer risk. The dramatic change in the potential cancer risk in the area is a result of EPA's 2016 revision of their ethylene oxide Integrated Risk Information System's toxicity assessment which indicated an estimated 30-fold increase in cancer potency. Because the NATA relies on modeling of emission data, we conducted a conducted a community level exposure investigation of ethylene oxide concentrations to better understand the risk from levels of ethylene oxide measured in the area surrounding the facility. The results indicated cancer risks at all sampling locations were elevated compared to the EPA's acceptable maximum risk of 1 excess cancer in 10,000 people, even after additional emission controls were installed at the facility. However, cancer occurrence was not elevated in the communities surrounding the facility. This risk assessment indicates that ethylene oxide may pose a hazard to human health in the area surrounding the sterilization facility and the need for additional research into toxicity of ethylene oxide in non-occupational, lower dose exposure scenarios.

**MP271 Effects of exposure to diesel exhaust particles and urban particles on blood brain barrier permeability**

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Air pollution has adverse effects on the central nervous system (CNS) and causes cerebrovascular disorders, including stroke, and neurodegenerative diseases. Tight junctions (TJs) in the epithelium play a critical role in the formation of a paracellular epithelial barrier against the extracellular environment. While the mechanisms underlying the CNS-related outcomes have not been fully elucidated, exposure to traffic-generated air pollutants has been associated with altered blood brain barrier (BBB) integrity and permeability. Nevertheless, evidence for that is still insufficient. In this study, we evaluated the alterations of BBB integrity caused by exposure to diesel exhaust particles (DEP) and urban particles (UP) using a murine bEnd.3 endothelial cell line, which was used as a BBB model. TJ formation and integrity were evaluated by measuring transepithelial electric resistance (TEER) and the expression of TJ proteins was assessed by confocal microscopy and western blot. DEP exposure decreased the expression of the TJ proteins Claudin-5 and ZO-1 by 55.33% and 58.58%, respectively, compared to the control; UP also decreased the expression of Claudin-5 and ZO-1 by 47.24% and 54.44%, respectively. In the TEER assay, DEP and UP exposure decreased the integrity of endothelial cells by 56.16% and 54.70% compared to the controls, respectively. The results of the present study, which are consistent with the results of our previous study performed using primary bovine brain microvessel endothelial cells, suggest that DEP and UP might alter the integrity and permeability of BBB and induce adverse effects in the CNS.

**MP272 Oxidative stress by diesel exhaust particulate exposure in primary glial cells from neonate rat brain**

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Diesel exhaust particulate matter (DEP), a major component of air pollution, is a complex mixture of numerous toxicants. In the recent past, air pollution has been associated with diseases of the central nervous system (CNS), including stroke, Alzheimer’s disease, Parkinson’s disease, and neurodevelopmental disorders. However, a few in vitro studies have examined the effects of DEP on the CNS. The aim of the present study was to evaluate toxic effects, especially oxidative stress by DEP exposure, utilizing different primary cell types. Oligodendrocyte precursor cells (OPC), mature oligodendrocyte (mOL), and astrocytes (AST) were isolated from neonate rat brain. The cells were exposed to several concentrations of DEP (2, 20, and 200 µg/mL) for 24 h, and cytotoxicity was evaluated using Hoechst assay and MTT assay. The generation of reactive oxygen species (ROS) was evaluated using the dichlorofluorescein diacetate method, and the total antioxidant capacity (TAC) was evaluated using bathocuproinedisulfonic acid disodium salt. The results showed that DEP exposure decreased cell viability and induced oxidative stress by increasing ROS generation and decreasing TAC in a dose-dependent manner in all three primary glial cell types. The number of dead cells after DEP exposure (Hoechst assay) was 1.9-2.8 times for OPC, 1.7-2.2 times for mOL, and 1.3-1.6 times for AST, compared to the control. The cell viability after DEP exposure (MTT assay) was 91.0-81.2% for OPC, 95.7-84.9% for mOL, and 97.6-92.0% for AST, compared to the control. The fluorescence by DEP exposure in DCDF-H-DA assay was 112.1-124.8% for OPC, 105.2-113.3% for mOL, and 103.1-106.3% for AST, compared to the control. Finally, TAC decreased after DEP exposure to 88.2-78.2% for OPC, 91.1-82.8% for mOL, and 96.2-87.9% for AST, compared to the control. These results showed that the cytotoxicity and oxidative stress caused by DEP exposure were more prominent in oligodendrocytes than in AST, which suggests that DEP exposure may cause demyelination, especially during development, and may interfere with regeneration of neuronal cells in adults.

**MP273 Status, Source Identification and Human Health Risk Assessment of Heavy Metals in Water Sources around Bitumen Field in Ondo State, Nigeria**

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The heavy metals concentrations, distribution and the chronic health hazard associated with the consumption of water sources in three communities that experienced bitumen seepages were assessed. The concentrations of Cr, Cu, Fe, Mn, Pb, Ni, V and Zn in sediment, surface and groundwater were determined in a total of 180 samples acquired bi-monthly from June 2012 to December 2013 by Atomic Absorption Spectrophotometer to evaluate the impact of bitumen spills. Principal component analysis (PCA) and cluster analysis (CA) were also used to study the interactions between metals and identify the possible sources of contamination. The concentrations of heavy metal in groundwater, surface water and sediment samples were in decreasing order of Fe > Mn > Zn > Cu > Pb > Ni > V > Cr, Mn > Fe > Zn > Cu > Pb > Ni > V >
Cr and Mn > Fe > Zn > Pb > Ni > V > Cu > Cr respectively. The average concentrations of Fe, Pb and Mn in groundwater were found to be above the World Health Organization (WHO) drinking-water quality standard of 0.1, 0.003 and 0.4 mg L⁻¹ respectively. In addition, the V/Ni ratios in groundwater samples ranged from 0.98 to 1.21 indicating the migration of these trace metals form bitumen into the water sources in this community. Furthermore, the PCA and CA showed significant intrusions of two diagnostic heavy metals (Ni and V) for petroleum contamination in groundwater samples. Conclusively, this intrusion, as well as the multivariate analyses showed positive significant correlation to petroleum contamination and could lead to heavy metal bioaccumulation in residents with a potential threat to public health.

MP274 Applying Environmental Risk Assessment for Managing Coal Combustion Residuals

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Environmental risk assessment has application in management of coal combustion residuals (CCR), commonly known as coal ash. CCR is created when coal is burned by power plants, and is a major industrial waste generated globally. In the United States, regulations for safe disposal of CCR are based on a culmination of extensive study on the effects of coal ash on the environment and public health. The country’s “CCR rule” establishes technical requirements for CCR landfills and surface impoundments under the Resource Conservation Recovery Act (RCRA), the nation’s primary law for regulating solid wastes. Coal ash can contain inorganic constituents that, if present in sufficient concentrations and certain forms, can pose risks to human health and wildlife if exposure occurs. Screening and “baseline” (quantitative) human health and ecological risk assessments were conducted for multiple coal ash impoundments as part of comprehensive site evaluations for developing corrective action plans. Risk assessments followed federal, regional, and state protocols. Without the risk assessments, proposed remedies may have been based primarily on comparison of coal ash constituent concentrations to state groundwater and soil standards. Comparisons to regulatory standards alone often omit context and consideration of natural conditions, as well as introduce greater uncertainty associated with potential environmental risks. By implementing standard risk assessment procedures, in combination with groundwater modeling and consideration of site-specific conditions (e.g., geology, hydrogeology), utility owners and regulatory agencies can select the best remediation strategies to manage risks associated with CCR to acceptable levels.

MP275 Determining Effluent Exposure and Cumulative Risk to Macroinvertebrates at The Mclean Lake Mine in Northern Saskatchewan using Autonomous Sensors

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Treated effluent from the McLean Lake uranium milling operation in northern Saskatchewan is released into the east basin of McLean Lake. This could potentially represent a toxicological risk to aquatic organisms. The goal of this study is to determine the cumulative risk from effluent exposure to benthic macroinvertebrates and identifying risk variations in different parts of McLean Lake. Ten monitoring locations were established in and near McLean Lake using real-time water quality monitoring sensors (Libelium® Smart Water). Each sensor was deployed to measure routine water quality (pH, conductivity, EC), turbidity, dissolved oxygen, and temperature) and send data every 4 hours for 4 weeks (Aug-Sept 2018). Water, sediment, and macroinvertebrate samples were collected at the same 10 monitoring locations. Major ions, dissolved metals, and routine water quality were measured in water, and total metals in sediments. The toxicological risk was estimated by calculating Hazard Quotients (HQs) based on water and sediment quality benchmarks for the long-term protection of freshwater aquatic life. Real-time conductivity data and other results (metals) were used to describe changes in contaminant exposure and help estimate the variability in toxicological risk. Preliminary results indicate that there were significant spatial and temporal variations in effluent exposure in Vulture Lake, and McClean Lake east basin. The individual HQs for zinc, arsenic, selenium, sulfate, and fluoride were higher than water quality benchmarks at some locations. Additionally, individual HQs for vanadium, nickel, arsenic, selenium, molybdenum, and cadmium were higher than sediment quality benchmarks at all monitoring locations. The cumulative risk for surface water was >1 in Vulture Lake and McClean Lake east basin. For sediments, cumulative HQs were >1 at all sampling locations and individual HQs >1 at several sites. This suggests that these metals and anions may represent a possible risk of adverse effect to macroinvertebrates. However, the taxon richness and abundance of macroinvertebrates were relatively low at all the stations and generally, community composition indices showed no correlation with field measurements of EC, which was used as a surrogate for effluent exposure. Thus, results to date suggest that there are no measurable adverse effects on macroinvertebrate communities at these locations.

MP276 Characterization of Wastewater from Ship’s Hull Cleaning by Hydrolasting – Chemical Compositions and Toxicity Potentials of Antifouling Biocides

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During periodic haul-out maintenance of ship, high-pressure water is sprayed to clear off foulants and antifouling paint on the ship’s hull. The sprayed water can be contaminated with particles and active substances released from the paints, and then introduced directly into the adjacent marine environment, if no further treatment of the waste was implemented. The particles and active substances can be sources of hazards to marine organisms in the environment. Wastewaters were collected for analyses of booster biocides and metals during ships’ hull cleanings. Total suspended solid and particle size distribution in the wastewater were also characterized. Copper and zinc were the most abundant metals in the wastewater, as were in the original composition of antifouling paint, exceeding local regulatory discharge standards and NOEC or LC50 values of almost all test species reported in the ECOTOX database. Zinc pyritohione and copper pyritohione were the most abundant booster biocides, exceeding the LC50s of 35 – 60% of test species, based on the database. Diuron was also detected in the wastewater collected from a ship painted for coastal navigation. Suspended solid contents were also far exceeded some local regulatory criteria. Particle size distributions differ among hull cleaning cases. Most particles distributed in the size range of less than 50 μm. General relationship between particle size and cumulative distributions was deduced, which may provide a possible treatment design (filtering size) for removal of particles in the wastewater before discharging into the environment. The physical and chemical characterization of wastewater from ship’s hull cleaning will give insights to the possible risk to the marine environment brought by hull cleaning activities and thus provide guidance for environment management of hull cleanings in terms of chemical hazard and biosecurity concerns.

MP277 Increased demand for chemical elements of emerging technologies. Is it a concern for environmental health?

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In recent years there has been an increase in the manufacture of several emerging technologies (computers, cell phones, robotics and all the gadgets we know). Similarly, there is an increase in the production of products used in renewable energy (photovoltaic and electricity). To be able to produce these are necessary some elements that are critical for their manufacture as it is very difficult to replace in addition to its scarcity in
the environment. These are the so-called technology critical elements and energy critical elements. It has been observed that some of these elements (EERs) have the capacity to bioaccumulate and produce biological effects. On the other hand, we recently observed that Tantalum shows biomagnification in aquatic ecosystems. It has been reported that REE levels have increased due to anthropic activities in China (China has started REE monitoring program). Globally, it has been reported that these elements have not increased, which may be due to the recent use of these elements. If there is no adequate life cycle of these elements and good recycling and e-waste disposal this could become a global problem. There is a lack of studies for these elements (baseline, biogeochemical process, effects on the environment as on human health), mainly on tantualum, gallium, germanium, indium, niobium, tellurium, thallium. Acknowledgements: FONDECYT regular 1161504, FONDECYT Initiation 1118091 and INACH RG01-18.

**MP278 Adult dragonflies as indicators of environmental metallic elements**

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Odonata are divided into two sub-orders, damselflies (Zygoptera) and dragonflies (Anisoptera). Dragonflies are both prey and predator in both life stages, favouring the bioaccumulation of toxic substances. Adult dragonflies are aerial predatory invertebrates that occur globally except in the polar regions such as Antarctica. Although a number of organisms have been used as indicators of environmental pollution, we know of no research on adult dragonflies as potential indicators of metallic elements in the environment. Furthermore, there is no information available about adult dragonflies and their responses to toxic metallic elements, nor the relative contribution patterns between sites, species, size classes, habitat types, and relation to possible pollution sources. However, research does show that metallic elements are toxic in elevated concentrations to all organisms. Given the unique life cycle of dragonflies, and their abundance in the environment we predict that adult dragonflies would be suitable indicators of elevated elemental concentrations. We analysed 105 adult male dragonflies from 21 sites across South Africa for 33 metallic elements including arsenic, lead, selenium, nickel, copper, cadmium, and chromium. The results indicated that all species of dragonflies, regardless of body size, are suitable indicators. Furthermore, different aquatic habitat types did not affect the metallic element concentrations at the scale of this study. Dragonflies collected near wastewater treatment plants showed concentrations of certain elements such as gold to be higher than from elsewhere. Elements such as arsenic and lead were found at elevated concentrations (relative to the other sites) in dragonflies collected near mining activities. Dragonflies from sampling sites near potential pollution sources, but had seemingly isolated water sources with no influx of external water sources, showed lower metallic element concentrations when compared with sites that have an influence of different water bodies. We conclude that adult dragonflies would be good indicators of environmental metallic elements regardless of size, species, habitat types, or distance to possible pollution sources.

**MP279 Using the USEPA's Species Sensitivity Distribution Toolbox for Environmental Risk Assessment**

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The U.S. Environmental Protection Agency (EPA) is piloting a new application of the Species Sensitivity Distribution (SSD) Toolbox, a resource created by its Office of Research and Development (ORD). While exploring options for how to integrate environmental toxicity data during systematic review, EPA's Office of Pollution Prevention and Toxics (OPPT) used the SSD Toolbox to assess the toxicity of trichloroethylene (TCE) in aquatic species. Acute toxicity data for algae, aquatic invertebrates, fish, and amphibians were curated to prioritize study quality and to assure comparability between toxicity values (e.g. comparing EC50s to EC50s). With this dataset, the Toolbox was used to apply a variety of algorithms to fit and visualize SSDs using different distributions. The tool’s output contained several devices for choosing an appropriate distribution and fitting method. However, for small datasets the ability for these measures to distinguish between distributions is limited, so during the analysis of TCE's data, visual inspection of the distributions was also useful. For each distribution the SSD Toolbox calculated a hazardous concentration for a percentage of species (HCp), which can be used in a risk evaluation like a concentration of concern or COC (a hazard value divided by uncertainty factors). For this case study, two SSDs were created, one using only algae hazard data and the other using hazard data for all aquatic species. HC05s were calculated for both SSDs and compared to other methods of integrating data. OPPT found the results of the SSD Toolbox would provide depth and context to the TCE risk assessment, especially for the hazard characterization of algae. This taxonomic group had a wide range of toxicity values, not easily characterized by one toxicity value from a single species. The HC05 for algae used toxicity values from nine species to estimate a concentration that would protect 95% of algae species. Also, the two SSDs provided visual representations of species’ sensitivities, allowing OPPT to quickly analyze whether certain groups of species are more sensitive than others. The tool is currently available on EPA's website. ORD is peer reviewing the tool and plans to make an updated version available in 2019. The views expressed in this manuscript are solely those of the authors and do not represent the policies of the USEPA. Mention of trade names or commercial products should not be interpreted as an endorsement by the EPA.

**MP280 Acute toxicity study of two chemicals to three terrestrial plants and species sensitivity distributions approach for environment risk assessment**

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It is estimated that approximately 12,000 kinds of chemical are distributed commercially in the world and about 40,000 kinds of chemical are distributed in Korea. The chemical regulation system such as EU-REACH has been established in various country and Korean government implemented the K-REACH (Hwa-Pyeong Law in Korean) in 2015 to control new or existing chemical. However, there is no regulation to prevent the use of products containing hazard substances (ex. carcinogenicity, mutagenicity, reproductive toxicity, high persistence/concentration) in advance. Although a risk assessment based on the K-REACH should be carried out in order to establish a control system, there are only few available (experimental) toxicity data for risk assessment. In particular, various studies on aquatic organisms have been conducted but toxicity studies on terrestrial organisms have been lacking and toxicity data are not sufficient. Korea has specified 21 substances that cause soil contamination including cadmium, copper, arsenic, mercury, cyanide and so on as controlled soil contaminants in the ‘Soil Environment Conservation Act’ and the management of these chemicals need to be strengthened. Two major chemicals (cadmium and cyanide) causing soil contamination were selected and toxicity effects to three terrestrial plants (Oats, Carrot and Chinese cabbage) were evaluated for the purpose of environmental risk assessment in Korea. Recently, the use of the SSD (Species Sensitivity Distribution) approach is recommended in risk assessment of chemicals. Therefore, in this study, SSDs were constructed based on acute toxicity data of those three species and the ECOTOX database for other species of different taxonomic groups. Hazardous concentrations (ex, HC5) for PNEC (predicted no effect concentration) of soil was estimated from SSD and predicted environmental concentration (PEC) of soil was calculated by Simplebox program using emissions amount (of pollutant release and transfer register system) and soil pollutants data provided by Ministry of Environment. A comparison of the PEC and the PNEC (the PEC_PNEC ratio) was applied for chemical exposure assessment in Korea.
MP281 In vivo and in silico analyses of estrogenic potential of equine estrogens in zebrafish (Danio rerio)
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Equine estrogens (EEs) have been isolated from the urine of pregnant mares, and widely used as a material of hormone replacement therapy pharmaceutical in post-menopausal women. Several previous studies have shown the occurrence of EEs in the aquatic environment. However, limited data are available on the potential estrogenicity and risk of EEs in aquatic organisms, including fish. The objective of this study was to evaluate the estrogenic potentials of major EEs, such as equilin (Eq), 17α-dihydroequilin (17α-Eq), 17β-dihydroequilin (17β-Eq), equilenin (Eqn), 17α-dihydroequilenin (17α-Eqn) and 17β-dihydroequilenin (17β-Eqn), on zebrafish (Danio rerio) using in vivo and in silico assays. Our quantitative real-time RT-PCR analyses revealed that the expression level of cytochrome P450 (CYP) 19A1b gene in developing zebrafish responded to various types and concentrations of EEs in a dose–response manner. The order of in vivo estrogenic potencies of EEs was as follows: 17β-Eq > 17α-Eq > Eq > Eqn > 17β-Eqn > 17α-Eqn, and the 50% effective concentration (EC50) of 17β-Eq and 17α-Eq were lower than that of 17β-estradiol. To further investigate the interaction potential of EEs with zebrafish estrogen receptor (ER) subtypes in silico, a three-dimensional model of the ligand-binding domain (LBD) of each ER was built and docking simulations were performed. Results revealed that six EEs interact with the LBDS of ERα, ERβ1 and ERβ2. Overall, the order of in silico interaction potentials of EEs with each ER LBD was as follows: 17β-Eq > 17α-Eq > Eq > 17β-Eqn > 17α-Eqn > Eqn. Furthermore, we identified the key amino acids interacting with EEs in each ER LBD, suggesting that amino acids identified may be attributable to the ligand-specific interaction with each ER. This is the first report showing the comprehensive analyses of in vivo and in silico estrogenic potential of EEs in zebrafish.

MP282 Computer-Aided Discovery and Redesign for aquatic toxicity (CADRE-AT): Predicting aquatic toxicity of pesticides and informing design of safer analogs
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The ubiquitous use of pesticides is expected to increase in coming years with the need to increase agricultural productivity. The large quantity of pesticides applied to crops underscores the need to develop robust methods to predict environmental hazard and apply rational design principles to minimize hazard prior to commercialization. Predictive methods to evaluate aquatic toxicity of pesticides are yet to displace animal testing. Here we describe the development of an in silico tool for predicting acute aquatic toxicity, CADRE-AT (Computer-Aided Discovery and Redesign for aquatic toxicity), which affords continuous predictions of toxicity based on quantum-mechanical electronic reactivity parameters, bioavailability estimates and identification of possible metabolites. We validate CADRE-AT for predicting ecotoxicity of a prominent group of pesticides and their metabolites. Acute mean lethal concentration values were predicted for each pesticide, and the results were compared with experimental values. We also compared the performance of CADRE-AT to that of another model developed in our groups, “rule of three,” which applies bioavailability and electronic reactivity parameters to define a “safe” chemical space for aquatic species. Both models were developed for commercial chemicals and had not been assessed for performance on pesticides. The rule of three correctly classified all pesticides with experimental data in their experimentally-determined category. The CADRE-AT approach misclassified three chemicals by one category of concern. These chemicals were further examined for their toxicity mechanisms and metabolic transformations to improve the model performance. Overall, the results demonstrate that the two in silico approaches are sufficiently robust and of relevance to both industry and regulatory decision makers in assessing environmental hazard associated with pesticides. These computational methods provide a fast and economically efficient method for screening pesticides before distribution so that their efficacy can be optimized, while minimizing unintended harm to environmental health.

MP283 Assessing the Potential Risk of Pesticides to Small Streams Using High Frequency Sampling in Southwestern Ontario Streams
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The Provincial (Stream) Water Quality Monitoring Network (PWQMN) program had been quantifying and tracking changes of water quality in rivers and streams across Ontario since 1964. However, the main limitation of this network is that it does not monitor current-use pesticides. The OMCEP and OMAFRA do coordinate a pesticide monitoring program for current-use pesticides, but only 4-10 samples are taken per year from only 18 locations across Ontario. Therefore, due to the lack of field data on the quantity of pesticides in streams during flow events, the temporal dynamics of the concentration of pesticides in Southwestern Ontario remain poorly characterized. To increase our understanding on how pesticide exposure changes during flow events and to investigate an alternative approach for monitoring pesticides, three autosamplers were deployed at six different sites in the Kettle Creek Watershed over a two-year period. The autosamplers were programmed to collect water samples every hour over the growing season from July to October in 2018 and June to September in 2019. The cost-effectiveness of this approach was increased by selecting the samples for analysis based on rainfall and flow data at the sampling sites. Water samples were analyzed for the presence of over 500 pesticides using GC-MS/MS and LC-MS/MS. The analysis showed that pesticides were detected at higher concentrations after significant rain and flow events. This type of data helps us to understand the baseline and peak concentrations of pesticides that aquatic systems can experience along with the frequency and duration of these peaks. The land use in the upstream catchment of each sampling site was quantified along with land use detected to individual crop types. This allowed for an examination of any relationships between upstream land use and crop type and the frequency, magnitude, and variety of pesticides detected in surface water.

MP284 Water quality monitoring and assessment of volatile organic compounds in petrochemical wastewater
J. Kim, S. Kim, Gwangju Institute of Science & Technology / School of Earth Science and Environmental Engineering

Excessive use of chemicals has emerged as results of a growing number of chemical accidents and increasing the amount of environmental damage. Generally, chemical accidents occur most often at industrial estates where a huge quantity of hazardous materials are stored, transported, and used, and therefore, concerns about the management of industrial chemicals have led to regulations in many countries. In this study, water samples from a reservoir near the petrochemical complex where a massive fish kill occurred in 2018 due to benzene spill were analyzed for volatile organic compounds (VOCs). Additionally, aquatic ecological risk assessment was conducted for detected VOCs based on the analyzed results. Samples were collected by grab sampling by following EPA method 5035A and the instrumental analysis was performed using Headspace-gas chromatography-mass spectrometry (HS-GC-MS) for 29 VOCs listed on EPA 500 series methods which cited under the Safe Drinking Water Act (SDWA) and chloroform. As a result of instrumental analysis, the method detection limits (MDLs) were found to range from 0.13 to 0.84 µg/L, the recoveries ranged between 59 % to 105 % except for 1,1-dichloroethylene (18.35 %), dichloromethane (34.86 %), and trans-1,2-dichloroethylene (46.53 %) with coefficient of variation (CV) less than 25 % except for 1,1-dichloroethylene (39.51 %) and cis-1,2-Dichloroethylene (40.40 %). From the
water samples, the concentration of detected VOCs ranged from 0.19 (trans-1,2-dichloroethylene) to 23.85 (chloroform) μg/L and particularly the concentration of benzene was 1.65 μg/L. As a result for ecological risk assessment, the ratios of a predicted environment concentration (PEC) and a predicted no effect concentration (PNEC) of the detected VOCs were lower than 1 which suggest that these substances were considered to present a risk to the aquatic ecosystem. Further studies should be performed with additional sample collection for four different seasons, different method for sample collection and instrumental analysis, and more standard solutions for monitoring and assessing the water quality.

MP285 ToxMate, a new tool for self-monitoring of the toxicity of water discharges by video-tracking the locomotor behaviour of aquatic invertebrates

D. Neuzeret, A. Decamps, ViewPoint; O. Geffard, Irstea / UR RIVERLY Laboratoire Ecotoxicologie; F. Maulin, M. Dauphin, ViewPoint; H. QUEAU, L. Garnero, Irstea Lyon / UR MALY Laboratoire Ecotoxicologie; A. Chaumot, Irstea / UR MALY Laboratoire Ecotoxicologie

Context : Water resources, biodiversity and health are major societal concerns. One of the prerogatives to preserve them is to limit the release of contaminants into the environment. It is in this context that self-monitoring of the toxicity of discharges is gradually emerging in legislation. To meet this need, standardized biotests are available, the most commonly used of which is based on the impact of spot samples on daphnia mobility (Daphnia magna) (ISO 6341 : 2012). This type of approach does not allow us to understand the toxicity of a release whose quality varies over time, so the results obtained are dependent on the sampling. In order to propose an innovative solution, a partnership between ViewPoint and the ecotoxicology research laboratory at Irstea Lyon was initiated in 2014. Methodology used : Toxicity assessment is based on the monitoring of locomotor behaviour, a sensitive, generic biomarker with an extremely short response time. The invertebrates used (Gammaridae, Lymnaeidae and Erpobdellidae) are species present in aquatic biocenoses in Europe and belong to different phylogenetic groups in order to obtain a wider range of sensitivity to contaminants. Main results: development and feedback : A laboratory phase made it possible to develop a behavioural analysis protocol and an indicator sensitive to the presence of contaminants while excluding so-called confounding factors (temperature, oxygen, noise, etc.). This new tool has been validated by putting it in a natural situation on two industrial sites. They made it possible to evaluate online, and with an autonomy of 30 days, the toxicity of a water at the end of the treatment plant and thus to detect several episodes of toxicity. Once the prototype has been developed, the ToxMate allows 48 organisms to be monitored in real-time, with secure online transmission and without the need for an on-site test condition. On-site online assessments were carried out on two wastewater treatment plants (La Feyssine-Lyon and Les Bouillides-Sophia-antipolis) as well as on a rainwater retention and infiltration basin. These follow-ups now allow self-monitoring and can inform the water manager in real time during a toxicity episode.

MP286 Design of a multidimensional density dependent matrix population model for assessing ecological risk to fish populations

D.H. Miller, USEPA / Mid-Continent Ecology Division; B.W. Clark, D.E. Nacci, US Environmental Protection Agency / Atlantic Ecology Division

Modeling exposure and recovery of fish and wildlife populations after stressor mitigation serves as a basis for evaluating population status and remediation success. Herein, we develop a novel multidimensional density dependent matrix population model that analyzes both size-structure and age class-structure of the population simultaneously over time. This population modeling approach emphasizes application in conjunction with field monitoring efforts (e.g., through effects-based monitoring programs) and/or laboratory analysis to link effects due to chemical and/or nonchemical stressors to adverse outcomes in whole organisms and populations. For demonstration purposes, we applied the model to investigate population trajectories for Atlantic killifish (Fundulus heteroclitus) exposed to 112, 296, and 875 pg/g of 2,3,7,8-tetrachlorodibenzo-p-dioxin with effects on fertility and survival rates. The Atlantic killifish is an important and well-studied model organism for understanding the effects of pollutants and other stressors in estuarine and marine ecosystems. For each exposure concentration, the corresponding plots of total population size, population size structure, and age structure over time were generated. For example, exposure to 875 pg/g of 2,3,7,8-tetrachlorodibenzo-p-dioxin resulted in a 13.1% decline in population size after 2 years, a 22.1% decline in population size after 5 years, and a 27.9% decline in population size over 10 years with plots of all size classes and age classes exhibiting declines. The present study serves as an example of how multidimensional matrix population models are useful tools for ecological risk assessment because they integrate effects across the life cycle, provide a linkage between endpoints observed in the individual and ecological risk to the population as a whole, and project outcomes for multiple generations.

MP287 Environmental Risk Assessments for Topical Antiseptic Ingredients: Benzalkonium Chloride


Benzalkonium chloride (BAC) is a cationic surfactant used in a variety of cleaning and personal care products, as well as agricultural and industrial applications. As the use of triclosan and triclocarban compounds in topical antiseptic products such as hand washes and rubs has been phased out, BAC has been used as a replacement that provides antiseptic benefits. The American Cleaning Institute (ACI) undertook an evaluation of the environmental safety of BAC used in the U.S. cleaning product industry, based on best available environmental fate and effects data for BAC from scientific literature and privately held sources. The risk assessment included conservative scenarios for current and future uses of the ingredients, using published data and modeling to estimate environmental exposures. Specifically, surface water and sediment monitoring data were used to characterize recent exposure levels, while the iSTREEM(R) model was used to estimate aquatic exposure distributions for the future scenario. Terrestrial exposures due to land application of biosolids were assessed based on BAC concentrations in wastewater treatment plant biosolids, as estimated using the SimpleTreat model in conjunction with concentration-dependent surfactant sorption. Aquatic toxicity data for BAC were extensive, with acute and chronic data available for freshwater and marine invertebrates, algae, and fish. Soil toxicity data were available for plants, invertebrates, and microbial processes related to soil fertility, and limited sediment toxicity data were also included. Taken together, the available data indicate no unacceptable risks associated with any central-tendency exposure estimates or with high-end exposure estimates in soil. Risks of chronic effects on invertebrates from BAC in effluent-dominated aquatic systems are difficult to interpret, because multiple reproduction studies with the most sensitive species (Daphnia magna) yielded vastly differing results. A priority for future research should be to clarify how factors such as dissolved organic carbon affect chronic BAC toxicity to invertebrates.

MP288 Environmental Risk Assessments for Topical Antiseptic Ingredients: Benzethonium Chloride


Benzethonium chloride (BZC) is a cationic surfactant used in topical antiseptic products to reduce infectious bacteria on hands in consumer, institutional, health care, and food handler settings. It is one of several compounds that may be used to replace triclosan and triclocarban, as their use in topical antiseptic products such as hand washes and rubs is phased out. The American Cleaning Institute (ACI) undertook an assessment of the environmental safety of BZC use in the U.S. cleaning
The field of manufactured nanomaterials (MNMs) is undergoing rapid development. Due to the diverse variants possible when synthesizing MNMs, multiple identities are possible for a given substance. The Canadian definition used under the Chemicals Management Plan (CMP) identifies nanomaterials as chemical substances manufactured at the nanoscale (1-100 nm) in at least one dimension internally or externally, or materials that exhibit at least one nanoscale property/phenomenon. Canada regulates these MNMs domestically under the Canadian Environmental Protection Act. The ecological risk assessment of MNMs will follow a similar regulatory process as other chemicals regulated under the CMP. The Canadian risk assessment approach will address the specific physical considerations required for MNMs, including fully characterizing their identity (size, shape, chemical composition), physicochemical properties (water solubility, dispersion stability, etc.), and toxicological effects. To bridge data gaps and standardize laboratory practices, the use of existing methodologies and tools, including the OECD test Guidelines and Guidance Documents for both MNMs and chemicals (with adaptations for MNMs), is encouraged. Traditional risk assessment principles applied for chemical substances assessment which should apply to MNMs include the use of weight-of-evidence in risk assessments, precautionary principle, use of analogue data and modelling tools to bridge data gaps, and use of a tiered approach tying together risk characterization and uncertainty. Specific challenges for the risk assessment of MNMs include defining shape and size variability effects, determining the impact of physicochemical properties for environmental fate, properly estimating the bioavailability potential, developing options to estimate data gaps (i.e. through environmental exposure models), and defining the impact of nano-specific properties. Developing strategies to work with knowledge gaps during the risk assessment process (such as read across and grouping strategies), are important to reduce uncertainties for supportable risk conclusions. Canada is involved in several international projects, and closely following other international projects, which aim to address these regulatory challenges and strategies for the risk assessment of MNMs.

MP289 Environmental Risk Assessments for Topical Antiseptic Ingredients: Chloroxylenol

Chloroxylenol (also known as parachlorometaxylenol or PCMX) has long been used in topical antiseptic and disinfectant products in health care and home settings. As the use of triclosan and triclocarban compounds in topical antiseptic products such as hand washes and rubs has been phased out, PCMX is being used as a replacement that provides antiseptic benefits. The American Cleaning Institute (ACI) undertook an environmental safety assessment for PCMX use in the U.S. cleaning product industry, integrating best available environmental fate and effects data for PCMX from published and privately held sources.

Chloroxylenol concentrations in U.S. surface waters have been extensively monitored, and data are also available to characterize concentrations in wastewater treatment plant (WWTP) effluent and percent removal during wastewater treatment. These data were supplemented with modeling (equilibrium partitioning and SimpleTreat) to estimate PCMX concentrations in sediment and in soil receiving land-applied biosolids. Predicted sediment and soil concentrations were low, because PCMX is only moderately hydrophobic. A conservative future scenario was also assessed using the iSTREEM® model, based on triclosan replacement with PCMX. Available toxicity data characterized acute effects of PCMX on freshwater fish, invertebrates, and algae, and a conservative margin of safety was targeted to compensate for the lack of chronic toxicity data.

MP290 A Canadian approach towards a risk assessment framework for manufactured nanomaterials
J. O’Brien, M. Sauve, Environment and Climate Change Canada; J. Gauthier, Environment and Climate Change Canada / Ecological Assessment Division

The field of manufactured nanomaterials (MNMs) is undergoing rapid development. Due to the diverse variants possible when synthesizing MNMs, multiple identities are possible for a given substance. The Canadian definition used under the Chemicals Management Plan (CMP) identifies nanomaterials as chemical substances manufactured at the nanoscale (1-100 nm) in at least one dimension internally or externally, or materials that exhibit at least one nanoscale property/phenomenon. Canada regulates these MNMs domestically under the Canadian Environmental Protection Act. The ecological risk assessment of MNMs
MP292 Monitoring the health and contaminant levels in Canadian Arctic beluga whales to help assess and communicate risks and benefits to Inuit

M. Houde, Environment and Climate Change Canada / Aquatic Contaminants Research Division; J. Stow, Fisheries and Oceans Canada; Z. Gillespie, Health Canada; A. Caughey, W. Joy, Government of Nunavut; L. Williams, Government of Northwest Territories; C. Watt, Department of Fisheries and Oceans; S. Ferguson, Fisheries and Oceans Canada; M. Gauthier, S. Ricard, Government of Quebec; E. Way-Nee, Fisheries Joint Management Committee; A.O. De Silva, Environment and Climate Change Canada / Water Science and Technology Directorate; J.L. Kirk, Environment and Climate Change Canada / Aquatic Contaminants Research Division; E. Jenkins, University of Saskatchewan; L.L. Loseto, Fisheries and Oceans Canada / Central and Arctic Region

Beluga whales (Delphinapterus leucas) are important country (traditional harvest) foods for Inuit. The health of the Arctic ecosystem, belugas and humans are all closely connected in the Arctic. The monitoring of beluga’s health and contaminant concentrations in country food has been a priority of the Canadian Government since 1991 via the Northern Contaminants Program. On an annual basis, health indicators (i.e., diet, hormones, diseases) as well as mercury and organic compounds have been monitored in hunted belugas in partnership with northern community members at Tuktoyaktuk, (Northwest Territories), Sanikiluaq and Pangnirtung (Nunavut). Results of biological parameters and pollutants, such as polychlorinated biphenyls, organochlorine pesticides, flame retardants and polyfluoroalkyl substances as well as mercury, are reported to the communities as well as regional and federal health agencies. These results are used to assess ecological risks of contaminants in whales. Concerns from community members have also emerged on the human health aspect of beluga whale consumption. As a result, a Beluga Risk/Benefit Communication working group was created in 2018 to support regional health authorities of the Inuvialuit Settlement Region and Nunavut Territory on the assessment of human health risks related to contaminants in beluga. The orientation of this group will follow assessment work conducted in Nunavik. This team, composed of Inuit organizations, regional health authorities, community co-management boards, human and beluga health experts as well as chemists and toxicologists, are also helping address the communication challenge of risk-benefits of beluga consumption. During initial discussions, regional health authorities have shared their needs and scientists have summarized the information available for each beluga whale population. Using existing data on mercury in beluga and previous health surveys in regional Inuit communities, a human health risk assessment was initiated to characterise the main sources of risk (e.g., contaminant, tissue, preparation method) and nutritional benefits (e.g., healthy fats, selenium) of eating beluga whale, as well as identify vulnerable groups of concern (i.e., young children, pregnant females). Critical gaps will be highlighted and communication plans and materials that effectively share information and results to communities will be developed in an effort to promote health of the Arctic marine ecosystem, beluga populations, and Inuit.

MP293 Could chemical activity based environmental quality guidelines replace traditional media concentration-based guidelines?

A. Dunn, Environment and Climate Change Canada; D.J. Spry, Environment and Climate Change Canada / Science and Risk Assessment Directorate

Environmental quality guidelines (EQGs) continue to be recognized and trusted tools for the assessment of chemicals, interpretation of monitoring data and development of risk management goals and performance targets. The methodologies published by the Canadian Council of Ministers of Environment (CCME) and many individual Canadian provincial/territorial jurisdictions continue to rely on empirical toxicological bioassay data with fish, invertebrates and plants. In contrast, risk assessments have made use of a broader range of inferential tools (QSAR, read-across, trend analysis, chemical activity) to arrive at hazard evaluations (PNEC=probable no effect concentrations) not currently used in guideline/criteria development. Since chemical activity relies purely on physical/chemical properties and may be easily modelled using spreadsheet based calculations, the approach has the potential to accelerate guideline/criteria development, reduce the use and reliance on test organisms and deal with mixtures of chemicals exhibiting baseline (narcosis) mode of action. Here we examine the use of the chemical activity approach to develop a ‘safe activity level’ (derived from an analysis of the activity levels of existing, empirical-based chronic EQGs for non-biomagnifying, nonpolar narcotics) and its use in EQG development for prospective substances with baseline MOA. The exercise was conducted for methods development, not regulatory purposes.

MP294 Effects of Cement Dust on Soil Microbial Population Around Lafarge Cement Industry in Ogun State, Nigeria

L. Ogunyebi, University Of Lagos / Department of Cell Biology and Genetics; K. Obeleagu, University of Lagos, Akoka / Department of Cell Biology and Genetics

The study investigated the impact of cement dust pollution from Lafarge Cement Industry, Ewekoro on physicochemical and microbial diversity of the soil. Soil samples were collected inside the cement factory and from the surrounding at 0 meters, 500 meters and 1000 meters away from the cement factory with the aid of soil auger at a depths of 0-10cm and 10-20cm and kept in a sterile nylon bags with appropriate labels. The soil samples were transported to the Laboratory in University of Lagos for chemical analysis. The soil pH was determined using pH meter, moisture content was determined by oven drying method, electrical conductivity was determined on a 1:1(V/V) soil/water mixture composed of a 10 gram soil scoop and 10 ml double-deionized water. The heavy metals contents were determined using Atomic absorption Spectrophotometer. Population diversity of microbial species was also examined using disc diffusion method. The methods showed that, pH of the soil ranged from 6.27±0.03 - 6.47±0.03. The highest pH values (6.47) was recorded at 500m away from the factory. The soil moisture content ranged from 15.78±2.52 - 9.65±1.16, with values decreasing progressively away from the factory site. The levels of heavy metals except Mg, Zn and Na were higher within the factory than in the control. Cr, Fe, Pb, Cd, Ca and Cu were significantly higher at P< 0.05 in all locations than in control. Isolated microbial flora consists of 5 bacteria genera belonging to, Corynebacterium, Clostridium, Bacillus, Flarobacterium and Micrococcus, and 8 fungal genera belonging to Aspergillus, Penicillium, Trichoderma, Mucor, Noecroia, Geotrichum, Rhizopus and Fusarium. The bacterial counts in both polluted and control soil were lower than the fungal counts in both soils. The lower counts of bacteria compared to fungi may be as a results of nutrient status of the soil. Microbial population diversity increased steadily away from the factory. The isolates are Considered are tolerant to slightly acidic pH and heavy metals from cement dust. Thus, the variation is attributed to the impact of pH and heavy metals on microbial population.

MP295 Ambient Air Quality Assessment around Lafarge Cement Factory in Nigeria

A.L. Ogunyebi, University of Lagos, Akoka / Department of Cell Biology and Genetics; T. Soyebo, University of Lagos, Akoka / Department of Cell Biology and Genetics

This study investigated the impact of cement dust pollution from Lafarge Cement Factory, Ewekoro on physicochemical and microbial diversity of the soil. Soil samples were collected inside the cement factory and from the surrounding at 0 meters, 500 meters and 1000 meters away from the cement factory with the aid of soil auger at a depths of 0-10cm and 10-20cm and kept in a sterile nylon bags with appropriate labels. The soil samples were transported to the Laboratory in University of Lagos for chemical analysis. The soil pH was determined using pH meter, moisture content was determined by oven drying method, electrical conductivity was determined on a 1:1(V/V) soil/water mixture composed of a 10 gram soil scoop and 10 ml double-deionized water. The heavy metals contents were determined using Atomic absorption Spectrophotometer. Population diversity of microbial species was also examined using disc diffusion method. The methods showed that, pH of the soil ranged from 6.27±0.03 - 6.47±0.03. The highest pH values (6.47) was recorded at 500m away from the factory. The soil moisture content ranged from 15.78±2.52 - 9.65±1.16, with values decreasing progressively away from the factory site. The levels of heavy metals except Mg, Zn and Na were higher within the factory than in the control. Cr, Fe, Pb, Cd, Ca and Cu were significantly higher at P< 0.05 in all locations than in control. Isolated microbial flora consists of 5 bacteria genera belonging to, Corynebacterium, Clostridium, Bacillus, Flarobacterium and Micrococcus, and 8 fungal genera belonging to Aspergillus, Penicillium, Trichoderma, Mucor, Noecroia, Geotrichum, Rhizopus and Fusarium. The bacterial counts in both polluted and control soil were lower than the fungal counts in both soils. The lower counts of bacteria compared to fungi may be as a results of nutrient status of the soil. Microbial population diversity increased steadily away from the factory. The isolates are Considered are tolerant to slightly acidic pH and heavy metals from cement dust. Thus, the variation is attributed to the impact of pH and heavy metals on microbial population.
the stacked filter unit and concentration of particulate matter of a specific aerodynamic diameter was recorded. Relative humidity, wind speed and temperature were measured using CW-HAT 200 handheld tester. CO, NH3, and H2S were measured using Tetra multi-gas monitor. SO2 was measured using BW (Model 0539). Noise level was measured with a CET-DT 805 sound level, VOC measured with the self-regulating gas alert Micro5Prid meter. The results generally showed low levels of CO while PM levels were above the WHO standards. Concentration of air pollutants studied decreased with distance (0-30m). The concentrations of particulate matter (PM0.3, PM2.0, and PM10) varied respectively between 141147 μg/m3, 2919 μg/m3, 171.0 μg/m3 in the first week; 40514 μg/m3, 1150 μg/m3 and 27 μg/m3 in the second week and 117327 μg/m3, 653 μg/m3 and 0 μg/m3 in the third week respectively. The temperature, relative humidity and wind speed measured in all sampling stations were within WHO Standard. The concentrations of particulate matter at all the seas- sons exceeded WHO and NAAQS guidelines. However, concentrations of PM were higher in the dry seasons compared to the wet season. Higher concentration of PM0.3 (141147 μg/m3), PM2.5 (2919 μg/m3), PM10 (171 μg/m3) and noise level (77.2 dBA) in particular was recorded. Higher concentration of PM was observed at specific distance (0-40m). Based on the observations in this study, continuous monitoring of PM levels and other air pollutants is required to ensure compliance with recommended regulations and for health risk assessment.

MP296 When a Neighbour Complicates Matters: Offsite Flow-through Issues for Fish and Aquatic Invertebrates at a Hydro Works Yard
M. Anderson, J. Widmeyer, SLR Consulting (Canada) Ltd.; B. Hatch, BC Hydro
SLR Consulting (Canada) Ltd. was retained by BC Hydro Power and Authority (Hydro) to conduct a Human Health and Ecological Risk Assessment (HHERA) of a former BC Hydro District Office works yard. The goal of this work was to assist Hydro in obtaining a BC Certification of Compliance to sell the property located in Port Alberni, BC, Canada. The challenge associated with this project were the multiple receptors, contaminant sources, and land use combinations requiring assessment and resolution as part of the certificiation process. The focus of the current presentation explains how contaminant sources were identified and risks were evaluated for benthic invertebrates and fish exposed to metals in surface water (copper, iron and manganese) and sediments (arsenic, chromium, lead and zinc). The property had two key sources of metals: one originating from onsite soils and the second originating from an offsite upstream creek traversing the site. Onsite groundwater investigations confirmed that metals originating from onsite soils (arsenic) did impact groundwater, but that the plume was stable, and groundwater was not discharging arsenic into the creek. Multiple drains contributing truck wash water and storm run-off from the offsite property were identified present and discharging into the creek. Seasonal surface water and sediment sampling confirmed that concentrations of metals in upstream sediments and surface waters (end of pipe and within the creek) were present and associated with the neighbouring property. Metals concentrations were highest in the creek closest to the offsite input drains and did not always attenuate to levels below the regulatory standards within onsite sediments and surface waters. The combination of the creek and offsite sources created a contaminant flow through scenario for metals. As part of the HHERA, concentrations of metals in sediment were used in combination with sediment toxicity testing to assess impacts to the benthic invertebrate community. Concentrations of metals in surface water were used in combination with fish trapping and habitat quality assessments to assess impacts to the fish community. Overall risks were concluded to be low and risk-based standards were met for these results.

MP297 Assessing Health Risk of a Chlorinated-Solvent-Contaminated Site Using a Novel Analytical Transport Model
J. Chen, National Central University / Graduate Institute of Applied Geology; C. Liang, Fooyin University / Department of Nursing
Chlorinated-solvent-contaminated site poses a significant threat to the human health and environment. It is too expensive and labor-intensive to obtain a sufficient amount of data for constructing numerical transport models of individual sites which generally require a detailed physical description of the hydrogeology and specification of the initial and boundary conditions as well as a sufficient number of hydrogeological parameters. Therefore, simple and rapid tools based on analytical transport models are widely used to assess (at an early stage) whether a site might pose a threat to groundwater. This study presents an analytical model for rapid assessment of health risk from exposure to the chlorinated solvent contaminated groundwater. This fast tool is achieved based on the analytical solutions derived for a set of simultaneous three-dimensional transient advection-dispersion equations (ADEs) coupled with sequential first-order biodegradation reactions. The accuracy and robustness of the derived analytical solution tool is evaluated and confirmed by comparisons of results obtained from the newly derived model and the currently available analytical model in the literature. The results show that the newly derived model agree well with the previous solution with a significant reduction in the computational time. An application example of the derived analytical solution tool is evaluated, and the final conclusions of results obtained from the newly derived model and the currently available analytical model are presented. The derived solution will be an effective and efficient tool for assessing health risk of chlorinated-solvent-contaminated sites.

MP298 Long-Term Ecological Effect Assessment After Chemical Accident
H. Jung, Korea Institute of Toxicology / Environmental Fate & Exposure Research Group
Recently, chemical spill accidents are becoming more frequent as industrial development progresses. The impacts of chemical accidents can be deadly, for both human beings and the environment. Many different types of chemicals can be toxic effect immediately in plant. However, even when an exposure occurs at a concentration too low to cause non-toxic effect, the chemical may accumulation over time in plant. Chemicals can exist in plant at low concentrations, which can affect genetic level and metabolism. In this study, we attempted to evaluate the phenotype, genetic level and metabolic effects of Arabidopsis thaliana L. plants at low concentrations of major chemicals (strong acids and organic compounds) long-term effect. Hydrochloric acid and hydrofluoric acid were selected as the sulfuric acid substances and phenol and toluene were used as the organic compounds substances. In the phenotype effect of chemical in Arabidopsis, they were exposed to control, 100, 1000, 5000 and 10000 mg/kg of each chemicals for 14 days. Each chemicals caused decrease of plant dry weight at highest concentration compared to control. Genetic levels and metabolic effects at low levels toxic effects on phenotypes were investigated. To investigate genetic level and metabolism, ongoing efforts are studying: 1) To understand the transcriptional changes under chemicals, Validation of appropriate reference genes for real-time quantitative PCR (RT-qPCR) gene expression analysis in Arabidopsis plants exposed to chemical stresses. 2) The use of metabolomic analysis to dissect plant responses to chemical stresses.

MP299 Peroxymonosulfate/chloride versus sodium hypochlorite disinfection on the formation and estimated cytotoxicity of disinfection by-products
T. Chen, Tongji University; T. Xu, Tongji University / College of Environmental Science and Engineering
The use of peroxymonosulfate (PMS) as an oxidant is receiving increasing interest for drinking water disinfection. However, it does not possess continuous disinfection ability compared with sodium hypochlorite (NaClO). PMS/Cl- can produce reactive chlorine species and thus provide
a persistent disinfectant residual in distribution systems. This study investigated the effect of PMS/Cl₂ disinfection versus NaClO disinfection on the formation and estimated cytotoxicity of CX₃R-type disinfection by-products (DBPs) under the same free chlorine dose. Results showed that HOCl/OCl⁻ produced in PMS/Cl₂-reacted with organic compounds to produce CX₃R-type DBPs. During PMS/Cl₂-disinfection, chlorofluorocarbon (CF) was dominant DBP and its concentrations increased as the reaction time, pH and Cl₂ dose increased. Chloral hydrate (CH₂) also increased steadily with the increase of reaction time and Cl₂ produced in PMS/Cl₂-process, but CH₂ concentrations increased first and then decreased as the pH increased. Due to the hydrolysis of haloacetonitriles (HANs) and haloacetamides (HAMS), their concentrations increased first and then decreased as the Cl₂ from PMS/Cl₂-increased or decreased as the pH increased during PMS/Cl₂-disinfection. Compared to NaClO disinfection, CX₃R-type DBPs concentrations varied Cl₂ dose, pH and reaction time exhibited similar trend during PMS/Cl₂-disinfection. After 24 h at pH = 6 and Cl₂ dose = 0.25 mM, the concentrations of CF, CH₂, DCAN, TCAN, DCAM and TCAM formed from tyrosine (Tyr) were 94.1, 18.5, 337.8, 0.7, 6.5 and 2.2 nM, respectively in PMS/Cl₂-disinfection, which was lower than that (236.6, 25.1, 351.7, 0.8, 6.7, and 2.3 mM) in NaClO disinfection. This is probably attributed to the oxidizability of PMS, which can oxidize Tyr and then prevent the formation of CX₃R-type DBPs. The cytotoxicity calculated from all investigated CX₃R-type DBPs produced in PMS/Cl₂-disinfection also showed a similar trend with NaClO disinfection, and the cytotoxicity is also significantly lower than that during NaClO disinfection. This study demonstrated the advantages of PMS/Cl₂ as an alternative disinfectant compared with NaClO, which may be important implications in drinking water disinfection.

**MP300 Contents and Migration-based Risk Assessment of Hazardous Chemicals in Children’s Products**

Y. An, Seoul National University of Science and Technology / Environmental Engineering; S. Chun, FITI Testing & Research Institute; K. Kim, Seoul National University of Science and Technology / Environmental Engineering

As the concerns over exposure to chemicals in products are increasing, there is a need to quantitatively assess the risk of exposure to chemicals in children's products. DEHP, cadmium and boron, which are commonly found in products, have been investigated in educational toy, pencil cases, and slimes. In this study, the contents-based risk assessment was set up as detailed as the migration-based risk assessment in children's products. The contents and migration of DEHP and metals (i.e. cadmium and boron) were analyzed by GC-MS and ICP-OES. Scenario-based exposure assessments were conducted using deterministic methods by ages (range 0-6, 7-12 and 0-12 years). Based on analysis results, the exposure dose and hazard quotient (HQ) were calculated and compared between the contents-based and the migration-based exposure scenario. In educational toy, the HQ of DEHP exceeded 1 in oral exposure at 0-6 years. In slimes, the HQ of boric acid exceeded 1 at oral exposure of 0-6 and 0-12 years. In conclusion, the results were the same for HQ-1 about the product, substance and age group in the content and migration-based risk assessment. Secondly, based on the content-based risk assessment, it was possible to assess the level of migration-based risk assessment. Proper regulation of products to reduce the number of birds used for testing. However, besides being a relevant study for plant protection products with certain chemical properties, the avian short-term dietary study has a feeding regimen that is more representative of how birds forage in the field than does the acute oral study. The dietary study can be an important refinement in a higher tiered ERA. Decision criteria are needed to determine a path forward that accomplishes the goal of reducing vertebrate animal testing but also allows for the use of the avian dietary study in risk refinement. The first goal of this project is to develop such criteria. Second, we will provide recommendations to address the design of avian dietary studies to ensure that the data are optimized to support an acute avian assessment. In addition, we will provide case studies to demonstrate the use of the criteria to decide when a dietary study could be used as a higher-tier refinement and how the study should be designed to support use in standard FIFA and endangered species assessments.

**MP301 A Meta-Analysis of Perfluorooctane Sulfonate (PFOS) Concentrations in Birds Around the World**

R. Flamenco, California State Polytechnic University, Pomona / Biology; A. Bonisoli Alquati, California State Polytechnic University, Pomona / Department of Biological Sciences

Perfluorooctane sulfonate (PFOS) is an emerging contaminant restricted under Annex B of the Stockholm Convention on Persistent Organic Pollutants (POPs). It is carcinogenic and teratogenic. PFOS was shown to bioaccumulate and biomagnify in top predators in marine food webs due to its proteophilic properties, yet no comprehensive analysis exists of variation in its concentrations across species, time and space. This meta-analysis explores variation in the concentration of PFOS across bird species, which are reliable sentinels for monitoring the concentrations of organic contaminants and their associated ecological risk. We collected more than 500 estimates of PFOS concentrations in eggs, liver, and blood from studies of more than 100 different bird species across all continents, to explore temporal, geographic, and taxonomic variation in PFOS concentrations. This allowed us to test which environmental and species-specific characteristics best predict PFOS concentrations in wildlife. Our results demonstrate a > 3.5-fold increase in PFOS concentrations in bird eggs from the 1970s to the 2010s, with the largest increase occurring in the temperate region. Average concentrations were significantly higher in the temperate region than in the polar region in both eggs and liver, but not in blood. Birds from temperate freshwater and marine environments had higher mean concentrations than temperate terrestrial and polar marine ones. These results are consistent with most anthropogenic sources of PFOS being at temperate latitudes. This is expected as high concentrations are found in fish and PFOS biomagnifies in food webs, it would also have much higher concentrations than more remote polar regions. Diet played an important role in explaining PFOS tissue concentrations. Piscivores and opportunists had the highest concentrations among all feeding guilds, while herbivores had the lowest. This study shows a global, widespread temporal increase in the concentrations of PFOS in birds’ tissues, with a few birds reaching liver concentrations that exceed values associated with documented adverse effects. This study will help identify bird groups that are at greater ecological risk from PFOS. Future developments of this study will incorporate information about the life history of the different species while accounting for their shared phylogenetic history to further clarify ecological risk and susceptibility of birds to PFOS contamination.

**MP302 The utility of the avian dietary toxicity test in ecological risk assessment and a path forward for reduction of animal use**

A. Bone, Bayer CropScience / Environmental Safety; L.W. Brewer, Compliance Services International / Department of Wildlife Toxicology; C. Habig, Compliance Services International; S. Levine, Bayer AG / Crop Science Division / Regulatory; D. Moore, Intrinsic Environmental, Inc.; S.R. Mortensen, BASF Corporation; S. Plautz, BASF / The Institute of Environmental and Human Health

There is a long history of the USEPA requiring both avian short-term dietary and acute oral studies to inform avian risk assessment for pesticides. Recently, the USEPA collaborated with People for the Ethical Treatment of Animals (PETA) to determine whether the results of the acute oral avian toxicity test or the short-term dietary toxicity test drove the avian acute ecological risk assessments (ERAs) for pesticides from 1998-2016. Their study concluded that in 99% of the cases, the dietary study did not change the risk conclusions derived using the acute oral study (OPPTS 850.2100, OCSP 850.2100 or similar). Therefore, EPA and PETA suggested waiving the dietary study for most plant protection products to reduce the number of birds used for testing. However, besides the relevant study for plant protection products with certain chemical properties, the avian short-term dietary study has a feeding regimen that is more representative of how birds forage in the field than does the acute oral study. The dietary study can be an important refinement in a higher-tier ERA. Decision criteria are needed to determine a path forward that accomplishes the goal of reducing vertebrate animal testing but also allows for the use of the avian dietary study in risk refinement. The first goal of this project is to develop such criteria. Second, we will provide recommendations to address the design of avian dietary studies to ensure that the data are optimized to support an acute avian assessment. In addition, we will provide case studies to demonstrate the use of the criteria to decide when a dietary study could be used as a higher-tier refinement and how the study should be designed to support use in standard FIFA and endangered species assessments.
The objective of the study was to apply simple air quality assessment techniques in urban sites that can be used as tools in environmental management programs. Two urban areas with vehicular traffic differences in Punta Lara (La Plata, Argentina) were selected as preliminary study sites. The Breezometer Meteoblue software was used as a secondary database of air pollution during the summer of 2019, a randomized temporary sampling of air pollutant concentration data was performed during the period January 1 and March 29. In situ sampling of lichen morphotypes was carried out to apply the Environmental Purity Index (IPA). The IPA index is calculated for each morphological type, such as the sum of the frequency (or coverage) of that morphological type in the total sampled trees. The IPA defines 5 pollution levels (A-E); the lowest index values indicate the highest air pollution. A protocol for taking and recording data was established. Concentrations of pollutants and weather data (temperature, atmospheric pressure, wind chill, direction, velocity, and humidity) were recorded. Data were tested by the Kolmogorov-Smirnov and normalized and the differences between sites were statistically analyzed by MANOVA (XLSTAT). Two wooded areas were selected January 2019 for the calculation of the IPA: area 1 (with a total of 50 trees) 16 presented lichens; and area 2 (with a total of 14 trees) 9 presented lichens. The percentage of lichen coverage was recorded in each tree. A rack (55 cm high x 25 cm wide) subdivided into 20 sub-frames and located at a height above 1.20 m. The frequency and percentage of coverage of different lichen morphotypes (croseo, foliose, fruticulous, and filamentous) was recorded. The IPA was calculated for each morphotype using the data obtained from frequency and coverage. The concentrations of polluting gases (in ppb) were: CO 161 ± 181; NO2 9 ± 4; SO2 1 ± 2 and O3 26 ± 11 (with maximums 1101, 27, 23 and 65 respectively). The concentrations of PM (ug / m3) were 19 ± 9 (P10) and 12 ± 7 (PM 2.5) with maxima of 58 and 63 respectively. The prevailing winds in the evaluated period were 25% from the NO and 27% from the SE. The result of the IPA in area 1 was 14.2 and in area 2 it was 17.8. Result that in both cases indicates a high level of contamination (B). This indicates that the main impact on lichens is mainly due to the effect of fixed sources of pollution and not to mobile sources.

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**Publicly Accessible Data Analytic Tools for Environmental Toxicology, Chemistry, and Risk Assessment**

**MP306 Benchmark dose estimation for event-time data using the statistical software R**

S. Jensen, N. Cedergreen, University of Copenhagen / Plant and Environmental Sciences; F. Khlex; ADAMA Deutschland GmbH; C. Ritz, University of Copenhagen / Department of Nutrition, Exercise and Sports

The benchmark dose (BMD) methodology is a regression-based approach for hazard characterization. It is recommended by several authorities due to its advantages over the no observed adverse effect level approach. However, the methodology is still mainly used for binomial and continuous data, although BMD estimation is also feasible and relevant for other types of endpoints. In particular, there has been no BMD definition for event-time data. We propose a non-mechanistic method for benchmark
dose (BMD) estimation for event-time data. The method combines existing methodology for event-time data analysis and benchmark dose estimation in a two-step approach. Specifically, we will introduce the proposed approach in the context of the existing BMD methodology. We demonstrate the approach through an example from the literature. The method is implemented in the statistical environment and software R in the recently developed extension package **bmd**.

**MP307 Choosing the right version of Positive Matrix Factorization**

*L.A. Rodenburg, Rutgers University / Environmental Sciences*

Positive Matrix Factorization (PMF) has emerged as a useful tool for source identification and apportionment of organic pollutants, including polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs), brominated diphenyl ethers (BDEs), perfluoro alkyl substances (PFAS), and polycyclic aromatic hydrocarbons (PAHs). PMF has been used to identify the sources of these chemicals in a wide variety of environmental compartments including surface water, sediment, wastewater effluents, organism tissues, atmospheric deposition and air, groundwater, etc. There are several versions of PMF available. The early PMF versions were created by Pentti Paatero and his colleagues. The most widely used of these early versions is PMF2. More recently, the USEPA built upon the original Paatero versions to create their own versions of PMF, the most recent being PMF 5.0. This presentation will compare and contrast PMF2 with PMF 5.0 for use in environmental source apportionment. PMF2 is a DOS program with no graphical user interface (GUI) and is not free. In contrast, PMF 5.0 has a GUI, is a free download, and includes bootstrapping and displacement routines than can be helpful in identifying the optimal number of factors contained in a data set. Despite these advantages, PMF 5.0 has some disadvantages: it often cannot converge on satisfactory model solutions and sometimes suggest a non-optimal number of factors. The differences between the two PMF versions will be illustrated using case studies.

**MP309 Holistic assessment of trophic level sensitives: A big data WOE case study**

*K.A. Connors, Procter & Gamble Company / Environmental Stewardship and Sustainability; S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; M.G. Barron, US Environmental Protection Agency / Gulf Ecology Division; M.R. Embry, Health and Environmental Sciences Institute (HESI)*

Regulators have been slow to adopt animal alternative assays (AA) into environmental risk assessment frameworks. Large environmental toxicity databases (e.g., EnviroTox, ECOTOX) and analytic tools can be used to develop qualitative weight-of-evidence (WOE) arguments to define when AA approaches may be appropriate. Derivation of a Predicted No Effect Concentration (PNEC) for ecosystems is the primary deterministic form of hazard extrapolation used in environmental risk assessment and it is driven by the most sensitive measured endpoint amongst the standard aquatic toxicity assays (e.g., acute and chronic tests in algae, invertebrates, and fish). These PNEC values, when viewed as probabilistic distributions for groupings of a large number of chemicals, can also be used to derive ecological thresholds for toxicological concern (e.g., TCCs). The fish embryo toxicity (FET) assay has been proposed as an AA assay for the acute fish toxicity assay. However, there is concern that the FET to fish correlation may not be adequately conservative for certain chemical classes or modes of action (MOA), specifically neurotoxicants. The EnviroTox database contains 738 chemicals with full acute datasets (acute and chronic tests for algae, invertebrates, and fish), and the PNECs for ~80% of these chemicals are driven by the sensitivity of algae or invertebrates, not fish. The PNECs for the acetylcholinesterase inhibitors are also driven by algal or invertebrate results (62 chemicals, with only 15% of PNECs driven by fish). In this presentation we will demonstrate how large datasets can be used to develop a WOE argument to support the use of AA. Specifically, we will explore trophic level sensitivities across chemical classes and modes of action in order to understand what factors drive PNEC variation. We will also discuss the importance of MOA and species selection on ultimate PNEC derivation.

**MP310 Protecting human health and the environment by regulating contaminants for the remediation of contaminated sites located in British Columbia, Canada**

*H. Osachoff, BC Ministry of Environment and Climate Change Strategy / Land Remediation Section*

In the province of British Columbia (BC), Canada, science and policy inform regulatory decisions to support contaminated sites remediation. The regulator sets environmental standards to protect human health and the environment, and persons responsible for contamination conduct remediation to meet the numerical or risk-based environmental standards. Recently, BC went through a process of updating 8500 environmental standards in 3 environmental media (soil, water and vapour) for 600+ substances. Standards to protect aquatic life, drinking water, terrestrial receptors, residential land use and more, were updated for current substances, or prescribed for new emerging substances such as poly- and per-fluorinated compounds. Implementation of such large scale standards setting and subsequent lessons learned will be shared for other regulatory policy and decision makers to consider when setting environmental benchmarks for remediation purposes. Additionally, decision makers in the regulatory oversight of BC contaminated sites are faced with different types of information, including factors relating to societal issues, economic implications, and scientific information, which all must be considered under administrative law to remediate contaminated sites appropriately and reasonably. Setting standards for contamination clean-up may also be influenced by these same factors so regulators setting standards balance influences while remaining transparent, defensible and credible. Examples of processes or strategies used to set environmental standards will be discussed including: (1) legislating a 5-year cycle of review to curate the science-based standards via routine maintenance thereby avoiding massive infrequent updates and enhancing business certainty; (2) enabling a 1-year period of transition before updated/new standards come into legal force, again for business certainty; (3) allowing remediation to be completed to the previous standards, and allowing the risk-based assumptions used to derive updated/new standards in detailed risk assessment, up to the coming into force date; (4) developing criteria to establish future standards updating practices (responding to urgency due to latest advancements in emerging contaminants and toxicology); (5) releasing 30 new or updated policy documents concurrent with the coming into force date of the updated/new standards to assist remedial practices with the latest requirements for site investigation and risk assessment.

**MP311 The Risk Assessment in the 21st Century (RISK21) web-tool**

*M.R. Embry, Health and Environmental Sciences Institute (HESI); S.E. Deglin, ILSI Health and Environmental Sciences Institute (HESI)*

The HESI Risk Assessment in the 21st Century (RISK21) project developed an integrated risk assessment framework that enhances efficiency and risk management. The project was initiated to develop a scientific, transparent, and efficient approach to risk assessment, relying on a problem formulation-based, exposure driven, tiered data acquisition. This RISK21 framework allows informed decisions on safety to be made when sufficient evidence is available, and it maximizes the ability to inform decisions and optimize resource usage. The program also developed a web-based tool that allows users to easily graph their risk assessment data and effectively communicate risk-based decisions, whether for a screening and prioritization purpose or a definitive risk assessment. This tool is freely available at www-risk21.org. The utility and uptake of this approach and the web-tool has been demonstrated via several hands-on case study workshops, led by RISK21 team members and hosted or sponsored by various groups, including government agencies. These workshops have engaged participants in real-world case examples, and combined, have already reached over 500 people with direct, hands-on use and application
of the web-tool in the US, China, Taiwan, Brazil, Argentina, and Canada, with additional workshops planned. Although application to-date has focused largely on human health risk assessment, the approach and the associated web-tool are broadly applicable across disciplines for risk assessment, prioritization, communication, and outreach. This presentation will provide a demonstration of the utility of the tool with a focus on applications for ecological risk assessment.

MP312 Using the AOP Wiki for the development of an acetylcholinesterase inhibition adverse outcome pathway

K. Conrow, Y. Garcia-Martín, Arizona State University; N. García-Reyero, US Army Engineer Research and Development Center; K.H. Watanabe, Arizona State University / School of Mathematical and Natural Sciences

Developing user-driven tools used for analyzing systems is of significant benefit to a variety of areas of research due to their wide applicability. Motivated by the push toward big data, these tools can allow access to useful data and models for various purposes, like environmental toxicology and risk assessments. User-driven tools rely on input from the community of researchers to create a wider base of knowledge. The AOP Wiki focuses on the construction of adverse outcome pathways (AOPs). These pathways link key events, which start with a molecular initiating event and result in an adverse outcome at a higher level of biological organization. This poster focuses on the process of contributing to the knowledge base of the AOP Wiki through the development of an AOP for acetylcholinesterase inhibition leading to neurodegeneration. A comprehensive literature review resulted in approximately 200 papers, with the 100 most relevant papers containing data from 12 species. We classified these papers according to their relevance for specific key events, which helped with the composition of appropriate entries and weight-of-evidence for the AOP Wiki. Our work revealed unanticipated benefits and weaknesses in the AOP Wiki in areas such as user-friendliness, scope of data needs for the weight of evidence, re-use of key events from existing AOPs or those being developed, and other practical insights from a new user's perspective. We provide recommendations to improve the accessibility, quality control and standardization of AOP entries and suggest new applications of the AOP Wiki knowledge base.

Life Cycle Assessment - Advancements and Applications

MP313 Life Cycle Assessment of an Aquaponic Food Production System, Identification and Mitigation of Environmental Hotspots

R. Ghamkhar, A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering; F. Wu, Jinan University / School of Environment

There has been a fast increase in global food demand, due to a rapidly increasing world population. Ecosystems have been degraded over time due to unsustainable agricultural practices, such as the overuse of nitrogen and phosphorus fertilizers. It is critical that future innovations in food production be sustainable on a large scale in order to meet growing protein and produce needs. Natural fish production environments are in danger of losing their carrying capacity due to anthropogenic activities, such as overfishing, waste emissions, and ecosystem change. One approach for fish production that minimizes waste and damages to ecosystems is tightening nutrient cycles. Aquaponic food production is considered a prospective solution to reduce the adverse environmental impacts of food production, including nutrient losses and water consumption. In aquaponics, a seafood-producing environment (aquaculture) is integrated with a soilless plant-production environment (hydroponic) with nitrifying bacteria in a symbiotic circulating setup. Combining these systems is anticipated to provide a more environmentally and economically sustainable food production process in comparison to separated aquaculture and agriculture systems. In this work, a comprehensive cradle-to-gate life cycle assessment utilizing multiple environmental impact categories (such as embodied water, and greenhouse gas emissions) is performed on an aquaponic system, which cultivates multiple vegetable species as well as carnivorous hybrid walleye (a native Midwestern fish breed). This provides the opportunity to investigate the environmental impacts of using closed-loop aquaponics compared to open natural systems to meet the increasing global demand for food production in a cold weather environment. Additionally, the main contributors to the system's environmental impacts are recognized. Heat, electricity, equipment, and fish food are contributing to >88% of environmental impacts in all investigated categories. Finally, practical alternatives on using different real-case scenarios (such as effective space heating, possible equipment lifespans, fishmeal-free fish food) are proposed and evaluated.

MP314 Insights from life cycle assessment of nano-silver enabled consumer products

A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering

Silver has been utilized for its antimicrobial properties since antiquity. Nano-scale silver (nAg) with dimensions of less than 100 nanometers (nm) is one of the most commonly used nanoparticles in consumer products due to its antimicrobial efficacy which has been found to be enhanced compared to bulk silver. These products include textiles, food storage containers, sprays, toothpaste, among others, with the goal of providing an antimicrobial characteristic to these products. A major question has been whether the benefits bestowed by the addition of nAg to consumer products outweighs the environmental costs. Life cycle assessment (LCA), a systematic tool for determining the environmental impacts of products and processes throughout their lifetime, has been applied to evaluate the environmental impacts of nAg enabled products. In most instances the additional environmental burden due to the incorporation of nAg is relatively small, however, that is not universally true across all products and environmental impact categories. This work utilizes life cycle assessment to frame the discussion as to the relative environmental costs (or impacts) and benefits (such as antimicrobial efficacy) enabled through the addition of nAg to consumer products, highlighting multiple consumer products. The findings suggest that although the additional environmental impact is often small, in some instances, due to the antimicrobial ineffectiveness of the nAg, the nanoeabling is not worthwhile. This may serve as the starting point for a framework to determine when the benefits of nanoeabling consumer products with nAg outweigh the costs.

MP315 Environmental Impacts of Phosphorus Recovery in Wastewater Treatment

M. Sena, University of Wisconsin, Madison / Civil and Environmental Engineering; M. Seib, Madison Metropolitan Sewerage District; D.R. Noguera, A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering

Wastewater treatment currently focuses on removing phosphorus (P) and nitrogen (N) due to their potential to cause eutrophication in bodies of water. With growing concern for the longevity of global phosphate rock stores, however, there is now interest in recovering these nutrients. One method for recovering P and N is through the precipitation of struvite (magnesium ammonium phosphate) which helps control unwanted precipitation of struvite in pipes and on other surfaces at the treatment plant lessening a challenging maintenance problem, and produces a valuable alternative fertilizer product. A potential concern with this technology is that the environmental impacts struvite recovery creates through the use of additional chemicals and energy are not offset by its benefits. A life cycle assessment (LCA) case study of the full-scale wastewater treatment plant (WWTP) in Madison, WI USA was used to assess the environmental tradeoffs of struvite recovery in wastewater treatment. Results showed that although the WWTP operation with the struvite system had environmental costs in all considered categories, there was improvement in the majority of the categories compared to operation of the plant before the struvite recovery system was implemented. Additionally, the struvite recovery system on its own showed a mix of positive and negative
environmental impacts across different categories. Thus, we conclude that struvite precipitation and recovery has an overall neutral environmental impact offsetting emissions it creates in other areas.

MP316 Global Environmental Footprints of Silver Nanoparticle Synthesis Methods and Industry Based Impact Projections Using Life Cycle Assessment
S. Temizel Sekeryan, University of Wisconsin / Civil and Environmental Engineering; A. Hicks, University of Wisconsin, Madison / Civil and Environmental Engineering
Silver nanoparticles (AgNPs) are well known mainly for their antibacterial, electrical and optical properties, which make them the most commercialized engineered nanomaterials (ENMs). They account for more than 50% of the global nanomaterial consumer products. Their sizes range from 1 nm to 100 nm and control their characteristics. Different synthesis methods are appropriate for different morphologies of AgNPs, therefore specific sizes require different mechanisms for production. The average production amount of AgNPs was approximately 370 tons/year for 2018, and this is expected to reach 800 tons/year by 2025, globally. Although ENMs are small fractions (~1E-06%) of the products by mass, their synthesis method has a high impact on the overall life cycle results of the products they are embedded. AgNPs may be synthesized through chemical, physical and biological techniques. This research performs cradle-to-gate life cycle assessments (LCAs) in order to evaluate global environmental footprints of seven different AgNP synthesis routes along with fifteen different inventories on a mass-based functional unit of 1 kilogram of AgNPs, using SimaPro 8.5.2 Software and TRACI 2.1 Impact Assessment Methodology. Results showed that one of the physical routes, flame spray pyrolysis with melt-spin incorporation method has the highest impacts across almost all potential environmental impact categories. Conversely, one of the most common wet chemistry methods used in the literature, chemical reduction with sodium borohydride is found to be the most environmentally conscious method among others. The LCA results are then combined with both the skeptical and optimistic AgNPs production amounts and global estimations are presented. Additionally, industry-based environmental impacts are projected for industries where AgNPs are mostly used such as textiles; coatings, paints, and pigments; consumer electronics and optics; cosmetics; medical and packaging. Given that each industry requires a specific size range, disaggregated global projections are created per industry. As some methods are more environmentally demanding than others, it is found that the industry-based impacts are not exactly proportional to the industrial shares. Since synthesis methods may affect the overall environmental performance of AgNPs embedded products, it may be worthwhile to shift methods to have more environmentally friendly products and to take a step towards sustainable solutions.

MP317 Life Cycle Hazard Assessment of Advanced Battery Technologies for Grid-Scale Energy Storage
D.B. Mayfield, A.S. Lewis, D.M. Mims, A.L. Dale, Gradient; A.C. Rohr, EPRI
Power-producing utilities are exploring opportunities to expand energy storage capacity, particularly through adoption of advanced battery technologies. As utilities begin to commit to specific battery technologies, there is a need to comprehensively understand potential public health and environmental impacts. This project examined potential risks for two broad categories of batteries (secondary and redox-flow), including lithium ion, lead acid, sodium sulfur, nickel cadmium, nickel metal hydride, vanadium redox-flow, and zinc bromide flow types. We examined possible exposure pathways, key chemicals, and known potential health or environmental risks at each stage of the life cycle, with a focus on lithium ion batteries. For example, the impacts of mineral extraction and refining are generally well known for key metals (e.g., cadmium, nickel, lead) used in battery technologies. However, with the shift to lithium ion and other battery types, the production capacity of minor metals (e.g., cobalt, lithium, vanadium) is expanding globally. Certain extraction processes (e.g., lithium processing from brines) are unique and may require additional study to ascertain any potential occupational or public exposures. Battery manufacturing processes are similarly evolving as new battery compositions are discovered. Accordingly, health and safety implications must be reconsidered as new battery chemistries are advanced. As domestic grid-scale manufacturing facilities develop, additional efforts are needed to generate and evaluate exposure and toxicological data in order to develop workplace safety standards. In-use batteries are not currently anticipated to be a significant source of exposure except in the case of accidents (fires or other physical damage). Disposal and recycling, however, have the potential to create exposure pathways that may affect both public health and the environment. Understanding potential human health and environmental impacts is difficult with current life cycle assessment tools given the lack of available toxicological information on key battery materials. Alternatives assessment may offer a more refined way to assess the comparative toxicity (and data gaps) of chemicals associated with batteries. For all tools to be effective, additional research is needed to understand exposure pathways, exposure concentrations, and chemical hazards associated with developments in grid-scale electric energy storage.

MP318 Reducing the environmental impact of fullerenes using an iterative approach combining life cycle assessment and green chemistry
M. Heidari, E. Lee, A. Ancilii, Michigan State University / Civil and Environmental Engineering
Fullerenes are nanomaterials which are used for energy, medical, water purification, composites and other applications. The material purity depends on the application and for solar cells, it needs to be higher than 99%. Purification has the largest environmental and cost impact in fullerene manufacturing. In this work we compared the environmental, health and cost impact of existing fullerene purification methods and developed an alternative process using an iterative methodology developed by our group. One key concern of nanomaterials is their potential toxicity for humans and the environment. The environmental toxicity of fullerenes without and with various solvents was calculated using Daphnia magna and the results included in the life cycle assessment. We compared chromatography, crystallization and complexion methods for fullerene purification. The complexion was identified as having the lowest environmental, health and cost impact and the use of 3,3',5,5'-Tetramethylbenzidine (TMB) was identified as the main concern in the current process. Fullerene purification using the complexion method was performed with TMB and optimized to maximize the yield for two alternative green solvents. The material and energy inventory were collected during the experiment and used to perform life cycle assessment of all the alternatives. Final results showing the overall reduction in fullerene environmental, health and cost impact obtained by combining experimental work and life cycle assessment using an iterative methodology will be presented.

MP319 Sustainable bioenergy systems: Life cycle assessment of wood pellets and wood logs for residential heating
P. Quinteiro, L.A. Tarelho, University of Aveiro / Centre for Environmental and Marine Studies & Department of Environment and Planning; A.C. Dias, University of Aveiro / Centre for Environmental and Marine Studies & Department of Environment and Planning; A.C. Dias, University of Aveiro / Centre for Environmental and Marine Studies & Department of Environment and Planning; A.C. Dias, University of Aveiro / Centre for Environmental and Marine Studies & Department of Environment and Planning
The use of bioenergy, based on wood feedstock, has been encouraged due to its potential to reduce fossil fuels dependency and greenhouse gas emissions. This study applies life cycle assessment methodology to compare the environmental impacts of three wood-based combustion systems for producing thermal energy for domestic heating: i) a pellets
stove using maritime pine pellets as feedstock; ii) a wood stove using eucalyptus and maritime pine logs as feedstock; and iii) a fireplace using eucalypt and maritime pine logs as feedstock. The functional unit is 1 MJ of thermal energy produced for domestic heating. System boundaries include: (1) forest management from both eucalypt and maritime pine species; (2) pellets and wood logs production; (3) distribution of pellets and wood logs, and; (4) thermal energy conversion, also including ashes disposal in landfill. Inventory data are representative of the current typical technological systems in Portugal. Environmental impacts were calculated for seven impact categories from the ReCiPe 2016 midpoint method: global warming, fossil resources scarcity, terrestrial acidification, freshwater eutrophication, marine eutrophication, ozone formation (human health) and ozone formation (terrestrial ecosystems). From all the heating systems analysed, the fireplace presents the worst performance for all the impact categories with the exception of freshwater eutrophication and marine eutrophication, when maritime pine split logs are burned in the fireplace. For both fireplace systems, the stage of eucalypt and pine split logs combustion for the thermal energy generation is the most relevant to most impact categories (70 to 96 % of the total impacts), with the only exceptions being fossil resources scarcity, freshwater eutrophication and marine eutrophication. Comparing the pellet stove with the wood stove, none of the systems is better than the other, for all the impact categories analysed. Reducing the environmental profile throughout the value chain and improving the energy efficiency of all the systems studied contributes to a more sustainable value chain management.

**MP320 Alternative uses of ornamental flower crop waste for lower environmental impacts**

J. Torres Ortega, University of la Salle / Environmental Engineering; O. Contesto Rubio, University of la Salle / Ingeniería Ambiental y Sanitaria; I. Herrera, CIEMAT / Energy

The growth of biomass residues, associated with impacts and environmental dynamics, promotes the research proposal for an LCA study for a biorefinery focused on the production of high value products. Ornamental flower crop residues have been used to establish the requirements of raw materials, nutrients and operating conditions to obtain from biofuels to other products used in fine chemicals, farceutics and others. A life cycle analysis was developed to know the most relevant aspects in waste management in a crop to be used in a biorefinery. The ornamental culture is found in Cundinamarca (Colombia). The most relevant results are related, on the one hand, with the savings of emissions in the category of impact of global warming and, on the other hand, the effects of the change in the use of the land of the elimination of residues of biomass of the soil and its relevance in the global saving of greenhouse gas emissions.

**MP321 Interaction of dietary nanoparticles with proteins could negatively impact their nutritional and functional properties**

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The nanoparticles used in food interact with biomolecules such as proteins. The interaction of protein and nanoparticles influences the functional and nutritional properties of the proteins. Hence, an in-depth understanding of the mechanism of their interactions becomes critical in addressing the safety of nanomaterials. Food grade and non-food grade particles of silica and titanium (nano- and micro-sized) were interacted with proteins of relevance to digestion and nutrition. Milk proteins such as α-casein, β-casein, α-lactalbumin, β-lactoglobulin, and bovine serum albumin and enzymes such as trypsin, chymotrypsin, pepsin, protease, and lysozyme were studied for their fate after interacting with particles. The changes in the structure and function of proteins when interacted with nanoparticles were studied using spectroscopic, and biochemical assays. Among the particles tested, nanoparticles showed higher interactions with proteins in comparison to micron-scale particles. Silica particles had a higher binding capacity than titania nanoparticles. The secondary structure proteins changed after interacting with nanoparticles which decreased the digestibility of proteins. The protein-particle interaction was not only determined by the physicochemical properties of particles but also the properties of proteins such as isoelectric point, hydrophobicity, and type of amino acid residues. From the above results, it is observed that food grade nanoparticles have a higher binding affinity of proteins with potential negative influence on their nutritional and functional properties.

**MP322 LCA a proposal of public policies of incentives based on a case study**

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Every day, society uses and consumes natural resources, expression of a linear vision that leads to the depletion of natural resources, the generation of large amounts of waste, which lead to various problems such as soil, water and air pollution, saturation of disposal sites and waste of resources due to the bad treatment or disposal of these materials. In Argentina, the regulatory framework has a negative impact on the reuse and recirculation of waste. In order to know the causes that generate this problem, a research was developed, based on the inductive method, (from the singular to the general), taking as a case of study a plant of the sanitary ceramics industry, where the generation and the use of waste, public policies, industry incentives, life cycle analysis and circular economy in the territory were analyzed. From the vision proposed by a circular economy process, different opportunities arose for the recirculation of waste, which imply important economic benefits for the company and save unused raw material. The implementation of a management system for the developed practices is conducted through the elaboration of procedures and protocols with normative support. The approach establishes a relationship between three different actors that coincide in the territory, the university, the industry and the municipality, for the use and management of waste, cost reduction, operational benefits, waste reduction for final disposal, and decrease in the consumption of raw materials also related to a lower exploitation of ecosystems to obtain them. Other actors participate with different complementary functions such as financial support, adaptation of infrastructure and strategic knowledge. Distributed benefits are identified on a multiplicity of actors, better waste collection in the territory, cyt - industry, cyt state. From the correct execution of this project, it can be expected that the results will be positive in several aspects, such as the optimization of the economic resources of the industries, a better management of natural resources, which is manifested in a reduction of the waste generated that go towards the sanitary landfill, added to the activities proposed in this work, which bring together different specific results which depends on actors involved.

**MP323 Development of Life Cycle Assessment (LCA) Framework by Incorporating the Point and Nonpoint Sources of Microplastics**

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Aquatic environments are contaminated with microplastic (MP) generated from anthropogenic activities. MP contaminants associated with plastic product life cycles create ecological impacts on aquatic organisms and health risks on human. Lack of solid framework and having plenty of knowledge gaps limits the incorporation of aquatic plastic into plastic product life cycles assessments. MP contaminating aquatic environments mainly divided into point sources and nonpoint (or diffused) sources considering the input location from land to water. Point sources are mainly wastewater treatment plants. Nonpoint sources are distributed over large area of land (such as cities and MP landfills) and difficult to locate the exact contamination point. This study focuses on the point and nonpoint MP contaminants in Japan and Thailand. Between 21 and 42% of global plastic waste is stored in landfills and reached water bodies through leaching. Especially in Asian developing countries, a major contributor of global MP the landfills is spread over the watersheds. In developed countries significant amount of MP are gone through wastewater treatment
Concentration predictions based on ocean numerical models have reported global temporal and spatial distributions of MP. The input to the models was based on the coastal coordinate based grid cells. The MP input quantities were estimated based on the mismanaged plastic wastes, gross domestic product, and future plastic waste in a specific region. However, in this study, we consider the inland point source and non-point source contributions and the stream flow impact using hydrologic models to estimate the MP flow into the ocean (the input into the ocean numerical models). Then a sensitivity analysis was carried out to find the importance of considering point sources, nonpoint sources and the application of hydrologic model for stream pollutant load carrying to the ocean. Considering the MP concentration variations in water, the potential effects related to ecotoxicity and effect on greenhouse gas emissions are discussed with the point of view of incorporating it to the Lifecycle Impact Assessment (LCIA). While the study focus on Asia region, the outcome of the study is applicable for the development of global framework to incorporate MP into LCA.

**MP324 Towards a consequential LCA of the future energy-transport nexus, with special focus on the role of lithium-ion batteries and their recycling**

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Modern societies are currently on the verge of two major interdependent transitions: a steady shift from fossil fuels to renewables as primary energy sources for electricity production, and a gradual replacement of internal combustion engines by electric power trains for transport (including growth in transportation-as-a-service, or TaaS). The increasing penetration of renewable, but inherently intermittent and hence non-dispatchable, energy sources in the grid mix will eventually require various degrees of grid-level energy storage. Lithium-ion batteries (LIBs) are a comparatively mature and reliable technology that can be easily scaled up to meet the requirements posed by grid balancing and buffering. At the same time, LIBs are also key to the growth of the Electric Vehicle (EV) sector, and the combined booming demand for Li, Co, Mn and Ni may pose challenges in terms of raw material availability and raise concerns about the associated ecological toxicity in mining. However, a widespread adoption of EVs would also lead to a corresponding availability of decommissioned battery packs, which opens the path to two potentially effective strategies: the second-life usage of LIBs in grid-connected stationary storage applications, and, eventually, the widespread adoption of LIB recycling schemes, enabling a large throughput of recovered metals to actively reduce the demand for the corresponding virgin raw resources. Our research aims to capture the complex interplay of all these factors by means of a high-level consequential life cycle assessment (CLCA), which sees the co-evolution of LIBs and their recycling as a vital cornerstone to enable both transitions to unfold. We present here a first, thorough attributional LCA (ALCA) of the primary Li, Co, Mn and Ni supply chains, intended as benchmarks against which to gauge the per-functional-unit environmental benefits of recycling, as well as the general layout of the CLCA work that is planned for the next two years.
Endocrine Disruptors, CECs and Agriculture in Developing Countries: The Nexus Bridging Environmental and Human Health

**TP001 Development of a screening method for TR disrupting chemicals by receptor-mimic chromatography**

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The MIPs showed higher selective retention ability only for TR-active chemicals and other non-active chemicals were rapidly passed through the column. By tuning the LC conditions, the TR-active and non-active chemicals were completely separated from the mixture sample. As results, the newly developed concept will be useful for the screening method of determination of receptor-active compounds. As TR-active chemicals, we employed Triiodothyronine, T3 and Thyroxine, T4. The MIPs were designed and prepared with acetylT4 as a template and 4-vinyl pyridine as a functional monomer. The prepared MIPs were packed into a column and evaluated by LC. In this study, we aim to prepare the adsorbents for thyroid hormone receptor (TR) active compounds, which are paid attention to influences as endocrine disrupting chemicals especially for children. According to the previous studies concerning of binding mechanism to TR, we prepared new molecularly imprinted polymers (MIPs) for the stationary phase in liquid chromatography (LC). We previously reported an estrogen-receptor (ER) mimic adsorbent and a screening of ER active compounds from the environmental water samples. The concept is an applicable procedure for certain receptor-active compounds. To clarify the possibility for use the concept, further appropriate evaluations are needed by the precise design based on molecular recognition mechanism on receptors, and then we can achieve the signals toward the strength of binding to receptors.

**TP002 In vitro assessments of endocrine disruptions of environmental contaminants via diverse receptors of the largemouth bass and the lake sturgeon**

S. Kohno, H.I. Schoenfuss, St. Cloud State University / Aquatic Toxicology Laboratory

Contaminants of emerging concerns have ubiquitously contaminated with both aquatic and terrestrial environments, and their biological effects are problematic in investigations at both field and laboratory. Especially, it is important to evaluate their long-term effects such as non-lethal endocrine problems to assess endocrine activities via nuclear hormone receptors (NRs) in vitro. Moreover, it is important to evaluate the effects of contaminant mixtures via co-existing receptors, since neither contaminant nor receptor exists alone. Here, we report developing NR trans-activation assay in vitro in the largemouth bass (LMB) and the lake sturgeon (LSG) as a model of estrogen receptor subtypes and different NRs, respectively. We characterized three isotypes of the nuclear estrogen receptors (Esr1, 2a, and 2b) using ESR-selective ligands for amniotes. The endogenous estrogen [17β-Estradiol (E2)] and ESR2-selective ligands (DPN and WAY200070) activated the transcriptions via LMB Esr1, whereas ESR1-selective ligand (PPT) did not activate LMB Esr1. All tested ligands activated the transcriptions via both LMB Esr1, 2a and 2b with a difference in the efficacy. These results suggested the importance of Esr subtypes to assess the estrogenicity of environmental samples. Indeed, the estrogenicity of surface water collected from the Maumee River showed a significant difference among LMB Esr subtypes. We also analyzed three NRs, androgen receptor (andr), esr1 and thyroid hormone receptor β (thrb) mRNA in LSG. Gonadal andr mRNA abundance was highest in tested 24 LSG tissues, while esr1 mRNA was higher in gonad and brain inferior lobe than other tissues in LSG. Cerebrum, eye, olfactory bulb, and inferior lobe expressed thrb mRNA more than other tissues of LSG. We revealed distinct tissue distributions of andr, esr1 and thrb mRNA in gonad and inferior lobe from other tissues in LSG. A proportion of these mRNA (andr: esr1: thrb) was 31:68:1 in gonad and 45:32:23 in the inferior lobe of LSG. To assess tissue-specific adverse effects, we will test the trans-activations of contaminants with mimicking these mRNA expression profiles in LSG in vitro. Results with a diversity of receptors and species and mimicking tissue in vitro provide a novel insight in risk and hazardous assessments of contaminants.

**TP003 Long and Short-Term Effects of Nitrate on Fathead Minnow (Pimephales promelas) Embryos and Juveniles**


Nitrate is a ubiquitous global aquatic pollutant, derived from fertilizers, manure, sewage, and industrial processes. Over the past ten years, nitrate has also been shown to be an endocrine disruptor that influences multiple endocrine pathways, including the hypothalamic-pituitary-gonadal axis, thyroid hormone regulation, and glucose regulation and metabolism. However, the outcomes of nitrate exposure can be highly variable, with nitrate being pathway-inductive in some scenario and repressive in others. A recent review of the literature indicated that maturational status and dose/duration of exposure may explain some of the outcome variation. Therefore, we tested the effects of environmentally-relevant nitrate (0, 2, 5, 10, 25, 100 mg/L NO3-N) on fathead minnow juveniles using long-term (2 months) and short-term (4 days) aquatic exposures. We also tested the effects of a wide range of doses (0, 0.08, 0.5, 1, 2, 3, 5, 8, 10, 12, 15, 20, 30, 50, 75, 100, 200, 500 mg/L NO3-N) on fathead minnow embryo development, hatching, and early larval growth. Here, we report effects of nitrate on growth, hormone concentrations (estradiol 17β, testosterone, 11-ketotestosterone, insulin), plasma glucose, and gene expression in juveniles, and mortality, developmental defects, hatching rate, growth, heart rate, and thyroxine concentrations in larvae exposed from fertilization through 16 days post fertilization. These experiments are part of a larger effort to develop coherent nitrate dose-response curves for fathead minnows exposed to nitrate.

**TP004 Occurrence of Growth Promoters in Beef Cattle Operations and their Transport in Runoff from Associated Environments**

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Occurrence of the synthetic hormones trenbolone acetate (TBA) and melengestrol acetate (MGA), TBA metabolites 17α-trenbolone (TB), 17β-TB and trenbolone, and beta-adrenergic agonist ractopamine (RAC) were assessed during a 220-day feeding trial. Pen floor manure (feces mixed with pen floor material) was subsequently used in a simulated rainfall experiment to assess the potential transport of these compounds in pen surface runoff. In cattle, TBA is metabolized and excreted primarily as 17α-TB (major) and 17β-TB (minor). Concentrations of the two metabolites measured up to 140 and 15 ng/g in feces and up to 50 and 5 ng/g in manure, respectively. MGA concentrations ranged from ≈10–40 ng/g in feces and manure. TBA and trenbolone were not detected. RAC, administered at high concentrations as a feed additive during the finishing stage before slaughter, was found at levels ranging from 1000–5000 ng/g. A portable rainfall simulator was used to apply water to a 1m2 area within each pen over 20-min rainfall periods. Runoff concentrations of MGA, 17α-TB, 17β-TB, and RAC ranged from 0.8-2.5, 2.0-7.5, 0.1-1.1, and 22-80 ng/L, corresponding to cumulative mass transport of 25, 66, 20, and 700 ng. Groundwater was collected from wells in feedlot alleys during the
Aquatic Toxicity Testing of “Difficult-to-Test” Substances - Meeting the Multi-Faceted Challenge

TP005 Dynamic Changes of Thallium Speciation and Toxicity to Freshwater Algae: Influences of Dissolved Organic Matter
K. Tsai, P. Chen, National Taiwan University / Department of Agricultural Chemistry

Thallium (Tl) is a trace metal widely used as a technology-critical element (TCE) in high technology industry nowadays. Due to its high toxicity to aquatic creatures, it is on the list of USEPA priority pollutants. Dissolved organic matter (DOM) is an important natural matrix in waters affecting metal species and toxicity. Although toxicities of monovalent and trivalent thallium (Tl⁺ and Tl³⁺) to freshwater algae have been investigated, their toxicities remain unclear in the presence of DOM. Besides, given the fact of fast and spontaneous reduction of Tl³⁺ to Tl⁺ (occurs within few hours), it is challenging to elucidate Tl³⁺ toxicity by long-term exposures (>= 72 h) in previous studies. In the present study, we will conduct flow cytometry-based algal bioassays for assessing acute (1-24 h) toxicities of Tl³⁺ and Tl⁺ to Microcystis aeruginosa and Pseudokirchneriella subcapitata in the presence of humic and fulvic acids (HA and FA) in culture medium. Time-course changes of thallium speciation will be monitored and analyzed by the high performance liquid chromatography-inductively coupled plasma-mass spectrometry. The toxicity endpoints including enzyme activity, reactive oxygen species, membrane permeability and potential will be evaluated using appropriate dyes. To characterize the binding of thallium and DOM, the spectra of Fourier transform infrared will also be obtained. The results of this study will provide insightful understanding in the toxicities of Tl³⁺ and Tl⁺ to freshwater algae, particularly with the presence of natural organic matters. The obtained information is also essential on the establishment of regulatory guideline to prevent TCEs contamination in aquatic ecosystems.

TP006 Determination of Persistent Organic Pollutants in Fish Tissues by Accelerated Solvent Extraction and GC-MS/MS
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Polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs) and polychlorinated diphenyl ethers (PBDEs) belong to a broad family of synthetic organic compounds known as halogenated hydrocarbons. The capacity of the halogenated hydrocarbons to bioaccumulate in fatty tissues and biomagnify up the food chain, in combination with their resistance to degradation and their toxicity, make this class of chemicals a serious threat to environmental and human health. Techniques such as Soxhlet and sonication are used for the extraction of halogenated hydrocarbons from food and environmental samples prior to their analytical determination. These techniques are, however, very labor intensive and suffer from high solvent consumption. Accelerated solvent extraction was developed to meet the new requirements of increased throughput and reduced solvent usage in sample preparation. With accelerated solvent extraction, extractions can be completed in very short periods of time and with minimal solvent as compared to conventional sample extraction techniques such as Soxhlet and sonication. Furthermore, interferences may be extracted along with desired analytes during those conventional extraction processes. These unwanted co-extractables can cause build up of nonvolatile materials on the GC injection port and the analytical column resulting in poor analytical results and high instrument maintenance costs. Additionally, challenges remain with high lipid content in which lipophilic pesticides may remain in the fatty layer even after the extraction. Recent advances using accelerated solvent extraction systems, as described in several publications, 1-19 include procedures for selective removal of interferences during sample extraction, thus combining extraction and purification into a single step. The method reported here is applicable for the determination of 29 halogenated hydrocarbons (6 PCBs, 16 OCPs, and 7 PBDEs) in fish tissues. The concentration ranges are 1-100 ng/g for PCBs, 0.5-10 ng/g for PBDEs, and 5-1000 ng/g for OCs.

TP007 The Challenges of Testing a Stereoisomeric Molecule in Support of an Ecological Risk Assessment of an Agrochemical
T. Carro, FMC Agricultural Solutions / Environmental Safety Assessment; J. Stry, J. Malin, L. Kong, FMC Agricultural Solutions

Stereoisomers are molecules that have the same molecular formula and bonded atoms sequence, while differing only in the 3D spatial arrangement of two or more atoms. In the agrochemical industry, a number of registered products and new development compounds contain stereogenic centers in their molecular structure. Ecotoxicity testing for the registration of pesticides requires an assessment of risk to non-target organisms through exposure in multiple matrices (e.g. exposures through diet, water, soil, etc.). When difficult-to-test substances such as stereoisomers are considered for registration, careful review of the proposed study designs are needed to develop a submission package that demonstrates acceptable risk to non-target organisms in the environment. The objective of this project is to develop a science-based approach for risk evaluation of stereoisomers while considering the following principles: 1) minimize, when reasonably possible, additional animal testing with stereoisomers; 2) acknowledge that when stereoisomers are present in an ecotoxicological matrix, they are inherently tested as part of the required regulatory study with the active substance; 3) consider experimental designs and models that thoroughly test stereoisomers without the need to conduct chiral synthesis and/or purifications. Through this project, study design challenges in ecotoxicology are identified, with a focus on issues that arise in specific matrices in routine laboratory study designs. Compound specific physical and chemical properties and behaviors in environmental fate studies are used to develop specific testing procedures with stereoisomeric agrochemicals. Further, a proposal for a tiered approach to the ecological risk evaluation of stereoisomers is introduced to demonstrate a strategy that can be implemented to support acceptable risk to non-target organisms in the environment.

Unraveling Complexity: Characterizing the Toxicity and Risk of Chemical Mixtures in the Environment

TP008 Can we predict synergic effect of chemicals to daphnids based on current knowledge of chemical mechanism of action?
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Even though studies on mixture toxicity of chemicals to aquatic organisms has been increasing in recent years, there is no general answer yet on which chemical combinations might have more than additive toxicity in the environment. Among an infinite number of chemical combinations, one approach is combining substances according to their chemical mechanism of action. Here we investigated several binary mixtures of chemicals using a daphnid (Ceriodaphnia dubia) reproduction test. As chemicals with similar mechanism of action, heavy metals (Cu-Cd, Zn-Cd) and organophosphate insecticide (EPN-BPMC) were expected to follow concentration addition (CA) model, respectively; however, Cu-Cd and EPN-BPMC mixtures demonstrated more than additive toxicity based on isobolograms at 25% and 50% reproduction inhibition. Contraindication drug information also provides possible combination with synergic toxicity. An analgesic antipyretic, acetaminophen and...
antibiotic oxytetracycline were expected to show synergistic effects, but they followed CA model in daphnid reproduction. Antibiotic sulfamethoxazole was co-exposed with trimethoprim, which inhibits tetrahydrofolic synthesis pathway as well as sulfamethoxazole and possibly induce synergistic effects; however, isobolograms indicated less than additive toxicity. Based on chemical metabolism, toxicity of target chemical increases when its metabolizing enzyme is inhibited by other chemical. Polycyclic aromatic hydrocarbons (PAHs) are metabolized by CYP1A1 in vertebrate species, so co-exposure with CYP1A1 inhibitor, α-naphthoflavone (ANF) was expected to cause more than additive toxicity. However, pyrene-ANF and phenanthrene-ANF mixtures demonstrated additive and less-than additive toxicity, respectively. Similarly, isobole exposure of CYP2C9 target drug, ibuprofen and CYP2C9 inhibitor, sulfamethoxazole caused offset effect contrary to our expectation. Present study suggests that mixture toxicity prediction for daphnids based on general knowledge of chemical mechanism of action and metabolism pathway did not work well since most of the accumulative knowledge has been established for vertebrate species. Further understanding of chemical mechanism of action and metabolism pathway in the daphnids will be needed to obtain further insight into the question on which chemicals mixtures might cause synergic effect in the environment.

TP009 Determining the pre-impact biological condition of lakes influenced by a mixture of legacy mining contaminants near Yellowknife, NT

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Natural resource extraction has supported the development of Canada’s far north, but in some cases, has also resulted in environmental contamination at a regional scale. Ore processing techniques used at mining operations in Yellowknife are responsible for the atmospheric release of approximately 20 000 tonnes of particulate arsenic trioxide, alongside a mixture of other heavy metal(loid)s. There is evidence that the rapid deposition of heavy metals in the surrounding area has caused ecological disturbances to aquatic food webs. This study examines lake sediment cores from 20 lakes within a 40 km radius of Yellowknife. Sediments were dated by 210Pb, 137Cs, and 226Ra, and the risk of a mixture of heavy metal(loids) to aquatic biota was assessed using emerging methods in palaeotoxicty. We found that sedimentary metal(loids) profiles show a peak in contaminant concentration during the height of mining operations, which decreases with distance from the city. Spatio-temporal analysis of lake sediments closest and downwind to the mine showed evidence that geogenic metal(loids) concentrations posed a risk to aquatic biota prior to the onset of mining operations. This risk increased substantially during the operation of gold mines in the region. Recently, the risk of some lakes has decreased. There is a notable positive trajectory towards recovery in the region, however our results indicate that aquatic ecosystems in Yellowknife continue to show lingering risk to aquatic biota despite termination of mining activities almost two decades earlier. <b>TP009</b>

TP010 Reducing Sample Preparation for Fine Particulate Matter Toxicology Studies: Re-suspension Solvent Selection

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The underlying mechanisms of the well-established health effects from particulate matter exposures have yet to be discovered. Implementation of a model to study the mechanisms that is amenable to high-throughput screening (HTS) is essential due to the variability in human exposures. Zebrafish have been established for HTS as well as for research into particulate matter through developmental exposures. Here we explored various media for re-suspension of particulate matter in zebrafish exposures and assessed the compositional variability in particulate matter based on the re-suspension media used. The particulate matter, standard reference material 1649b (SRM1649b), selected was re-suspended into either DMSO, acetone, or methanol with both whole particle suspensions and the soluble fractions prepared. An aliquot of each preparation was used for chemical analysis of polycyclic aromatic hydrocarbons (PAHs, n=118) using GC-MS. A range of concentrations (0-200 μg/mL) of SRM1649b were tested in 5 day developmental exposures in zebrafish and mortality and morphological/behavioral changes were determined (n=32/treatment). Significant differences were observed between re-suspension solvents in the concentrations of individual compounds and classes of PAHs, with over two-fold differences in total PAH concentrations. Differences between the re-suspension solvents were also observed in behavioral and morphological changes in zebrafish at 5 days post fertilization. This work details the importance of vehicle selection when conducting particulate matter exposures and identifies the potential to select a vehicle that is amenable to both toxicity studies as well as for the initial extraction of particulate matter from a filter, reducing sample preparation and potential chemical losses.

TP011 The Effects of 17α-Ethinylestradiol (EE2) and Hydroxypropyl-β-Cyclodextrin (HPβCD) on the Heart Rate of Embryonic Japanese Medaka (Oryzias latipes)

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Estrogen toxicity has been an area of priority in aquatic toxicology over the last 20 years. Recent evidence has indicated that a rapid, non-genomic, non-classical estrogen signaling pathway exists via the G protein coupled estrogen receptor (GPER). GPER is expressed in many biological systems, with roles in the cardiovascular system and metabolic pathways. The primary objective of this research was to investigate the effect of 17α-ethinylestradiol (EE2) on the heart rate of embryonic Japanese medaka (Oryzias latipes). A 5–20 % decrease in embryonic heart rate was observed in 120 and 144 hour post fertilization medaka embryos exposed to 0.1 ng/L, 1 ng/L, 10 ng/L, 100 ng/L, and 1000 ng/L EE2 (P≤0.05). This effect was attributed to the activation of GPER through the use of GPER and ERα and ERβ agonists and antagonist, highlighting a novel mode of action for EE2 toxicity. The secondary objective was to determine if the presence of the odour suppressant, hydroxypropyl-β-cyclodextrin (HPβCD), could alter the toxicity of EE2. HPβCD is an amphiphilic toroidal compound that can bind non-polar compounds such as fragrances and pharmaceuticals within a central cavity. The combination of EE2 and HPβCD in a 1:4 molar ratio (EE2:HPβCD) resulted in an embryonic heart rate that was significantly greater than EE2 alone at 120 and 144 hours post fertilization (P<0.05). EE2:HPβCD was also not significantly different from the control at 144 hours post fertilization, indicating that HPβCD reduced the effect of EE2 on embryonic heart rate (P>0.05). This research suggests that EE2 can cause a decrease in the heart rate of embryonic Japanese medaka through GPER activation, non-classical estrogen signaling, and this effect can be reduced by the presence of HPβCD.

Approaches for Understanding Diversity in Species Sensitivity to Chemicals

TP012 Standard Species Sensitivity Test on Species with Different Reproductive Strategies

L.M. Jackson, University of Cincinnati / Biology

Fish models are commonly used as indicator and test species contamination in aquatic environments. Although most model fish species are representative of many of the different fish species in the wild, there are still many species that remain underrepresented or unrepresented in environmental toxicology studies. This study aims to use varying reproductive strategies as the determining factor for conducting species sensitivity toxicity tests at different life stages. A comparison of sensitivities of Danio rerio, Pimephales promelas, Gambusia affinis,
and *Heterandria formosa* to the standard reference toxicants of NaCl, KCl, and CuSO4. Twenty-four-hour old fish and larve will be exposed to different concentrations of the reference toxicants as determined by LC50. Details of ongoing experiments and results will be presented at the SETAC National Meeting in Toronto, Canada.

**TP013** The verification of a benthic injury dose-response model for polychlorinated biphenyls

_E. Wirth_, NOAA / OR&R/ARD; _C. Rios_, New York University; _B.S. Shaddrix_, CSS, Inc. / NOAA / National Centers for Coastal Ocean Science; _P.L. Pennington_, NOAA / Office of Response and Restoration; _K. Finkelstein_, NOAA

While industrial inputs of polychlorinated biphenyls (PCBs) have long since ceased, environmental contamination related to PCBs is a continuing issue in coastal ecosystems. PCBs are hydrophobic and accumulate to high levels in sediments. In risk assessment, it is critical that an assessment of injury is measurable, but often these estimates are difficult to determine for benthic organisms. To better understand and predict these injuries, Finkelstein et al. (2017) developed a PCB dose-response benthic injury model based on historical laboratory toxicity data and equilibrium partitioning theory. The objective of this study was to assess whether the model would be appropriate for use in assessing damage to natural resources from exposure to PCBs. New acute aqueous toxicity data were generated and model response was compared. This research will address the application of this benthic injury model across multiple Arcorol mixtures using the same testing conditions and estuarine species. A series of acute, aqueous exposures of PCBs to the grass shrimp *Palaemonetes pugio*, the mysid *Americana bahia*, and the amphipod *Leptochirus plumulosus* will be conducted. It is expected that the validity of this model will be confirmed and that additional comparative toxicity data will decrease the predicted variability associated with using a compilation of literature values.

**TP014** Impact of salinity on the fitness of *Hyalella azteca*

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Global climate change continues to cause alterations in environmental stressors, such as changes in salinity, which are detrimental to aquatic ecosystem health. Furthermore, changes in temperatures and salinity may act synergistically with anthropogenic pollutants and exacerbate pre-existing threats to aquatic biota. This research aims to provide a robust assessment of the effects of the alterations in salinity on the fitness of the epibenthic amphipod *Hyalella azteca*. Full-life cycle bioassays have been conducted with *H. azteca* cultured under three different salinity conditions representing a gradient from freshwater control (0.2 ppt) to increased salinity due to salt-water intrusion (6.0 ppt). A two-fold reduction in the number of offspring produced was recorded in elevated salinity groups relative to control groups, suggesting *H. azteca* reproductive capacity may be diminished in future climate scenarios. Offspring of *H. azteca* cultured under elevated salinities were significantly larger than those from control groups, suggesting a life history modification towards the production of fewer, larger offspring as predicted by life-history theory. Conversely, the analysis of lipid content of *H. azteca* demonstrated no clear effect of salinity owing to high inter-individual variability. This study provides fundamental information about the fitness potential of *H. azteca* in a changing climate. In addition, this study further supports the need to consider the effects of global climate change when conducting risk assessment of contaminants of concern.

**TP015** Combining Omics Technologies and Environmental Epigenetics to Assess The Effects of Harmful Cyanobacteria on Japanese Medaka

_C. Goncalves Athanasio_, Ontario Tech University / Biosciences; _C. Flaherty_, Ontario Tech University; _D. Simmons_, Ontario Tech University / Faculty of Science

Harmful algal blooms (HABs) cause negative impacts on aquatic ecosystems and significant economic losses. HABs occur when populations of algae and cyanobacteria grow too fast, and can produce toxins that threaten drinking water sources, affect aquatic organisms, and the decomposition of the bloom can lead to hypoxic conditions. However, the specific mechanisms behind the toxic effects of harmful algae on fish remain unclear. In addition, little information is known about the potential long-term effects of biological toxins on the health of aquatic animals or on public health. Omics technologies, including proteomics and metabolomics, allow a global view of the molecular processes occurring in an individual, and a better understanding of the complex molecular mechanisms involved in aquatic organisms’ response to environmental pollutants. The analyses of epigenetic modifications combined to omics technologies would open novel possibilities to understand the complexity of the effects and to examine the historical exposure of an organism. Therefore, the goal of this study is to assess the impacts of HABs exposure on fish development and health using a combination of ‘omics and epigenetic approaches. We aim to assess the windows of susceptibility and the long-term effects by performing life cycle assays with the Japanese medaka (*Oryzias latipes*). Information about the effects of HABs on early life stages and physiological development in fish will inform decision makers, allowing them to create policy that will have positive consequences, and help to prevent deleterious effects on freshwater ecosystems.

**TP016** Transgenerational impacts of crude oil exposure on genome-wide gene expression in developing Gulf killifish embryos

_J. Park_, University of California, Davis / Environmental Toxicology; _C.D. Hess_, C.A. Brown, Louisiana State University / Department of Biological Sciences; _F. Galvez_, Louisiana State University / Dept of Biological Sciences; _A. Whitehead_, University of California, Davis / Environmental Toxicology

Growing research demonstrates that biological impacts of environmental toxicants can persist across several generations. One of the toxicants of concern is crude oil, which can originate from natural and anthropogenic causes, and can impact large geographic areas, and affect diverse species in sensitive habitats. Much research has sought to reveal impacts of oil exposure on development and physiology, including its underlying mechanisms. In contrast, relatively little is known of the biological impacts of oil exposure that persist across one or more generations. We characterized the developmental and transgenerational impacts of laboratory weathered crude oil exposure in Gulf killifish (*Fundulus grandis*) using transcriptomic and physiological endpoints. After exposing adult killifish to weathered crude oil and control conditions, we tested whether F1 and F2 descendants of exposed animals had altered gene expression and sensitivity to oil toxicity during embryogenesis. We found that parental oil exposure disrupted developmental gene expression patterns in offspring across multiple generations, and we identified molecular responses that are potentially involved in persistent transgenerational impacts of crude oil exposure.
Emerging Landscape for Toxicity Testing: WET Method Challenges and Refinements to Applied In Vitro Assays for Effluents

TP017 Reducing Acutely Toxic Effluent: Effectiveness of Environmental Monitoring and Compliance Regulations in Ontario
L. Kennedy, Ontario Ministry of the Environment, Conservation and Parks / Aquatic Toxicology Unit; T. Watson-Leung, Ministry of the Environment, Conservation and Parks / Aquatic Toxicology Unit; D.G. Poirier, Ontario Ministry of the Environment, Conservation, and Parks

It was not that long ago that over half of the water being released into the natural environment from many companies in Ontario, Canada would kill organisms exposed to it within a matter of hours or days. In 1987 the provincial government identified the need to control the discharge of toxic and persistent compounds and the Municipal/Industrial Strategy for Abatement (MISA) was implemented. The stated goal was to “stop pollution at its source.” Initially the program was comprised of comprehensive physical, chemical and toxicological monitoring of all discharges (process and cooling water) from almost 200 companies, representing 9 different industrial sectors. After analyzing data from thousands of samples and assisting the industries with identifying “best available technologies economically achievable” (BATEA) for removing toxicants from the effluent streams, the Ministry promulgated a series of Effluent Monitoring/ Effluent Limits Regulations under the Environmental Protection Act, 1990. The MISA program was instrumental in the significant reduction in acutely toxic discharges across all industrial sectors. Testing completed between 1989 and 1991 indicated that as many as 41% of all discharges caused acutely toxic effects. By 2015, this number had declined to 2%. However, the chronic monitoring data indicates that there is still potential for ecological harm. Some industrial sectors are still seeing almost 65% of their effluent samples causing reduced growth or reproduction in exposed organisms when compared to laboratory controls. This poster presents the industry specific acute and chronic toxicity data for over 26,000 samples collected over the past 30 years.

TP018 The Evaluation of Acute and Chronic Effluent Toxity and Permit Compliance Based on Endpoint Selection

Whole effluent toxicity (WET) testing is required for facilities in the United States which discharge treated wastewaters directly to surface waters as a requirement within the Natural Pollutant Discharge Elimination System permit. Both acute and/or chronic toxicity testing with aquatic organisms may be a requirement to determine if the wastewater discharge has the potential to cause an impact on the receiving waterbody. Current test methodologies have been developed and promulgated by a variety of regulatory and stakeholder organizations. Within the United States the specific requirements that result in a test meeting the facilities permit criteria vary from state to state. The most common endpoints utilized for permit compliance include the No Observed Effect Concentration (NOEC), Lowest Observed Effect Concentration (LOEC), median lethal concentration (LC50), and the 25 Percent Inhibition Concentration (IC25) which are generated from hypothesis testing. Additionally, some states have proposed to adopt USEPA’s Test of Significant Toxicity (TST), which evaluates the toxicity of a sample at a single effluent concentration. This review summarizes and discusses multiple case studies where the toxicity of the effluent samples was evaluated using all of the applicable test endpoints.

TP019 Evaluation of state-specific whole effluent toxicity testing implementation guidance and policy to improve whole effluent toxicity testing methods
N. Love, GEI Consultants, Inc.; S. Skigen-Caird, GEI Consultants, Inc. / Ecology; S. Pargee, GEI Consultants, Inc. / Ecological Division

Whole effluent toxicity (WET) testing methods are highly prescriptive when it comes to certain requirements such as test acceptability criteria and test conditions to control test variability and maintain consistency between tests and laboratories. However, there are some areas where WET methods are less prescriptive such as allowing options for different dilution water use, leaving decisions up to the regulatory authority to implement on a statewide-level or permit-by-permit basis. By allowing states flexibility, better decisions can be made to accommodate site-specific conditions that may require modified WET testing conditions. Even with the allowance for flexibility, there are some states who have not specified requirements in guidance or policy, leaving labs and dischargers to interpret the WET methods which can result in variability in WET test outcome. This lack of specific guidance can also lead to inconsistencies in interpretation of results, depending on the individual regulator reviewing the data. This analysis will focus on the different WET guidance and policy documents for a variety of states to evaluate areas where consistency exists, and where it does not or could benefit from enhanced clarity. By better understanding the differences in WET implementation across the country, WET methods could be improved by adding detail to WET method requirements.

TP020 A Whole Effluent Toxicity Conceptual Model - Applications to Causes of Toxicity, Ambient Conditions, and Method Refinements

Publicly-owned treatment works (POTWs) in the United States are required, through the National Pollutant Discharge Elimination System Program, to conduct periodic chronic whole effluent toxicity (WET) testing to determine if discharged effluent would impact aquatic life beneficial uses of the receiving water. As treatment levels and management practices have improved, observations of toxicity to organism survival has largely been replaced by intermittent and low magnitude effects to sublethal test endpoints (e.g., reproduction, growth). Given this trend over time, and in an effort to better focus POTW and regulatory resources on the reasonable protection of beneficial uses in the receiving water, the Central Valley Clean Water Association funded a comprehensive study of toxicity testing data from 66 POTWs in California from January 2011 through March 2017. The study characterized the frequency and magnitude of chronic toxicity, the efficacy of toxicity reduction/toxicity identification evaluations, documentation of potential sources of variability in sublethal test endpoints (e.g., reproduction, growth). This trend over time, and in an effort to better focus POTW and regulatory resources on the reasonable protection of beneficial uses in the receiving water, the Central Valley Clean Water Association funded a comprehensive study of toxicity testing data from 66 POTWs in California from January 2011 through March 2017. The study characterized the frequency and magnitude of chronic toxicity, the efficacy of toxicity reduction/toxicity identification evaluations, documentation of potential sources of variability in sublethal test endpoints (e.g., reproduction, growth). Given this trend over time, and in an effort to better focus POTW and regulatory resources on the reasonable protection of beneficial uses in the receiving water, the Central Valley Clean Water Association funded a comprehensive study of toxicity testing data from 66 POTWs in California from January 2011 through March 2017. The study characterized the frequency and magnitude of chronic toxicity, the efficacy of toxicity reduction/toxicity identification evaluations, documentation of potential sources of variability in sublethal test endpoints (e.g., reproduction, growth). Given this trend over time, and in an effort to better focus POTW and regulatory resources on the reasonable protection of beneficial uses in the receiving water, the Central Valley Clean Water Association funded a comprehensive study of toxicity testing data from 66 POTWs in California from January 2011 through March 2017. The study characterized the frequency and magnitude of chronic toxicity, the efficacy of toxicity reduction/toxicity identification evaluations, documentation of potential sources of variability in sublethal test endpoints (e.g., reproduction, growth). Given this trend over time, and in an effort to better focus POTW and regulatory resources on the reasonable protection of beneficial uses in the receiving water, the Central Valley Clean Water Association funded a comprehensive study of toxicity testing data from 66 POTWs in California from January 2011 through March 2017. The study characterized the frequency and magnitude of chronic toxicity, the efficacy of toxicity reduction/toxicity identificat...
TP021 Application of Treatment to Minimize Pathogen Interference in Chronic Toxicity Testing with Ceriodaphnia dubia
B.C. Jorgenson, Pacific EcoRisk; N. Lynch, Pacific EcoRisk / Department of Chemistry; S.L. Clark, Pacific EcoRisk

The presence of pathogens contributing to chronic toxicity to Ceriodaphnia dubia/an efficient sample was investigated in this case study. A wastewater treatment plant effluent consistently demonstrated chronic toxicity to C. dubia/with an accompanying flat concentration response curve. An initial pathogen-focused toxicity identification evaluation (TIE) was performed. A single treatment was then selected for subsequent toxicity testing to be performed side-by-side with the baseline effluent treatment. The selected treatment successfully removed both toxicity and the flat concentration response curve.

TP022 LED light as an alternative to incandescent for Ceriodaphnia dubia culturing
J.L. Bouldin, Arkansas State University / Biological Sciences; R. Cooper, Arkansas State University

Incandescent light sales will be banned by 2020, so alternatives for use in culture organism light/dark cycles need to be investigated. Although they have a slightly higher up-front cost, LED lights last longer, are cheaper to operate over time, and produce less heat than incandescent lights, which is important for maintaining stable culture and test conditions. Over three distinct three-month periods, we tested for a difference in Ceriodaphnia dubia survival and fecundity, as well as neonate performance in reference toxicity tests (NaCl) from culture boards maintained with incandescent or LED lights with comparable light intensity. We compared survival, 14-d average total neonates, number of broods and days to third brood of 8 or more neonates, and number of days to first brood for culture boards. Endpoints for reference toxicity tests included NOEC, LOEC, and control group percent variation. We found no significant differences between any parameters tested, and conclude that LED lights at comparable light intensity are a viable alternative to incandescent for C. dubia cultures.

TP023 Impairment of the teleost stress response persists after weathered oil exposure
M.M. Alloy, M. Cartolano, R. Sundaram, A.X. Plotnikova, E.M. Milton, M. McDonald, RSMAS, University of Miami / Marine Biology and Ecology

Polycyclic aromatic hydrocarbons (PAHs) are a ubiquitous contaminant, closely associated with natural oil seeps, anthropogenic combustion, and oil spills. PAHs have been shown to impair the vertebrate stress response curve. That toadfish stimulated to elicit a stress response showed no significant impairment in mounting that response at the hypothalamic-pituitary level. However, these same individuals with elevated plasma ACTH levels showed significantly reduced plasma cortisol relative to controls. This cortisol response impairment remained after exposure had ceased long enough for CYP1A expression (a marker of PAH exposure) had reduced to levels not significantly different from controls. The amount of cholesterol in the liver and plasma will be determined.

TP024 Imaging of mitochondrial surface area and reactive oxygen species as a toxicity endpoint in the rainbow trout liver cells line, RTL-W1
O. Ulker, Ankara University / Department of Toxicology; J. Anadu, M. Minghetti, Oklahoma State University / Integrative Biology

Multiple endpoint cytotoxicity assays based on fluorescent dyes have been instrumental in advancing our knowledge of chemical mode of toxic action. For instance, Resazurin (the main active ingredient in the alamarBlue dye) has been shown to be a sensitive indirect indicator of cellular metabolic activity. In an attempt to find a more direct indicator of mitochondria toxicity, we have used a combination of commercially available dyes (MitoTracker and MitoSOX) to evaluate if cell imaging could be used as a sensitive toxicity endpoint. In addition, the dye H2DCFDA was used as an additional indicator of oxidative stress. To address this question the fish hepatic cell line RTL-W1 was exposed to AgNO3, CdCl2, azoxystrobin, and paraquat. Dose response curves were generated using a multiple endpoint cytotoxicity assay based on the dyes Alamar blue, CFDA-AM, and Neutral Red, which are indicators of metabolic activity, cell membrane and lysosomal integrity, respectively. Then, cells were exposed to the effective concentrations (EC) EC10, EC25, and EC50, and mitochondrial surface area was measured in cells stained with MitoTracker and MitoSOX. An automatic imaging reader was used to capture all images and measure the total mitochondrial surface area which was subsequently divided by the number of nuclei resulting in the average surface area per cell. Reactive oxygen species (ROS) were measured by fluorimetry in a parallel set of cells exposed to the same conditions but stained with H2DCFDA. RTL-W1 cells showed a reduced mitochondrial surface area after exposure to toxicants, however, the strongest effect was provoked by azoxystrobin, a known mitochondria inhibitor. The H2DCFDA ROS assay proved to be an appropriate tool to detect ROS formation as shown by the H2O2positive control results, which were significantly greater than the control. However, excluding azoxystrobin, which induced a mild reduction in ROS, none of the other chemicals tested were found to induce ROS at a significant level. In summary, these data show that measurement of mitochondria surface area can be used as a sensitive and specific endpoint of mitochondria toxicity.

TP025 The Qol fungicide trifloxystrobin inhibits oxidative respiration and induces deformity in zebrafish (Danio rerio)
C.L. Souder, University of Florida / Physiological Sciences; L. Yang, Institute of Hydrobiology / Chinese Academy of Sciences; T. Huang, Northeast Normal University / State Environmental Protection Key Laboratory of Wetland Ecology and Vegetation Restoration / School of Environment / Northeast Normal University; Y. Zhao, School of Environment / Northeast Normal University; C.J. Martyniuk, University of Florida / Physiological Sciences

Strobilurins (Qol inhibitors) are a relatively new class of agrochemical fungicide first discovered in the wood-rotting mushroom Strobilurus
tenacellus. These chemicals are applied to vegetables and fruits to protect against pathogenic fungi by inhibiting complex III of the electron transport chain. Trifloxystrobin received EPA registration in 1999 and is used in agriculture, and it can enter the aquatic environment, and can adversely affect organisms. However, data are scarce on how propiconazole may affect early developmental life stages. The objectives of this study were to evaluate the potential effects of trifloxystrobin during zebrafish development. Firstly, wildtype zebrafish (ABTu strain) embryos at ~6 hours post fertilization (hpf) were exposed to trifloxystrobin (0.25-2 µM) for 24 hours to evaluate the effects on oxidative respiration. Trifloxystrobin exposure at doses of 0.5 µM and higher induced basal respiration, maximal respiration, oligomycin-induced ATP linked respiration, spare capacity, and non-mitochondrial respiration, indicating compromised mitochondrial bioenergetics in zebrafish embryos. Embryonic exposure to trifloxystrobin (15-120 nM) for 144 h also induced developmental toxicity, most apparent at concentrations above 30 nM. Trifloxystrobin decreased hatch rate and increased malformation rates (pericardium edema and spinal lordosis). Survival rates up to 72 h did not differ among groups, but at 60 and 120 nM, larvae showed 100% mortality with 144 h exposure. A Visual Motor Response (VMR) test was used to measure larval fish exposed to the lowest concentration in the assay (15 and 30 nM), however the results showed no evidence of changes in locomotor activity. This study demonstrates that trifloxystrobin can disrupt mitochondrial bioenergetics in zebrafish embryos, and cause developmental toxicity at environmental relevant concentrations. Therefore, the potential risk of trifloxystrobin to aquatic organisms needs further attention.

TP026 Sub-lethal effects of propiconazole on zebrafish (Danio rerio) development, oxidative respiration, and larval locomotor activity

C.J. Souders, University of Florida / Physiological Sciences; P. Xavier, University of Florida / Department of Physiological Sciences / College of Veterinary Medicine; V. Perez-Rodrigues, U Florida / Physiological Sciences; N. Ector, U Florida; J. Zhang, U Florida / Henan Open Laboratory of Key Subjects of Environmental and Animal Products Safety / Henan University of Science and Technology; C.J. Martyniuk, University of Florida / Physiological Sciences

Propiconazole is a triazole fungicide used in agriculture. Via run-off, it can enter the aquatic environment, and can adversely affect organisms. However, data are scarce on how propiconazole may affect early developmental life stages of fish. The objectives of this study were to evaluate the potential sub-lethal effects of propiconazole during zebrafish development. Wildtype zebrafish (AB strain) embryos and larvae were exposed to propiconazole (0.1-100 µM) for up to 150 hours post fertilization (hpf) depending upon the endpoint measured. Propiconazole decreased survival and induced hypopigmentation in fish at 100 µM compared to the water and solvent controls. Pericardial edema was also noted in embryos and larvae (beginning at 2-3 dpf) exposed to 100 µM propiconazole. To visualize the effects of propiconazole on the circulatory system in more detail, we exposed transgenic zebrafish (globin-LCR:eGFP) to the fungicide. Hematopoietic changes were observed within 48 hours of exposure to 100 µM, and blood cells became diffuse, indicating pooling of blood in the pericardial region. We measured oxidative respiration in embryos as sufficient ATP is needed for development. Exposure to 100 µM propiconazole (~6-30 hpf) reduced basal respiration (~50%), oligomycin-induced ATP linked respiration (~70%), proton leak (~30%), and non-mitochondrial respiration (~50%), indicating compromised mitochondrial bioenergetics. A Visual Motor Response (VMR) test was used to measure larval fish exposed to propiconazole for a 6-day period and larval fish exposed to the highest concentration in the assay (10 µM) showed evidence of hypoactivity. This study demonstrates that propiconazole can induce hypopigmentation in zebrafish, disrupts mitochondrial bioenergetics, and alters locomotor activity. However, these sub-lethal responses were observed at concentrations above what is typically detected in the environment.

TP027 Mitochondrial dysfunction and gliotoxicity: Novel mechanisms of neuroendocrine disruption

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Mechanisms of neuroendocrine disruption can be many, and include neurohormone receptor agonism/antagonism, inhibition of neuropeptide synthesis/processing, and mitochondrial dysfunction. Radial glia (RGCs) are primary progenitor cells in the central nervous system that are capable of generating neurons and astrocytes. These cells are also the major cell type synthesizing neuroestrogens in fish, and the teleost brain has a high capacity to express aromatase which allows for remarkable neuroplasticity observed with teleosts. As neuroendocrine cells require ATP to synthesize, package, and release neuropeptides, we hypothesize that chemicals in the environment can act to impair mitochondrial bioenergetics of glial cells in the central nervous system. To test this, we isolated a mixed sex population of radial glial cells from goldfish (Carassius auratus) whole brain and measured metabolic function of the cells following a 24 hour exposure to fluazinam, a broad spectrum fungicide. Using immunohistochemistry and real-time PCR for glia and neuron-specific markers, we demonstrate that the radial glial culture was more than 95% pure, and that cells that expressed glial fibrillary acidic protein (GFAP) (i.e., RGCs) were significantly enriched in the culture compared to those synthesizing the neuronal markers myelin basic protein and growth associated protein 43, which were close to non-detectable in real-time PCR assays. Following a 24 hours exposure to three different doses of fluazinam, a mitochondrial stress test using the Seahorse XF24 Extracellular Flux Analyzer was conducted to assess metabolic function of the RGCs. Reduced maximum respiration and spare capacity of RGCs were observed compared to the control group with 25μM Fluazinam. Thus, fluazinam significantly decreased bioenergetics capacity of these neuroestrogen-producing cells. These studies demonstrate that the bioenergetics of RGCs are sensitive to environmental contaminants, and further studies are required to determine if such disruptions lead to functional impairment of the cells in vitro and in vivo.

TP028 Constructing Adverse Outcome Pathway Networks for Mitochondrial Dysfunction

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Mitochondria are key targets of many environmental contaminants, as specific chemicals can interact directly with mitochondrial proteins, lipids, and ribonucleic acids. These direct interactions serve as molecular initiating events (MIEs) that impede ATP production and other critical functions that mitochondria serve within the cell (e.g., calcium and metal homeostasis, apoptosis, immune signaling, redox balance). A limited but growing number of adverse outcome pathways (AOPs) have been proposed to associate mitochondrial dysfunction with effects at organismal and population levels. These pathways involve key events (KEs), such as altered membrane potential, mitochondrial fission/fusion, and mtDNA damage, among others. To illustrate the current state of the science for AOPs involving mitochondria (mtAOPs), we identified AOPs involving KEs for various hallmarks of mitochondrial dysfunction from the AOPWiki. Furthermore, we used these pathways to build an exploratory mtAOP network and identify the localization of mitochondrial KEs. Among 224 AOPs in the wiki, 29 included KEs related to mitochondrial dysfunction. In the mtAOP network, there were several cases where KEs for some form of mitochondrial interference or dysfunction also represented a MIE (e.g., KE 1260 “Direct mitochondrial inhibition”; KE 1446 “Increase, Uncoupling of oxidative phosphorylation”; KE 1481 “Inhibition of mitochondrial DNA polymerase gamma”), thus signifying direct mitochondrial toxicity. However, in most of the current mitochondrial AOPs, mitochondrial dysfunction was an intermediate KE linked...
to both upstream and downstream KEs. For example, KE 40 “Decrease, Mitochondrial ATP production” was a network hub associated with numerous pathways. In addition, the network was used to identify potential downstream consequences of mitochondrial dysfunction, including adverse outcomes for “parkinsonian motor deficits,” “growth inhibition,” “kidney toxicity,” “mortality,” and “reproduction decline.” Taken together, this organization indicates that the current state of knowledge identifies mitochondria as involved with multiple AOPs, primarily as an intermediate KE. Given the wide range of chemicals that affect mitochondria, and the centrality of energy production and signaling to ecologically important outcomes such as pathogen defense, homeostasis, growth, and reproduction, mitochondrial AOPs are expected to play a significant, if not central, role in environmental toxicology.

Canadian Oil Sands Part 1: Advances in Chemical Characterization, Reclamation and Monitoring Research

TP029 Analysis of Halogenated Polycyclic Aromatic Hydrocarbons in Sediment from the Alberta Oil Sands Region


With the third largest oil reserve in the world, the production of oil is a huge source of economic growth and development in Canada. The concern stemming from the industrial activity in the oil sands is that polycyclic aromatic compounds (PACs) will be deposited from the atmosphere and into lake ecosystems where they persist long after. Previously, halogenated polycyclic aromatic hydrocarbons (HPAHs) have been detected from the biological organisms from the Alberta oil sands region (AOSR). This study focused specifically on identifying HPAHs in lake sediments from AOSR. Our approach was to use one-step accelerated solvent extraction (ASE) for sample preparation and analysis by gas chromatography coupled with high-resolution time-of-flight mass spectrometry (GC-HRTOF-MS) for the identification and quantification of HPAHs.

TP030 Evaporative Emissions of Polycyclic Aromatic Compounds from Alberta’s Oil Sands Tailings Ponds Water

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Polycyclic aromatic compounds (PACs) are semi volatile organic compounds emitted from Alberta’s oil sands tailing ponds (OSTPs). Their toxic effects via exposure and their ubiquity in our environment classify them as priority compounds for monitoring. These open-air OSTPs are known plume of OSPW-affected groundwater confirmed their diagnostic abilities. A secondary objective was to assess anthropogenic derived artificial sweeteners and per- and polyfluoroalkyl substances (PFASs) as potential tracers for OSPW. Despite the discovery of acylsulfane and PFAS in most OSPW samples, trace levels in groundwaters influenced by the Alberta McMurray bitumen background in groundwaters influenced by the Alberta McMurray formation. Improved sampling methods and quantitative analyses of two groups of mono-aromatic acids (Family A and B) were employed to analyze OSPW and bitumen-affected natural groundwaters for source discrimination. Both groups of mono-aromatic acids showed significant enrichment in OSPW, while ratios of O2-O4 containing heteroatomic ion classes of acid extractable organics (AEOs) did not exhibit diagnostic differences. Evaluating the mono-aromatic acids to track a known plume of OSPW-affected groundwater confirmed their diagnostic abilities. A secondary objective was to assess anthropogenic derived artificial sweeteners and per- and polyfluoroalkyl substances (PFASs) as potential tracers for OSPW. Despite the discovery of acylsulfane and PFAS in most OSPW samples, trace levels in groundwaters influenced by general anthropogenic activities preclude them as individual robust tracers. However, their inclusion with the other metrics employed in this study served to augment the tiered, weight of evidence methodology developed. This methodology was then used to confirm earlier findings of OSPW migrations into groundwater adjacent to the reclaimed pond at Tar Island Dyke, and reaching the Athabasca River system.

TP034 The Treatment of Oil Sands Process-Affected Water with the Kearl Treatment Wetland

A. Cancelli, Simon Fraser University / Resource and Environmental Management; F. Gobas, Simon Fraser University / Resource & Environmental Management; A. Bekele, Imperial Oil

Large volumes of oil sands process-affected water (OSPW) have been generated through mining operations and bitumen extraction in the atmosphere, allowing us to better understand their emissions and fate from oil producing locations. To do so, water samples taken from different OSTPs in the summers of 2016 and 2017 were analyzed for polycyclic aromatic hydrocarbons (PAHs) and alkylated-PAHs, and were screened for nitro and oxy-PAHs. An equilibrium chamber study was then devised to more appropriately determine the air-OSTP water partition coefficients for PACs. This chamber study setup used thin-film polymer-coated glass beads as passive samplers for fugacity measurements of PACs in air and water. We will be presenting the levels of PACs found in OSTP waters as well as the results of the chamber experiment using the complex mixture of OSTP waters. Furthermore, the newly determined partition coefficient values will be used to estimate the net emissions of PACs from Alberta’s OSTPs.
Canadian oil sands. While the industry has successfully reduced water requirements, treatment technologies are still needed to reduce the ecological footprint from bitumen extraction and mitigate the risks of OSPW in tailings ponds. Ongoing efforts have identified treatment wetlands as one viable technology with the potential to improve water quality of OSPW, which is currently subject to a zero-discharge policy. We have investigated the removal efficiency of a range of organic contaminants present in OSPW in a constructed treatment wetland at Imperial’s Kearl Oil Sands site. Polyethylene (PES) and polar organic chemical integrated samplers (POCIS) were used to measure freely dissolved concentrations of polycyclic aromatic hydrocarbons (PAHs) and naphthenic acids (NAs) in the OSPW within the wetland, respectively. In 2017, PES were deployed in the inlet and outlet of the KTW for two deployments (Jul. 21 - Aug. 29, and Aug. 29 - Sept. 29). In 2018, both PES and POCIS were deployed to measure changes to both PAH and NA freely dissolved water concentrations. The results show statistically significant (p < 0.05) reductions in dissolved concentration of PAHs as a result of wetland treatment during both 2017 deployments. The first deployment measured a mean reduction in concentration of 75.4% (SD 18.2%), and 82.4% for the concentration of S(19PAHs). The second deployment measured a mean reduction in concentration of 36.7% (SD 30.2%), and 57.0% for the concentration of S(25PAHs). The results from the 2018 investigations demonstrate the capacity for the Kearl Treatment Wetland to reduce concentrations of PAHs and NAs in OSPW. Higher concentration reductions were observed for NAs that are fully hydrogenated compared to their ionized counterparts within the same carbon group. Concentrations of SPAHs and SNAs declined 67% and 54%, respectively, over 28 days in the KTW. Our data indicate that treatment wetlands may be an effective tool to help treat OSPW. Using this empirical data, we have developed an environmental model that can be used to evaluate the fate of organic contaminants in treatment wetlands with the goal to evaluate the feasibility of these systems for specific wastewater challenges. The model also demonstrates the roles of different biogeochemical removal mechanisms of pollutants in the wetlands.

TP035 Fish Health in the Alberta Peace River Oil Sands Area
M.E. McMaster, Environment and Climate Change Canada / Water and Science Technology Directorate, Aquatic Contaminants Research Division; G. Tetreault, M. Evans, Environment and Climate Change Canada / Water, Science and Technology Directorate; T. Clark, Environment and Climate Change Canada / Water and Science Technology Directorate Aquatic Contaminants Research Division; J. Cunningham, Environment and Climate Change Canada / Aquatic Contaminants and Research Division; E. Ussery, Environment and Climate Change Canada / Aquatic Contaminants Research Division; A.G. Wynia, Environment and Climate Change Canada / Aquatic Contaminants Research Division
As part of the Canada-Alberta Oil Sands Monitoring Program (OSM), fish health within the Athabasca and Peace River watersheds was evaluated using methods developed for the Canadian Environmental Effects Monitoring program. Baseline fish health was assessed in both watersheds by collecting data over a three year period. Baseline data was evaluated for existing differences in fish health between sites sampled within each watershed and reference site variability was assessed in order to help make decisions when differences exist. The Athabasca River data has been assessed previously and this presentation will describe fish data from the Peace River collected from 2015-2017. Measurement endpoints include indicators of growth, reproduction and survival as well as indicators of fish exposure and contaminant levels. Data will provide a baseline against which future changes in fish populations will be judged and compared to. Information will be used to develop site-specific cumulative effects monitoring approaches and will contribute to the development of better predictive capabilities for oil sands environmental impact predictions. On the Peace River mainstem, longnose sucker have been selected as a large bodied sentinel species and trout perch as a small bodied sentinel species. Walleye are also being used for fish contaminant monitoring within the mainstem as they are consumed by resident populations. Design of the program is to look for effects, to confirm those effects, then to use developed critical effect sizes to make decisions on steps forward depending on the source of the change.

TP036 Laser ablation of White Sucker opercula to differentiate migratory and residency exposure to bitumen-derived chemicals from the Athabasca Watershed
T. Clark, Environment and Climate Change Canada / Water Science and Technology Directorate; M.E. McMaster, Environment and Climate Change Canada / Water and Science Technology Directorate / Aquatic Contaminants Research Division; K.R. Munkittrick, Wilfrid Laurier University / Biology
The Athabasca oil sands deposit, situated in the Lower Athabasca Region (LAR) of northern Alberta, Canada contains the province’s largest of 4 bitumen deposits, encompassing more than 42,000km². One major challenge in the LAR pertains to the differentiation between natural versus anthropogenic sources of potentially deleterious bitumen-derived substances. Over the last decade, the Canadian and Alberta governments have collaboratively developed and established a long-term Oil Sands Monitoring (OSM) Plan, with consideration of environmental concerns attributed to the potential impacts of oil sands surface mining operations on the Athabasca River watershed. The Athabasca River and its tributaries, as well as the Peace-Athabasca Delta and Lake Athabasca, are home to various large bodied migratory fish species. Many of these fish species are known to overwinter in Lake Athabasca and migrate up the Athabasca River to spawn and then reside for the duration of the open water months. With the potential for elevated inputs and concentrations of potentially toxic chemicals in the LAR aquatic receiving environment associated with increased oil sands development, pinpointing these sources is of primary interest. A component of OSM has investigated large bodied fish health since 2011, with White Sucker (Catosostomus commersoni) serving as the sentinel species due to its close interaction with the littoral zone. The five investigated LAR sites were chosen based on their proximity to industrial activities (upstream and downstream), as well as their proximity to the McMurray oil sands formation. One major challenge associated with assessing large bodied fish health at these designated sites has been the uncertainty of identifying exposure sites due to fish migration. As such, this study aims to utilize the opercula from White Sucker that were collected from each of the five LAR sites since 2011 to reconstruct residency, migration and fish life history. Laser ablation (LA-ICPMS) of the opercula will allow for quantification of elemental compositions found within growth annuli, which will then be used to differentiate between fish residencies and migrations.

TP037 Histopathological investigation of lake chub in a tributary adjacent to Athabasca oil sands activity
J. Cunningham, Environment and Climate Change Canada / Aquatic Contaminants and Research Division; E. Ussery, Environment and Climate Change Canada / Biological Sciences; M.E. McMaster, Environment and Climate Change Canada / Water and Science Technology Directorate, Aquatic Contaminants Research Division
The Athabasca River, which is a tributary to the Peace River, is adjacent to Athabasca oil sands activity in Northern Alberta, Canada. The Peace River is known for its polycyclic aromatic hydrocarbons (PAHs). Naturally occurring exposed bitumen beds combined with Oil Sands industry expansion, and associated surface mining activity in the region, contribute to PAH richness in the environment. Central to the industry expansion in the oil sands region is the Athabasca River. Numerous oil companies mine adjacent land for naturally occurring bitumen as well as utilize its waters in the petroleum extraction process. As a result, resident fish in the Athabasca and its tributaries may be exposed to either naturally occurring sources of bitumen or anthropogenically refined sources extracted through surface mining. Monitoring programs were developed ten years ago by both the Canadian and Alberta governments to investigate fish health in the lower Athabasca River and its tributaries. One such tributary is the Ells river located depending on the source of the change.
approximately 60 km north-east of Fort McMurray. The Ells serves as the predominant drinking water source for the First Nations community of Fort McKay, as well as representing an important food gathering location. As such, the health and productivity of this tributary is of high importance. Previous studies have reported a myriad of health effects in fish exposed to PAHs including altered visual acuity and reproductive effects. This study employs a histopathological examination of the effects of PAH exposure (both natural and anthropogenic) on various tissues of adult lake chub (*Couesius plumbeus*) at two sites in the Ells River. These sites were chosen to represent (a) naturally occurring PAH exposure from exposed bitumen beds as well as (b) a site more heavily impacted by anthropogenic activity. At each site, 20M and 20F wild fish were collected, euthanized and Gill, gonad, intestine, kidney and eye were all extracted and preserved for subsequent histological analysis. Tissues were embedded and slides were created and stained with Hematoxylin/Eosin for examination and comparison between sites. This work contributes to a larger, multi year, wild fish health monitoring program on the lower Athabasca River and its tributaries.

TP038 Characterization and Biodegradation of Oily Sludge using GCxGC TOFMS and its Toxicity Analysis using Triticum aestivum

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Petrochemical industries produce large amounts of solid and liquid waste. Among the solid wastes, oily sludge is accumulated at the bottom of the crude oil storage tanks in oil refineries. Oily sludge cannot be directly dumped without any pre-treatment as it is highly toxic, mutagenic, and carcinogenic in nature therefore classified as priority environmental pollutants by the USEPA. The objective of this study was to characterize the oil and solids associated with the sludge and to test the feasibility of slurry phase biodegradation in presence and absence of coco-peat powder as an immobilizing agent, using indigenous microbes associated with the sludge. The oily sludge was found to contain 19-22% heavy oil when extracted using soxhlet extraction. The oil extract was further separated using column chromatography and was characterized in GCxGC TOFMS in 2D mode for aliphatic, aromatic and polar fraction. The individual fractions were processed using ChromaTOF software and the compounds were identified using their characteristic mass to charge ratio. The biodegradation studies were conducted in batch mode in mineral medium where residual oil was estimated using liquid-liquid extraction followed by column chromatography. The study was performed for a duration of 60 days where total petroleum hydrocarbon, maltene, asphaltene and CFU counts were measured periodically. It was found that the indigenous bacteria could degrade the oily sludge, where 49% degradation was seen in presence of coco-peat powder, where 76.1% removal of maltene and 8.3% asphaltene removal was observed. Biodegradation in absence of coco-peat powder was limited to only 36%, where 44.8% removal of maltene was seen while asphaltene removal was only 6.6%. The componentwise biodegradation of oily sludge were also compared using GCxGC TOFMS in 1D mode where n-alkanes ranging from pentadecane to Pentatriacontane and cycloalkanes ranging from Nonylcyclohexane to Octadecyclohexane were compared. It was observed that aliphatic fraction was highly biodegradable compared to other fraction whereas asphaltene fraction was least biodegradable because of their highly complex and large molecular structure. Phytotoxicity of oily sludge was also determined using *Triticum aestivum* where the plants were grown in pots at various concentrations (0-100%) and the root and shoot length were measured along with chlorophyll concentration, the IC50 was calculated using hill and was found to be 24.5%.

Canadian Oil Sands Part 2: Recent Advances in Toxicological Characterization of Oil Sands and Dilbit Chemicals

TP039 Ambient Concentrations and Total Deposition of Inorganic Sulfur, Inorganic Nitrogen and Base Cations in the Athabasca Oil Sands Region

E. Edgerton, ARA, Inc.

Trace gas, particulate matter and deposition data collected in the Athabasca Oil Sands Region (AOSR) from 2000-2017 were evaluated as part of a broad scientific programmatic review. Results showed significant spatial patterns and temporal trends across the region. Concentrations of reactive gases were highest near the center of surface oil sands production operations and decreased towards the edges of the monitoring domain by factors of 8, 20, 4 and 3 for sulphur dioxide (SO2), nitrogen dioxide (NO2), nitric acid (HNO3) and ammonia (NH3), respectively. 18 of 30 sites showed statistically significant ($p<0.05$) negative trends in SO2 concentrations suggesting an $\sim$40% decrease since 2000. In contrast, only 2 of 30 sites showed statistically significant temporal trends (1 positive, 1 negative) for NO2. NH3 data showed (i) marked and varied wildfire impacts, and (ii) exhibited very high seasonality, with low concentrations during winter and significantly higher values during the summer. Particulate matter (PM10) measurements were more limited, but also showed significant spatio-temporal variability. Comparison of PM10 and PM2.5 data showed that >80% of sulphate (SO42-) was in the PM2.5 fraction, while >60% of calcium (Ca2+), magnesium (Mg2+), sodium (Na+) and chloride (Cl-) were in the PM10-2.5 fraction. Ion balances of both PM10 and PM2.5 contained cation excesses at near-field oil sand sites, but PM2.5 samples at forest health sites >20km from surface production locations contained anion excesses. Monthly average concentrations of PM10 ions showed peak Ca2+ during March-April to November, but peak SO42-, NIH4+ and nitrate (NO3-) from November-March. Deposition estimates showed rapid declines as a function of distance to oil sand operations. Estimated total nitrogen (N) and total sulphur (S) deposition to forest health monitoring sites ranged from 2.0-5.7 kg ha-1a-1 and 2.1-14.0 kg ha-1a-1, respectively. Potential acid input (PAI) ranged from 0.46-0.79 keq ha-1a-1 and was mostly 0.1-0.2 keq ha-1a-1 throughout the domain, except for two clusters of sites near the center of oil sand operations.

TP040 The Impact of Atmospheric Acid Deposition on Tree Growth and Forest Understory Vegetation in the Athabasca Oil Sands Region

D. McIsaac, WBEA

Atmospheric acid deposition is of major concern in the Athabasca Oil Sands Region (AOSR) in northern Alberta, Canada, which is home to the third largest oil reserve in the world. After decades of oil sands production in the AOSR, the potential impact of deposition on forest health, including tree growth and understory biodiversity is still not clear. We evaluated the relationship of modelled atmospheric deposition of nitrogen (N), sulphur (S), base cations (BC), and derived potential acid inputs (PAI) from surface oil sands mining with: (1) the radial growth (i.e. basal area increment; BAI) of jack pine (*Pinus banksiana* Lamb.) trees using data from two decadal time periods, prior to (1957-1966) and during active oil sands development (2001-2010) in the AOSR; and (2) forest understory vegetation (abundance, diversity, and composition), which is an important component of forest biodiversity. BAI of jack pine trees varied with N, S, and BC deposition between the two time periods, and with site location relative to main emission sources. Growth was higher in areas close to the oil sands surface mining operations prior to and after oil sands development. This relationship held for the recent period with BAI positively related to atmospheric deposition, but the slope of this relationship was similar or slightly lower in the active period versus the non-active period. Understory vegetation; including vascular plant cover, richness, and diversity increased in relation to modelled atmospheric N and S deposition. There was limited correlation between soil pH or the BC:Al ratio (indicators of soil acidification) and BAI and understory vegetation.

Sulfur, Inorganic Nitrogen and Base Cations in the Athabasca Oil Sands Region

E. Edgerton, ARA, Inc.

Trace gas, particulate matter and deposition data collected in the Athabasca Oil Sands Region (AOSR) from 2000-2017 were evaluated as part of a broad scientific programmatic review. Results showed significant spatial patterns and temporal trends across the region. Concentrations of reactive gases were highest near the center of surface oil sands production operations and decreased towards the edges of the monitoring domain by factors of 8, 20, 4 and 3 for sulphur dioxide (SO2), nitrogen dioxide (NO2), nitric acid (HNO3) and ammonia (NH3), respectively. 18 of 30 sites showed statistically significant ($p<0.05$) negative trends in SO2 concentrations suggesting an $\sim$40% decrease since 2000. In contrast, only 2 of 30 sites showed statistically significant temporal trends (1 positive, 1 negative) for NO2. NH3 data showed (i) marked and varied wildfire impacts, and (ii) exhibited very high seasonality, with low concentrations during winter and significantly higher values during the summer. Particulate matter (PM10) measurements were more limited, but also showed significant spatio-temporal variability. Comparison of PM10 and PM2.5 data showed that >80% of sulphate (SO42-) was in the PM2.5 fraction, while >60% of calcium (Ca2+), magnesium (Mg2+), sodium (Na+) and chloride (Cl-) were in the PM10-2.5 fraction. Ion balances of both PM10 and PM2.5 contained cation excesses at near-field oil sand sites, but PM2.5 samples at forest health sites >20km from surface production locations contained anion excesses. Monthly average concentrations of PM10 ions showed peak Ca2+ during March-April to November, but peak SO42-, NIH4+ and nitrate (NO3-) from November-March. Deposition estimates showed rapid declines as a function of distance to oil sand operations. Estimated total nitrogen (N) and total sulphur (S) deposition to forest health monitoring sites ranged from 2.0-5.7 kg ha-1a-1 and 2.1-14.0 kg ha-1a-1, respectively. Potential acid input (PAI) ranged from 0.46-0.79 keq ha-1a-1 and was mostly 0.1-0.2 keq ha-1a-1 throughout the domain, except for two clusters of sites near the center of oil sand operations.
TP041 Epiphytic Lichen and Novel Geostatistical Approach to Evaluate Spatial and Temporal Changes in Atmospheric Deposition in Athabasca Oil Sands Region

**M. Landis, Integrated Atmospheric Solutions**

Temporal and spatial atmospheric deposition trends of elements to the boreal forest surrounding bitumen production operations in the Athabasca Oil Sands Region (AOSR), Alberta, Canada were investigated as part of a long-term lichen bioindicator study. The study focused on eight elements (sulfur, nitrogen, aluminum, calcium, iron, nickel, strontium, vanadium) that were previously identified as tracers for the major oil sand production sources. Samples of the in situ epiphytic lichen Hypogymnia physodes were collected in 2002, 2004, 2008, 2011, 2014, and 2017 within a ~150 km radius from the center of surface oil sand production operations in the AOSR. Site-specific time series analysis conducted at eight jack pine upland sites that were repeatedly sampled generally showed significant trends of increasing lichen concentrations for fugitive dust linked elements, particularly at near-field.

TP042 Effects of diluted bitumen exposure on repeat swimming performance and striated muscle of Atlantic salmon smolts

**T. Gillis, University of Guelph / Integrative Biology; S. Avey, University of Guelph / Integrative Biology; C. Kennedy, Missouri Department of Conservation / Department of Biological Sciences; A.P. Farrell, University of British Columbia / Zoology; S.L. Alderman, University of Guelph / Department of Integrative Biology**

Diluted bitumen (dilbit), a type of crude oil, is transported from Canada’s oil sands across the continent, increasing the potential for accidental spills. Due to the high viscosity of bitumen extracted from the Alberta oil sands, it must be diluted with natural gas condensates to form diluted bitumen (dilbit). Dilbit is mainly exported via extensive transcontinental pipeline networks, raising concern for potential leaks and spills into lakes and rivers located along transportation routes. Although major dilbit spills have occurred in the past and future spills are inevitable, there remain significant research gaps on the aquatic toxicity of dilbit. In the present study, whole-transcriptome sequencing was utilized to characterized molecular responses in liver of sub-adult fathead minnow (Pimephales promelas) exposed to 0, 3, 10, or 30% dilbit water-accommodated fractions (WAF) for 7 days. There was a total of 281, 469, and 307 significant differentially expressed transcripts (FDR-adjusted p ≤ 0.05) in the 3, 10, 30% WAF treatment groups, respectively. There was a marked skew towards downregulation of transcripts, with at least 94% of transcripts being downregulated in each WAF treatment. Furthermore, gene ontology analysis revealed many genes being involved in calcium ion binding, the renin-angiotensin system, the immune system, and the inositol trisphosphate signaling cascade. Alterations in gene expression following dilbit exposure were predicted to be linked to downstream cardiac and hepatic toxicity, including liver hyperplasia, heart failure, liver cirrhosis, and cardiac enlargement. Future studies will focus on metabolic physiological endpoints in fathead minnow to examine how changes in gene expression may affect organismal fitness. Through RNA sequencing, results from this research will elucidate the molecular mechanisms of dilbit toxicity and provide insight on potential impacts of dilbit spills on aquatic organisms. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).

TP043 Effects of weathered sediment-bound dilbit on the health of zebrafish embryos (Danio rerio)

**S. Everitt, University of Lethbridge / Biological Sciences; G.G. Pyle, University of Lethbridge; S. Wiseman, University of Lethbridge / Biology**

Due to the high viscosity of bitumen extracted from the Alberta oil sands, it must be diluted with natural gas condensates to form diluted bitumen (dilbit) to facilitate transportation through pipelines. Pipelines stemming from the oil sands span thousands of freshwater environments and pose a risk to aquatic organisms. If dilbit is spilled into or near a waterbody, environmental factors such as evaporation (weathering) and interaction with sediments can alter the fate of dilbit and its subsequent toxicity to aquatic organisms. Most studies of dilbit to date have focused on exposing fish to the water-accommodated fraction of fresh dilbit. Here, we present the first study that addresses the toxicity of weathered, sediment-bound dilbit to zebrafish embryos (Danio rerio). Zebrafish embryos were exposed to the water-soluble fraction of weathered sediment-bound dilbit from 30 minutes post-fertilization to five days post-fertilization. Exposed embryos showed increases of pericardial edema, yolk sac edema and incidences of uninflated swim bladder. There was no change in the abundances of transcripts related to oxidative stress (sod, gpx, gst, gelc), but wnt11--important for signaling in the Wnt pathway that has a role in swim bladder formation--was significantly down regulated. There was a concentration dependent induction of cyp1a, suggesting the embryos were exposed to polycyclic aromatic hydrocarbons that may have been responsible for the deformities. These results show that despite weathering and combination with sediment, water-soluble compounds remain bioavailable and negatively affect the early development of zebrafish.

TP044 Whole-transcriptome sequencing of sub-adult fathead minnow liver following water-accommodated conventional heavy crude oil exposure

**N.E. Andrzejczyk, University of California, Riverside / Department of Environmental Sciences; D. April, University of Saskatchewan / Veterinary Biomedical Sciences; V. Palace, IISD-Experimental Lakes Area; D.M. Janz, L.P. Weber, University of Saskatchewan / Veterinary Biomedical Sciences; D. Schlenk, University of California, Riverside / Environmental Sciences**

The Oil Sands region of Alberta, Canada has one of the largest known reserves of bitumen, containing an estimated 50 billion cubic meters of bitumen. Bitumen, a heavy type of crude oil, is mixed with natural gas condensate or synthetic oils to decrease viscosity for more efficient transport, thus forming diluted bitumen (dilbit). Dilbit is mainly exported via extensive transcontinental pipeline networks, raising concern for potential leaks and spills into lakes and rivers located along transportation routes. Although major dilbit spills have occurred in the past and future spills are inevitable, there remain significant research gaps on the aquatic toxicity of dilbit. In the present study, whole-transcriptome sequencing was utilized to characterized molecular responses in liver of sub-adult fathead minnow (Pimephales promelas) exposed to 0, 3, 10, or 30% dilbit water-accommodated fractions (WAF) for 7 days. There was a total of 281, 469, and 307 significant differentially expressed transcripts (FDR-adjusted p ≤ 0.05) in the 3, 10, 30% WAF treatment groups, respectively. There was a marked skew towards downregulation of transcripts, with at least 94% of transcripts being downregulated in each WAF treatment. Furthermore, gene ontology analysis revealed many genes being involved in calcium ion binding, the renin-angiotensin system, the immune system, and the inositol trisphosphate signaling cascade. Alterations in gene expression following dilbit exposure were predicted to be linked to downstream cardiac and hepatic toxicity, including liver hyperplasia, heart failure, liver cirrhosis, and cardiac enlargement. Future studies will focus on metabolic physiological endpoints in fathead minnow to examine how changes in gene expression may affect organismal fitness. Through RNA sequencing, results from this research will elucidate the molecular mechanisms of dilbit toxicity and provide insight on potential impacts of dilbit spills on aquatic organisms. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).
Environmental pH can change both the uptake of ionizable organic chemicals (IOCs) into exposed organisms and subsequent biological effects. Dissolved organic chemicals from oil sands process-affected water (OSPW) from Base Mine Lake has been previously demonstrated to bioconcentrate in fish, meaning any unintentional release of OSPW poses a risk to organisms in the surrounding water bodies, such as the Athabasca River. It has been shown that bioconcentration of these chemicals in fish correlated well with their partitioning to phospholipid-coated silica beads, thereby indicating that biodistribution is governed by partitioning into membrane lipids rather than storage lipids. It remains unclear, however, whether organic chemicals from fresh and treated OSPW would behave similarly. Furthermore, previous research using an in vitro screening assay was used to study the permeation of IOCs across an epithelium of cultured rainbow trout gill cells (RTgill-W1). It was found that a lower pH allows for greater permeability of the epithelium for acidic organics. The purpose of this study is to repeat those partitioning and in vitro assays with a broader range of OSPW samples at pH values representative of the Athabasca River during summer flow (approximately pH 7.5) and OSPW (approximately pH 8.5). Samples of OSPW from the operational inventories of several oil sands operators, along with samples from before and after Syncrude’s pilot treatment process are being characterized for their partitioning to phospholipids and permeation across gill epithelia. This study will support a better understanding of the impact of OSPW on the aquatic organisms in freshwater bodies surrounding the Athabasca Oil Sands Region and the effectiveness of Syncrude’s pilot treatment process to attenuate potential adverse effects of OSPW on aquatic organisms.

**TP046 Predicting Non-linear Adsorption of Naphthenic Acids (NAs) onto Carbonaceous Sorbents - Application of the Lognormal Langmuir (LNL) Isotherm Model**

C.W. Davis, ExxonMobil Biomedical Sciences, Inc.; A. Bekele, Imperial Oil; W. Zubot, Syncrude Canada, Ltd.; M. Gamal El-Din, University of Alberta / Civial and Environmental Engineering

Naphthenic acids (NAs), present in oil sands produced waters (OSPWs) from bitumen mining and processing in the Athabasca River Basin have been demonstrated to exert toxic effects on aquatic organisms in concentration ranges typical of raw produced water samples. Consequently, significant efforts have been made to evaluate methods for treating NA-containing OSPWs sufficiently such that direct release, or beneficial re-use is possible. Sorption to carbonaceous materials (i.e., GAC, Charcoal, etc...) has been widely used as an effective removal system for neutral organics in wastewater treatment systems. More recently, petroleum coke (PC) and other technical sorbents have been demonstrated to effectively remove NAs from OSPW samples in laboratory and pilot-scale systems. However, there are several key aspects of NA removal via PC that have yet to be addressed, most notably - the variable composition of NAs in OSPWs and how the interactions of the individual species with pet coke sorbents affects the overall removal capacity. The goal of this work is two-fold - First, a non-linear isotherm model, with a single chemical-specific parameter, is fit to a large set of adsorption isotherms (N = 69) for NAs onto several technical sorbents. This non-linear model (the LNL model) demonstrates excellent agreement with experimental adsorption data (RMSE = 0.203, N = 194) for PC, with a single total site density (qmax) and distribution of binding site energies (σκ), which are chemical-independent. The use of a non-linear isotherm model with a single chemical-specific parameter greatly simplifies the process of predicting sorptive behaviors for new chemicals, while addressing non-linear sorption of chemicals. Second, a model for predicting the observed LNL isotherm median Langmuir binding constants (the chemical-specific parameter) is presented which relies on only two chemical descriptors - the molecular weight (MW) and the excess molar refractivity (E) of a representative NA structure of a given carbon number (C) and hydrogen degeneracy (Z). While the RMS error for the model is larger than those previously observed for neutral organic compounds (RMSE = 1.51, N = 69), previous application to neutral organics has demonstrated lower overall errors in the predicted sorbed concentrations (q) relative to those of the binding constants themselves. This modeling approach represents a first attempt at deriving molecular-descriptor based models for the individual sorption of NA species onto carbonaceous sorbent materials.

**TP047 Assessing the toxicity of bitumen-derived chemicals in groundwater**

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Groundwater in the oil sands region near Fort McMurray, AB, Canada contains chemicals originating from natural bitumen and OSPW sources. While research is underway to better elucidate natural from anthropogenic sources of bitumen influence by using advanced separation and high resolution analytical methodologies, little is understood regarding the toxicity of these different source inputs. Significant dilution of these groundwater inputs often prevents detection of these bitumen- and OSPW-derived chemicals in surface waters of the Athabasca River watershed, further complicating investigations of the potential environmental impacts of tailings seepage. A multi-year investigation is underway to identify the primary toxic compounds/classes within these bitumen-influenced waters, and to determine if the drivers of toxicity are different between natural and OSPW sources. An initial investigation determined that whole groundwaters with bitumen influence from natural and OSPW sources were all toxic in fathead minnow embryo-larval assays and Hyalella azteca acute and chronic assays. Freshwater mussel (Lampsilis sp.) glochidia were also sensitive to some of the tested groundwaters. A follow-up investigation collected large volumes (>150L) each of these same groundwater sources with subsequent fractionation of the soluble organics using differences in polarity. Effects-directed analysis (EDA) of the generated fractions using acute assays with Vibrio fischeri, Daphnia magna, Ceriodaphnia dubia, Hyalella azteca, Hexagenia sp., Lampsilis sp., fathead minnow, and Japanese medaka indicated that toxicity varied by species and endpoint, however any observed toxicity was always associated with the fractions containing the least polar (i.e., O2 chemical species including naphthenic acids) and most polar (i.e., O4+ chemical species). Further iterations of chemical fractionation of the bioactive fractions are underway as part of this EDA investigation, using bioassays previously identified as sensitive to bitumen-derived organic mixtures. This work is intent on identifying the compound classes of interest within the soluble organic mixtures of bitumen-influenced waters, thereby providing critical information for the development of water monitoring programs and remediation initiatives in the oil sands region.
TP048 Effects-directed analysis of bioactive water soluble polar organic fractions from industrial and natural bitumen sources

M.R. Rodrigues, Environment and Climate Change Canada / Aquatic Contaminants Research Division; R. Frank, A.J. Bartlett, Environment and Climate Change Canada / Water Science and Technology Directorate; L.E. Deeth, University of Guelph / Department of Mathematics and Statistics; M. Dunnin, Environment and Climate Change Canada; G. Dixon, University of Waterloo / Biology; M. Hewitt, Environment and Climate Change Canada / Water Science and Technology Directorate

Identification of the organic compounds of concern within bitumen-influenced waters is critical for effective monitoring and reclamation within Canada’s oil sands region. Effects-directed analysis (EDA) provides an effective tool to prioritize bioactive and unique compounds of interest in complex mixtures, allowing for chemical and toxicological characterization. Bioactive fractions from natural and industrial bitumen-influenced water sources subjected to a first tier EDA were further fractioned in a second tier using reverse phase high performance liquid chromatography (HPLC). Secondary fractions were analyzed using liquid chromatography-time-of-flight mass spectrometry (LC/TOF-MS), indicating successful fractionation was achieved, with fractions generated according to decreasing polarity. Toxicity was assessed using the Microtox(R) assay and Hyalella azteca due to sensitivities exhibited to the first tier EDA fractions. Here, the Microtox(R) and H. azteca assays were most sensitive to the polar organics of the primary fractions and secondary fraction recombinated treatments. To a lesser degree, they were also sensitive to the least polar secondary fractions isolated from the polar primary fractions. The lack of recoverable toxicity in the individual secondary fractions may indicate that there are interactive effects within the more complex mixtures of polar organics (e.g. primary and recombinated fractions) that lead to greater toxic potency than when the chemical components are separated into less complex mixtures. Methodological adjustments in secondary fraction preparations are required to advance this phase of the EDA.

TP049 Quantifying the accumulation of 13C-labelled phenanthrene in phytoplankton and transfer to corals using Cavity Ring Down Spectroscopy

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While bioaccumulation of persistent pollutants is a serious concern, accumulation kinetics and pathways in aquatic organisms and their food chains are hardly quantified mostly due to methodological limitations. Polycyclic aromatic hydrocarbons (PAHs) are persistent, toxic and bioaccumulative organic pollutants. Here, we present a novel method to quantify the accumulation and uptake kinetics of a PAH, phenanthrene using stable isotope 13C-labeling and cavity ring down spectroscopy (CRDS). We demonstrated the efficiency of the method in a one-step experimental marine food-chain experiment using phytoplankton and corals. We first quantified accumulation of phenanthrene in the microalga, Dunaliella salina , demonstrating dose-dependent accumulation with a bio-concentration factor (BCF) of 2590 ± 787 L/kg dry weight. Subsequently, we quantified the uptake rates and accumulation of 13C-phenanthrene in tissues of the coral Acropora millepora via two exposure routes: (a) contaminated (13C-phenanthrene labeled) D. salina, (b) direct diffusive uptake from seawater. While uptake rate of 13C-phenanthrene in corals was faster through aqueous exposure than dietary exposure, passive diffusion showed larger variability and both routes exhibited similar accumulation levels. The developed method presents 13C-PAH labeling and analysis by cavity ring down mass spectroscopy as a promising tool to resolve uptake and transport of persistent organic pollutants with sensitivity, accuracy and detection levels similar to more complicated techniques based on IRMS or the use of radioactive traces which could be inherently toxic.

TP050 Factors Influencing the Field Bioaccumulation of Organic Contaminants in Bivalves

C. Xin, City University of Hong Kong; D. Kuo, City University of Hong Kong / Architecture and Civil Engineering

The biota-sediment accumulation factor (BSAF) model based on equilibrium partitioning theory (EqP) have been suggested as a simple tool to estimate bioaccumulation potential of contaminants in benthic ecosystems. High variability has been observed in field BSAF measurements and they may pose limitations to the applications of the BSAF model. To uncover factors behind such variability in field bioaccumulation, more than 3000 field BSAFs for 38 species of bivalves were collected from 49 peer-reviewed articles. Totally, 96 persistent organic contaminants (e.g., PCBs, PAHs, and organochlorine pesticides) were included. Results show that the variation in field BSAFs of bivalves can be 4-6 orders of magnitude for individual compounds. The mean, standard deviation, or interquartile range of BSAFs exhibited no significant correlation with hydrophobicity (KOW), organic carbon sorption coefficient (KOC), and black carbon sorption coefficient (KBC) for all contaminants (P>0.01). Temperature had no correlation with BSAFs for PCBs (N=105, P>0.01) and pesticides (N=43, P>0.01) and only a weak correlation for PAHs (N=171, R2=0.18, p< 0.01). The body size of bivalves shown no correlation with BSAFs for pesticides (N=291, P>0.01), a very weak correlation for PCBs (N=633, R2=0.02, p< 0.01), and a moderate correlation for PAHs (N=853, R2=0.50, p< 0.01). Narrowed variability in BSAFs was observed when the hydrodynamics of sampling sites was considered. For sites with standing water (e.g., lakes and lagoons), about 90% of BSAFs gather within +/-1 log unit of the theoretical BSAF in EqP model (log BSAF=0). For sites with unidirectional flowing water (e.g., rivers), over 80% of the log BSAFs are less than -1. The BSAFs for sites with complex hydrodynamic (e.g., intertidal zones and estuaries) are most variable, with log BSAF spanning a range from -4 to 2. This indicates the hydrodynamics may be a key factor influencing bioaccumulation of organic contaminants under field conditions.

TP051 Streamlining Freshwater Bioaccumulation Bioassays: Letting the Worms Do the Hard Work

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Laboratory bioaccumulation tests measure the movement of contaminants from field-collected or spiked sediment into the tissues of the test organism and adequately provide quantitative information concerning potential for exposure and trophic transfer at sites under investigation or at dredged material placement sites. For use with freshwater sediments, only bioaccumulation test method using the oligochaete Lumbricillus variegatus is currently standardized. The use of un-sieved sediment is recommended when investigating the bioaccumulation of contaminants from field-collected sediments. Sieving is only recommend when desirable to remove predatory organisms or large amounts of extraneous materials. At test termination, sediment is typically sieved through a fine-meshed screen sufficiently small to retain the oligochaetes. However, because sediment is typically used “as received” (without pre-test sieving), vegetative material (for example, live or decaying root fibers) and sand grains too large to pass through the sieve present in the sediment will collect on the sieve along with the test organisms. A large fraction of vegetative material typically results in labor-intensive and very time consuming effort to retrieve the organisms after sieving and may result in reduced recovered biomass. Recovery of oligochaetes is typically achieved by painstakingly pipetting organisms transferred to a shallow pan. We developed a “self-extraction” method to efficiently separate L. variegatus from the other materials retained on the sieve (“detritus”) during the process of washing the fine-grained test
Biomagnification of hydrophobic organic compounds (HOCs) increases in fish with increasing trophic levels, and plays an important role in affecting steady-state concentrations of HOCs in aquatic organisms. Effluent is the main source of contaminants of emerging concern, which may pose a threat to aquaculture. Effluent is the main source of contaminants of emerging concern (CECs, e.g., pharmaceuticals, personal care products). To assess the potential bioaccumulation, uptake and depuration of CECs on farmed fish, tilapia (Oreochromis mossambicus) was exposed to diltiazem and GenX at environmentally relevant concentrations. Results will be presented on the tissue and plasma bioconcentration values and projections. This work will provide aquaculturists with knowledge to make proactive management decisions regarding CECs in surface waters and potential fish bioaccumulation while improving our general understanding of human exposure to pollutants from nontraditional water use.

**TP054 Presence of bioaccessible legacy and current-use pesticides in Chinook salmon habitat in the Sacramento River watershed, California**

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Juvenile Chinook salmon of the Sacramento River, California, face a variety of environmental stressors as they migrate to the Pacific Ocean. This includes exposure to anthropogenic pollutants, such as legacy and current-use pesticides, which were and are widely applied throughout the watershed. As hydrophobic compounds, these pesticides are often found in sediments of aquatic systems and have the potential to bioaccumulate in resident benthic invertebrates. Previous studies have demonstrated the ability of these contaminants to elicit adverse olfactory effects to fish. This study aims to investigate the potential for pesticide exposure via dietary routes in benthic food webs to juvenile Chinook residing in the Sacrament River channel and the Yolo Bypass, a corresponding floodplain that has been indicated as an important rearing habitat. Sediments were collected throughout the study area during both flooding and non-flooding conditions. Accelerated solvent extraction (ASE) was utilized to determine the total concentrations of pesticides present in the sediments, and the bioaccessible fraction was assessed using single point 24-h TENAX extractions. Both methods indicated higher concentrations of the legacy pollutants p,p'-DDE, p,p'-DDD and p,p'-DDT in the Cache Slough region of the Yolo Bypass than in the Sacramento River. Additionally, detectable concentrations of three current-use pyrethroid insecticides, bifenthrin, esfenvalerate and lambda-cyhalothrin, were found in Yolo Bypass and Lower Sacramento River regions, yet not detected in the Upper Sacramento River channel. These results indicate that Chinook salmon feeding in the benthos of the Sacramento River channel and Yolo Bypass floodplain are characterized by different pesticide exposure regimes, with Chinook residing in the floodplain potentially exposed to higher concentrations of legacy contaminated.

**TP055 Trophic dynamics of selenium along a gradient of exposure concentrations in a boreal lake ecosystem**

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Selenium (Se) is both an essential micronutrient and a contaminant of concern, and is of particular interest in mine-affected waterbodies in Canada. The objective of this research was to characterize the trophic dynamics of selenium along a gradient of exposure concentrations in a Canadian boreal lake ecosystem. From June 20 to August 22, 2018, six limnocorals (littoral, ~3000 L enclosures) were spiked with mean measured concentrations of 0.4, 0.8, 1.6, 3.1, 5.2 and 7.9 µg Se/L as selenium, with three untreated controls (background aqueous Se = 0.09 µg/L). Water, periphyton, phytoplankton, sediment, benthic macroinvertebrates, zooplankton and female finescale dace (added on day 21 of the experiment) were collected throughout and at the end of the experiment. Total selenium was measured in all matrices. Non-linear (polynomial) regressions and generalized additive models were used to determine the relationships between aquatic and biota Se. Preliminary results show significantly greater enrichment of Se by phytoplankton relative to periphyton, and taxonomic differences in accumulation of Se by invertebrates (Heptageniidae > Chironomidae > Zooplatkton). Variability in bioaccumulation of Se by fish and relationship with shifts in diet along the gradient of Se exposure concentrations will be discussed. This research provides new information on patterns of enrichment and trophic transfer of Se over a gradient of exposure concentrations and will aid in the prediction of Se exposure and risk assessment under similar environmental conditions.
TP056 Elevated blood metal levels and cyto genetic damage induced in rats exposed in situ to groundwater and air emissions at a municipal landfill, Nigeria

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Solid waste landfills in developing nations have been known to be major source of environmental pollutants including heavy metals, thus, constituting ecological risk to exposed populations. This study herein investigated the levels of lead (Pb), cadmium (Cd), chromium (Cr) in blood and potential cytogenetic alterations in rats exposed in situ to underground water and ambient air emission from Olusosun landfill in Lagos, Nigeria. Male Wistar rats (5 rats/point/duration) were exposed at three different points to air emissions and underground water (via drinking) from the landfill for 4, 8, 12, 16, 20 and 24 weeks. Rats concurrently sited at 17.3 km from the landfill site served as control. Rats’ blood levels of Pb, Cd and Cr were measured after each exposure periods using atomic absorption spectrophotometer (AAS) and formation of bone marrow micronucleus and polychromatic erythrocyte/normochromatic erythrocytes (PCE/NCE) ratio were analysed. The strength of the linear relationship between blood metal levels and cytogenetic alterations were determined using Pearson’s correlation analysis. Blood levels (in mg/L) of Pb, Cd and Cr in the landfill exposed rats were significantly elevated (p < 0.05) compared to those of the corresponding control throughout each periods of exposure. Also, there was significant (p < 0.05) increase in the frequency of micronucleated polychromatic erythrocytes (MNPCNE) with significant (p < 0.05) decrease in PCE/NCE ratio at all points and periods of exposure compared to the control. No strong correlation (p > 0.05) was observed between blood metal levels and exposure periods; frequencies of MNPCNE; and PCE/NCE ratios respectively during the study periods. The concentrations (mg/L) of heavy metals such as Pb, Cd, Cr, Cu and Fe in the underground water were observed to be above permissible limit for drinking water. In situ exposure to underground water and air emissions at the landfill led to elevated blood levels of heavy metals in exposed rats. However, no strong correlation observed between blood metal levels and cytogenetic damage implies that other unanalyzed toxic agents present in the landfill compartments might have contributed either additively or synergistically with the metals in inducing the observed cytogenotoxicity in the erythropoietic stem cells. This finding is of ecological and health risk to animal and human populations who co-exist in the vicinity of major municipal waste dumping sites in developing countries.

TP057 Chromium, arsenic, and other elements of concern in fish from remote boreal lakes and rivers: drivers of variation

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Eating fish has numerous health benefits, but it is also the dominant exposure pathway for contaminants to enter the human body. Across northern Ontario, Canada, various freshwater fish have elevated concentrations of chromium (Cr), arsenic (As), and mercury (Hg), which has invoked consumption limitations issued by the provincial government, a concern for people in remote First Nation communities who rely on such fish for subsistence. However, while piscine Hg concentrations have been well studied in this remote region, far less is known about As, Cr, or other elemental concentrations in boreal fish. In this study, we measured 11 elements (including Hg, As, and Cr) in 388 fish sampled from 17 river sites and 7 lakes across northern Ontario. All fish were also analyzed for stable carbon (δ13C), nitrogen (δ15N), and sulfur (δ34S) isotopes, which provide indications of fish diet and anadromy. Our aim was to determine the effect of: 1) trophic ecology; and 2) local abiotic characteristics (e.g., geology) on elemental concentrations. Overall, the concentrations of most elements were low, often below detection limits (e.g. lead) or advisory benchmarks (ABs) set by monitoring authorities (e.g., selenium). However, traces of Hg, As, and Cr were detected in most fish, sometimes at elevated concentrations that exceeded their respective ABs. Preliminary results show that Hg and As, but not Cr concentrations were related to fish size and trophic ecology (i.e., δ13C and δ15N), suggesting bioaccumulation of the former elements. Fish with elevated δ34S values, suggestive of anadromous behaviour, had lower Hg and higher Se concentrations; δ34S was not related to piscine As or Cr concentrations. On-going analyses include assessing the relationship between Cr, As, and Se concentrations in fish with proportions of various geologic features within delineated watershed (e.g., mafic intrusions, glacial till). Results from this study address current gaps in our understanding of As and Cr uptake in fish, and will be help refine consumption guidelines and future monitoring programs based in the “Ring of Fire” mining development region.

TP058 Exploratory methodology for hexavalent chromium determination in fish tissues

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There is rising concern across the Canadian boreal ecozone regarding metals accumulation in commonly consumed freshwater fish. While there has been considerable effort to study and monitor mercury (Hg) concentrations in these fish, less work has examined the cycling of other metals. Recently, the Ontario Ministry of the Environment Conservation and Parks (OMCP) issued consumption limitations in various boreal riverine fish due to concentrations of chromium (Cr). However, these limits are based on monitoring total Cr concentrations, even though not all forms of these metals are toxic to humans or wildlife. The currently consumption advisories are, therefore, likely overestimating the risk to consumers, a major issue for remote aboriginal communities across northern Ontario because of their reliance on these fish for subsistence. In the environment, the majority of Cr exists either as benign and nutritionally essential form (trivalent Cr or Cr3) or in potentially toxic form (hexavalent Cr or Cr6). However, no method has been established to differentiate these forms of Cr in biotic samples because of the potential for oxidation throughout extraction procedures, particularly in low pH acidic techniques commonly used for total Cr analysis (e.g., EPA Method 3052). The goal of this project is to test two extraction techniques and validate findings using Speciated Isotope Dilution Mass Spectrometry (SIDMS, EPA Method 6800). Lab work is anticipated to begin in June 2019 and will test two types of extractions: (1) a microwave assisted extraction (MAE) using methanol and water (20, 50, 80, and 100% v/v) and, (2) direct measurement of Cr6 using an alkaline digestion with MAE (i.e., EPA Method 3060A) and subsequent Cr3 measurement on residual tissue using total procedures (i.e., EPA Method 3052). Extracts from both approaches will be analyzed using ion chromatography coupled with inductively coupled plasma mass spectrometry (IC-ICP-MS) at Laurentian University. We plan to validate the method with the most promising results using SIDMS, during which each Cr species is “labeled” with an isotopically enriched spike in the corresponding species form. The inter-conversions that occurs between species after spiking can be traceable and corrected for by back calculation. Results from this work will be help refine consumption guidelines and future monitoring programs based in the “Ring of Fire” mining development region and beyond.
TP059 Validation of Toxicological Interpretation of Diffusive Gradients in Thin-films in Marine Waters Impacted by Copper

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As part of the ambient monitoring program being conducted for the Puget Sound Naval Shipyard & Intermediate Maintenance Facility at Naval Base Kitsap in Sinclair and Dyes inlets of the Puget Sound, receiving waters of the Inlets are routinely monitored for trace metals and toxicity to assess water quality status, track progress in achieving water quality goals, and demonstrate protection of aquatic life. In 2016, aqueous metals bioavailability tracking, using diffusive gradients in thin-films (DGT) passive samplers was incorporated into the monitoring program. Eight subsequent in situ campaigns have recorded labile (CDGT) Cd, Cu, Ni, Pb, and Zn at twelve stations. A current obstacle to regulatory acceptability of CDGT data is validation of an uptake response that reliably mimics that of aquatic organisms. Towards reconciliation of CDGT Cu and natural ligands in respect to toxicity, ex situ studies in 2018 quantified DGT lability of Cu in Sequim Bay seawater at varying dissolved organic carbon (DOC) concentrations (as Suvannee River natural organic matter), while simultaneously determining and modeling biota correlation (as EC50 values of Mytilus galloprovincialis [Mediterranean mussel] larvae). Embryo-larval development tests, using Mytilus, were selected as they are among the most sensitive saltwater bioassays used for aquatic life criteria development and are the basis for the current EPA Criterion Maximum Concentration of Cu in seawater. In the current study, Mytilus larvae Cu EC50s in seawater from five ecological communities with diverse DOC quality, were assessed against the previous model, and the toxicological protection provided by Cu-DOC binding is discussed in terms of fluorescence characterization.

TP060 Trophodynamics and parabolic behaviors of polycyclic aromatic hydrocarbons in an urbanized Lake food web, Shanghai

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Understanding the trophic movement and trophic magnification factor (TMF) of polycyclic aromatic hydrocarbons (PAHs) is an important criterion to assess their fate and potential effects in an aquatic ecosystem. This study investigated concentrations and trophodynamics of 16 priority PAHs in food webwb (food web comprising whole bodies) and food webm (food web containing only muscles) of total 14 species. TMF values of PAHs in food webm ranged from 0.34 for pyrene to 0.68 for phenanthrene compared to TMF values of food webwb ranged from 0.34 for pyrene to 0.74 for fluorene. Because of two opposing scientific views for biomagnification and biodilution of PAHs in the food web, albeit based on a rather limited number of studies, our study investigated that there is parabolic behavior of most of the PAHs. Concentrations of PAHs in the red-eared terrapin (Trachemys scripta elegans) were biodiluted which showed that this species metabolises such compounds. Hepatobiliary system (such as gall bladder and liver) in the whole body considered to have higher bioaccumulation potential of organic compounds than extrahepatic tissue (muscles).

TP061 Bioaccumulation prediction of persistent organic pollutant in freshwater mussel using passive sampling

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Accurate prediction of persistent organic pollutant (POP) uptake in benthic organisms is critical for bioaccumulation prediction higher in the food web. The case of freshwater mussel such as Elliptio complanata is of particular interest due to their biology. They live in sediment and consequently are exposed to porewater concentration but filter feed on particles and plankton that are in equilibrium with the water column. In this study, we tested the passive sampling approach as a tool to predict POP bioaccumulation in E. complanata and estimate the relative contribution of water and porewater in POP uptake into E. complanata. We used polyethylene (PE) sheets as passive sampler to measure the freely dissolved water column and porewater concentrations. PE were co-deployed with caged mussels for a period of 2-3 months in summer in several streams of the Anacostia watershed. Our analysis was targeted on 119 PCB congeners, 34 PAHs and several organochlorine pesticides. Lipid, protein and carbohydrate content in mussel were also measured. Streams selected had a wide range of POP concentration from below to above EPA water quality criteria for the protection of human health. Various scenarios were observed with water column being the source, the sink, or at equilibrium with the sediment porewater, depending on the streams and pollutants considered. Equilibrium partitioning-based models were first tested using water column concentration measured and various partitioning coefficient to lipid (Klip) reported in the literature. Results showed reasonable agreement within a factor of 2 to 10 between predicted and measured concentrations depending on the Klip value used. Models were further refined to include nonlipid organic matter but did not show significant improvement in the predictions. Additionally, the fractional contribution of pore water to bioaccumulation is being estimated for E. complanata for one site and used in the model for the remaining sites. By linking water concentrations to uptake in freshwater organism, it is possible to estimate load reductions necessary to achieve a target concentration in tissue for the protection of human health.

TP062 Spatial and temporal trends in cyclic volatile methylsiloxanes in top predatory fish in Canadian lakes

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Organosiloxanes are high production volume chemicals and are common components of many personal care products, cosmetics, as well as many other materials such as dry-cleaning solvents and industrial cleaning fluids. Due to their usage patterns and physiochemical properties, the majority of releases to the environment are through solid and water waste streams where they bind to aquatic sediments or volatilize to air. Cyclic volatile methylsiloxanes (cVMS) such as octamethylocyclohexasiloxane (D4), decamethylocyclopentasiloxane (D5), and dodecamethylocyclohexasiloxane (D6) have been detected in different compartments of the aquatic environment including water, sediment, and biota. Concentrations of D4,
D5 and D6 in whole-body homogenates of top predator fish, lake trout and walleye, from sites across Canada were measured as part of Environment and Climate Change Canada’s (ECCC) National Fish Contaminants Monitoring Program. Due to the volatile nature and ubiquitous presence of cVMS in personal care products, contamination during laboratory processing can be a concern. To address this, a background study on the laboratory pre-processing of samples was conducted to determine the optimal processing procedures. Additionally, a multi-year collaborative study between ECCC and the Global Silicone Council adds validity to this dataset by allowing for an inter-laboratory comparison of cVMS concentration data. The objectives of this study were to assess spatial trends of cVMS in predatory fish from sites across Canada, conduct an interlaboratory comparison of trends in cVMS concentrations in lake trout collected from Niagara on the Lake in Lake Ontario and incorporate appropriate QCs during sample processing to facilitate quantification of contamination and subsequent background correction of sample concentrations.

TP063 Determination of Oxybenzone, Clofibrate, and Sulfamethoxazole in Water, Sediment, and Fish from Galveston Bay and Clear Creek Areas

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Environmental chemical contaminants have been of major concern as they can cause adverse health effects in single or multiple forms — even at trace levels. They are derived from different activities; and they include pesticides, personal care products, pharmaceuticals, and byproducts of various industrial processes. The contaminants often referred to as contaminants of emerging concern (CEC) are of growing awareness and concern because of their possibilities of interacting with biological systems to cause serious health issues. CEC are used daily and are continuously released into the environment via various waste streams. Galveston Bay and Clear Creek receive waters from several sources including runoffs which may contain a significant number/concentration of contaminants with a high possibility of human exposure. The potential adverse effects of the contaminants on humans, human environment, and the ecosystem can range from acute to chronic and are of significant importance. This study analyzed the presence of selected CEC: oxybenzone, sulfamethoxazole, and clofibrate in the water, sediment, and fish samples from the Galveston Bay and Clear Creek areas. Samples were collected from the identified locations, extracted using standard protocols, and analyzed using high-performance liquid chromatography coupled with an ultraviolet/visible detector. Results quantified, and bioaccumulation calculated. The results showed the presence of the contaminants in the samples analyzed. The concentration of oxybenzone in water and sediment samples were 1.85 ± 0.82 and 1.30 ± 1.55 ppm respectively. Oxybenzone in fish tissues/organs was 38.49 ± 14.64 ppm, this is 2.081% and 2.961% its concentration in water and sediment samples. Clofibrate was detected at a concentration of 0.45 ± 0.31 and 2.28 ± 3.76 ppm in water and sediment samples. Its concentration of 7.76 ± 2.46 ppm found in fish tissues/organs is 17 and 3 times more than the levels in water and sediment. Sulfamethoxazole was below detection limits. Thus, the results revealed that oxybenzone and clofibrate are present in the locations analyzed and they bioaccumulate in fish tissues/organs with a high probability of biomagnification in higher animals. Oxybenzone has a higher bioaccumulative capacity and may produce more toxic interactions. The data from this research is an impetus for the continuous monitoring of the levels of CEC in the Galveston/Clear Creek areas bodies of water and the aquatic environment.

TP064 Influence of dissolved organochlorines on bioaccumulation in San Diego Bay, California

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San Diego Bay is a natural embayment used for both recreation and industry and comprises a large working waterfront as well as several military facilities. Previous studies and ongoing monitoring programs in this region have identified elevated levels of PCBs and other organochlorines in both sediment and biota samples. However, the influence of dissolved organochlorine concentrations in the water column, due to flux from sediment or other sources, to bioaccumulation has not been characterized. Quantification of the site-specific influence of sediment and water column contamination on food web contamination is a critical component of establishing effective sediment cleanup targets and assessing regulatory attainment. The purpose of this study was to evaluate the specific contributions of sediment organochlorines, including pesticides and PCBs, to the water column via flux and transport mechanisms, and relate these data to spatial and temporal variations in biota concentrations and bioaccumulation model estimates. Samples were collected at 10 stations within San Diego Bay that represented a large range of sediment contaminant concentrations. Organochlorine concentrations in sediment grabs, mid-depth water column passive samplers, sediment-water interface passive samplers, and biota (zooplankton and fish) were measured in Spring and Fall 2018. These data were used to evaluate the distribution of organochlorines from the sediment through the water column, and examine the correspondence with measured and predicted biota concentrations. Sediment porewater and bulk sediment concentrations were highest at stations 1, 3, and 5, with a clear gradient in concentration between the sediment porewater concentration to the mid-water depth dissolved concentration. Highest tissue PCB concentrations were present in all the fish species sampled (shiner perch, topsmelt, and spotted sand bass), and were found at stations 1 and 8 during both sampling events, as well as station 7 in Spring 2018 and station 3 in Fall 2018. The highest concentrations were frequently found in both North and Central San Diego Bay. A site-specific bioaccumulation model will be used to determine expected biota concentrations and investigate the relative influence of sediment and water column matrices on food web contamination.

TP065 Evaluation of published bioaccumulation data for per- and polyfluoroalkyl substances across aquatic species

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Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals of concern across the globe, and some of the PFAS chemicals are known to be bioaccumulative in aquatic and avian species. A literature search for bioaccumulation information for PFAS compounds has been done, and the reported bioconcentration factors (BCFs), bioaccumulation factors (BAFs), biota-sediment accumulation factors (BSAFs), biomagnification factors (BMFs), and trophic magnification factors (TMFs) have been assembled and evaluated for quality. The quality evaluation involved assigning a low, medium, or high-quality ranking to the studies based upon criteria such as “Were the measurements for BCFs performed according the OECD 305 protocol?”, “Were uptake and elimination rates measured?”, “Were adequate numbers of field samples collected to obtain representative samples for biota and water phases?”, and “Were field samples co-located in space and time?” From this dataset, we will present information on the aquatic species with measured bioaccumulation metrics and on chemical subgroups within the PFAS universe with measured bioaccumulation data. From these data, we will identify
gaps and limitations in bioaccumulation information for PFAS chemicals and develop some initial estimates on the variability of BCFs and BAFs sorted by organism trophic level. This abstract does not necessarily reflect USEPA policy.

**TP067 Antidepressants in the sea: Washed away or taken up? Quantifying Fluoxetine and Venlafaxine in cuttlefish and crabs**

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Prescriptions of antidepressants are still on the rise worldwide, and their excretion may result in a potential contamination of the aquatic compartments. Indeed, antidepressant residues such as fluoxetine (FLX) and venlafaxine (VEN) are currently detected at low concentrations, from ng.L⁻¹ to µg.L⁻¹. Due to bioaccumulation, however, the toxicity of these micropollutants is not necessarily represented by their concentration in the water body. Furthermore, these compounds conceived to treat depressive or anxiety disorders are worrisome because they can trigger neurobiological changes through targeting the serotonergic system of non-target organisms, such as marine invertebrates. Indeed, juvenile shore crabs and cuttlefish, which are particularly vulnerable to predators, thrive in the intertidal zone and coastal water. To study the effects of antidepressants at environmental concentrations, juvenile cuttlefish and crabs were exposed during 30 days to fluoxetine alone or in mixture with venlafaxine (i.e., 2.5 ng.L⁻¹ and 5 ng.L⁻¹). Behavioural test results showed an effect of the antidepressant on predation and camouflage. Now we investigate if VEN or FLX are bioaccumulated in these juvenile organisms at environmentally realistic concentrations. A former method from Robert et al. (2017) was updated to allow detecting and quantifying the two antidepressants at very low concentrations (pg.mg⁻¹). QuESChERS method was used for extraction and chemical analysis was done via LC-MS-MS.

**TP068 Can we say something about the bioaccumulation potential of molecules sharing the same chemical formula without knowing their exact structures?**

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Non-target analysis (NTA) is rapidly gaining popularity as a screening-level analytical technique. Based on high-resolution mass spectrometry, it enables swift acquisition of thousands of mass spectra, thereby allowing for the detection of a wide array of chemical contaminants and their metabolites in environmental and biological samples. Oftentimes, it is relatively easier to obtain the chemical formula, i.e., the numbers of each type of atom in a molecule, but more demanding and time-consuming to elucidate their exact chemical structures one by one. Therefore, we need to prioritize the chemical formulae that are most likely to be “troublesome” (e.g., bioaccumulative) and hence need further elucidation of their exact structures. In this presentation, we will present a model-based method to automatize the prioritization of thousands of chemical formulae based on bioaccumulation potential, e.g., to what extent a chemical can be biomagnified along a food chain. In the meanwhile, we will establish how variable the bioaccumulation potential can be for isomers sharing the same chemical formula. For each of the chemical formulae detected in environmental samples (e.g., sediment), the approach makes it possible to enumerate a range of plausible isomers by extraction from the ChemSpider database or random generation from the Molgen model. The model predicts their partition coefficients between octanol, water and air using poly-parameter linear free energy relationship (pLFER) and the biotransformation half-life in biota using the automated Iterative Fragment Selection (IFS) algorithm. These parameters allow us to evaluate the bioaccumulation potential of individual isomers. Chemical formulae are ranked based on the number (or percentage) of isomers that are identified to be bioaccumulative. We found that the water/air (KAW) and octanol/air (KOA) partition coefficients predicted for one chemical formula can span over more than six orders of magnitude whereas the octanol/water (KOW) partition coefficient is much less variable. The biotransformation rate constants predicted for one chemical formula in both fish and humans span around two orders of magnitude. This work is the first effort that seeks to characterize environmental chemical bioaccumulation potential while by-passing the need for converting mass formulae to structure. It could direct future NTA studies to formulae that are predicted to have environmentally undesirable properties.

**TP069 Avoiding bias in human health and ecological risk assessments by using censored regression methods to develop tissue bioaccumulation models**

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The approach to handling left-censored results (i.e., non-detects) in co-located tissue and soil data sets, which are used to develop bioaccumulation regressions for predicting tissue concentrations from soil concentrations, may lead to unintended bias in risk estimates. Risk assessments for humans and upper trophic level wildlife frequently require estimates of contaminant concentrations in food or prey tissue. Ordinary least squares linear regression may be used to estimate food or prey tissue concentrations from environmental media concentrations if enough co-located data are available. If there are non-detects in the tissue, soil, or both, a decision about how to handle non-detects in the regression is needed. Despite the availability of censored regression methods, common practices have been to exclude the non-detects or substitute proxies for non-detects (e.g., using detection limit or one-half detection limit values). Censored regression methods, which estimate the regression using, for example, maximum likelihood estimates, account for the uncertainty about the actual values of the censored data. To explore the consequences of the selected approach, we evaluated the magnitude of bias that could be introduced into human or wildlife risk assessment by exclusion or substitution approaches. The outcomes of simplified upper trophic level wildlife risk estimates using various approaches to handling non-detects were compared using simulated data sets across a range of detection limits (i.e., proportions of censoring), regression slopes, and standard deviations. Monte Carlo simulations were used to develop confidence bounds on wildlife exposure and risk estimates under various scenarios. As expected, in data sets with few non-detects (e.g., < 5%), the approach to handling non-detects had little effect on the risk assessment outcome. However, when non-detects represented a substantial portion of the results (e.g., >25%) the approach to handling non-detects resulted in substantial bias. In our simulations, censored regression methods consistently yielded more accurate results (based on slope and intercept comparisons) than exclusion or substitution approaches. The magnitude of bias introduced by substitution methods and the accuracy of censored regression approaches depended not only on the proportion of non-detects in the data, but also on the slope and relative variability of the tissue-to-soil relationship.

**TP070 Quantifying Primary Sources of Variability in Laboratory Bioaccumulation Tests**


Bioaccumulation tests are a critical component of regulatory dredging evaluations. Standard bioaccumulation tests conducted in accordance with procedures outlined in the Ocean Testing Manual (OTM) and the...
Inland Testing Manual (ITM) utilize *Macoma nasuta* (a clam), *Alitta virens* (a polychaete) for marine tests and the oligochaete *Lumbricus variegatus* for freshwater tests. Tests are designed to detect statistical differences in tissue residues of dredged and reference sediment exposed test organisms. However simple statistical differences may not equate to biologically relevant differences, therefore it is important to understand the role of variability associated with test design (laboratory exposure and tissue chemistry) and provide guidance to ensure appropriate expenditure of resources for additional analysis only when biologically relevant differences have been established. While many labs have demonstrated capability to conduct bioaccumulation tests and many labs have demonstrated capability to quantify tissue residues, the interlaboratory variability associated with conducting exposures and quantifying resulting tissue residues in 28-day bioaccumulation tests has never been addressed. To quantify variability of laboratory bioaccumulation tests, the USACE-ERDC, the USGS-CERC and two commercial bioassay laboratories (EA and EcoAnalyt) participated in an interlaboratory evaluation. Marine (*M. nasuta* and *A. virens*) and freshwater (*L. variegatus*) species were exposed in standard 28-day bioaccumulation tests to marine and freshwater sediment, respectively, contaminated with low levels of PCBs (1-2ppm total PCBs) [LGRC(1)]. At test termination all participating labs provided resulting tissues to ERDC’s lab for analysis to enable quantification of exposure variability. In a separate, parallel experiment, the ERDC conducted a second set of 28-day *M. nasuta* and *A. virens* bioaccumulation tests utilizing the same marine sediment and exposure conditions and provided splits of the resulting tissue composite to ERDC’s in-house lab and three commercial analytical laboratories for purposes of quantifying analytical variability. Evaluation of variability associated with both exposure and tissue analysis will be summarized and the implications for determining biologically relevant differences in 28-day bioaccumulation tests discussed.

**TP071 Towards an improved understanding of the bioaccumulation and trophic transfer of microplastic particles**

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Observations of microplastic particles (MPs) in the environment and their detection in the stomachs and intestines of aquatic organisms have been reported since the early 1970’s. Given that the size of MPs is in the same size range of the particles and prey ingested by suspension-feeding invertebrates, an argument has been proposed regarding the potential of microplastic to be consumed by organisms low in the food-web, which could then facilitate transport of MPs to higher trophic-level organisms. Whereas several studies continue to report microplastic in the gastrointestinal tract (GIT) of various species, strong evidence for a bioaccumulation process remains poorly understood for this methodologically challenging group of materials and there currently exists no systematic review that has been conducted to assess the issue related to the bioaccumulation of microplastic. The ingestion of particles of varying sizes for aquatic organisms can vary from species to species and is strongly influenced by physiological and behavioural traits that are related to the size of the organism and its feeding strategy. Consequently, some species may be susceptible to ingesting and accumulating MPs, however, there currently exists limited mechanistic understanding related to the potential of MPs to bioaccumulate. The bioaccumulation potential of MPs thus represents a concern to regulators assessing the environmental risks of MPs, as their bioaccumulation may result in internal levels that can impact both individuals and populations. The objective of this presentation is to summarize observations obtained from a critical review of the literature related to the biological uptake and bioaccumulation of MPs reported over the last 50 years in both aquatic and terrestrial species at all levels of biological organization. The critical review includes an assessment of the quality of the data associated with studies reporting biological uptake and bioaccumulation, a summary of trends with respect to size and types of MPs reported, guidance with respect to monitoring of species most sensitive to ingesting MPs and the potential for trophic transfer.

**Adverse Effects of Chemicals on the Microbiome**

**TP072 Unveiling the endangered St. Laurence Estuary beluga’s skin microbiome and its potential utility in halogenated flame retardant exposure monitoring**

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Multiple sources of contaminants (e.g. wastewater effluent, industry runoff) represent toxicological hazards to coastal organisms including marine mammals. Persistent and bioaccumulative chemicals such as polybrominated diphenyl ethers (PBDEs) are at high levels in the blubber of St. Lawrence Estuary belugas, posing a continuous threat to an already endangered population. Current beluga contaminant monitoring relies on skin biopsies, a highly invasive procedure that is challenging for the study of marine mammal populations. Skin microbiome analyses represent an innovative and non-destructive biomarker approach to monitor environmental toxicants and animal health. Presented here is a beluga skin microbiome analysis aimed to investigate the beluga skin microbiome communities, understand the relationship between biopsy contaminant concentrations of halogenated flame retardants and the skin microbiome and, to identify potential biomarkers for early detection of altered ecosystem health. Biopsy samples were collected from the dorsal regions of adult belugas and analyzed for the concentrations of 35 PBDEs and 13 emerging halogenated flame retardants. The skin microbiome was obtained by swabbing the beluga skin, extracting bacterial DNA collected, and performing 16S amplicon-based DNA sequence analysis. A total of 117 samples, including skin swabs, sea water controls and sequencing controls, were sequenced using Illumina MiSeq technology, and amplicon sequence variants identified and assigned to a taxonomy profile using Qiime2. Further metadata analysis, including contamination-microbiome differential abundance analysis, was initiated using the taxonomic profiles of the skin microbiomes, sample metadata, and contaminant metadata. Skin microbiome analysis revealed that belugas have their own distinct skin microbiome, which differs from the surrounding seawater. There were no significant differences between the skin microbiome of male and female belugas nor at different geographic regions within the estuary. However, notably, we identified several bacterial taxa at the phylum and genus level that were strongly correlated with concentrations of certain contaminants. These warrant further investigation as potential biomarkers. Results to date do suggest a potential utility of skin microbiome analysis for non-invasive monitoring of contaminants in belugas that warrants further study as a tool to aid investigation of such species at risk.

**TP073 The Binding of Antidepressants to Analogous Transporters on Neurons and Bacterial Cells, What Might this Mean for Gut Microbiota?**

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Pharmaceuticals such as serotonin reuptake inhibitors (SSRIs) can be found downstream of wastewater treatment plants. Studies are continuously being conducted to elucidate the impacts these contaminants may have on aquatic organisms. With recent understandings of a microbiome-gut-brain axis and the ability of bacteria to synthesize and transport biogenic amines, such as serotonin, it is useful to understand how SSRIs may also influence the relationship between aquatic organisms and their gut microbiomes. Inhibition of bacterial growth cultured from the gut of *P. promelas* when exposed to fluoxetine, a common SSRI, has been
observed. In order to better understand the mechanisms of inhibition, we propose to first assess if these bacteria hold the sodium symporters: uptake-2 plasma membrane monoamine transporter (PMAT) and the organic cation transporter (OAT), encoded within the same solute carrier gene family as the serotonin reuptake transporter (SERT) found on neurons and other host organism cells. This study will be conducted using five bacteria species cultured from the gut of *P. promelas*, and a fluorescence-based assay consisting of fluorophores that mimic serotonin which can be taken up into the cells specifically by OAT and/or PMAT. If fluorescence is observed, it can be acknowledged that the bacteria cells carry the applicable sodium symporters. Furthermore, an exposure of the same bacterial species to fluoxetine and the fluorophores will be performed to identify whether fluoxetine is binding to OAT and/or PMAT resulting in inhibition of growth. This study should allow for identification of sodium symporters on the bacteria cells being investigated and determine if fluoxetine is impeding growth of the bacteria by binding to these transporters. This preliminary data is crucial in understanding how the SSRI, fluoxetine, may cause dysbiosis of gut microbial communities, potentially influencing fish homeostasis. For further insight into how fluoxetine effects the intestinal microbiome, future research will be conducted to identify perturbations of the gut microbiome of *P. promelas* due to fluoxetine exposure in vivo.

**TP074 The sub-chronic effects of polycyclic aromatic hydrocarbons (PAHs) on the sheephead minnow gut-microbiome and foraging behavior**

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The microbiome plays a key symbiotic role in maintaining host health and aids in acquiring nutrients, supporting development and immune function, and modulating behavior, therefore protecting the host from opportunistic pathogens and other environmental stressors. Microbial communities can vary in species composition and have functionally different roles depending on their location within the host. However, more research is needed to elucidate the potential impact of environmental pollutants on microbial communities and how they can mediate toxicity to the host. Recent studies have shown that contaminants can change the composition and function of vertebrate microbiomes with some evidence showing a shift towards species that are capable of degrading specific chemicals. The Deepwater Horizon disaster that occurred in April 2010 was the second largest oil spill in history and had catastrophic effects on several ecologically important fish species in the Gulf of Mexico. This study aims to determine if exposure to weathered oil will affect the abundance and composition of fish gut-associated microbiomes as well as foraging behavior. We accomplished this by sequencing the gut microbiome of a native Gulf estuarine species, the sheephead minnow (Cyprinodon variegatus). Fish were exposed to oil within HEWAF (High Energy Water Accommodated Fraction) over a 7-day period and whole gastrointestinal tracts were sampled for microbiome analyses. Fish also underwent a foraging behavioral assay to determine feeding efficiency before and after the 7-day exposures. We predict that microbes involved in degrading polycyclic aromatic hydrocarbons (PAHs) will increase in abundance, and that foraging behavior will become less efficient, potentially due to microbiome dysbiosis.

**TP075 Soil Acidiﬁcation Accelerates Nitrogen Loss via Anaerobic Ammonium Oxidation Coupled With Ferric Reduction**

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Long-term application of nitrogen fertilizer in agricultural leads to gradual acidification of soil, but nitrogen loss in acidified soil has less attention. Anaerobic ammonium oxidation coupled to iron reduction (Feammox) is a recently discovered pathway contributing to nitrogen loss in various ecosystems such as paddy soils. However, little is known about the Feammox under soil acidification in an agricultural ecosystem. Meanwhile, the specific approach of Feammox is still not clear. Here, Feammox has been demonstrated in the red clay of Southwest China using 15N isotopic tracing technique, and mechanisms of Feammox under acidic conditions have been clarified. Results showed that the potential N losses linked with Feammox was 0.94 ± 0.08 mg N kg⁻¹ d⁻¹ and Feammox accounts for 86.2% of total N losses under acidic conditions. This rate was significantly higher than that at higher pH values treatments. Microbiological data suggested that a significant increase in the abundance of *Clostridium* and *Acidimicrobiaceae* under acidic conditions which possibly involved in ammonia oxidation and NOX⁻ reduction. Based on the results of the prediction of abundance of functional gene contents, the functional categories of nitrate and nitrite reduction or transfer were significantly higher under acidic conditions. Ammonia may firstly be oxidized into NO2⁻ by microbial and then reduced to N2 by Fe(II) by reduct reaction and it could be the mechanism of Feammox under low pH conditions. Overall, this study evaluated the potential rate of N loss via Feammox and demonstrated Feammox made an important contribution to N loss in acidic soils.

**TP076 Sub-chronic dietary exposure to the organochlorine pesticide dieldrin alters the gut microbiome of zebrafish (Danio rerio)**

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The gastrointestinal (GI) system is the first line of defence for dietary exposures to environmental contaminants. Long-term ingestion of chemicals can lead to GI pathology and an altered microbiome. This is important as gut dysbiosis is significantly associated with animal and human disease. The organochlorine pesticide dieldrin is a legacy environmental contaminant, accumulating in tissues of organisms. Dieldrin is lipophilic and bioaccumulates up through trophic levels, resulting in significant dietary exposures. The objectives of this study were to determine how environmentally relevant levels of dieldrin affected gut morphology and its microbiome in zebrafish. Adult male zebrafish (AbTu strain) beginning at 5 months of age were fed a measured amount of pelleted feed of either control or dieldrin (measured at 16 ng/g and 163.5 ng/g dry weight). Zebrafish in the three experimental groups did not show any difference in weight gain over 4 months. Body burden levels of zebrafish at the end of the exposure were 10.8 ng/g and 18.32 ng/g wet weight (10x and 20x above background levels). Dietary exposure to dieldrin did not induce any notable gut pathology. The gut content was extracted from males in each group and 16S rRNA sequencing conducted, followed by QIIME analysis pipeline. Interestingly, dieldrin fed to fish at 16 ng/g lowered the abundance of Firmicutes, bacteria involved in energy resorption, and one that is common to many disease states (e.g. diabetes, obesity). Detailed evaluation on class level revealed a decrease in Clostridia (class of Firmicutes), Betaproteobacteria and Verrucomicrobiae species following dieldrin treatment. Changes in the abundance of these microorganisms are observed in many human diseases. Approaches are ongoing to annotate the observed changes in microbiome composition with predicted effect on bacterial bioactive metabolites. This study demonstrates that low dose exposure to dieldrin can dysregulate the microbiome-host axis, however the long-term impacts of gut dysbiosis on fish health remain unknown.
TP077 Impacts of emerging short-chain PFASs on fatty acid metabolism and the microbiome

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There is growing concern over long-term chronic exposure to per- and polyfluorinated alkyl substances (PFASs), a group of >4000 chemicals widely used in consumer and industrial products. PFASs have become ubiquitous contaminants in drinking water and food, and are associated with increases in serum total cholesterol in adults, reduced birth weight, and decreased antibody response to vaccination in children. A leading hypothesis for why PFASs are bioavailable and interact with many biological targets is that they mimic endogenous fatty acids and hence may interfere with their metabolism. This study is investigating, at a mechanistic level, how PFASs interact with the gut microbiome and its role in fatty acid metabolism. We hypothesize PFASs may disrupt lipid metabolism by interfering with the processing of essential short-chain fatty acids (SCFA) or by disrupting the gut microbiome. To test this hypothesis, we have leveraged a suite of innovative molecular tools, including lipidomics, droplet digital PCR (ddPCR), and 16S rRNA sequencing, using the mouse as a model organism. Male and female C57BL/6 inbred mice have been exposed to several short-chain perfluorinated alkyl ethers and one short-chain perfluoroalkyl acid. The chemical structures of these short-chain acids suggest they may compete with or inhibit short-chain fatty acids produced by gut bacteria such as butyrate, a 4-carbon fatty acid with key neuroprotective and nutritional roles. In this talk we will present initial results from our integrative analysis of how PFAS exposure changes the composition of the gut microbial community using ddPCR and sequencing. We will also discuss the use of liquid chromatography high resolution mass spectrometry (LC-HRMS) to probe differences in microbiome function with PFAS exposure, including how we can probe the extent to which PFASs participate in and alter fatty acid metabolism pathways. This study seeks to establish, for the first time, PFAS-microbiome interactions in adult mice and also develop novel lipidomic methods to trace impacts on fatty acid metabolism, focusing on PFASs of unknown toxicity and of high relevance to ongoing drinking water contamination.

TP078 Evaluating the viability of microbial viability assays for the microbiome of the built environment

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The microbiomes of built environments are a major route by which humans are exposed to both commensal and pathogenic microbes. Despite growing interest in these microbiomes, elucidation of their community structures and mechanisms of transmission to humans are challenged by an inability to distinguish viable microbes from relic DNA. Previous studies have used pre-treatment of samples with propidium monoazide (PMA) coupled with downstream molecular profiling (e.g. qPCR or DNA sequencing) to attempt to characterize the viable fraction of a microbial community. While these studies have met with some success, most have focused entirely on synthetic communities and failed to validate their read-outs. Here, we describe our ongoing efforts to rigorously benchmark “PMA-seq” (PMA treatment followed by 16S rDNA amplicon sequencing) as a screen for microbial viability in a combination of synthetic and natural microbial communities. Our first validation experiment focused on synthetic mixtures of living and heat-killed Escherichia coli and Streptococcus sanguinis. Here, we were able to successfully reconstruct the communities of live/dead E. coli and S. sanguinis using PMA-seq. Next, to test the effects of biomass and sample diversity on PMA-seq, we sampled communities of variable initial biomass (computer mice and screens, soil, and saliva) and combined them with known mixtures of living and dead E. coli as internal controls. These trials demonstrated sub-optimal performance, especially at high biomass, suggesting that further protocol tuning is needed. Once this is complete, we will apply PMA-seq to unspiked environmental samples from the Boston subway system (seats, grips, and ticketing touchscreens) to identify and quantify living microbes in that environment. This is the first study to employ a comprehensive evaluation of the performance of PMA-treatment to test the viability of microbes in built environments. In the future we will conduct additional testing of PMA-seq on high biomass and diverse communities of microbes, as detailed above. Further work will plan to expand our work to include other methodologies used in human research to distinguish active vs. dormant microbes, such as RNA-seq. Detection of viable microbes within a community will allow for further elucidation of interactions between different microbes and with the ecosystem/host, potentially furthering our knowledge of the interplay between the environment and human health.

Toxicity Beyond PAHs: New Insights Into Effects of Weathered Oil After Spills

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Thousands of petroleum hydrocarbon compounds are present in mixtures in petroleum releases and this presents challenges for attributing hazard (toxicity) at spill sites. Non-targeted GCxGC-MS analyses of historically impacted groundwater have tentatively identified more than 1,000 unique polar metabolites that include acids/esters, alcohols, phenols, ketones, and aldehydes. Our goal was to better elucidate the toxicity attributable to petroleum biodegradation metabolites in groundwater at petroleum release sites. The potential aquatic toxicity of biodegradation metabolites was thus investigated in three ways. 1) Individual components’ toxicity was estimated through the development of a relative ranking system. Here, metabolites chemically identified in groundwater plumes were grouped into 5 families (i.e. alcohol) and 22 classes (i.e. alkyl alcohol), and searched for in reference dose (RfD) databases. Resulting RfDs were compared to regulatory guidance thresholds and ranked (i.e. low, moderate, high). Chemical families corresponding to higher degradation tended to have lower risk rankings. 2) In vitro tests were run on groundwater samples. Eight (8) groundwater samples that represented upgradient (local background conditions) and downgradient (intending to contain metabolites but not hydrocarbons) groundwater were collected and submitted to a laboratory for chronic aquatic toxicity tests as well as in vitro genotoxicity and endocrine assays. Chronic aquatic toxicity bioassays included EPA method 1000 (Pimephales promelas; survival and growth) and EPA Method 1002 (Ceriodaphnia dubia; survival and reproduction). No consistent changes between upgradient and downgradient samples for aquatic toxicity, genotoxicity, or estrogen receptor activity were observed. 3) In vivo bioassay results were complimented by computational toxicology approaches. Similar to the risk ranking, ecotoxicological data was pulled from the European Union’s chemical registration database (QSAR Toolbox 4.2 software; OASIS LMS) for identified metabolites. The literature query yielded empirical studies on invertebrate and vertebrate aquatic toxicity data that suggests decreasing aquatic toxicity along the hydrocarbon degradation pathway and with decreasing alkyl chain length. Finally, the bioaccumulation potential of various compounds along the degradation pathway were modeled to better understand the potential risk of accumulation up the food chain.
TP080 Modeling Analysis of the Importance of Photo-oxidation to Oil Weathering, Water Column Exposure and Aquatic Toxicity
D.P. French-McCay, A. Dissanayake, RPS Ocean Science

Oil weathering and fate processes (evaporation, photo-oxidation, dispersion by turbulence and dispersant use, dissolution, biodegradation, sedimentation) modify the chemical composition of floating oil, affecting aquatic exposure and toxicity in surface waters. During periods of calm winds, evaporation quickly removes the volatiles and semi-volatiles in the original spilled oil, leading to little water column exposure and toxicity. However, during windy periods much more oil is entrained, increasing dissolution and exposure of surface water biota to PAHs and other semi-volatile and semi-soluble compounds. Photo-oxidation changes the composition of the surface oil, creating polar products that dissolve more readily than their precursors during these entrainment events, as well as during calm periods. This implies that photo-oxidation may increase the effects of oil on surface water biota over and above the known effects of photo-oxidation of PAH toxicity on clear-bodied organisms. However, the balance of formation rates of photo-oxidized products with dissolution, physical dispersion and biodegradation determines the degree of exposure and their effects on biota. Modeling analyses using pseudo-components representing the fate of various hydrocarbon groups and oxidation products, along with toxicokinetic modeling of narcotic effects, demonstrates the relative importance of photo-oxidation products in contributing to exposure and toxicity, as compared to compounds originating in the oil and photo-enhanced toxicity from PAHs.

TP082 Ten years Biomarker Monitoring Following the M/V Hebei Spirit Oil Spill in Korea -Biochemical Responses in Pelagic and Benthic fish
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After the M/V Hebei Spirit oil spill incident (7th December, 2007) in the west coast of Korea, contamination of biliary PAH metabolite and hepatic biomarkers in a pelagic and a benthic fish was monitored for ten years. Concentrations of 16 PAHs and alkylated PAHs in fish muscle were highest (22.0 ng/g d.w. for 16 PAHs and 284 ng/g d.w. for alkylated PAHs) at 5 days after the spill and then decreased rapidly to background levels at 11 months after the spill. Elevated levels of biliary PAH metabolites and EROD activity were found in fish collected from areas affected by the oil spill immediately after the spill. Biochemical responses based on hepatoxidation (CYP1A mRNA, CYP1A protein, and EROD) showed a significant relationship with the concentrations of biliary PAH metabolites in resident fish. The biochemical responses of pelagic and benthic fish to petrogenic PAHs exposure resulting from the HSOS were generally similar to those observed following other large oil spills. The physiological recovery of resident benthic fish was slower than that of pelagic fish. The slower recovery of benthic fish is possibly due to feeding habits on contaminated benthic organisms.

TP083 The biodegradation of dispersed oil does not induce toxicity
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The acute toxicity of dispersed oil is well understood, and oil dilutes to levels below those of acute concern within hours of dispersion whether oil is dispersed by high energy waves or with lower energy turbulence in the presence of chemical dispersants. Nevertheless, concern has been raised that the subsequent biodegradation of the dispersed oil might increase the acute toxicity by generating and releasing toxic by-products. We show here, using Americamysis bahia as the test species, that this does not occur. In the 16 days after dispersion, the indigenous microorganisms in seawater collected from the New Jersey shore removed 78% of the detectable hydrocarbons in a lightly weathered light oil. Sequential 96hr acute toxicity tests during this process showed no mortality.

TP084 The effects of the Deep Water Horizon oil spill on marine algae - A comparison of species sensitivity to field-collected source oil
K.A. Softechek, Smithers Viscient, LLC / Ecotoxicology

Limited algal toxicity data have been generated with crude or weathered oils as part of oil spill response and impact assessment activities. Smithers conducted a series of toxicity tests using four standard microalgae and one macroalga species: Dunaliella tertiolecta, Skeletonema costatum, Isochrysis galbana, and Thalassiosira pseudonana, and Ectocarpus siliculosus. Eight toxicity tests with Dunaliella and Skeletonema, and four each for Isochrysis, Thalassiosira, and Ectocarpus were conducted with field-collected source and weathered oil samples collected during the Deepwater Horizon (DWH) MC252 Spill of National Significance. A portion of the data was evaluated to compare the sensitivity of the five algal species tested to one of the field-collected source oil samples from the Gulf of Mexico after the DWH oil spill. As crude oils are mixtures of poorly water soluble hydrocarbons, exposures of weathered oil water-accommodated fractions (WAFs) were conducted at nominal loading concentrations of 100, 50, 25, 13, and 6.3% of a 1000 mg/L or 1.0 mL/L(oil) solution. Exposure solution samples were collected at the beginning and end of each exposure or renewal period for chemical analysis of volatile organic compounds (VOCs), parent and alkylated polycyclic aromatic hydrocarbons (PAHs), and saturated hydrocarbon compounds (SHCs). The toxicity of the oil sample was determined and evaluated on the basis of No-Observed Effect Concentration (NOEC) values based on average specific growth rates. The results of the toxicity tests were determined based on the nominal loading percent WAF based on the dissolved sum of toxic unit (ΣTUs) of the whole oil.

TP085 The Freshwater Oil Spill Remediation Study (FOReSt) - Examining minimally invasive remediation methods for oil spills
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Potential environmental impacts of oil spills are a concern for the Canadian public and the oil industry. There is also uncertainty on the part of regulators and the scientific community on which methods are best to employ when cleaning up oil spills in different environments. Improving the clean-up procedures, and demonstrating their effectiveness under realistic field situations is required. In 2018, the International Institute for Sustainable Development-Experimental Lakes Area (IISD-ELA) began a collaborative program to examine the fate and behaviour of diluted bitumen (dibit) and conventional heavy crude oil in the freshwater shoreline environment. In 2018, model oil spills in contained shoreline environments (15 X 2.5m) were used to quantify the efficiency of immediate product recovery and then to compare degradation via Monitored Natural Recovery (MNR) of residual oil constituents. Basal degradation rates of residual (i.e., after initial clean-up) weathered conventional crude and dibit were determined by assessing concentrations of oil constituents in water, sediment, and soil, including polycyclic aromatic compounds (PAHs) and their alkylated analogues (alkyl-PAHs). Microbial community shifts appeared to respond to the presence of oil and potential impacts of residual oil were evaluated at multiple trophic levels over a period of 16 weeks. Degradation trajectories were significantly different for dibit and conventional heavy crude oil in the low energy shoreline environments. Results form the 2018 pilot study were used to design a larger study being performed in 2019 that focuses on comparing the efficacy of oil removal using nutrient additions, a shoreline cleaner, and engineered floating wetlands relative to natural attenuation.
TP086 The toxicity of oil photo-products from Macondo oil to Gulf killifish embryos

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Oil spill risk is assessed solely on a limited number of measured compounds, usually the polycyclic aromatic hydrocarbons (PAHs). However, research on the Deepwater Horizon Incident suggests that solar radiation transformed over 50% of the mass of the PAHs in surface slick oil into photo-products within weeks of the spill. Current research is attempting to advance the scientific understanding of oil photo-product risks by producing comprehensive data on the bioavailability and dose-dependent toxicity of these compounds. Using a solar simulator, laboratory-weathered Macondo oil (i.e., dark control) was irradiated. This light-exposed oil (i.e., total irradiated oil) was separated on a silica gel into a saturated aromatic fraction and a polar fraction. The dark control, the total irradiated oil, and the saturated aromatic and polar fractions of the total irradiated oil were exposed to Gulf killifish embryos to assess the bioavailability and toxicity of each fraction. Preliminary work attempted to develop an oil exposure regime that generated large volumes of oily water of each oil fraction for continuous-flow exposures. Based on these preliminary experiments, a custom-dosing regime was developed consisting first of the generation of oily-water effluents prepared by passing brackish water through oily gravel contained in a glass desorption column at 4 °C. Following collection of the oily effluents from the glass columns, these oily waters were then used as stocks to create serially-diluted concentrations for use in toxicity testing on Gulf killifish embryos. Water chemistry was characterized using a two-dimensional gas chromatography method to identify and quantify oxygenated PAHs, carboxylic acids, and ketones from their parent compounds. We also used a solid-phase microextraction method to determine the bioaccumulation potential of each oil type. Finally, we evaluated biological responses and toxicity of these oily fractions in Gulf killifish over a 21-day exposure period. Results from this study will be used to examine the importance of photo-products with respect to exposure and toxicity to aquatic biota.

TP087 Toxicity Assessment of Hydrocarbon and Polar Components of Groundwater Plumes at a Terrestrial Crude Oil Spill Site


Nearly forty years after an oil pipeline rupture spilled 1.7 million liters of light crude into the adjacent sandy soil near Bemidji, Minnesota, groundwater contamination of the underlying aquifer continues to be evaluated. Biogeochemical processes and hydrologic transport of the parent petroleum hydrocarbons and their more soluble transformation products at this site have been the focus of extensive research since the time of the spill. The objective of this study was to provide an initial evaluation of potential toxicity of petroleum hydrocarbons and their polar metabolites currently found in groundwater at the site. Groundwater sampling included six wells along a gradient of hydrocarbon and polar metabolite contamination; ranging from a background reference well to hydrocarbon-dominated contamination to metabolite-dominated contamination. Toxicological characterizations included cell-based (aryl hydrocarbon receptor, AhR) transactivation assays and fathead minnow embryo developmental assays. Endpoints evaluated in the embryo assays included total body length, pericardial area, blood circulation, hatching rate, and survival. This array of sublethal endpoints allows for targeted assessment of toxicity. Dose-response relationships were generated for the cell-based assays and the in vivo embryo developmental assays. In vitro potency estimates indicated AhR activity in the metabolite portion of the plume, as well as in the hydrocarbon portion of the oil plume.

TP088 Toxicity of Gasoline, Diesel and Weathered Diesel Related Petroleum Hydrocarbons to Freshwater and Marine Organisms


The purpose of this study was to determine environmental effects-based concentrations of total petroleum hydrocarbons for assessing the impacts of fresh gasoline and fresh or weathered diesel in the freshwater and marine environments. The study was conducted by the Washington State Department of Ecology (Ecology) and Nautilus Environmental to determine the no-observed effects concentration (NOEC) and lowest-observed effects concentration (LOEC) of gasoline (C7-C12), diesel (C10-C24) and weathered diesel, in addition to IC25 and IC50 endpoints, using aquatic toxicity bioassays. This presentation compares results obtained with weathered diesel in groundwater from a contaminated site with previous results obtained with fresh gasoline and diesel. In separate experiments, hydrocarbons within either the diesel or gasoline range were spiked into toxicity test solutions and weathered diesel in contaminated groundwa- ter was obtained from a well-characterised site in Washington State. Petroleum mixtures were tested with two freshwater and two marine organisms. Freshwater organisms were the fathead minnow (Pimephales promelas) and a cladoceran (Ceriodaphnia dubia). Topsmelt (Atherinops affinis) and the echinoderm, purple sea urchin (Strongylocentrotus purpuratus) were the marine species tested. Tests were conducted according to USEPA test methods and Ecology’s whole effluent toxicity (WET) guidance document or “Canary Book” (Marshall, R., 2016). Publication No. WQ-R-95-80. Aquatic toxicity tests were conducted at Nautilus Environmental in Burnaby, BC. Hydrocarbon concentrations in toxicity test solutions were measured using Northwest Total Petroleum Hydrocarbon - Gasoline/Diesel (NWTPH-Gx and NWTPH-Dx) Methods at the Manchester Environmental Laboratory, Port Orchard, WA. Gasoline caused similar toxicity between topsmelt, fathead minnow and Ceriodaphnia, which were more sensitive than the echinoderm. The most sensitive endpoint for gasoline was fathead minnow biomass IC25 1.5 (1.2 - 1.7) mg gasoline/L with NOEC 1.0 and LOEC 2.1 mg gasoline/L. Diesel was generally more toxic than gasoline to all test organisms. The order of toxicity from most to least for diesel was as follows: echinoderm < cladoceran > topsmelt > fathead minnow. The most sensitive endpoints for diesel were: the cladoceran IC25 reproduction, 0.17 (0.16 - 0.19) mg diesel/L with NOEC 0.15, and LOEC 0.22 mg diesel/L. With the weathered diesel tests, this pattern changed. The fish became the more sensitive organisms, and the invertebrates were relatively insensitive to the groundwater concentrations of weathered diesel that we tested. All test organisms were generally less sensitive to the weathered diesel compared with fresh diesel. This may indicate that volatile compounds present in the fresh diesel may be responsible for greater toxicity to the organisms and in particular, the invertebrate species.

TP089 Weathering reduces the partitioning of hydrocarbons from oil trapped in river sediments but not the bioavailability of polycyclic aromatic compounds

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Oil spilled in rapidly flowing and turbulent rivers will be dispersed in the water column and may be entrained into bed sediments by hyporheic flows associated with pressure gradients caused by variable riverbed forms. Once filtered by bed sediments, hydrocarbons in trapped oil will partition into interstitial waters that support the development of fish eggs deposited in gravel by spawning salmon and other fish species, causing a risk of toxicity and recruitment failure due to components such as polycyclic aromatic hydrocarbons (PAHs). However, the extent of gravel contamination decreases as oil viscosity increases. Highly viscous heavy
New and Existing Chemical Contaminants in Changing Arctic and Antarctic Environments

TP090 Persistent Organic Pollutants (POPs) and Emerging Chemicals of Arctic Concern in Canadian Arctic Air
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Canada's Northern Contaminants Program (NCP) monitors for persistent organic pollutants (POPs) and other Chemicals of Emerging Arctic Concern (CEAC) in air at the High Arctic station of Alert, Nunavut (82°30'N, 62°20'W) since 1992. Air samples were screened for emerging contaminants, including halogenated flame retardants (HFRs), neutral and ionic per- and polyfluoroalkyl substances (PFASs) and other CEAC, to assess the long-range transport potential (LRTTP) of these compounds in support of chemical control initiatives. Temporal trends of POPs, HFRs and PFASs in the air are derived up to 2016 to better understand and evaluate the effectiveness of national and international regulations. Most legacy POPs are showing declining trends in Arctic air. POPs that are recently listed under the Stockholm Convention have started to show declining tendency in air. However, a time lag in declining trends for recently-regulated chemicals is observed. Many HFRs, which are used as replacement chemicals for polybrominated diphenyl ethers (PBDEs), are frequently detectable in Arctic air. The current study will explore the various factors affecting atmospheric levels of POPs and CEAC in Arctic air including chemical control regulations, source changes and effects of climate change.

TP091 Organotin contamination in the Arctic and subArctic environment
J.R. Kucklick, National Institute of Standards and Technology / Chemical Sciences Division; M. Ellisor, O2SI Smart Solutions an LGC Standards Company

The occurrence of organotins (OTs), particularly tributyl tin (TBT), in the marine environment has been widely studied in many regions across the globe. Research and monitoring in areas with high ship traffic, where historically TBT was used in antifouling coatings, has linked certain OTs with biological impacts particularly in invertebrates. In the Arctic and Subarctic, OTs are of continued concern as they are still widely used despite TBT being restricted from use on most marine vessels. The highest OT concentrations found in Arctic fauna are in regions associated with human activity especially marine transportation. There is an overall trend of declining butyl tin (BT) concentrations in Arctic fauna especially moluscs which are the subject of a limited number of long-term monitoring studies. The incidence of imposex has likewise generally declined in moluscs in response to declining TBT concentrations. There are a number of knowledge gaps in OT occurrence and transport in the Arctic that warrant continued monitoring. OTs, in particular octyl tins, are heavily used in the production of plastic, hence leaching from plastic may be an unrecognized source to Arctic regions. This review also found several studies reporting volatile tin species in the atmosphere suggesting atmospheric transport of volatile tins to the Arctic is possible. Relative to other more well known persistent organic pollutants, there are few reports of OTs in marine mammals and temporal tend studies are needed to define trends in BTs and search for the occurrence of other tin species.

TP092 Understanding the long-range transport of Perfluoroalkyl Substances (PFAS) using a High Arctic ice core
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Poly- and perfluoroalkyl substances (PFAS) are extremely persistent and bioaccumulative compounds that are distributed ubiquitously in the environment. They can be formed from the atmospheric oxidation of volatile precursor compounds or directly transported in their acidic form through the atmosphere and oceans to remote locations. Ice caps are commonly used to study temporal trends of contaminant since these elevated locations are expected to receive deposition solely from the atmosphere where they preserve a record of contamination. To improve our understanding of long-range transport (LRT) mechanisms to the High Arctic, a 15-meter ice core representing an accumulation period of forty-eight (48) years (1968-2016) was collected from the ice field adjacent to Mt. Oxford on northern Ellesmere Island, Nunavut, Canada at an exact location of 84.2°N, 73.8°W. Samples were concentrated using solid phase extraction (SPE) and analyzed by liquid chromatography-tandem mass spectrometry (LC-MS/MS). Ion chromatography-mass spectrometry (IC-MS) analysis will also be performed on sub-samples to determine major ions. Both perfluorocarboxylic acids (PFCAs) and perfluoroalkyl sulfonic acids (PFSA) are present in the ice core with interannual variations. This data will be compared to an ice core collected at 75.2°N, 82.7°W (Devon Island Ice Cap, Devon Island, Nunavut, Canada) to confirm our previous findings. The current ice core provides ten (10) additional years of deposition record and is located at a higher latitude close to suspected emission sources.

This data will be used to better understand transport mechanisms, pollutant sources and production changes of PFAS.

TP093 Using Ice and Sediment Cores to Quantify Climate-Warming Induced Inputs of Legacy Mercury to Lake Hazen, Nunavut
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Mercury (Hg) emitted from anthropogenic sources can undergo long-range atmospheric transport to the Arctic where it may cause health concerns for Arctic wildlife and indigenous people. Many sediment records do not show a clear decline in Hg deposition despite estimates that Hg emissions from anthropogenic sources have recently stabilized or declined, suggesting that Hg is being remobilized in catchments and delaying the recovery of lakes following emission reductions. To date there is little data on whether the input of legacy Hg increases Hg accumulation in lakes. We hypothesize that the climate-warming induced melting of glaciers may be remobilizing legacy Hg from glaciated watersheds into downstream lakes, providing an important subsidy of Hg in addition to modern Hg inputs. To test this hypothesis, we will compare Hg accumulation rates through time measured in an ice core and sediments cores collected from the Lake Hazen watershed, Nunavut, Canada. By comparing ice and sediment core data, we can determine
TP094 Disentangle local and remote contamination in fjord ecosystem of the high Arctic: The Kongsfjorden (Svalbard, Norway) as model system


Arctic fjord ecosystems are linked intimately to the dynamics of sea/ice, input of glacial melting water and it is reasonable that these complex interactions may be perturbed by global warming, ocean acidification, loss of sea-ice, and human impact on local and global scale. The impact of human activities on the marine ecosystems involves the continuous release of hundreds of thousands of legacy and emerging substances, and despite of several studies on the influence of legacy substances, there is only little knowledge on new threats related to local release of pollutants. The aim of this study is the comprehension of the contaminant dynamics in the Kongsfjorden and to disentangle the role of point-sources and its seasonality respect to the material released into the water column after ice melt. The results obtained within three sampling cruise carried out in Kongsfjorden (Ny-Ålesund, Svalbard, 79° N 12° E) in two different seasons (June 2016, March 2017 and July 2018) is shown. This fjord is a high-latitude (sub)-Arctic fjord, influenced by both the Atlantic water masses of the WSC (West Spitsbergen Current) and the Arctic-type coastal waters as well as a glacial input of melt water. The experimental design was drawn up to sample seawater (surface and bottom) and fine grained sediment along the main axis of the fjord in order to evaluate the dynamics of “old POPs” and “new” emerging contaminants: PCBs; PAHs; nonylphenols (NPs); bisphenol A (BPA), CUPs, PFAAs together with the determination of sediment texture, Organic C, total N, C/N ratio, δ13C and biogenic silica. In summer, the concentrations measured in seawater varied from 2.9 to 40.4 ng/L for PAHs, from 0.13 to 1.5 pg/L for PCBs and from 0.15 to 2.5 ng/L for PFAAs. Values found in winter were not significantly lower than the summer ones: the absence of solar irradiation and the lower temperature probably inhibited the degradation of these POPs, competing with the greater anthropogenic pressure and the ice melting inputs occurring in the spring-summer period. The statistical analysis on PCBs data supported the additive effect of season and distance from the glacier, but not their interaction: PCBs were higher in June than in March and decreased with increasing distance from the glacier in both sampling seasons. This trend highlights the release of POPs from melting glaciers acting as secondary sources of legacy pollutants.
Island, Hudson Bay and Ungava/Labrador. These regions were characterized by environmental parameters such as ice coverage, air temperature, precipitation and climate indices (i.e., Arctic, North Atlantic and Pacific/ North American Oscillations) through time. Results indicated that liver mercury concentrations were higher in seals collected from the western locations. Mercury and selenium concentrations in liver increased with age of seals, in a site-specific manner, to about 15 years of age. Temporal trends of mercury in liver increased significantly in seals from the Central Arctic and the Hudson Bay (4.7%, p < 0.05); other trends (Beaufort Sea, Hudson Bay, Ungava/Labrador) were not significant. Hepatic selenium concentrations increased with age of animals, however results indicated that exposure of seals to selenium decreased over the period of 1997-2017. The decreasing selenium trend was significant in seals from Ungava/ Labrador (-3.1%, p < 0.0001). Relationships of contaminants with climate parameters will be discussed.

**TP097 Environmental sources and trophic transfer of PFAS to the sub-Arctic ringed seal foodweb of Lake Melville, northern Labrador, Canada**

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Perfluoroalkyl substances (PFAS) are synthetic organic compounds that are highly persistent. Among these, perfluoroalkyl sulfonates (PFASs) and perfluoroalkyl carboxylates (PFCAs) have been shown to bioaccumulate in terrestrial and aquatic organisms. The ringed seal (Phoca hispida) is a semi-enclosed estuarine fjord located in northern Labrador eastern Canada, has not been previously evaluated for PFAS. Local sources of PFAS in the Lake Melville region are a military base in terrestrial and aquatic environments. The ringed seal (Phoca hispida) is a semi-enclosed estuarine fjord located in northern Labrador eastern Canada, has not been previously evaluated for PFAS. Local sources of PFAS in the Lake Melville region are a military base and airport and distant sources are PFAS delivered through atmospheric deposition and ocean circulation. We hypothesize that PFAS may be released from sediments into the water column through land disturbances related to climate change and development. Thus PFAS monitoring is warranted to determine exposure to Indigenous people feeding on ringed seals, fish, and other traditional country foods. The objectives of this research are to identify environmental sources of PFAS and assess their bioaccumulation in the Lake Melville food web. Biota and water samples were collected between 2013-2018 with seal samples provided by hunters during the local harvests. Liver and muscle of seals and fish, water, plankton, and other invertebrates were extracted then analyzed for a suite of PFCAs and PFASs using liquid chromatography tandem mass spectrometry. The total PFAS corresponded to 5.9 ± 1.5 ng/g dry weight (dw) for plankton >500 μm and 4.8 ± 1.6 ng/g dw. for plankton in the 153-500 μm size. In fish muscle, the total PFAS corresponded to 2.3 ± 0.3 ng/g wet weight (ww) in flatfish and 1.5 ± 0.6 ng/g ww. in cod. Seals liver in 2017 corresponded to 68 ± 12 ng/g ww. The predominant PFAS in ringed seal liver were each negatively correlated with body length, negatively correlated with C-13 stable isotopes, and positively correlated with N-15 stable isotopes, suggesting that increasing trophic position and greater freshwater/terrestrial feeding strategies were associated with higher PFAS burdens in seals. Evaluating trophic biomagnification factors (TMF) of PFAS requires consideration of different approaches compared to traditional hydrophobic organic contaminants. PFAS differ in that their measurements are commonly in liver, that they are lipophobic and bind to proteins, and the lack of practicability in sampling large marine mammals on a whole body basis. In this research, various TMF assessments are considered. This study is the first to investigate PFASs in the ringed seal food web in Labrador.

**TP098 Accumulation of PBDEs in Harp (Pagophilus groenlandicus) and Hooded Seals (Cystophora cristata) from the Northwestern Atlantic**

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Polybrominated diphenyl ethers (PBDEs) are highly lipophilic components of bromanized flame retardants that are environmentally persistent and bioaccumulative. PBDEs are taken up from the gastrointestinal tract and accumulate mainly in fat depots and liver tissues. Seal species inhabiting Arctic and sub-Arctic regions can have upwards of 30% of their body mass composed of blubber. When those blubber stores mobilized for energy, stored toxicants are also released into circulation. Most studies reporting accumulation of PBDEs in seals have focused on harbor and grey seals with few examining harp and hooded seals. In this study, PBDEs were analyzed in blubber from stranded harp and hooded seals sampled along the northeast coast of the U.S. (1999-2010). A PBDE congener profile was determined for each individual. The results show that both species of seals are accumulating PBDEs with BDE-47 being the dominant congener. Mean ZPBDE concentrations in harp seal were 70.55 ± 33.59 ng/g ww and for hooded seals 94.28 ± 42.65 ng/g ww. The results of this study are consistent with previous studies reporting a decrease in bioaccumulation with an increase in bromination. For both species, BDE-47 represented the highest percentage of the ZPBDEs, composing over 50% of the ZPBDEs in harp seals. When compared to stranding condition code, animals found alive had overall higher PBDE concentrations than those found in a state of moderate decomposition. This difference could be due to decreased blubber levels in the decomposed animals or potential degradation of the compounds in the blubber. Almost all seals used in this study were yearlings which is the most likely age class to strand. Yearling seals are at a crucial stage of development, especially of their immune system, which can be impacted by high levels of contaminants like PBDEs and increase the susceptibility to disease. Thus, serum samples were also collected from harp and hooded seals (2017-2018) for analysis of PBDEs, metabolites, and RNA to indicate changes in gene expression related to PBDE exposure.

**TP099 Temporal trend of perfluoroalkyl substances and current-use pesticides in penguin eggs from the Ross Sea (Antarctica)**


PFASs and CUPs have been detected in most ecosystems, including those in remote areas. They are long-range transported and can reach the polar regions. Antarctica and the Southern Ocean show extreme climate; due to the low temperatures and winter darkness, contaminants degrade very slowly; moreover, they can be trapped in snow and ice and eventually released during summer melting. When in the seawater, they can enter trophic webs and bioaccumulate mostly in predators that feed directly or indirectly on the cryopelagic community. PFASs include thousands of chemicals but the compounds usually detected in the environment belong to the class of perfluoroalkyl acids (PFAsAs), such as perfluorooctanesulfonic acid (PFOS), and perfluorooctanoic acid (PFOA). The Stockholm Convention has recently restricted the production and use of PFOS;
however, it is still manufactured and used in various industrial processes in China. CUPs such as dacthal, chlorpyrifos and endosulfan are, or have been, high production volume chemicals i.e N1000 t/y globally. Unhatched eggs are very useful non-destructive samples already successfully used to determine chemical levels. Unhatched eggs of Adelie penguin (Pygoscelis adeliae) (n = 18) were collected at Edmonston Point (74° 21’S, 165° 08’E) (Ross Sea, East Antarctica) during the XVII (2001/02) and the XXX (2014/2015) and the XIV (2018/2019) Italian Expeditions, in the framework of the Italian Antarctic Research Programme (PNRA). The general aims were to assess the PFAA and CUP bioaccumulation in penguin eggs, to assess their transfer to the chick embryo, and to evaluate a temporal trend. On-line SPE-HPLC-MS revealed the occurrence of 12 PFAAs in eggs and chick embryos. PFOS and PFOA were detected in all samples collected in 2001, with concentrations ranging 0.3–0.53 ng g⁻¹ wet weight (wt) in eggs (mean value: 0.42 ng g⁻¹ wet wt) and 0.05–0.08 ng g⁻¹ wet wt (mean value: 0.07 ng g⁻¹ wet wt) in chick embryos. Lower levels were detected in 2015 samples, with mean values of 0.3 and 0.005 ng g⁻¹ wet wt of PFOS and PFOA, respectively. This decreasing trend was not observed for PFHxA, PFNA, PFDA, PFUnA, PFDoDA, PFTrDA, PFTeDA concentrations. PFHxA showed the highest levels in the egg samples collected in 2015 (mean value: 0.8 ng g⁻¹ wet wt), confirming an ongoing input of these compounds from long-range transport and/or local sources.

**TP100** Trophic and fitness correlates of Hg and POP exposure in incubating female Antarctic petrels

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Increasing environmental perturbations threaten Antarctic wildlife, with some populations showing demographic declines. Yet, our understanding of the drivers and effects of exposure to toxic contaminants such as mercury (Hg) and persistent organic pollutants (POPs) in Antarctic wildlife is still limited. The Antarctic petrel is one of the least known Antarctic species, with poor documentation about contaminant exposure and effects on its physiology and fitness. Here we measured Hg and 14 POPs in blood cells and plasma, respectively, of 30 female Antarctic petrels from Svarthamaren (Antarctica) during the early incubating period. We recorded female and egg morphometrics, and monitored the nests until chicks were approx. 20 days old. Carbon (δ13C) and nitrogen (δ15N) stable isotopes measured in the females’ blood cells served as proxies of feeding habitat and trophic position, respectively, during spring (pre-laying period). The aim of this study was 1) to document POP concentrations in blood for the first time in this species, and characterise its trophic drivers; and 2) test the effect of female blood Hg and POP concentrations on i) female and egg morphometrics, ii) hatching success, iii) chick survival and body condition. Blood Hg burdens (mean±SD, 2.4±1.03 µg/g dry weight) were three-fold higher than those previously documented in the same population, and were related to the female spring trophic position. PCB concentrations were very low when compared to other Polar seabirds. By contrast HCB (1.02±0.36 ng/g wet weight, ww), Mirex (0.72±0.35 ng/g ww) and 4,4’-DDE (1.02±1.49 ng/g ww), were present at burdens comparable to those of ecologically-similar Antarctic seabirds (i.e. snow petrels). POP concentrations showed no clear relationship with either spring feeding habitat or trophic position. Two non-exclusive factors could explain this: 1) POP exposure is homogeneous over females’ feeding habitat in spring; 2) intrinsic factors such as differential POP mobilisation from internal pools to blood and into the egg during its formation overcome trophic drivers in explaining plasma POP concentrations in incubating females. Preliminary analyses showed no strong associations between female blood Hg and POP residues with their egg and fitness parameters. Yet, HCB and Mirex burdens were inversely related to the females’ body condition. Future monitoring is warranted to test Hg and POP long-term effects in this Antarctic petrel population.

**Microplastics in the Environment: Transport, Fate and Ecological Effects**

**TP101** Different microplastics can influence structure and function of sediment microbial communities

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Plastics are now ubiquitous in freshwater, coastal and open ocean environments. Sediments therein have been discovered to be major sink for microplastic. While plastic polymer type has been reported to influence the composition of floating plastic biofilm communities, studies to date have not investigated the effects of different microplastics on sediment microbial communities or sediment biochemical activities. Here, we present the results of a sediment microcosm experiment established with microplastics (50-300 µm) of different petroleum-based polymers (polyethylene [PE], polyvinyl chloride [PVC] and polyurethane foam [PUF]) and one bio-polymer (polylactic acid [PLA]). We characterized the sediment bacterial compositions and functional gene abundances after 7 and 16 days incubation using 16S MiSeq and quantitative polymerase chain reaction (qPCR) analyses, respectively. Nitrogen cycling was also evaluated by measuring dissolved inorganic N fluxes and denitrification rates (calculated via sediment slurry incubation experiments using a 15N isotope pairing technique). We observed that bacterial community compositions differed significantly between the biopolymer, petroleum-based polymers and non-amended sediment, with PVC being the most distinctly unique community. Nitrification gene abundances and inorganic N fluxes revealed that nitrification was highest in the biopolymer (PLA) and PUF, and lowest in PVC treatments. Correspondingly, denitrification rates were inhibited in PVC, but highest in PLA and PUF. Both denitrification and nitrification activities were higher in PE, PUF and PLA treatments than the non-amended control. This suggests that: (1) microplastics may enhance sedimentary nitrogen cycling processes and (2) sediment microbial communities may have the capacity to use plastics as carbon substrate. Overall, our study shows that the environmental presence of different microplastics may alter the structure and function of sediment microbial communities. This underlines the need for greater evaluation of the consequences of plastic contamination to sediment microbial ecosystems and biogeochemical cycling.

**TP102** An Assessment of Plastic Ingestion in Black sea bass, Centropristis striata: A Lab and Field Study

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The accumulation of microplastics (granules of plastic < 5mm in one dimension) in oceans is one of the major environmental concerns of our age. Due to their large specific surface area and hydrophobic properties, microplastics can absorb numerous organic pollutants. Intake of microplastics by marine organisms may therefore result in introducing toxicants to the organism itself and to the food chain, possibly leading to their bioaccumulation. Though a number of marine organisms have been found to ingest microplastics, few studies have been performed on commercial fishery species such as black sea bass (Centropristis striata), an important fishery off the East coast of the United States. To understand the plastic ingestion in black sea bass and subsequent transfer of associated pollutants, studies were conducted both in field and laboratory. The
results from field study showed three macroplastics, which are currently being analyzed through u-FTIR. Additionally, in the lab we conducted pellet feeding experiments to investigate the possibility of transfer of organic pollutants from microplastics to fish tissue. PVC pellets were spiked with bis (2-ethylhexyl) phthalate (DEHP) and allowed to grow biofilm. Pellets were fed to late juvenile sea bass and we recorded 78% pellet ingestion and did not find any significant difference in ingestion (after 12 h) for biofilm vs. no biofilm or 0% phthalate vs. 10% phthalate. 20 % the total ingested pellets were recovered from the GI tracts after 120 hrs and these pellets were analyzed to determine loss of phthalate. Our results showed no significant difference in phthalate levels in control vs. recovered pellets. However, tissue analysis is required to draw any conclusions on the pollutant transfer to organism. Liver analysis will be performed with LC/MS/MS to verify any accumulation of DEHP and its metabolite MEHP. We anticipate that our results from both field and lab experiments will contribute to the current knowledge on the plastic pollution in C. striata and will inform fishery management about the potential concerns regarding human consumption of black sea bass that have ingested plastics.

TP103 Non-targeted analysis of leachables in plastic fragments and microplastics collected in beach sediments

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Plastic fragments, microplastics and other plastic litters have been detected in aquatic systems globally. In particular, plastic particles have been reported in shellfish and in the gut content of fish. Recent studies suggest the potential role of plastics as vectors of chemical pollutants. Standardized methods are urgently needed to identify and quantify the chemicals which can leach from these materials (leachables). To date though, chemical migration studies focused on characterizing known chemicals, an approach referred to as targeted analysis. However, very few tools are available to assess the migration of “unexpected” or “unknown” chemicals. This approach, also called non-targeted analysis, has recently been developed for food contact materials, including plastics. There are however no standard non-targeted methods applicable to the study of plastic fragments and microplastics. In this study, a non-targeted approach was developed to study leachables from plastic fragments and microplastics collected in beach sediments in Martinique, a French island located in the Caribbean. The plastic particles were extracted with methanol and analyzed using liquid chromatography coupled to time-of-flight mass spectrometry (LC-QToF-MS). Several hundreds of molecular features were detected in the extracts. Several of these features were successfully identified based on the accurate mass of parent ion, isotopic patterns, retention time and multiple MS/MS fragment ions with matching abundance ratio.

TP104 Vertical distribution of microplastics and their presence in marine snow in offshore waters of South Korea

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Microplastics can be vertically transported by physical mixing as well as biological interaction. There is, however, still limited in situ observation data in vertical profile and characteristics of microplastics in offshore areas. In this study, the vertical distribution of microplastics larger than 20 μm was evaluated at 14 stations in offshore waters of Yellow Sea and South Sea of Republic of Korea. Each seawater sample of 100 L was collected at four to six vertical layers from surface (1 m below sea surface) to bottom (1 m above sea floor) based on the presence of thermocline and water depth. In addition, the presence of microplastics in marine snow was determined in the mid-column samples. Every single particle was identified and confirmed with micro-FT-IR spectroscopy after density separation with lithium metatungstate solution and wet peroxide oxidation. The abundance of microplastic was in the range of 15-2080 particles/m³. The average microplastic abundances in the surface (295 ± 488 particles/m³) and bottom (316 ± 477 particles/m³) were higher than mid-column (124 ± 108 particles/m³), but they were not significantly different each other (Kruskal-Wallis test, p > 0.05). The highest microplastic abundance was found in bottom water among the vertical layers at 7 out of 14 stations surveyed, in surface water at 5 stations and in mid-column at 3 stations. At 9 of 13 stations except for one station that had no thermocline, the microplastic abundance in the upper thermocline was higher than that in lower thermocline layer, respectively. The abundance of microplastic increased by decreasing size, showed the peak in between 50 and 100 μm and then decreased < 50 μm in all layers. Fragment was the most abundant shape in all layers, accounting for 81% in surface, 86% in mid-column and 84% in bottom waters. In all samples, 33 different types of polymers were identified by micro-FTIR spectroscopy. While polypropylene that was less dense than seawater was the most dominant type in the surface water (24%), alkyd that was denser than seawater was the most dominant type in the mid-column (24%) and bottom (26%) waters. Among 1863 marine snow examined, 63 (3.4%) contained microplastics. The microplastics in marine snow form accounted for 0-37.5% (average of 9.3%) of the total microplastics in the water sample of the sampling layer.

TP105 From Your Laundry To The Lake: Blue Jeans As A Source Of Anthropogenic Microfibers To The Aquatic Environment

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Originally designed as work-wear in the 17th century, blue (denim) jeans have become a modern fashion staple within the last 70 years with 450 million pairs of jeans sold per year in the US alone. Cotton is the most common material used in the production of denim textiles, including blue jeans. Although cotton fibers are classified as a ‘natural’ fiber, and therefore assumed to be an environmentally friendly material compared to synthetics, cotton can often contain additives and dyes that could influence its persistence and toxicity in the aquatic environment. During washing, frictional forces can cause the loss of microfibers and associated chemical additives from cotton materials to outgoing wastewater. Wastewater treatment plants (WWTPs) are known conduits of microfibers to the aquatic environment. We hypothesize (1) blue jeans are a major contributor of cotton microfibers to WWTPs and (2) that WWTP effluent is a conduit for cotton/cellulose microfibers to enter the aquatic environment. To investigate blue jean washing as a source of microfibers to wastewater, we washed triplicate pairs of Levi Strauss & Co. straight-legged, dark-wash blue jeans (98-100% cotton). Three treatments included: new distressed, new, and used jeans. Microfibers were chemically characterized using Raman spectroscopy. Results show that a single pair of blue jeans shed approximately 2,840 fibers per L, 90% of which were cellulose and/or contained indigo dyes. This release rate of ~100,000 fibers per pair of new jeans compares to 1,900 per new fleece jacket. To determine if WWTP effluent is a conduit for cellulose/cotton fibers to enter the aquatic environment, three replicate 24-h composite samples of final effluent were collected for microplastics and microfiber analysis from two WWTPs in southwestern Ontario. Approximately 90% of particles in the effluent samples were microfibers with 70% of the microfibers consisting of cellulose and/or indigo dyes. The chemical make-up of fibers found in WWTP effluent corresponds in morphology and spectral signal with those released from washing blue jeans, indicating blue jeans may be a source of microfibers to the aquatic environment. Scalled up, our results suggest that approximately 0.7 - 5.7 billion cellulose microfibers per day are discharged to Lake Ontario via each sampled WWTP.
TP106 Analysis of polymer additives in fish exposed to two microplastic fiber types
A.M. Lewie, L. Ferguson, Duke University / Civil and Environmental Engineering; L. Hu, Normal University Shanghai; M. Chernick, D.E. Hinton, Duke University / Nicholas School of the Environment

Microplastic particles derived from synthetic polymers are ubiquitous environmental pollutants. Most synthetic polymers utilize a suite of chemical additives and dyes to enhance the functionality and coloring of the material. Common polymer additives, including plasticizers, antioxidants, and dyes, are of environmental concern due to their role as suspected endocrine disruptors and/or mutagens. Microplastic fibers are the dominant particle type found in many environmental samples, including gut content recovered from organisms. We hypothesize that microplastic fibers may act as a delivery mechanism for chemical additives to aquatic organisms that ingest or are otherwise exposed to them. We have designed laboratory-based exposure experiments to test this hypothesis. In these experiments, green polyester and clear polypropylene fibers were used in a 21-day exposure with Japanese Medaka mating pairs. Both fibers were sourced from a Chinese fabric store. We applied a non-targeted mass spectrometry approach to identify relevant additives in the fibers that may be absorbed by fish after fiber ingestion. A custom, curated database of known organic polymer additives and dyes was used in concert with liquid chromatography-high resolution Orbitrap mass spectrometry (LC-HR/MS) to analyze organic extracts and tank water leachates of the fibers. Specifically, 6-day freshwater leachates and ethyl acetate solvent extracts of transparent polypropylene and green polyester fibers were analyzed. Based on library matching and/or computational mass spectrometry evidence, tentative identification of several known polymer additives was obtained. Multiple plasticizers (Dibutyl phthalate), textile dyes (C. Disperse Blue 60), antioxidants (Irganox 1010), and surfactants (PEGn) have been tentatively identified in both the organic extract and tank water leachate of the fibers. Fish exposed to microplastic fibers were carefully dissected and sectioned by tissue type: gills, gut, gonads, and liver. The tissue types, plus feces and embryos were extracted and analyzed by LC-HR/MS for detection of plastic additives identified in the respective fiber types. Results will be discussed in context of novel additive identifications and potential for uptake and accumulation in microfiber-exposed fish.

TP107 Investigating the effects of microplastics and their associated chemicals to fathead minnows at multiple levels of biological organization
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Due to the pervasiveness of microplastics (plastic < 5 mm) in aquatic environments, the public, scientists, and decision-makers often ask whether microplastics pose an ecological threat. However, investigation into the effects of microplastics to aquatic organisms is often conducted using simplistic scenarios that do not capture the reality of microplastics as a complex contaminant. These studies generally investigate effects by exposing low trophic-level species to extremely high concentrations of pristine microplastics. The goal of my project is to investigate how environmentally relevant concentrations and types of microplastics affect fathead minnows at multiple levels of biological organization. Fathead minnows were exposed to fragments of virgin polyethylene and polyethylene collected from the shore of Lake Ontario at two concentrations: 100 and 2400 particles per L. The exposure began at the egg stage, 24 hours post-fertilization, and will last until all breeding groups from the control treatment have laid at least 1000 eggs (5-7 months). Throughout this experiment, I will be investigating effects at the suborganismal-level (e.g. histopathology, gene expression), the individual-level (e.g. survival, length, body condition), and the population level (e.g. reproductive success, sex characteristics). I will also be quantifying length, deformities, and epigenetic effects in offspring. Results to date will be presented at this conference.

TP108 Municipal sewage sludge as a source of microplastics in the environment
C. Rolsky, V. Kelkar, R.U. Halden, Arizona State University / Biodesign Center for Environmental Security

Wastewater treatment plants are known to contribute to microplastic (MP) pollution in freshwater and terrestrial environments, but studies on MP abundance in sludge are scarce. We aimed to provide an initial estimate of mass loads of MPs in sludge by compiling literature (n = 7) reported particle counts and dimensional data and then converting these into units of MPs mass per sludge mass. Conversion factors used were informed by the average weight of plastic beads, particles, pellets, films, and fibers. Data on MP abundance were found to be inconsistent with respect to analytical methods and quantification units used. Polymer types present in sludge were identified in 57% of studies. The average weight ± standard deviation in units of mg by MP class was 1.5 ± 0.5 for fibers, 12 ± 4 for particles, 55 ± 1 for fragments, 0.3 ± 0.1 for films, 13 ± 1 for plastic pellets and 3.4 ± 0.1 for microbeads. Based on the weights obtained, the mass loadings of MPs in sludge in units of mass per mass of dry weight sludge were highest for China followed by the United States, Finland, the Netherlands, and Sweden. Mass loading data underscore the significance of the MP pollution problem and found significant geospatial variation worldwide.

TP109 Trophic transfer and depuration of 6 μm virgin fluorescent-label polystyrene microplastics in Daphnia magna and Pimephales promelas
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Small size, appealing color and buoyancy promote ingestion of microplastics by aquatic organisms. Occurrence and reports of plastic debris in the gastrointestinal (GI) tract of fish has been well documented in scientific literature increasing attention on human health due to a probable exposure to microplastics through the consumption of contaminated fish. However little is known about the behavior of microplastics in organisms of higher trophic levels after ingestion of prey species that had accumulated microplastics. Most of the available research regarding microplastic toxicity has focused on marine aquatic organisms through direct feedings or waterborne exposures at the individual level. Food chains from invertebrates to vertebrates have not been investigated in depth with regard to the transfer of microplastics. The freshwater zooplankton Daphnia magna and the freshwater teleost fish Pimephales promelas are well-known model species used in standard toxicological studies and ecological risk assessments, and provide a simple model for food chain transfer and facilitate the evaluation and comparison of data among different studies. The aim of this study was to assess the trophic transfer of two concentrations (2000 part/mL and 20 part/mL) of 6μm virgin fluorescent-label polystyrene (PS) microplastics between Daphnia magna and Pimephales promelas, as well as to investigate the depuration rates of the plastic particles within the bodies of both species. Epifluorescence microscope was used to determine and count the number of particles within the organs of both species. Bioaccumulation factor (BCF) were calculated for Daphnia magna and their values ranged between 0.026-0.033, bioaccumulation factor (BAF) were calculated for Pimephales promelas and their values ranged between 0.094-0.205. Along the 5 days of exposure, microplastics were only found within the GI tract of both species; no translocation to other organs or tissues was observed in this study. 96h after exposure all microplastic particles were depurated from the GI tract of both species when they were moved to fresh media and fed. Based on the low estimated values of BCF and BAF for both species, the quick depuration rates and the null translocation of microplastics to organs and tissues other than
the GI tract, we conclude that microplastics have a very low probability of bioconcentrating and further bioaccumulating under environmental conditions.

**TP110 Removal of microplastic from wastewater effluent using an electrocoagulation process**

D. Elkhathit, University of Rhode Island / Environmental Engineering; E. Carissimi, Federal University of Santa Maria; V. Oyanedel-Craver, University of Rhode Island

The main goal of this study was to evaluate the use of electrocoagulation (EC) to enhance the removal of microplastics from wastewater effluents. EC has been applied for the treatment of wastewater from a variety of industries (petrochemical, textile, tannery, dairy, and food processing) and has proven to remove pollutants such as pharmaceuticals and heavy metals. Microplastics (MPs, plastics fragment smaller than 5 mm) detected in marine and freshwater environments can have negative impacts on ecological and human health. The effluents of wastewater treatment plants (WWTPs) have been identified as one of the major sources of MPs released into the environment. Due to their size and density, MPs are not completely removed during conventional wastewater treatment processes. However, scarce information is available about alternatives for the enhancement of MPs removal from wastewater effluents. EC is the electrochemical dissolution of metal electrodes into metal ions that aggregates with suspended particles and adsorb dissolved contaminants. The agglomerates formed during EC can either settle and be removed through filtration; or float due to the hydrogen microbubbles released at the cathode and move the flocs upward, which can be removed by overflow or skimmed from the surface. In this study, we assessed the removal of MP using both synthetic and real wastewater effluent collected from a local utility. The experiments were performed in batch reactors, and parameters such as current density, pH, and electrolysis time were varied to determine the most effective operational conditions. Removal efficiencies in synthetic wastewater obtained ranged between 98% and 99% using initial pH between 4 and 7 and applying current densities of 2.88 mA/cm² and 8.07 mA/cm², respectively. However, the lowest operating costs were obtained using the current density of 2.88 mA/cm² with initial pH of 4 since it requires low energy use. For real wastewater effluent, EC process removed 96.5% of MPs, 92.2% of COD, and 88.8% of fecal coliform colonies using the best conditions found for synthetic wastewater. In conclusion, the applicability of EC process proves to efficiently remove MPs from the effluent at municipal WWTPs, reducing the impacts of these discharges in the receiving natural waters, and consequently fewer negative impacts on the ecosystem and public health.

**TP111 Polyethylene and polystyrene microplastics uptake by immune cells of Atlantic salmon (Salmo salar L.)**

L. Abrikissa Garcia, Y. Park, V. Kiron, P.A. Olsvik, Nord University / Faculty of Biosciences and Aquaculture

The ubiquitous presence of microplastics in the marine environment is a recent but increasing concern worldwide. Microplastics are ingested accidentally by the marine fauna or enter indirectly through the food chain. They can accumulate in several cells and tissues, and affect the normal biological functions of the organism, including their defence mechanisms. However, there are still many uncertainties about the immune cells response to microplastics. The degree of uptake in cells, responses to environmental relevant concentrations, or if differences exist in the response of immune cells from different organs are points that remain unclear. Moreover, very little is known about the toxicity of different polymer types. This study aimed to shed light on the physical impact of microplastics on immune cells from Atlantic salmon. We isolated immune cells from head kidney, blood and intestine and exposed them to green fluorescent polyethylene microparticles (1-5 pm) and red fluorescent polystyrene microbeads (2.1 pm). Cells were exposed to three microplastic treatments (polyethylene, polystyrene or a mix of both) and to three concentrations termed high (50 mg/L), medium (5 mg/L) and low (0.05 mg/L), the latter being an environmental concentration. After incubating the cells for 1, 24 or 48 h, mortality and microplastic uptake were analysed by image flowcytometry. Our study is the first to use image flowcytometry for microplastic exposure experiments. Using this method, we were able to determine the lethal concentration of microplastics uptake by immune cells in fish. It is also the first study to use environmental relevant microplastic concentrations in an exposure experiment. We found that, even at this low concentration, the immune cells from Atlantic salmon ingested microplastic particles. We also observed that immune cells responded differentially depending on the types of polymers. Polyethylene was generally more phagocytosed by Atlantic salmon immune cells than polystyrene. Polyethylene might thus have a stronger impact on the immune system of the fish. This study provides new information about the impact of microplastics on aquatic animals at the cellular level. Furthermore, image flowcytometry can be applied to other species to increase our overall knowledge of the effect of microplastics in the environment.

**TP112 Microplastics in the Delaware Bay: Distribution and direct effects on major zooplankton**

A. Internicola, J. Cohen, University of Delaware

Plastic debris is an emerging pollutant of growing concern. The most abundant form of plastic marine pollutants consists of pieces smaller than 5 mm, referred to as microplastic marine debris (MPMD). Despite studies on the effects of MPMD on marine organisms, there has yet to be a systematic investigation on the impact of MPMD at the population, community, and ecosystem level. Coastal systems are a hotspot for the accumulation of MPMD and may serve as an important link between land-derived waste and MPMD in the open ocean, yet to date, the extent of the potential hazards of MPMD are unknown in the Delaware Bay; a well-mixed temperate estuary with extensive urban land use in parts of the watershed. The two primary objectives of this research are: 1) to assess the physiological effects of MPMD on *Acartia tonsa*, a common calanoid copepod in the Delaware Bay; and 2) to quantify the distribution and types of MPMD in the Delaware Bay. Copepods were exposed to various concentrations of microbeads and fibers over a 24-hour period to determine the lethal concentration of MPMD and over the lifetime of the organism to determine the effects of MPMD on growth and development. Neuston tows were taken at 16 stations in the Delaware Bay from tidal freshwater to the coastal ocean outside the bay mouth. A representative 1% subsample of the total MPMD collected was taken for Fourier-transform infrared analyses and plastic formulation was identified by comparing the spectra collected to known spectra. The highest concentrations of MPMD occurred upstream, near the estuarine turbidity maximum zone and areas of urban land use. The majority of MPMD consisted of fragments and filaments with the most commonly identified formulations being polyethylene and acrylonitrile-butadiene-styrene irrespective of plastic type. Studying this coastal ecosystem will provide valuable insight on the fate of land-derived MPMD as well as predictions on what impacts MPMD may have on major zooplankton in the Delaware Bay as this may have bottom up effects on higher trophic levels.

**TP113 Assessing the presence and concentrations of microplastics in the gizzards, intestines, and feces of Virginia waterfowl**

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Microplastics have become a ubiquitous water pollutant. While a substantial amount of research on their impacts on marine ecosystems has been conducted, the effect of microplastics on freshwater food webs remains poorly understood. Previous studies that have attempted to assess microplastic contamination in freshwater waterfowl via fecal analyses have failed to provide strong confirmation of microplastics ingestion due to concerns regarding the contamination of those samples with exogenous
plastic particles. In this study, we assessed the presence and concentrations of microplastic particles in the gizzard and intestines of the Canada Goose (Branta canadensis), the Ring-necked Duck (Aythya collaris), the Long-tailed Duck (Clangula hyemalis), and the Bufflehead (Bucephala albeola), hunted in the Piedmont and Coastal Plain of Virginia and donated by hunters. Fecal samples from B. canadensis were also collected from nearby areas and examined for differences in microplastic contamination. Gizzard samples were processed by rinsing with deionized water over a set of stacked sieves. Fecal and intestinal samples were assessed in a similar manner, but included an initial oxidation step to disaggregate any organic matter. Plastics were identified under a dissecting microscope. Microplastic particles collected from each of these samples will be quantified in terms of abundance by source (primary or secondary), location, and polymer type using infrared spectroscopy. While this study is still ongoing, results so far have revealed the presence of secondary microplastic fibers in fecal samples. We expect to find microplastic particles in most of our gastrointestinal tract samples, which will provide firm evidence that freshwater birds consume microplastics. We also expect to find evidence of greater microplastic consumption in resident geese taken from suburbanizing areas of the Piedmont than in migratory geese collected from Coastal Plain sites. Additionally, we also expect higher concentrations of microplastics in fecal samples around urban areas and along rivers downstream from wastewater treatment plants. This study will contribute to a more thorough understanding of microplastic ingestion patterns in eastern North American waterfowl.

**TP114 Exploring the Importance of Microplastic as a Vector of Metals to Suspension Feeders**

*C. Bruno, City University of New York / Environmental Science; W.G. Wallace, The Graduate Center / City University of New York / Earth & Environmental Science*

Microplastic (MP) in the oceans was first recorded in the early 1970’s. We now know that MPs are found in all of the world’s oceans, at every trophic level, from surface to seafloor. Some MPs are similar in size to suspended sediment particles and algae and, as such, they may be inadvertently ingested by marine filter feeders. When ingested, MP may serve as a vector of adsorbed pollutants. Metals, such as Cadmium (Cd), readily adsorb to the surface of plastic particles, ingestion therefore represents a pathway for plastic and associated toxins to enter, and then be transferred within, the food web. Even though MP is ubiquitous in aquatic systems, comparatively little is known about its interactions with organisms and the environment. Assessing how marine invertebrates are affected by the ingestion of MP is important in understanding how MP enters the marine food web and affects ecosystems overall. Furthermore, it is critical to understand how associated toxins may be transferred to higher trophic levels via these food webs, and potentially affect human health. This study aims to answer the following question: Do MPs serve as a vector of toxic metals, specifically Cd, when consumed by a model marine zooplankton, *Artemia salina*? It is hypothesized that MP will act as a vector of Cd to *A. salina* when ingested. In order to answer this question *A. salina* were fed polystyrene MP particles (5.7-8.9 μm) saturated with Cd-109 or a mixture of saturated MP particles and algae. Subsequent to feeding, *A. salina* were allowed to depurate and were radioanalyzed every 30 minutes for 2 hours. Preliminary results suggest that *A. salina* assimilate greater amounts of Cd associated with MP particles when fed a mixture of algae and MP compared to when fed MP alone. This research is the first of its kind to bridge the gap between what is understood about metal sorption kinetics to what is unknown about how microplastics act as a vector of toxic metals to marine filter feeders and how those interactions may affect ecosystems.

**TP115 Drivers of microplastic pollution – Do seabirds significantly contribute microplastics to the environments around breeding colonies**

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The presence and persistence of microplastics in the environment is becoming increasingly recognized, however, understanding the distribution and various drivers of microplastics within different environmental systems is less studied. Seabirds have been identified as a possible bi-vector of plastic pollution in the marine environment, however, the role of animals as vectors for microplastic pollution has yet to be fully examined. We examined two species of seabirds known to ingest plastics (Northern fulmars [Fulmarus glacialis] and thick-billed murres [Uria lomvia]) as potential significant vectors for the transport of microplastics in and around breeding colonies. With the guidance of local Inuit hunters from Qikiqtaaluk National Wildlife Area, Nunavut. The water and sediment samples were collected along a transect away from the bird colony. We expected to find a higher concentration of seabird guano in water and sediment samples resulting in the accumulation of microplastics in the environment at sites closer to the breeding colony. The results from these samples will indicate whether seabird are significant drivers and concentrators of microplastics in the coastal environment.

**TP116 Occurrence of fine microplastics in seawater from Japanese tropical area and their partitioning between seawater and beach sand**

*Y. Kameda, Chiba Institute of Technology / Creative Engineering*

Microplastics (MPs) greater than 20 μm were measured in surface water and beach sand from Japanese tropical area, Okinawa. These MPs were collected and measured by a novel developed methods with Fourier transform infrared microscopy (μFTIR) shown in poster MO279. The samples were collected at three sites where their contamination properties are much different. The concentrations of MPs were 380 p/m3 in Azama beach, 260 p/m2 in tropical beach and 660 p/m2 in Mibaru beach, respectively. Principal polymer type was PE, but the numbers of their types were 3 in Azama beach, 6 in tropical beach and 7 in Mibaru beach, respectively. Their polymer profiles were different among sampling sites but profiles were more complicated at annual average COD concentration in sea water were higher. Size distributions of numbers of MPs showed that MPs in Azama beach was the largest, and Mibual beach was the smallest though MPs size distributions were smaller than those in effluent from wastewater treatment plants. These results indicated that size distribution of MPs and numbers of polymer types were influenced by MPs released from land, but MPs concentration were not because of micronizing by UV radiation and ocean wave. The most predominant polymer in beach sand was PE, which is similar to that in sea water. But the size distribution of MPs in sand was smaller than 100 μm. Moreover, PE- MPs concentration in sand had good relationship to that in sea water. These indicated that smaller PE- MPs might be trapped and accumulated in beach sand.

**TP117 Microplastics loading estimation and their daily variation on urban areas to sewage treatment plants in Japan**

*Y. Kameda, E. Fujita, Chiba Institute of Technology / Creative Engineering*

Microplastics (MPs) greater than 20 μm were measured in wastewater from residential areas to sewage treatment plants (STPs) at 19 STPs in Japan in order to estimate MPs loading in Japan. Daily variations of MPs concentration and polymer types in wastewater were also investigated. These MPs were analyzed by a Fourier transform infrared microscopy (μFTIR) with the automatic mapping system as well as microscope.
counting method. MPs concentrations by microscope counting were remarkably lower than those by μFTIR method because there were many clear small particles which couldn’t be identified. These results indicated that microscope counting was much difficult to measure MPs though the daily variations of spheres, fibers and films were associated with human activities such as taking bath, and washing dishes and clothes. MPs concentrations by μFTIR were 4180, 2400, 2160 and 2460 p/L at 7, 9, 18 and 21 o’clock, respectively. The median diameters in 4 daily samples were approximately 50 μm. The predominant polymer was Nylon (polyamid) and the compositions were different among 4 daily samples. In Japan, many kitchen tools were made of nylon or nylon-coating. It could peel off during cooking. In this poster, we will reveal the MPs loads and their removal ratios to STPs. These data will be important parameters to simulate MPs concentration in surface water in rivers and lakes.

TP118 Occurrence of fine microplastics in surface water from a river contaminated by sewage treatment plant effluent in Japan
Y. Kameda, E. Fujita, Chiba Institute of Technology / Creative Engineering

Microplastics (MPs) greater than 20 μm were measured in surface water from a Japanese urban river contaminated by effluent from many wastewater treatment plants. These MPs were collected and measured by a novel developed method using Fourier transform infrared microscopy (μFTIR) with the automatic mapping system. The concentration of MPs increased with the current. The highest concentration was 1471 p/m³ at the river mouth. This concentration was approximately 300 times higher than that from previous study where MPs greater than 335 μm were measured. Particle size distribution of MPs showed that 98.8 % particles were those less than 335 μm and that the median diameter was about 100 μm. The size distribution of MPs surface area also could be revealed that MPs smaller than 335 μm accounted for from 42.7% to 82.8% to all surface area of MPs. Major polymer types detected were PP, PE, PET, PS and PMMA except the river mouth sampling site. On the other hand, Nylon, PVA, ABS-resin and PU-resin were detected at only the river mouth. According to the large decrease of HHCB concentration in surface water, sea water was mixed at the river mouth. Therefore these 4 polymers may be more dominant in sea water at Tokyo Bay. These results indicated that general analysis methods for MPs by picking and FTIR underestimate MPs concentration in surface water remarkably and this analysis technique will be one of the most powerful tool to measure MPs. It also indicated that small MPs were dominant in surface water and they were very important for ecological risk assessment.

TP119 Prediction of polyethylene microplastic concentration originated from face wash products and lip products in surface water by AIST-SHANEL model
Y. Kameda, E. Fujita, Chiba Institute of Technology / Creative Engineering

The concentrations of polyethylene microplastics (PE-MPs) originated from facial wash products and lip products were simulated in surface water in Tsurumi river by AIST-SHANEL model. AIST-SHANEL was established by National institute of Advanced Industrial Science and Technology in Japan. This model can estimate chemical concentrations over 109 Class a river systems in Japan for risk assessment. It can also estimate monthly exposure concentration in a 1 km mesh with emission, climatic, geographical, sewage and industrial statistics in river systems. Almost all of facial wash products do not contain MPs now. Lip products contain remarkably high concentration of PE-MPs smaller than 10 μm in a diameter. In order to predict their concentrations, their net national consumptions, PE-MPs concentrations in each product and their removal rates in sewage treatment plants were used as input data. Predicted concentration of PE-MPs from facial wash products was compared to those observed by Fourier transform infrared microscopy with the automatic mapping system. The results indicated that maximum concentration of PE-MPs from facial wash along the river was 2.3 p/m³ and the contribution to all PE-MPs observed was 12%. It suggested that voluntary regulation of PE-MPs in facial wash products was effective to their reduction in river water. On the other hand, it also demonstrated that other countermeasures were needed for PE-MPs reduction in water. PE-MPs concentration from lip products were estimated that it ranged from 6,000 to 11,000 p/m³. Unfortunately, it was difficult to measure these small MPs by FTIR. Further researches are needed to confirm their occurrence, characteristics and environmental behavior.

TP120 An International research about environmental behaviors of fine microplastics along Kuroshio current ( Western Pacific ocean )
Y. Kameda, E. Fujita, Chiba Institute of Technology / Creative Engineering

Western Pacific ocean is considered to be one of the areas with the highest concentration of microplastics (MPs) in the world. Asian countries must investigate their occurrences, characteristics, sources and environmental behaviors. To understand their behavior, international researches by Asian researchers are needed by using one precision analysis method. This presentation will introduce this dream team research. In our research, an automatic analysis method are used to measure MPs larger than 20 μm in a diameter in surface water and other environmental media. By using these methods, the occurrence in environment such as their concentration, polymer profiles and their size distributions can be revealed along Kuroshio current which begins from Marshall island, Philippines, East China sea, Taiwan and flows northeastward past Japan. The samples are now being collected from open sea, coastal areas, beach sands and aquatic organisms around Japan, Taiwan, China, East China sea, small islands around the equator and northern and Australia. This presentation will also present some research data. This project will be a first action to monitor various pollutants in the western Pacific ocean by Asian and Oceanian scientists collaboration.

TP121 The presence, distribution, and concentration of microplastics in the lower basin of the Chesapeake Bay, USA near wastewater treatment plants
T. Duong, University of Mary Washington / Earth & Environmental Sciences; B. Odhiambo, M. Hoffman, T.E. Frankel, University of Mary Washington / Earth and Environmental Sciences

The Chesapeake Bay is a large estuary located along the east coast of the United States, with numerous wastewater treatment plants (WWTP) located throughout its basin. This area supports a vast diversity of aquatic biota throughout the eastern United States. While effluent from WWTPs has been identified as a major contributor to microplastic pollution, little research has been conducted to examine microplastic contamination in the Chesapeake Bay watershed areas surrounding these effluent streams. Microplastics are unique in that their size (<5mm) enables them to be easily ingested by aquatic organisms, causing adverse health effects such as energy depletion and digestive tract obstructions. MPs may also biomagnify throughout trophic levels, ultimately posing a threat to human health due to consumption. In this study, the presence of microplastics in major rivers in the lower basin of the Chesapeake Bay, USA was examined. Water samples and sediment samples were collected in the Potomac and Rappahannock river upstream, midstream, and downstream of WWTP outfall sites via dip sampling and grab/core sampling, respectively. Sediment samples were treated with a wet peroxide oxidation using Fenton’s reagent to digest natural organic matter and sodium chloride to separate MPs from the treated sample material, and surface water samples were filtered by vacuum filtration to separate suspended particles from water. The presence, type, and quantity of MPs was then assessed using light microscopy. While this project is currently ongoing, we expect to find that MPs are more abundant in samples collected at WWTP outfall locations rather than locations upstream or downstream from those sites. Additionally, we expect to find MPs accumulated in sediment below the alluvial bed, indicating that the sedimentation of plastics has been an ongoing occurrence in the past. The results of this study will provide novel information regarding the current and historical distribution of MPs in the Chesapeake Bay.
TP122 Chronic Toxicity of Micro- and Nanoplastic Particles on Daphnia magna

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The presence of plastic debris in the aquatic environment is a potential threat to aquatic organisms. The continual degradation of larger debris under natural environmental conditions, as well as wastes from commercial production are sources of micro-sized and probably nano-sized plastic particles in natural waters. Studies have investigated the acute toxicity of micro- and nanoplastic particles on Daphnia magna. However, to date, information regarding their potential sublethal effects on aquatic organisms is limited. This study assessed the chronic toxicity of 20 nm and 200 nm polystyrene nanoparticles (PS-NPs) on Daphnia magna. The effect on survival, growth, swimming behavior, reproduction and feeding rate was investigated over 21 days using a static renewal method. During the chronic exposure, tested animals were reared in moderately hard rear water, fed with green algae (Chlamydomonas reinhardtii) and YCT following the recommended feeding standard by Environment and Climate Change Canada (ECCC) for chronic toxicity studies with Daphnia magna. PS-NP suspensions were added to the rearing media. The rearing media was changed three times a week, and the PS-NPs were renewed. Survival and reproduction were monitored by a daily count for mortality, immobility, number of neonates, number of broods and first day to brood. Other effects such as differences in hopping frequency, heartbeat rate, postabdominal curling, thoracic movement and swimming behaviour were also measured throughout the duration of the experiment. There was no significant difference in survival for animals exposed to both sizes of the PS-NPs relative to the controls. However, exposed daphnids exhibited reduced feeding and growth rates. Also, the first day to brood was delayed and the number of broods was reduced for both particle sizes relative to the controls. The reduced growth rate may be attributed to the reduced feeding rates of the animals in the presence of the PS-NPs. These results suggest that nanoplastics may have major impacts on the ecological system through delayed reproduction and reduced growth rate which may eventually lead to disruption in population size.

TP123 Occurrences, Distribution and Chemical Characterization of Microplastics in Lagos Lagoon

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Microplastics (MPs) particles are one of the most serious problems affecting the aquatic species and environment. However, there is still a lack of precise knowledge about the occurrences, distribution and chemical characterization of microplastics particles in Lagos Lagoon. Twenty-four sampling points were investigated within eight stations based on solid waste floating pathway. The results obtained demonstrate occurrences of MPs in all sampling points. Fragments particles were dominants across the stations consisting of (63.3%) while fiber (5.2%) were observed in lesser quantities. There were significant differences in MPs concentration between sampling stations (P < 0.05). The presence of different types of polymer in the MPs was confirmed by FTIR-ATR spectroscopy, with predominant abundance of polyethylene. Microplastics abundance in Lagos Lagoon varied markedly in sampling points, and positively correlated with the microplastics polymer morphological categories (P< 0.001 and P< 0.05), which confirmed the important role of anthropogenic factors in microplastics distribution.

TP124 Anthropogenic Fibres in the Embryonic Offspring of the Viviparous Surperch, Cymatogaster aggregata

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Anthropogenic fibres (AFs), including synthetic fibres (termed microplastics when < 5 mm in length), semi-synthetic fibres, and natural fibres are ubiquitious in aquatic environments. There is some evidence that AFs, especially microplastics, can be toxic to animals following ingestion, due to both physical and chemical interactions involving the polymer itself and other added or absorbed contaminants. Although AFs have been identified in a large number of marine species, it is unknown whether these fibres can be encountered by the developing embryos of viviparous fish. We investigated the presence of AFs in the gastrointestinal tracts (GIs) of pregnant female shiner surfperch (Cymatogaster aggregata) and in their unborn, embryonic offspring. Following chemical digestion, fibres were morphologically characterized using both light and scanning electron microscopy. A mixture of synthetic, semi-synthetic, and natural AFs was found in both the adult GIs and in the bodies of the embryos, at levels higher than levels of laboratory contamination. Preliminary evidence suggests that the AFs may occur in higher numbers in the embryo GIs compared with the rest of their bodies, indicating that these fibres may be entering the embryos from the uterus via either ingestion or incorporation during development, rather than direct maternal transfer via vasculization. This work provides further evidence of the widespread abundance of AFs, including microplastics, raising questions about the potential harm that these particles may cause to developing embryos, and highlighting scanning electron microscopy as a useful tool for characterizing AFs that have been isolated from biota.

TP125 Microplastic distribution in stormwater from different pavements and removal in bioretention cells

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Despite the fast-growing research on microplastic distribution and quantification in aquatic environments, little research has focused on urban stormwater runoff. In urban environments, low impact development green infrastructures such as bioretention cells are often implemented to collect, infiltrate, and treat urban runoff. Bioretention cells consist of a depression in the ground filled with engineered media and are covered with mulch and vegetation. While they are typically designed to reduce flooding, they are also able to reduce the concentration of some contaminants such as total suspended solids. Given that microplastics are a type of particle, we hypothesized that bioretention cells would be efficient at removing microplastics from urban runoff. Our study site was located at the Toronto and Region Conservation Authority (TRCA) Kortright Centre in Vaughan, Ontario, Canada. Stormwater samples were collected from 4 different locations receiving runoff from 4 different pavement types: asphalt road, asphalt parking lot, concrete parking lot, and recycled-tire pavement. Water samples were also collected from the inlet and outlet of a bioretention cell receiving runoff from the recycled-tire pavement parking lot. The samples were sieved to 106 um and counted visually before characterization by FTIR spectroscopy. The concentration of microplastics increased as the size range decreased from > 1mm, 500 um - 1 mm, 300 um - 500 um, to 106 um - 300 um. The average concentration in the smaller size fraction was 3 to 10 times higher than in the larger size fraction analyzed. The results showed high percent decreases in microplastic concentrations between the inlet and outlet of the bioretention cell, e.g., a 62%-reduction from 147 particles/L to 56 particles/L and an 81%-reduction from 704 to 134 particles/L in a second pair of samples. Altogether, the results suggest that bioretention cells are efficient at filtering out plastic particles.
TP126 Can Microplastics Act as a Medium to Concentrate Waterborne Microcystin?

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The potent liver toxins microcystins (MCs) and microplastics (MPs) are both emerging environmental contaminants now recognized as being widely distributed across the globe. MCs are a diverse group of monocyclic heptapeptide hepatotoxins produced by several genera of freshwater cyanobacteria. MPs are defined as small particles of plastic less than 5 mm in diameter. MPs may impact ecosystems by adhering to and/or being ingested by organisms, which may cause harmful physical effects. Additionally, MPs may be a source of hazardous chemicals via their additive ingredients and/or sorption of environmental contaminants. The exchange of contaminants between MPs and ambient waters is influenced by the physicochemical properties of MPs, the nature of the contaminant, and environmental conditions. Studies have demonstrated the ability of MPs to act as a medium to concentrate hydrophobic (non-polar) contaminants in aquatic environments, driven by their characteristic surface hydrophobicity. This research has not been extended to MCs. MCs are relatively hydrophilic (polar) molecules, implying that their affinity for MPs is negligible; however, many MC congeners contain hydrophobic (non-polar) amino acid residues. Inherent in this lies the question: Can microplastics act as a medium to concentrate waterborne microcystin? To address this question, we developed a laboratory-based experiment to measure the rate and concentration at which a mixture of four MC congeners (MC-LA, -LR, -YR, and -RR) sorb to one of four types of plastic resin pellets (low-density polyethylene, polystyrene, polyethylene terephthalate, and polyvinyl chloride) with and without a biofilm. Our preliminary experiment indicates that MPs can act as a medium to concentrate waterborne MCs, dependent on type of plastic and MC congener. We found that (1) polystyrene exhibited greater sorption capacity across all MC congeners compared to low-density polyethylene, and (2) sorption concentration was directly related to MC congener polarity. This research seeks to understand if and how two dominant environmental issues—namely, microplastic pollution and cyanobacterial harmful algal blooms—interact in a freshwater environment.

TP127 Evaluation of the presence of microplastics in commercial fish and water from the Tecolutla estuary, Veracruz, Mexico

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Microplastics are persistent pollutants with a maximum length of 5000 μm. They contain additives and are vectors of other toxic contaminants, such as POPs and metals. Their presence in sediment increase temperature and decrease permeability. On the other hand, plastic particles are transported efficiently through water bodies. Because of the scarcity of microplastics’ studies in Mexico, the objective of this work was to determine the length, number, color, and shape of microplastics present in commercial fish and water from the Tecolutla, Veracruz estuary. Samples were collected in five stations during three climate seasons (North winds, dry and rainy) in 2016 and 2017. In the laboratory, fish gastrointestinal tracks were dissected and digested using 30% H2O2 to disintegrate the organic matter. The residues were filtered through cellulose paper (Whatman No. 40). For water samples, the volume was measured and filtered through cellulose paper (Whatman No. 40). All filters were dried at 50 °C for 24 h. Finally, microplastics were characterized using a stereoscopic (Zeiss 475022) and a digital microscope (Celestron) with the help of ImageJ software. The validation of polymer particles was carried out by Fourier transform infrared spectroscopy (FTIR) on a Cary 600 FTIR spectrometer. In 155 fish analyzed, 882 microplastics were found, with lengths of 40 - 4180 μm. It is estimated that each organism consumed 4.72 pieces. In the 27 liters of water analyzed, the total number of particles found was 452, with lengths of 10 -1730 μm. There was a significant difference in the length of the microplastics found in water in the different seasons. The predominating color in both matrices was black, followed by blue and red. Regarding form, the most common in all cases was fiber. Based on FTIR analysis, the majority of detected microplastics were polyethylene (PE), polystyrene (PS) and polyethylene terephthalate (PET). The present work concludes there are microplastics in organisms and water in all climate seasons. This is the first evaluation of this pollutant in the Tecolutla estuary and therefore, it is essential to evaluate the ecological significance of plastic particles in aquatic environments.

TP128 Microplastics ingestion in an edible bivalve: Polymesoda caroliniana (Bosc, 1801) from Tecolutla, Veracruz, Mexico


Microplastics (MP) with a length < 5000 μm have become a concern in recent years because of their negative impact on aquatic environments. There is a lack of studies on this type of emerging contaminants in Mexico; this situation makes it difficult to estimate people’s exposure to these contaminants due to shellfish consumption. Therefore, the objective of this study was to calculate human MP ingestion through the analysis of the presence of MP in the edible clam Polymesoda caroliniana in Tecolutla in Veracruz, Mexico. Samples were collected in Larios estuary along three climate seasons (Rains, Dry, and North-winds). In the laboratory, the visceral mass of the clams was extracted to proceed with a 30% hydrogen peroxide (H2O2) digestion (10 mL / 1 g of tissue); the residues were filtered through cellulose paper (Whatman No. 40) and these were dried at 50 °C for 24 hours. The particles’ characterization was done with a stereoscopic microscope (Zeiss West Germany 47 50 22), a digital microscope (Celestron 10X - 150X) and ImageJ software. 88.3% of the clams presented MP, most of which were black fibers; the dominant MP size was < 638 μm. The estimated average concentration was 2.6±1.03 particles/g; therefore, in a 100 g clam cocktail, the consumer could ingest 296 MP. There were no statistically significant differences in the number and size of the analyzed particles among climate seasons. Exposure to MP through bivalve consumption is lower in Mexico (286 MP/year) than in Belgium (6,842 MP/year), France (2,024 MP/year) or China (13,650 to 68,250 MP/year). Fourier transform infrared spectroscopy (FTIR) analysis in a Cary 600 FTIR spectrum (Agilent), showed that the main polymers found in microplastics were: LDPE, Epoxy resin (ER), PET and Cellophane (CP). These results reveal the availability of these contaminants in the Tecolutla River, and therefore that people who consume this type of food are ingesting microplastics on a regular basis. This is the first investigation to perform an MP assessment on bivalve mollusks for human consumption in Mexico. As a result, it is recommended to establish a monitoring program to evaluate the presence of microplastics in edible organisms.

TP129 Ingestion and impacts of tyre particles and synthetic fibers on freshwater invertebrates

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Tyre wear particles and synthetic fibres are considered to be amongst the most common types of microplastics reaching aquatic ecosystems. Their effects on freshwater biota are, however, mostly unknown. Fibres are assumed to impact organisms mainly by ingestion and physical effects, while tyre particles may additionally release potentially toxic compounds.
This study aimed to determine the acute and chronic effects of tyre particles and fibres on freshwater invertebrate species with different habitat preferences and feeding strategies (i.e., Daphnia magna, Asellus aquaticus, Hyalella azteca and Lumbriculus variegatus). Tyre particles were milled from end-of-life passenger car tyres (Grenaa, Denmark) and sieved to obtain a particle size between 25 and 75 um. Fibres were produced by washing polyester fleece blankets and were between 101 and 2194 um (IQR: 493-992 um) in length and 29 um in width. Acute and chronic toxicity studies were carried out based on standard protocols (OECD 202/211/225 and ASTM E1706-05). Depending on their different habitats, the test organisms were exposed to five increasing concentrations in the water phase (D. magna, H. azteca, A. aquaticus; 0, 0.00015, 0.0015, 0.015, 0.15 g/L) or mixed into the sediment (A. aquaticus, H. azteca and L. variegatus; 0, 0.002, 0.02, 0.2, 2 g/kg). Ingestion and immobility or mortality were assessed for acute and chronic exposure. Additionally, reproduction was assessed during chronic exposure for D. magna and L. variegatus. Single fibres were ingested by all invertebrate species except for D. magna, but caused no adverse effects at the tested concentrations. Tyre particles were ingested by all test organisms in a dose-dependent relationship. Also for tyre debris, no adverse effects were observed at the tested concentrations, except for D. magna reproduction, which was significantly reduced (51%, p < 0.05) at the highest test concentration. The science is finally being published with several strong reports and critical reviews providing sound assessments of microplastic (MP) exposure concentrations vs. adverse ecological effects. Only in parts of Asia are MP concentrations at levels capable of causing adverse organism responses. These other stressors, such as macro-plastics, pesticides, other synthetic organic chemicals, metals, nutrients, altered hydrology and degraded habitat, are strongly linked to adverse ecosystem effects. Given the shortage of research and remediation funding, and the limited resources of environmental managers and their institutions, it is important to focus on those problems causing the greatest damage to our ecosystems.

TP130 Case studies on the use of metal-doped plastics to assess nano- and microplastic fibers in urban and natural environments
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The time and resource intensive nature of particulate plastic (nano- and microplastic particles and fibers) analysis often hinders researchers from preforming mechanistic studies to understand the fate, transport and biological interactions these materials have in both urban and natural environments. While progress is still ongoing to develop analytical methods to measure particulate plastic in field studies, researchers who study these processes in bench top or pilot scale studies can take advantage of an entirely different approach. In the last years, we have synthesized a variety of particulate plastics with an embedded inorganic fingerprint which can be used as a proxy to detect plastic by common analytical techniques for metals analysis, such as ICP-MS, EDX, and XRF. This allows us to more quickly and quantitatively assess plastic in complex matrices than is currently possible with other methods that measure plastics directly. In practice, this allows us to investigate the basic processes and pathways which control particulate plastic fate and provide statistically robust datasets and replicates to form stronger conclusions about the associated risks particulate plastics pose. To highlight the utility of this approach, we used these materials in a number of different test systems investigating the movement and effects of particulate plastic. In this poster, I will provide a brief overview of these applications including 1) the use of sewage sludge as a fertilizer and subsequent nanoplastic mobility through porous media, 2) the interaction and uptake of nanoplastics with wheat plants and 3) the trophic transfer and effects of nanoplastic and microplastic fibers from biofilms to snails. Beyond the case studies specifically highlighted here, these metal-laden particulate plastics are suitable to study a wide variety of fate, transport, eco-toxicity and interactions with organisms. Therefore, this approach can also be used as a platform for others in their own field of study and this poster will provide a launch pad on which to discuss these topics with SETAC attendees.

TP131 Does increasing complexity of exposure scenarios change the toxicity of microplastic and chemical co-exposures to Daphnia magna?
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Although microplastics (MP) are increasingly recognised as a contaminant of concern in the environment, several recent studies have shown that the toxicity of pristine MPs is negligible. However, the potential of MPs to act as vectors for chemicals (co-pollutants) commonly found in the environment, often termed the Trojan horse effect, is currently being explored. This study aims to quantify the potential transfer of chemicals of concern and assess the toxicity of MPs to Daphnia magna. In addition to polyethylene microbeads (1-5 um), four chemicals were selected for the study; diclofenac (anti-inflammatory), triclosan (antimicrobial), DEET (insecticide) and Sodium Lauryl Sulphate (SLS) (surfactant) due to their range of uses and widespread presence in environmental water samples. Standard toxicity assays using the OECD 202 test (Acute 48 hour exposure) were conducted initially with the MP and the individual chemicals in varying media to explore a range of water conditions, including daphnia conditioned medium (with proteins). This allowed the calculation of the Lethal Concentration for 50% of the population (LC50 values) for each pollutant to establish the baseline for future comparisons of their mixtures, and to confirm that the MP are taken up dose-dependently. Particle stability in the media and surface charge were determined as this can affect subsequent surface binding. A chemical mass balance was undertaken to establish if the concentration of chemicals on the MP surface changes under competitive binding conditions, by comparing chemical concentration using GC/LC-MS and protein concentrations using a standard extraction. This exposure was performed at chemical concentrations equivalent to individual LC50 values as a starting point. Following this, further analysis was undertaken to represent more environmentally realistic scenarios (i.e. waste water outflows) in terms of the concentrations of chemicals used within the study, to ascertain any potential change in toxicity based on the environmental exposure conditions and chemical concentrations. This is an important step towards understanding the environmental toxicity of MPs in real world conditions and the interaction of MPs with other environmental pollutants.

TP132 We All Hate Plastic Garbage, But Microplastics Are Not the Villains
G.A. Burton, University of Michigan / School for Environment and Sustainability

The science is finally being published with several strong reports and critical reviews providing sound assessments of microplastic (MP) exposure concentrations vs. adverse ecological effects. Only in parts of Asia are MP concentrations at levels capable of causing adverse organism responses. These same areas, however, have elevated levels of chemicals, solids, BOD, and solids due to a lack of wastewater treatment. This raises an obvious question of which of these stressors cause the greatest ecosystem impairment? MPs are a minor vector for chemical biouptake compared to food and at concentrations below toxicity thresholds established in laboratory studies. Where they exist in high numbers, there are other stressors of greater importance from an ecosystem management perspective. These other stressors, such as macro-plastics, pesticides, other synthetic organic chemicals, metals, nutrients, altered hydrology and degraded habitat, are strongly linked to adverse ecosystem effects. Given the shortage of research and remediation funding, and the limited resources of environmental managers and their institutions, it is important to focus on those problems causing the greatest damage to our ecosystems.
TP133 Concentration of Microplastics in Wetlands and Stormwater Retention Ponds
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Microplastics are small plastic particles, < 5 mm in size, and are an ill understood pollutant in Earth's environment. Urban rivers may be contaminated with microplastics and are a vector for microplastic transport to marine environments. Stormwater runoff, which is rainwater and snowmelt that collects airborne and ground level contaminants but does not penetrate into the soil, could be a potential route for microplastics from terrestrial environments into urban rivers. This project aimed to assess the magnitude of microplastic pollution in constructed and natural wetlands, including stormwater retention ponds, which accumulate contaminants present in stormwater runoff. It was hypothesized that the environment surrounding the ponds would have an impact on the magnitude of microplastic pollution, with high-population/high-use sites having a greater magnitude of microplastic pollution than low-population/low-use sites. Large-volume water samples were collected from stormwater retention ponds and natural wetlands from Edmonton, Alberta, Canada, corresponding to different use profiles: residential, industrial, agriculture, natural, highway-adjacent, parks. Samples underwent an extraction process with filtration to separate microplastics from other debris, peroxide digestion of organics, and size fractionation. The microplastics collected were counted via visual microscopy and confirmed by testing with a hot probe. The microplastic concentrations found were similar to other local freshwater bodies, though there was no variation according to land use. Fibres and films made up the majority of microplastics identified, with the concentration of microplastics increasing with decreasing size class. Further analysis with Raman spectroscopy is ongoing to determine the chemical identity of plastics that are present. Further research is required to understand how pond design and the stagnancy of stormwater retention ponds affects microplastic concentration in the water column compared to flowing river systems.

TP134 Microplastic contamination across several trophic levels within a deep-sea food web
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Microplastics (particles < 5mm) are ubiquitous in aquatic and terrestrial ecosystems. Ingestion of microplastics is a concern for wildlife due to toxicological and physical impacts. Trophic transfer of microplastics (i.e. the movement of material among trophic levels) has been observed in nature, but has not been documented in well-understood food webs. Understanding microplastics fate in food webs is crucial to quantify the ecological effects of microplastics worldwide, and will benefit from research conducted well-defined food webs. The Monterey Bay deep submarine canyon food web is well studied with multiple decades of ecological and environmental data, and is thus a model system to examine the trophic fate of microplastics. We sampled 17 different species across approximately five trophic positions, and captured a wide variety of feeding behaviors. Gut contents of each individual were digested in a potassium hydroxide solution, sieved using a 100um mesh, and visually quantified for microplastics greater than 100um in size. A representative subsample of particles was analyzed via Raman Spectroscopy to determine the polymer type and confirm that particles were anthropogenic. Microplastics were found in all species and across all trophic levels. Of the particles found, the majority were blue fibers, which aligns with other studies. There was no difference in microplastic concentration between animals from different trophic levels; however, there does seem to be a trend whereby larger animals have more microplastics in their gut. To better understand the fate of microplastics in food webs, other measurements should be assessed, such as tissue samples, respiratory pathways and other internal organs to test for routes of exposure and potential bioaccumulation and biomagnification. This work will contribute to our collective understanding regarding the fate of microplastics in food webs, and inform global models of microplastics distribution and movement.

TP136 Contamination of anthropogenic microparticles in resident and transplanted Mytilus californianus mussels in San Francisco Bay
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High abundances of anthropogenic microparticles, including microplastics, have been found in San Francisco Bay waters and prey fish, indicating a need to evaluate more broadly the accumulation of microplastics and associated chemical contaminants in the Bay food web. Filter feeders such as bivalves are widely used for biomonitoring, as they can act as integrators of contaminants from the water column. Mussels are an important lower trophic level organism in the Bay, and may therefore represent a significant route of microplastic entry into the food web. The objective of this study was to quantify and compare the abundance and types of anthropogenic microparticles in 90-day transplant and resident Mytilus californianus mussels in San Francisco Bay. We collected resident M. californianus from three Bay sites and one less urban reference site outside the Bay, and 90-day transplants from seven sites within the Bay. We used KOH digestion on composite samples of seven whole organisms to recover anthropogenic microparticles. For a subset of extracted particles, we used Raman spectroscopy to identify chemical composition. For each transplant site, polycyclic aromatic hydrocarbon (PAH) tissue concentrations were also evaluated in composite samples of bivalves deployed and collected alongside those analyzed for microparticles. We detected anthropogenic microparticles in all sample types and at all sites, and fibers were consistently the most dominant category. Transplanted mussels had higher numbers of anthropogenic microparticles per mussel compared to mussels from the resident and reference sites, indicating relatively rapid uptake. We compared anthropogenic microparticle and PAH concentrations in mussels with concentrations in other Bay compartments and with similar bivalve studies reported in the literature. Implications for the magnitude of potential impact will be discussed.

TP137 Microparticles and Microplastics in San Francisco Bay Area Stormwater
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Plastics in the ocean, and more specifically microplastics (< 5 mm), have been gaining global attention as a pervasive and preventable threat to the health of marine ecosystems. Stormwater runoff is believed to be one of the primary pathways for plastic pollution to enter San Francisco Bay. Primary microplastics from industry and other activities (e.g., plastic nurdles, plastic trimming operations), as well as secondary sources of larger plastics fragmented by photooxidative degradation or physical abrasion (e.g., tire abrasion due to roadway wear), can be entrained in stormwater runoff from the landscape and enter drainage systems. This study measured microplastics and other microparticles in stormwater from 12 small tributaries to San Francisco Bay. These tributaries varied in urban and non-urban land uses and were distributed across the region. We employed a new method, collecting depth-integrated samples during storm events to estimate microparticle loads in stormwater. Microparticles captured on sequential 355 micron and 125 micron sieves were manually
counted using visual techniques; approximately 7% of the microparticles were then analyzed using spectroscopy to determine whether they were microplastic. Microparticles were identified in stormwater from all 12 small tributaries, discharging between 1.3 and 30 microparticles per liter. The microparticle concentrations observed were consistent with some studies and higher than others previously reported in the literature. Black rubber fragments made up 47% of all particles sampled, potentially originating from tire wear. A load to the Bay of 10.9 trillion microparticles per year from small tributaries was estimated using a land-use/runoff model. Approximately two-thirds of those particles were estimated to be microplastic. This microparticle load estimate is 230 times greater than the estimated annual load from wastewater treatment plants discharging to the Bay. The results of the load modeling effort suggest that industrial areas may be linked to higher microparticle concentrations in stormwater. We recommend additional investigation into sources of microplastics in the landscape, including a greater number of relevant landscape attributes (e.g., imperviousness, proximity to roadways) to more fully explore factors that contribute to higher levels of microparticles in stormwater.

**TP138 PCB-spiked microplastics act as a vector for PCB bioaccumulation in to two marine polychaetes**

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Microplastic (< 5mm) pollution is a pervasive problem in marine waters and sediments. Macro- and micro-plastics have been found in marine mammal, bird, and turtle digestive systems at sites where these species are of ecological importance, and have been linked to mortality associated with starvation. In addition, lower trophic level tissue concentrations for legacy hydrophobic organic contaminants such as polychlorinated biphenyls (PCBs) might make microplastics an exposure risk to higher trophic levels. Hydrophobic pollutants, such as PCBs, sorb to plastics, and it is possible that microplastics act as a vector of these contaminants into the biological community. Current research on the relevance of this phenomenon, compared to traditional mechanisms of contaminant transfer to biological systems, is inconclusive. Towards understanding the role of microplastics as vectors of PCBs in marine sediments, we designed a bioaccumulation study using two Pacific Ocean relevant benthi polychaetes commonly used in EPA laboratory-based bioaccumulation studies: the free-burrowing deposit-feeding Neptys caecoides and the mucus tube-forming, surface, deposit-feeding Neanthes arenacodentata. Using high density polyethylene microplastic beads (63-75 um dia) spiked with PCBs typically used as performance reference compounds in passive sampling studies (i.e. not found in the environment), mixtures of plastic and sediment were created (0.1%-3.0% plastic w/w). Sediment varied in total organic carbon (TOC) content (approx. 0.1%-1%), PCB concentration (approx. 0-1 mg/kg), and physical characteristics (coarse coral sand to fine, silty sediment). Polychaetes (worms) were subsequently exposed for 28 d to assess bioaccumulation of PCBs. Because plastics were spiked with PCBs not commonly found in the environment, differentiation between spiked and natural sediment-associated PCBs accumulated in worm tissue could be determined. Polychaete survival was not adversely affected by plastic concentrations at the highest dose (3% w/w) in any sediment tested. PCB bioaccumulation results are in review and will be presented. This study addresses gaps in the literature regarding the effects of microplastics on the transfer of PCBs into biota in the presence of sediments, with a focus on those with relatively low TOC content. The coral sand sediment selected for this study represents a scenario of particular interest, where low TOC content and potentially high sediment plastic concentrations (due to collection from the North Pacific Gyre), may make microplastics a relevant source of biological uptake of PCBs in these systems.

**TP139 Microplastic behaviour in mesocosm wetlands**

S. Warrack, IISD-Experimental Lakes Area / Department of Environment and Geography; M.D. Rennie, Lakehead University / Biology; M.L. Hanson, University of Manitoba / Environment and Geography

Different factors may affect the settling rate of a microplastic particle e.g., nutrients, biofilm growth, shape of particle, particle type, emergent macrophyte growth, etc. Microplastics can be colonized by biofilms, which may change the plastics’ buoyancy, causing it to move deeper in the water column, or even settle in the sediments. Nutrients, such as phosphorous, can enhance biofilm formation. The shape and the type of polymer of the microplastic will affect its buoyancy and ultimately where it will end up within the water column. Microplastics within systems containing lots of emergent macrophytes, may also alter settling rates as microplastics may adhere to the plant. We conducted two studies, a long-term study to characterize microplastic settling rates, and a short-term study to assess whether nutrient addition and emergent macrophyte growth affected the settling rate of films and fibres in controlled outdoor mesocosm experiments. In the long-term study (July 2017 to April 2019), replicate wetland mesocosms were treated with microplastic fibres, films, foams, microbeads, and fragments. Densities of microplastics within the surface water and sediments were assessed over the span of the experiment. In the short-term study (July 2018-April 2019), all replicate wetland mesocosms were treated with both fibres, and films. There were three treatments: (1) control, (2) no cattails with nutrient addition, and (3) cattails with nutrient addition. Our long-term study indicated that foams, fragments, and microbeads (cosmetic) do not appear to settle within our system, and float on the surface of the water column. Fibres and films settle, and have higher densities within the sediment layer over time. Fibres followed a seasonal pattern when settling, peaking in late fall (2017: 4.3%, 2018: 6.14% fibres settled), and plummeting in spring (2018: 1.06%, 2019: 0.25% fibres settled). Our short-term study indicated that fibres settled within our systems, films did not. The no cattails with nutrient addition treatments had the highest amount of fibres settling. All treatments had highest amounts of settled fibres during the first 2 weeks of sampling (control: 2.42%, no cattails with nutrient addition: 4.62% and cattails with nutrient addition: 6.89% fibres settled). Biofilm development was higher within the nutrient addition tanks, which also followed the trend of increased densities of microplastics within the sediments. Our research on factors affecting microplastic settling rates in freshwater systems will help improve our understanding of microplastic behavior in freshwater systems. This research will also help improve existing management policies and practices in place that relate to microplastics.

**TP140 Microplastic exposure pathways in marine teleost fishes in the Charleston Harbor estuary, SC USA**

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Coastal estuaries represent a critical habitat for many species including plankton, fish, marine mammals and birds. These organisms use estuaries like Charleston Harbor, SC USA as vital breeding areas, nursery sites, and feeding grounds. As outlets of watersheds, and in this case in proximity to an urban center, estuaries may also carry increased levels of microplastic debris (defined as < 5mm). Increased trophodynamics in these organic-rich environments presents the potential for multiple pathways of exposure in estuarine ecosystems, such as trophic transfer via ingestion of prey, or consumption and filtration of water and sediment. Teleost fishes (Spot, Leiostomus xanthurus; Red Drum, Sciaenops ocellatus; Striped Mullet, Mugil cephalus; Bay Anchovy, Anchoa mitchilli; Atlantic Menhaden, Brevoortia tyrannus; and Spotted Seatrout, Cynoscion nebulosus) were sampled from Charleston Harbor estuarine waters and digestive tracts dissected. Gut contents of fish were digested in 1M KOH and sieved (63um-1mm). Microplastics from gut contents were counted and classified by color and type (fragment, fiber, tire wear, film,
Previous work using a dietary exposure model that applies results from a local study finding 1% of zooplankton contain microplastics shows that microplastic in zooplankton translates to significant exposure potential to filter-feeding fish. However, this dietary exposure model only accounts for the fraction of microplastics that are able to be ingested by zooplankton. Preliminary results in Atlantic Menhaden showed levels of (larger) microplastic generally higher than predicted for modeled dietary exposure via zooplankton (~1-15 particles for smaller individuals < 5 g, N=4). Observed microplastics in fish analyzed thus far (N=5) ranged from 89 to 177 particles, indicating a potential for other pathways besides solely trophic transfer. Large particles (100µm - 5 mm) were common, and detection in field collected samples of smaller particles (< 63 µm), which are biologically relevant to zooplankton, needs further method refinement to fully assess trophic pathways. Ongoing work will quantify presence of microplastic in fish from different feeding guilds to further relate to dietary exposure risk and fate of microplastics. Fishes that have discriminatory feeding behavior, such as predators like Red Drum and Spotted Seaturtue, are hypothesized to be less likely to encounter microplastics than filter-feeding fish, like Menhaden and Bay Anchovies.

**TP141 Investigating bacterial biofilms that form on bio-based microplastics: Evidence of distinct communities**

K. Uhlig, R.C. Hale, College of William & Mary / Aquatic Health Sciences; B. Song, Virginia Institute of Marine Science / Biological Sciences

Plastic debris provides a novel habitat for microbial fouling communities. Marine-borne microplastics may be more persistent than natural polymeric debris (e.g. cellulose, lignin and chitin) common in coastal and open-ocean systems, potentially allowing for greater transport and distribution of associated colonizing microbes (commonly referred to as a biofilm). Biofilm formation on microplastics affects the fate of plastic debris by way of altering the density of floating plastics, initiating biodegradation, and facilitating ingestion by organisms. Furthermore, pathogenic and invasive species have been found to colonize plastic debris collected from the open ocean. This study compared the estuarine biofilms of five polymer types using next-generation sequencing. The polymers examined include two conventional plastics (high-density polyethylene (HDPE) and polyvinyl chloride (PVC)), and two bio-based plastics, (poly-3-hydroxybutyrate (PHB) and polylactic acid (PLA)).

Two grams of production polymer beads (< 5mm) were deployed for up to four weeks in individual fiberglass mesh bags the lower York River, a major tributary of the Chesapeake Bay. Triplicate samples for each plastic were retrieved during low tide after 7 days, 14 days, and 28 days of immersion. The biofilms investigated in this study include three different stages of development: early colonization, exponential growth, and the pseudo-stable stage, with the goal of capturing early differences in microbial communities that may be blunted in field-collected samples. DNA was extracted from the biofilm microplastics and the 16S rRNA genes amplified using PCR. Purified amplicons were sequenced on the Illumina MiSeq platform and the resulting Amplicon Sequence Variants (ASVs) were taxonomically classified using the SILVA v.132 database at 80% similarity. Here we present findings that suggest that the microbial biofilm communities that form on bio-based microplastics are distinct from those on conventional plastics. We also investigate the presence of potentially pathogenic and hydrocarbonoclastic bacteria amid previous reports of increased Vibrio spp. presence on marine debris collected from the open ocean.

**TP142 Bioaccumulations of microplastics on medaka fish**

Y. Oshima, Faculty of Agriculture, Kyushu University / Fisheries; H. Ogawa, Y. Liu, Y. Shimasaki, Kyushu University / Faculty of Agriculture

This study was performed to elucidate the uptake and bioaccumulation of MP in Japanese medaka (Oryzias latipes) and assessed uptake and depuration kinetics. We exposed medaka to fluorescent MP (2 µmPS, 20 µmPS, 20 µmPE at 10^6 beads/L, 200 µmPS at 10^4 beads/L) for 2 weeks and depurated for 1 week. Water was changed once for 3 days. Fish were sampled at 1, 3, 5, 7, 10, 12, 14, 15, 17, 19, 21, 24 d and fixed with formalin, and then make optimally clean. MPs in the body were directly identified and counted by All-in-One fluorescence microscope (BZ-X810, Keyence, Japan). MP in water was counted after filtration. The calculated bioaccumulation factors in medaka were estimated to 206, 23, 22, 85 and its biological half-life until 17d were estimated to 0.6, 0.6, 0.63, 0.57 at 2 µmPS, 20 µmPS, 20 µmPE, respectively. Further, intake pathway of MP from drinking or filtration will be discussed.

**TP143 Investigation of Microplastics in the Waishkey Bay, Bay Mills Indian Community, Brimley Michigan**

D. Napoletano, A. McGlinch, D. Cryderman, Bay Mills Community College

The Waishkey Bay is located in Eastern Upper Peninsula of Michigan, along the land of the Bay Mills Indian Community, Brimley, MI. It’s location at the outflow of Lake Superior into the St. Marys River creates a unique aquatic ecosystem within the Laurentian Great Lakes. The Bay Mills Indian Community follows a traditional lifeway, which relies heavily on fishing and tourism industries within the bay. The Waishkey Bay watershed receives discharges from three National Pollutant Discharge Elimination System permitted facilities, one active landfill, and other non-point sources of contamination. These sources of contamination may be linked to a rising count of microplastics found in the Waishkey Bay. Microplastic is bio-accumulative and is a threat to the fish species, environment, and possibly human health. In a community-based participatory investigation, analysis of microplastics within Waishkey Bay began in fall 2017. Sediment was collected at ten locations throughout the bay and its tributaries. Approximately 300g was collected using either Ponar sampler in the open bay or stainless-steel spade in washable tributaries. Samples were separated by fraction using a stainless-steel strainer separating fractions at 1.00mm, 300um, and less than 300um. Samples were then digested in aqueous 0.05M Fe(II) and 30% hydrogen peroxide. Plastic particles and fibers were then picked from samples under microscope. Plastics were identified in samples collected from all locations throughout seasonal efforts. The average number of microplastics found within 1.00mm sediment fractions was 11, with an average plastics mass of 1.275mg per sample. An average of 35 microplastics were found in sediment fractions sized 300um, with an average mass of 2.6mg per sample. Sediment samples < 300um contained an average of 8 microplastic fibers, and the average mass of plastic per sample was 0.3mg. This data will be combined with biota and open water analysis during the current sampling season. In all, we are building a baseline of monitoring information upon which the Bay Mills Indian Community can focus future efforts.

**TP144 Modeling aquatic and terrestrial transport pathways for microplastics entering WWTP systems**

C.M. Holmes, Applied Analysis Solutions, LLC; J. Amos, Waterborne Environmental, Inc. / Geospatial Data Technologies; S. Dyer, LeTourneau University / Biology and Kinesiology

Microplastics may enter the environment from a number of sources and in many forms. Plastic particles may be present as influent into municipal wastewater treatment plants (WWTPs). A large portion of these are removed from the water phase during the treatment process, and generally end up in the solids (i.e., sludge). Sludge disposal varies by country, region and locality, including landfill, incinerator, compost, or as land-applied biosolids. There is potential for particles in biosolid applications to reach aquatic systems depending on application location and subsequent environmental conditions. We present a broad-scale model designed to estimate emissions and model the fate of plastic particles exiting WWTPs into the terrestrial and aquatic environments, using spatially-explicit information on WWTPs, river hydrology and terrestrial transport potential. This regional/continental scale model is based on publicly available datasets and contained in a modular and transparent framework which is scalable and portable to multiple geographies. This presentation will demonstrate the utility of the model as applied to different regions, and how the resulting information about ultimate mass disposition within the environment (e.g., soil, freshwater, sediment, marine) and surface water
Organisms in marine waters are exposed to a wide range of contaminants from a variety of sources including wastewater treatment plant effluent, surface runoff from roads, combined sewer overflows, and others. These exposures are often related to biological responses which can affect the health and behavior of individuals, alter reproduction, and impact species survival. Traditional analytical approaches have provided occurrence information on a selected set of traditional and emerging contaminants. In order to provide a more holistic assessment of exposures in the marine environment we are combing monitoring based on high resolution mass spectrometry (HRMS) approaches with hydrodynamic modelling. The HRMS methods provide a broad assessment of exposures by capturing a range of organic contaminants, including metabolites and transformation products, particularly compared to traditional targeted methods. For example, recent sampling in the Salish Sea incorporating HRMS analytical methods identified more than 80 compounds including herbicides, pharmaceuticals, vehicle-related compounds, plasticizers and flame retardants. Unexpected contaminants such as methamphetamine and toxic fungicide metabolite 4-hydroxy-chlorothalonil were detected, as well as transformation products of herbicides and plasticizers that have not been reported elsewhere. In addition to contaminant identification, HRMS methods are being utilized to develop source signatures based on the unique and consistent occurrence of a suite of organic contaminants for a given source category. This allows the evaluation of the magnitude of exposure from different sources at different time points. The Salish Sea Model is being used to incorporate transport considerations in the exposure assessment. The Salish Sea Model is a three-dimensional hydrodynamic and biogeochemical model capable of resolving inter-basin exchange and biogeochemical response. The hydrodynamic component of the model uses the finite-volume community ocean model, with loads from 99 wastewater outfalls and runoff from 161 watersheds, including 22 major rivers to the inner waters of the Salish Sea. The combination of watershed and point-source inputs allows assessment of cumulative exposures from multiple point and non-point sources. The model also facilitates separate prediction of the temporal and spatial exposure patterns of these unique source profiles. The HRMS data can provide a means to validate model outputs, and inform on actual exposure patterns based on model predictions. In this way the combination of HRMS analytical methods and advanced hydrodynamic modeling can provide exposure assessments from different sources and be used to inform management responses.

TP145 Exposure Assessment in Marine Waters Combining High Resolution Mass Spectrometry and Hydrodynamic Modeling

A. James, Z. Tian, University of Washington, Tacoma / Center for Urban Waters; T. Khangaonkar, Pacific Northwest National Laboratory

Organisms in marine waters are exposed to a wide range of contaminants from a variety of sources including wastewater treatment plant effluent, surface runoff from roads, combined sewer overflows, and others. These exposures are often related to biological responses which can affect the health and behavior of individuals, alter reproduction, and impact species survival. Traditional analytical approaches have provided occurrence information on a selected set of traditional and emerging contaminants. In order to provide a more holistic assessment of exposures in the marine environment we are combing monitoring based on high resolution mass spectrometry (HRMS) approaches with hydrodynamic modelling. The HRMS methods provide a broad assessment of exposures by capturing a range of organic contaminants, including metabolites and transformation products, particularly compared to traditional targeted methods. For example, recent sampling in the Salish Sea incorporating HRMS analytical methods identified more than 80 compounds including herbicides, pharmaceuticals, vehicle-related compounds, plasticizers and flame retardants. Unexpected contaminants such as methamphetamine and toxic fungicide metabolite 4-hydroxy-chlorothalonil were detected, as well as transformation products of herbicides and plasticizers that have not been reported elsewhere. In addition to contaminant identification, HRMS methods are being utilized to develop source signatures based on the unique and consistent occurrence of a suite of organic contaminants for a given source category. This allows the evaluation of the magnitude of exposure from different sources at different time points. The Salish Sea Model is being used to incorporate transport considerations in the exposure assessment. The Salish Sea Model is a three-dimensional hydrodynamic and biogeochemical model capable of resolving inter-basin exchange and biogeochemical response. The hydrodynamic component of the model uses the finite-volume community ocean model, with loads from 99 wastewater outfalls and runoff from 161 watersheds, including 22 major rivers to the inner waters of the Salish Sea. The combination of watershed and point-source inputs allows assessment of cumulative exposures from multiple point and non-point sources. The model also facilitates separate prediction of the temporal and spatial exposure patterns of these unique source profiles. The HRMS data can provide a means to validate model outputs, and inform on actual exposure patterns based on model predictions. In this way the combination of HRMS analytical methods and advanced hydrodynamic modeling can provide exposure assessments from different sources and be used to inform management responses.

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TP146 Non-targeted analyses of soybean grown hydroponically in municipal wastewater effluent and surface waters

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Water scarcity has led to water reuse for crop irrigation from different water sources that can contain organic chemicals of concern, including regulated and non-regulated chemicals. Previous studies have used targeted analytical approaches to quantify chemical concentrations in food crops, but, to date, no studies have used non-targeted or suspect-screening analyses via high resolution mass spectrometry (HRMS) to evaluate organic chemical features in food crops irrigated with different water sources. Soybeans (Glycine max) were hydroponically grown with secondary-treated municipal wastewater effluent, surface water, and tap water to compare the number of chemical features and types of tentatively identified chemicals in soybean shoots from each water source. After 14 days of hydroponic growth, soybean shoots were weighed for biomass and then extracted for HRMS analysis. Chemical features were compared against the USEPA's Distributed Structure-Searchable Toxicity database (DSTTox). Those with a >=90% match score were tentatively identified using the USEPA's CompiTox Chemicals Dashboard and categorized by chemical class, LogP, and molecular mass. Soybean biomass was significantly greater when grown in wastewater effluent compared to surface water or tap water. Municipal wastewater effluent contained about 400 chemical features of which 90 chemicals were tentatively identified at the >=90% confidence level. Soybean shoots grown in wastewater effluent had 1000 chemical features of which 300 chemicals were tentatively identified and classified as either hormones/pharmaceuticals and personal care products (n=60), industrial chemicals (plasticizers, flame retardants, dyes n=40), or biogenic compounds (plant and fungi compounds n=75). The numbers of chemical features in surface water and tap water, and their respective plant shoots, did not differ substantially from wastewater soybean shoots. Likewise, LogP histogram distributions for identifiable chemicals were similar among water samples and plant shoots as well as the number of chemicals in major chemical classes. These data suggest that chemical features for soybeans grown in wastewater were similar to soybean grown in nearby surface waters or tap water. These results indicate that wastewater effluent may be a viable source of water for growing edible crops. Ongoing work includes additional chemical analysis and a quantitative risk assessment of the chemicals present in soybeans grown in treated municipal wastewater.

TP147 The development of Non-Targeted Analysis workflows for the use of chemical prioritization in environmental water samples


The analysis of contaminants of emerging environmental concern has been an ongoing priority due to their potential for adverse effects on wildlife and human health. With many tens of thousands of chemicals in use today, prioritizing specific chemicals or mixtures of chemicals that should be targeted for analysis has become increasingly difficult. We are developing non-targeted chemical screening tools to look for a broad range of possible chemical contaminants present in environmental waters using liquid chromatography and quadrupole/time of flight mass spectrometry (Waters Xevo LC-QToF), as a first step in the process to assess which chemical contaminants pose a risk to human health and aquatic life and prioritize analytes for future targeted methods. A variety of analysis techniques are being used, including liquid chromatography with different stationary phases (C18, HILIC), and multiple sample collection and preparation methods, including both grab samples with solid phase extraction and polar organic chemical integrative samplers (POCIS) samples. Ideal method conditions needed for data analysis and assessment workflow, including blank subtraction, retention time monitoring, replicate injections, peak alignment, and sequence set up (with possible sample randomization) are also being investigated. One specific workflow is presented and applied to wastewater, surface water, and source and treated drinking water samples collected throughout a single watershed on multiple sampling seasons and flow conditions. The main goal of this work is to examine the occurrence, fate, and transport of chemical contaminants as they travel along a stream flow path from wastewater treatment plant discharge downstream to a drinking water intake and through finished drinking water. Such a sampling design will help determine where in the water cycle chemicals are introduced, which chemicals
resist attenuation via natural processes or during treatment, and whether any new, potentially toxic chemicals are released in the environment as a result of those treatments.

TP148 Examination of trends and variations in contaminants via non-targeted mass spectrometry: An Everglades case study
A. Henderson, Florida International University / Chemistry; B. Ng, Florida International University; S. Landeweer, Florida International University / Chemistry and Biochemistry; N. Quinete, Florida International University (FIU) / Southeast Environmental Research Center SERC; P.R. Gardinali, Florida International University / Chemistry & Biochemistry and SERC

The Contaminant Assessment and Risk Evaluation (CARE) project evaluated traditional contaminants in the Florida Everglades such as metals, nutrients, and organic contaminants. The CARE project was focused directly in the Everglades, and human inhabited areas such as Everglades City and Chokoloskee were excluded from the project. Making these prime areas for determining contaminant flux. The Barron River in Everglades City is fed from the wetlands to the North, which are fed by the agricultural areas near Immokalee. Surface water and sediment samples were obtained seasonally in 2018-2019 from the Barron River transect through Everglades City. Recently, citizen reports of symptoms of potential contamination has renewed interest in the area. These reports have spurred the development of a non-targeted screening method for surface and sediment matrices. Surface water samples (10 mL) were processed by online solid phase extraction followed by liquid chromatography-high resolution mass spectrometry using a Thermo Q Exactive. Samples were analyzed in positive and negative ionization modes in full scan from m/z 100-800 at a resolution of 140,000 and data dependent MS2 for confirmation with an NCE of 30. Data processing was performed using Thermo Compound Discoverer version 3.0. Sediment extractions were achieved through sequential analysis via a Dionex ASE 200 with water, methanol, and acetonitrile. This method proved to be the simplest extraction method, with no significant variation from separately extracting sediment samples. Features found in aqueous samples showed heavy seasonal and spatial variations. Spatial variation showed limited anthropogenic contamination in northern sites closest to the Everglades, while sites further south showed more features of human origins (i.e. pharmaceuticals (Oxyphenol), and industrial chemicals (Tetrahydrofurfuryl methacrylate)). Seasonal variations between the wet and dry seasons showed more anthropogenic contaminants during the dry season, as water flow from the wetlands is greatly reduced during the dry season. The sediment extraction method developed was successful in extracting a variety of compounds and elucidating the differences between sites. Sediment data showed a lower H:C ratio in the northern sites (mean 1.52, n=404) when compared to the southern sites (mean 1.65, n=452), likely from more heterotatox containing natural products, compared to higher amounts of anthropogenic compounds found at southern sites.

TP149 Assessing Reproducibility using Quality Controls for Non-Target Analysis of Environmental Samples
B. Ng, Florida International University / Chemistry and Biochemistry; N. Quinete, NC State University / Florida International University / SERC; P.R. Gardinali, Florida International University / Chemistry & Biochemistry and SERC

Majority of approaches for the screening of environmental contaminants target individual chemical compounds or classes of chemical compounds using highly specific analytical methods. Despite their ability for low level detection and quantification, novel contaminants or transformation products which may pose a risk to humans and wildlife are often overlooked by these methods. Recent advances in mass spectrometry as well as chemometrics have led to the evolution of non-targeted screening approaches to address the presence of unknown organic contaminants. Currently there are currently no established standard methodology or process in how non-target analysis (NTA) should be performed. The goal of quality assurance (QA) for analytical measurements is to reduce errors to acceptable limits and involves the use of quality control (QC). QA applies to the overall measures taken by a laboratory to ensure quality of operation, while QC relates to the measures associated with the quality of individual samples or batches of samples - control the errors. The purpose of a quality control in the analytical process is to acquire valid measurements. As of this moment, there are no established QA/QC guidelines for the validation of analytical performances for NTA. In this study, some quality control guidelines will be proposed to be followed in non-targeted screening methodologies. Workflow reproducibility was assessed using an in-house QC mixture containing selected compounds with a wide range of polarity that can be detected either by electrospray ionization (ESI) positive or ESI negative. The analysis was performed by liquid chromatography coupled to high resolution mass spectrometry (LC-HRMS).

Data processing was done using the software compound discoverer 3.0 using an environmental workflow, which searched a multitude of databases, including Chemspider, EPA Toxcast, MzCloud and others. In this study, we have specifically evaluated method precision, accuracy and reproducibility through an in-house QC mixture in terms of peak area and retention time variability, true positive detection rate and intraday (within days) and interday (consecutive days) variations. It was found that peak area varied a lot for both intraday and interday, but retention time did not, it had a relative standard deviation (RSD) of less than 5% for both intra and interday. The detection rate was greater than 75% for most of the detected compounds, with a few exceptions.

TP150 Pairing high throughput chemical and biological analysis in environmental assessment workflows
C. Zwiener, Environmental Analytical Chemistry, Center for Applied Geoscience, University of Tuebingen / Geosciences; S. Baumann, Agilent / Academic and Government Applied Marketing; T. Anumol, Agilent Technologies, Inc.; S. Vikstrom, Agilent Technologies

Exposure sample analysis for exposomics is increasingly using suspect screening analysis (SSA) in addition to routine targeted chemical analysis. Meanwhile, toxicology testing is increasingly using effects directed analysis (EDA) to supplement multiple/whole organism testing. High throughput methods like SSA and EDA require less time and money than traditional testing, a benefit to risk assessments and other assessments such as routine monitoring. Our goal is to introduce these new approaches and provide concrete examples of how EDA along with complementary SSA and non-targeted analysis help identify and prioritize anthropogenic compounds found in our environment and biological samples. Limited information exists about exposure and toxicity for tens of thousands of chemicals in commerce. High throughput techniques like non-targeted (NTA) and effects-directed analysis (EDA) enhance our understanding of the occurrence and biological activity of chemicals in exposure related samples and their impact on the environment. This course will describe the use of these high(her) throughput techniques and how they can be used to characterize toxicity and prioritize thousands of chemicals in samples related to exposure pathways (e.g., air, water, sediment, food) or biological samples (e.g., urine, saliva, blood). High resolution mass spectrometry (HRMS) is a prominent tool in suspect screening and NTA studies, as the technique can hypothetically detect all chemicals in a sample leaving the researcher to dissect the data to propose at their identities. EDA pairs biological activity testing (e.g., cellular, bioluminescence, and impedance assays) with HRMS to discover and identify compounds that produce effects. Software tools and multivariate statistics allows for high throughput evaluation of complex interactions between anthropogenic compounds, the environment, people, and health.
TP151 Understanding Pesticide Removal and Transformation in Woodchip Bioreactors

M. Hattaway, O. Wright, University of California, Davis / Civil and Environmental Engineering; A.S. Burant, California Department of Pesticide Regulation / Surface Water Protection Program; H. Bischel, T.M. Young, University of California, Davis / Civil and Environmental Engineering

Woodchip bioreactors are an inexpensive, low-tech solution to treat agricultural runoff and mitigate the amount of nitrogen, phosphorous, and possibly pesticides that is released into waterways. However, understanding how the many physicochemical and biological processes occurring in these systems affect the removal or transformation of pesticides in the bioreactor can be challenging. The current study will identify transformation products of a set of pesticides representing a broad range of classes, including neonicotinoids, pyrethroids, and fipronil, in bench-scale bioreactor effluent. Compounds will be analyzed using both liquid and gas chromatography time-of-flight mass spectrometry (LC-QTOF-MS and GC-QTOF-MS), and identified using suspect libraries generated from literature sources and pathway prediction models. Identification of breakdown products will aid in elucidating the specific processes and identifying parameters to be tweaked for optimal pesticide removal.

What’s in Your Neighborhood? Assessing and Understanding Metal(loid) Exposure and Risk in Urban Systems

TP152 Oxidative potential of fine aerosols from National Air Pollution Surveillance network in Canada - influence of source sectors and metal concentrations

P. Shahpoory, T. Harner, V. Celto, E. Dabek, Environment and Climate Change Canada / Air Quality Research Division

Air pollution is a major global health risk. It has been associated with respiratory and cardiovascular diseases as well as increased morbidity and mortality rates. Human exposure to fine particulate matter (PM), especially PM with aerodynamic diameter ≤2.5 μm (PM2.5), is one of the main causes of the adverse effects across the world. Oxidative potential (OP) is a measure of inhalation toxicity of airborne PM. The redox-active constituents of PM react with lung antioxidants in the epithelial lining fluid, resulting in oxidation of antioxidants. Excessive loss of antioxidants results in oxidative stress, inflammation of the epithelial tissue, and chronic diseases. The OP depends on various factors such as PM chemical composition, mass-size distribution, and ambient concentrations. PM chemical composition is influenced by the emission sources and transformation processes in the atmosphere. Among PM components, transition metals, water-soluble organic species and quinones are the major contributors to OP, however, metals are considered to have a greater impact due to their relatively high mass mixing ratios in PM. In this work, we investigated the OP of PM2.5 samples from the National Air Pollution Surveillance sites across Canada, covering urban, traffic, industrial, and background source sectors, as well as temporal profiles. We applied a novel OP method that we developed in-house – it considers the reaction of PM with major lung antioxidants in simulated lung lining fluid and determines the redox state of the samples. The results are evaluated through correlation analysis with PM2.5 components including total and soluble transition metals, and the measured electrochemical reduction potentials of the samples. The preliminary results indicated links between OP, the reduction potentials and changes in major PM2.5 components. This study introduces a new approach for evaluating the inhalation toxicity of PM. Moreover, it provides an insight into how the current trends in urbanization and anthropogenic activities, as well as various emission sources contribute to metal concentrations, human exposure and health risks associated with fine inhalable PM in Canada.

TP153 Long-term Monitoring and Inhalation Risk Assessment of Metals in PM10 in the Great Lakes Basin

W. Li, H. Dryfhout-Clark, Environment and Climate Change Canada / Air Quality Processes Research Section; K.A. Brice, Environment and Climate Change Canada / Air Quality Research Division; H. Hung, Environment and Climate Change Canada / Air Quality Processes Research Section

The Great Lakes is an important resource to wildlife and humans in North America. To protect this great freshwater lake system, Canada’s Great Lakes Basin (GLB) Monitoring and Surveillance Program has been monitoring contaminants in air and precipitation since the 1990s, aiming at assessing the atmospheric deposition of contaminants to the lakes. Long-term monitoring for metals in airborne particles was measured at three sites in the GLB: namely Burnt Island (1992-2013), Point Petre (1988-current) and Egbert (1988-2008) using PM10 high volume air samplers. Exposure to atmospheric metals may lead to a variety of toxicological symptoms in humans and wildlife. The temporal trends of metals in the GLB atmosphere may be changing in response to changes in their usage and emission patterns. To assess such changes, temporal trends were developed using the digital filtration method combined with the Seasonal Kendall test for trends. Sources of metals in the atmosphere were investigated by various techniques including enrichment factor analysis, positive matrix factorization analysis, and potential source contribution function analysis. Cancer and non-cancer risks were assessed for ten metals which have cancer or non-cancer toxicities and could pose a potential public health risk to people by inhalation exposure. It was found that the 19 target metals were detected in at least one sample, with concentrations ranging from not detectable to 850 ng/m3. Aluminum, iron and zinc were the dominant metals, while bismuth, cadmium, cobalt had the lowest concentrations. Trend analysis suggested that the concentrations of most metals decreased significantly with time, suggesting emission reduction during the sampling period. The United States (US) was the major source area for metals in airborne particles measured at the three sites. Generally, the estimated carcinogenic and non-carcinogenic risks were less than 10-6 and 1, respectively, which were within the acceptable levels according to the USEPA.

TP154 Metals in Road Dust and Implications for Urban Health in Toronto

C.L. Wiseman, University of Toronto / School of the Environment; J. Niu, C. Levesque, P.E. Rasmussen, Health Canada / Exposure and Biomonitoring Division

In a major urban system such as Toronto, characterized by a high population density and traffic activity, the volume of metal-enriched road dust originating from non-exhaust sources which may be resuspended to the air is a major public health concern. Road dust is enriched with toxic metals originating from, for instance, the wear and tear of brake system components, tires and asphalt surfaces. The goal of this study is to characterize the metal enrichment patterns in road dust particle size fractions that may be resuspended to the air and inhaled by exposed individuals in Toronto, Canada. As part of this, annual loadings and road-to-air resuspension fluxes of metals in inhalable fractions are estimated. Road dust samples were collected from 2015 - 2016 as a function of road class. Samples were fractionated into two particle sizes during collection: (1) bulk hopper (coarse debris), and (2) inhalable dust box (fine material, nominally 5 μm). Sixty four samples were digested in a mixture of HF, HClO4, HNO3 and HCl and elemental concentrations were measured in digests using ICP-MS. Annual elemental loadings to roads and resuspension fluxes (road-to-air) were estimated using measured metal concentrations combined with available data on the annual mass totals of road sweepings for Toronto. For this, the inhalable fraction was estimated to range between 5 and 10% of the mass total. Metals of health concern were found to be enriched in inhalable fractions of road dust. The greatest enrichments were observed for Cd and Zn. The respective geometric mean (GM) [95% CIs] concentrations of these elements in inhalable vs.
bulk samples were: Cd: 0.55 [0.47, 0.63] μg/g vs. 0.25 [0.22, 0.29] μg/g and Zn: 649 [575, 732] μg/g vs. 252 [218, 292] μg/g. Annual deposition rates for Toronto roads were relatively high for several elements, including Cu and Pb. For instance, a total weighted mean of 736 - 754 kg of Pb was estimated to be deposited on Toronto roads annually, of which 59–118 kg/yr Pb would have been available for resuspension in the inhalable fraction. The study results highlight a need to more closely examine the potential of road dust to serve as a primary source of atmospheric pollution and its role in contributing to a range of human health outcomes.

**TP155 Metalloid enriched topsoils in a multiple land-use area in Tuscany (Italy): Geogenic versus anthropogenic contributions and associated health risk**

F. Monaci, University of Siena / Life Sciences; E. Donegan, BOKU University of Natural Resources and Life Sciences; D. Baroni, University of Siena / Department of Environment Earth and Physical Sciences

The Piana di Scarlino is a partially refilled wetland in the SW of Tuscany (Central Italy) which has hosted chemical and power plants since the 1960s. Presently, in the area there are urban settlements (the main urban center, Follonica, has a population of approx. 25,000), farms, tourist facilities, and industrial districts, mainly based on H2SO4 and TiO2 production as well as waste incineration. In the last two decades the soil and groundwater of the Piana di Scarlino, have been found polluted with arsenic (As) and heavy metals. This prompted local authorities to implement remediation measures and environmental monitoring programs to protect the resident population and the local agricultural produce. In 2013, we initiated an environmental surveillance program in the area within an IPPC permitting procedure for monitoring As and heavy metals and assessing human health implications. The study initially aimed at establishing topsoil data to be used as baseline for long-term monitoring. Overall total As concentration of superficial soils (0-5 cm), collected from 44 sampling sites randomly selected within a circular area up to 1.5 km around the industrial district, was on average 33.8 ± 35.9 μg/g. This value, is approximately 3 times higher than the European baseline and highlights a general enrichment of topsoil As content. This is mainly attributable to widespread geochemical anomalies characterizing Southern Tuscany and to the historical mineral processing and smelting activities carried out in the Scarlino area until the mid-90s. The highest As concentrations were found in soils from sampling sites in the proximity of a pyrite ash dump, where concentrations over 200 μg/g were reached. Average concentrations (32.9 μg/g) from agricultural and grazing soils were also much higher than the baseline for Italian agricultural lands (7.56 μg/g). Although soils from urban sites generally showed the lowest As concentrations, average As concentrations for the urban area (21.8 μg/g) remained over the screening values (20 μg/g) for contaminated soils set by the Italian regulatory framework for residential areas. In this context, we used multi-element analysis supported by techniques for monitoring atmospheric depositions to improve estimation of exposure and related health risks arising from the nearby industrial activities as well as to assess the relative contribution of historical and present-day As sources in the Scarlino area.

**TP156 Effect of Soil Particle Size and Extraction Method on the Oral Bioaccessibility of Arsenic**

Y. Lowney, Alloy, LLC / Health Sciences; S. Roberts, University of Florida / Department of Environmental and Global Health; L. Stuchal, University of Florida / Center for Environmental and Human Toxicology; N.G. Odezulu, University of Florida / Physiological Sciences; M. Kozuch, University of Florida / Center of Environmental and Human Toxicology

Decades of research has clearly established that there are site- and soil-specific factors that control the bioavailability of arsenic from soil, and that these factors should appropriately be factored into human health risk assessment (HHRA) of contaminated sites. Guidance from the USEPA and several State agencies provide useful information regarding inexpensive “in vitro” methods to estimate the bioavailability of arsenic from soils, and the process for incorporating the in vitro bioaccessibility (IVBA) data into HHRA. The animal research that establishes the relative oral bioavailability of arsenic from soils, and which underlies the IVBA methods, was largely conducted using soils sieved to < 250 um. Recently, the USEPA updated their guidance on assessing exposures to chemicals in soil at contaminated sites, and now recommends that HHRA of contaminated soils focus on soil particles < 150 um. This research evaluates soils from several arsenic-contaminated sites to assess the effect of two different IVBA methods on soils from diverse regions and arsenic sources. For a matched set of soils, the research also evaluates the effect of particle size. The findings and implications for HHRA of arsenic in soil will be addressed.

**TP157 Characterizing Metals/Metalloids and Microplastics in Municipal Compost Produced from the Organic Fraction of Municipal Organic Waste**

M. Dodd, Royal Roads University / School of Environment & Sustainability; D. McCartney, University of Alberta / Civil & Environmental Engineering

Municipal leaf, yard and garden waste, and food scraps are currently banned from disposal in landfills in various municipalities including Victoria. Municipalities have therefore established composting facilities where these materials are converted into valuable soil amendments. Atmospheric input, road runoff, pesticides, paints on nearby structures, vehicular traffic, littering and other activities can potentially introduce metals and other contaminants such as microplastics into leaf and yard waste which may eventually end up in compost. It has been suggested that microplastics may adsorb metals thereby increasing their retention in different substrates including compost. This paper will present our findings of the metal and or metalloid concentrations present in compost, the metal and or metalloid concentrations present in compost, and the metal and or metalloid concentrations present in compost. The compost was sampled at 10 different facilities, each of which had primary leaf and yard waste as feedstock and the other five were facilities which had primarily residential food waste as feedstock, e.g., source separated organics. Three composite samples were collected at each facility. Each composite sample was prepared using ten 2-L increments (point samples) that were collected from random locations of the pile. Each gross sample was quartered in the field to provide about 3 L of sample. Samples were then split for analysis of general compost properties (TN, TP, TK, pH, OM, C:N, Na, Mg, Ca, Pb, Zn), metals/metalloids by ICP-MS and XRF, and in vitro bioaccessibility. After oxidation of organic matter in the compost samples using Fenton’s reagent, microplastics were separated by density separation with sodium iodide and characterized by microscopy and FT-IR. The results of these analyses will be presented including: differences between the two types of compost; relationship between metals and microplastics content; and potential human and environmental risk associated with using these municipal sourced composts incorporating metal bioaccessibility.

**TP158 Contaminant risks in stormwater leachate from crumb rubber and thermoplastic elastomer artificial turf infills used in Pacific Northwest playfields**

J.A. Colgan, King County Department of Natural Resources and Parks / Water and Land Resources Division

Many concerns exist surrounding the use of crumb rubber infill for turf fields. Some concerns are well-known and documented such as the release of metals to stormwater runoff at levels high enough to cause impacts to aquatic life. The large Pacific Northwest city of Seattle is located in King County, Washington. All County-owned artificial turf playfields contain crumb rubber infill. However, local regulations require crumb rubber fields to incorporate treatment technology to remove metals from stormwater effluent due to documented metals releases, particularly zinc. These
Benzobicyclon (BZB) is a recently registered rice pro-herbicide in the United States. Studies on the environmental fate of benzobicyclon have been conducted in regions including California and Japan. Benzobicyclon is pending registration in Louisiana, where rice and crayfish are cultivated in the same fields and harvested in production cycles. Pesticides applied to rice paddies have the potential to persist in the rice field and result in prolonged exposure to crayfish. Previous studies have shown that benzobicyclon has a strong affinity for sediment and a low toxicity to crayfish. Exposure of benzobicyclon to P. clarkii determined no acute effects, while chronic effects of benzobicyclon were reported in some invertebrates. Benzobicyclon undergoes hydrolysis in flooded rice paddies to form benzobicyclon hydrolysate (BH), the active ingredient. The purpose of this investigation was to determine how benzobicyclon degrades and persists in a Louisiana rice field. Fields treated with benzobicyclon were sampled for water and sediment through two growing seasons, 2018 and 2019. Benzobicyclon and benzobicyclon hydrolysate were extracted from water and sediment samples and analyzed by HPLC. Concentrations of BZB were found to be higher in sediment, suggesting that sediment acts as a sink for BZB, while BH concentrations were higher in water.

These data coincide with the partitioning trends of BZB and BH in other studies. Concentrations of both compounds were below the limit of detection after 43 days post-application. The hydroxyl radical rate constant of the hydrolysate was estimated in this study. Previous studies have shown that hydroxyl radical degradation is most significant in shallow waters, such as a flooded rice field. Characterizing the hydroxyl radical rate constant is important when determining the rate of degradation of benzobicyclon in Louisiana rice fields. The hydroxyl radical rate constant of BH was estimated using competition kinetics. An equimolar mixture of BH and a competitor, with a known rate constant, were exposed to hydroxyl radicals. The rate constant was estimated to be $9.8 \times 10^{12}$ (M$^{-1}$/h). Understanding the fate of benzobicyclon in Louisiana rice fields is pertinent to know how this pesticide will potentially impact crayfish production and health.

### Chemistry and Exposure Assessment

**TP160 Environmental Fate of Benzobicyclon in a Louisiana Rice Field**

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**TP161 A Critical Review on Snow Scavenging of Cyclic Volatile Methyloisoxanes**

*S. Xu, Dow Chemical Company / Toxicology and Environmental Research and Consulting*

Snow scavenging was speculated as a deposition mechanism in polar regions for airborne volatile methylsiloxanes (VMS), a group of emerging contaminants related to personal care products. In this presentation, the issue of snow scavenging of two representative VMS, octamethylenecyclotetrasiloxane (D4) and decamethylene-cyclododecasiloxane (D5), is critically reviewed. Modeling and experimental data are presented, as well as future research directions are proposed. Briefly, the snow scavenging of VMS was used to explain the unexpected detection of cVMS from the coastal area of Antarctica. However, model calculations suggest that sorption of VMS by atmospheric particulates and snow particles is minimal. In a recent laboratory study, the sorption coefficients on snowflakes (KiA) and the snow scavenging ratios were measured at different temperatures, varying from -2 to -20°C, using 14C-labeled D4 and D5 against a benchmark compound, cyclopentanone. The results - consistent with the modeling assessments - show that the sorption of VMS by snow is too small to increase their deposition potential. In these experiments almost 99% of all D4 and D5 in a snowpack was lost during the snow melting process through re-volatilization and degradation, and D4 and D5 became non-detectable in snowmelt water. Therefore, the existing data suggest that snow scavenging is not an effective deposition mechanism for these volatile hydrophobic compounds. In the view of these results, speculation of snow scavenging of methylsiloxanes in the coastal area of Antarctica seem to be questionable. It is planned to verify these findings by actual measurements in the future field research.

**TP162 Long-Term Monitoring and Trend Analysis of Cyclic Volatile Methyloisoxanes (cVMS) in Aquatic Environments Impacted by Wastewater Effluent**

*R. M. Sexton, Hyla Environmental Consulting, LLC / Toxicology, Environmental Research & Consulting; J. Kim, The Dow Chemical Company / Toxicology and Environmental Research and Consulting; J.A. Durham, Dow Corning Corporation / Toxicology and Environmental Research Consulting; C. Mund, T. Boehler, Evonik Nutrition & Care GmbH; N. Meguriya, Shin-ETSU*

Cyclic volatile methylsiloxanes (cVMS) are widely used in consumer applications. Because wastewater represents the major post-use disposal route for cVMS, the Silicone Industry Associations in North America, Europe, and Japan initiated a global monitoring program of predominant cVMS, including octamethylocyclotetrasiloxane (D4), decamethylene-cyclo-pentasiloxane (D5), and dodecamethylene-cyclohexasiloxane (D6) in surface
sediments and aquatic biota. Aquatic environments that are impacted by municipal wastewater effluents were selected as study areas for the monitoring program, and included Lake Pepin (USA), Lake Ontario (on the border between Canada and USA), Oslofjord (Norway), and Tokyo Bay (Japan). The target objective of the monitoring program was to determine if concentrations of cVMS were stable or changing, which is defined as a statistically significant (α=0.05) annual rate of change of ≥6% per year (net change of -2% to 34%) detected with 80% power (β=0.20). Target matrices for each study area include surface sediments, benthic invertebrates near the base of the food chain, low trophic level forage fish, and high trophic level piscivorous fish. The monitoring period was from 2011 to 2016. Generally, concentrations of cVMS in both surface sediment and biota showed decreasing trends over the monitoring period; however, the statistical power was relatively weak in many cases. Thus, considering the annual variability, concentrations of cVMS in biota and sediment have been stable or decreasing in most monitoring locations based on the aforementioned statistical criteria. This presentation will discuss more details of monitoring data and their trends over the project period by location and species.

TP163 Identification and Reduction of Analytical Bias for Analysis of Siloxanes


When analyzing for siloxanes, careful consideration of the potential for analytical bias is critical to success. It is therefore imperative that the proper quality control (QC) is performed to ensure the accuracy of results. This is especially true when the analytes are present in common personal care products, and/or the reagents and analytical instrumentation utilized in the method. Siloxanes possess physical/chemical properties that are distinctly different from carbon-based materials of similar size and also different reactivity with reagents, instrumentation and contaminants present in the environment or lab. These differences can lead to mis-identification, overestimation and even underestimation of the analyte of choice. In this presentation, various collection, processing, and analytical methods are critically reviewed to demonstrate sources of contamination and loss. Incorporation of a robust QC program allows for successful isolation and identification of sources of analytical bias. Some siloxanes undergo rearrangement in heated inlets, analytical chromatography columns or during sample processing under typical conditions of processing and analysis. Interactions and mass transfer of siloxane can also occur at the time of sample collection with typical collection media and sample processing environment or during storage over time. Therefore, a strong QC program utilizing matrix matched blanks, individual and combined spiked samples, and replications are critical when evaluating environmental and biological samples for concentrations of siloxanes. The types of QC samples necessary to identify locations of analytical bias are further discussed. Methods for reducing or eliminating analytical bias during sample collection, processing, and analysis are recommended. Some examples are 1) careful selection of sorbent material that does not catalyze rearrangement reactions of Si materials, 2) use of instrument septa and columns that do not contain Si materials, and 3) consideration of method conditions in order to a) avoid material exchange between samples and lab surroundings and b) minimize changes of pH and heat, thus reducing the potential for undesired reactions occurring during processing.

TP164 Quantification of ppb dimethylsilanediol in water by NMR

D. Eldred, The Dow Chemical Company / Analytical Sciences; S. Allmann, Wacker Chemie; D. McNett, The Dow Chemical Company / Toxicology Environmental Research and Consulting; H. Pracy, DuPont / Analytical Sciences; C. Roggenbuck, The Dow Chemical Company / Analytical Sciences; S. Xu, Dow Chemical Company / Toxicology and Environmental Research and Consulting

There is a growing interest to evaluate the environmental fate of volatile methyl siloxanes (VMS), particularly in aqueous environments. Dimethylsilanediol (DMSD) is the principle hydrolysis product of VMS and is relevant to detect at low concentration levels. 1H NMR is employed to achieve DMSD detection and characterization at single digit part per billion (ppb) concentrations through silylmethyl measurement. Relative to more selective 29Si NMR, 1H offers several advantages to facilitate detection at environmental concentrations. The number of equivalent protons per silicon, lack of 1H-1H coupling, high natural abundance, relatively short spin lattice relaxation, and strong gyromagnetic ratio are all features which lend themselves to facilitating DMSD detection by 1H NMR. To achieve low concentration silylmethyl detection in aqueous environments, water suppression through a composite of a multipass Shaped pulse PResaturation and WATER GrAdient Tailored Excitation with 5 pairs of symmetric pulses (SPR-W5-WATERGATE) is applied as an alternative to the more traditional presaturation approach. Measurement of DMSD can be significantly influenced by sample preparation. Siloxanes are frequently used as glass, metal and plastic lubricants; facilitate joint seals in chemical reactions; and are common in personal care products such as deodorants and shampoos. At the inlet for chromatography methods it is difficult to differentiate inadvertent siloxane exposure vs inadvertent condensation of DMSD. Measurement under standard NMR conditions avoids high inlet temperatures, and dramatic concentration shifts that may influence the sensitive hydrolysis and condensation balance for DMSD and silicone/siloxane materials in the sample. We demonstrate that the use of a reverse osmosis treated water supply with negligible DMSD content can be used to generate a suitable control standard, 4,4-dimethyl-4-silapentane-1-sulfonic acid. Introduction of a small amount of the weighed internal standard solution is demonstrated suitable for measuring DMSD with high fidelity.

TP165 Comprehensive Multiphase Nuclear Magnetic Resonance: A Powerful Tool in Optimizing Biofuel Production

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Algae are seen as one of the most important sources of biofuel. They can be grown rapidly and take carbon dioxide from the atmosphere during growth, reducing overall carbon emissions. Conventionally, subcritical water extraction (water under pressure and heat) is used to extract algae to produce biofuel. However, the composition of components, in the extract or left behind, is not well understood, and the chemical and physical mechanisms that prevent the materials from being extracted efficiently have yet to be elucidated. Nuclear magnetic resonance (NMR), a powerful tool to provide information at molecular level, traditionally has developed in to 3 separate fields dealing with solids, gels and solutions due to hardware requirements. Comprehensive Multiphase (CMP) NMR combines all electronics and hardware into a universal probe that permits a holistic overview of all phases (i.e., liquid, gel-like, semi-solid, and solid) in intact samples. Applying CMP-NMR to algae extraction provides a unique insight into what has been extracted (liquid phase), what has been swollen (potentially extractable with method optimization) and what is inaccessible to extraction solvent, subcritical water in this.
TP166 Distribution and Fate of Petroleum Hydrocarbons in Coastal Seawater, Sediment, and Bivalves after the Hebei Spirit Oil Spill Incident

M. Kim, J. Jung, J. An, S. Ha, U. Yim, Korea Institute of Ocean Science and Technology / Risk Assessment Research Center

An estimated 12,547 kilo liters (10,900 M/T) of crude oil was spilled in December 2007 after the collision between the oil tanker Hebei Spirit and a barge carrying a crane. More than 375 km of western coastline of Korea were impacted by the spill, threatening the health of natural marine ecosystem and various mariculture activities. Spatiotemporal variations of oil contamination were investigated until 2018 since the spill. Polycyclic aromatic hydrocarbons (PAHs) and/or total petroleum hydrocarbons (TPH) in seawater, sediment, and bivalves were analyzed. Immediately after the spill, the direct impact of the Hebei Spirit oil spill was clearly recognized at most sites surveyed. TPH concentration in seawater was 154 times higher than the Korean marine water quality standard of 10 ppb on average. PAH concentrations in sediments measured immediately after the spill ranged from 3.2 ng/g to 71,200 ng/g, with an average of 3,800 ng/g. Parent and alkylated PAHs in bivalves increased up to 1,200 and 106,000 ng/g, respectively, which were 60 and 1000 times higher than the pre-spill concentration level. The oil component concentrations in seawater and bivalves were several orders of magnitude higher than those detected at reference sites. The distribution of oil contamination showed considerable variability depending on the proximity to the spill location. Thereafter the oil contamination in the media have decreased gradually to background levels with varying degrees of half-lives depending on the matrices. Recovery from the impact was the fastest in seawater, followed by bivalves and sediment. The clear impact of the oil spill, however, was still observed at several sites even ten years after the spill. This results demonstrate persistence of the impact of oil pollution at sites of specific conditions. Continuous long-term monitoring of oil contamination is needed especially at the sites of lingering oil to understand and estimate the continuing impact of the Hebei Spirit oil spill.

TP167 Toxicological effects of Escravos light crude oil and three dispersants on Clarias gariepinus (the African sharptooth catfish)

E.G. Nwabudike, J.K. Salihu, University of Lagos / Department of Zoology

The control of crude oil spills in aquatic ecosystems involves the use of dispersants which act by breaking up the oil to facilitate degradation. However, dispersants may synergise or moderate the toxicity of crude oil. This study investigated the single- and joint-action toxicity of Escravos Light Crude Oil (ELCO) and three dispersants (Rig Wash/Degreaser (RW/D), Oil Slick (OS) and Gold Crew (GC)) against Clarias gariepinus, the African Sharptooth catfish. The biochemical, genotoxic, haematological and histological effects of sublethal concentrations (1% and 10% of 96 hLC50) of ELCO:dispersants mixtures were also investigated over a period of 28 days. The derived 96 hLC50 values revealed that the dispersants, RW/D (0.15 mL/L) was the most toxic, followed by OS (0.17 mL/L), GC (0.28 mL/L) and ELCO (7.53 mL/L) was the least toxic when acting singly. Joint action toxicity evaluations of ELCO:RW/D, ELCO:OS and ELCO:GC at ratio 9:1 was synergistic with synergistic ratio values of 2.12, 2.07 and 3.34 respectively. The biochemical studies revealed that the activities of reduced glutathione, superoxide dismutase and catalase in the kidney of C. gariepinus treated with 10% 96 hLC50 of ELCO:RW/D and ELCO:OS while glutathione-s-transferase levels in ELCO:RW/D and ELCO:GC were significantly (p < 0.05) reduced. Gill malondialdehyde levels in C. gariepinus exposed to sublethal concentrations of ELCO:RW/D and ELCO:OS were significantly (p < 0.05) higher than the control. Genotoxic indices such as micronuclei, blebbled nuclei, irregular erythrocytes, DNA tail length and tail DNA percentage were significantly increased (p < 0.05) dose-dependently in treated C. gariepinus. Haematologic indices such as erythrocytes, haemoglobin, packed cell volume and mean corpuscular volume were significantly decreased (p < 0.05) whereas mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration increased significantly (p < 0.05) in treated C. gariepinus. Gill histological anomalies such as blunt and curved secondary lamella, necrosis, eroded epithelium, hyperplasia, and epithelial lifting were induced in C. gariepinus exposed to sublethal concentrations of the ELCO: dispersant mixtures. The results demonstrate the need for holistic evaluations of chemical mixtures for oil spill control and the consideration of fisheries in the receiving aquatic ecosystem in setting ecologically sensitive crude oil:dispersant ratios.

TP168 A more cost-efficient extraction method for polycyclic aromatic hydrocarbons (PAH) in sediments and soils using accelerated solvent extraction (ASE)

Z. Xia, N. Klaassen, I.G. Idowu, J. Stetefeld, G.T. Tomy, The University of Manitoba / Department of Chemistry

Accelerated solvent extraction (ASE) is a novel extraction method that is accepted by the U.S. Environmental Protection Agency (USEPA) for extracting solid matrices. ASE is commonly used to extract polycyclic aromatic compounds (PACs) from solid materials. PAHs, the most common PACs, have been identified as priority compounds by the USEPA. The development of ASE extraction methods for PAHs can be traced back to the 1990s. Recently, a one-step ASE method that negated the need for adsorption chromatography was reported by Kim et al. to extract PAHs from marine sediments. Inspired by the previous work, the Centre for Oil and Gas Research and Development (COGRAD), which is committed to advancing the analytical measurements of oil and gas related compounds in an ISO-17025 accredited laboratory, decided to further investigate the one-step ASE method for PAHs on two standard reference materials (SRMs). The overarching goal was to verify the suitability of the one-step method and its applicability to improve laboratory efficiency.

TP169 High Performance Liquid Chromatography Methods for Analysis of Polycyclic Aromatic Compounds in Ambient Air Samples from the Great Lakes Basin

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The determination of polycyclic aromatic compounds (PACs) in air samples is of concern due to the toxic, mutagenic and/or carcinogenic properties of these compounds. Since 1990, ambient air sampling has been conducted in the Great Lakes Basin (GLB), with the collection of particulate phase and vapour phase semi-volatile organic pollutants on glass fiber filters (GFFs) and polyurethane foams (PUFs), respectively, from approximately 350 m³ of air. Up until 1999, the GFFs were Soxhlet extracted with dichloromethane and since then with Accelerated Solvent Extraction (ASE) using a hexane:acetone mixture (7:3, v/v), while the PUFs were Soxhlet extracted with hexane. The extracts were subjected to clean-up using silica columns and dichloromethane elution prior to
Analysis by high performance liquid chromatography (HPLC) with fluorescence (FLD) and ultra violet (UV) detection methods that have been developed for the analysis of parent polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs. An acetonitrile/water gradient at 1.5 mL/min flow rate and a Vydac C18 high carbon content column (150 mm x 4.6 mm), 5 μm particle size was used in separating twenty-three parent PAHs. An Agilent C18 narrow bore column (150 mm x 2.1 mm), 5 μm particle size and an acetonitrile/water gradient at 0.6 mL/min was used in separating the twenty-two alkylated PAHs. For improved fluorescence sensitivity, the optimum excitation and emission wavelengths were used for all the PAHs, while the gradient solvents were degassed continuously to eliminate quenching of the response. The column temperature was maintained within ± 0.5°C for stable retention times. On-column detection limits in the range of 0.03 - 0.5 pg were obtained for the parent PAHs and 0.1 - 3.0 pg for the alkylated PAHs. The developed methods have been used successfully to determine the parent PAH levels in air samples collected since 1990 and alkylated PAHs since 2016.

TP170 Trends and Human Exposure to Polycyclic Aromatic Hydrocarbons (PAHs) in the Atmosphere of the Canadian Great Lakes Basin (GLB)
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Polycyclic aromatic hydrocarbons (PAHs) are widespread contaminants that have been targeted for monitoring in the environmental due to their related health effects of lung, gastrointestinal, skin, and bladder cancers. Studying the long-term trends of PAHs in the atmosphere of the Great Lakes Basin (GLB) is important to determine whether the concentrations of PAHs are changing in response to domestic and international control strategies. To address the challenge, we investigate the spatial and temporal trends of atmospheric PAHs under the GLB Monitoring and Surveillance Program, which has been operating since 1990. High volume air samplers were used to collect air samples for the analysis of PAHs at three locations in the GLB, namely Point Petre, Burnt Island and Egbert, between 1995 and 2015. The atmospheric temporal trends of PAHs were determined by the digital filtration technique, and human exposure to atmospheric PAHs was estimated using the USEPA method for lifetime lung cancer risks. Our results suggest that the concentrations of total PAHs (ΣPAHs) ranged from 51-20,000 pg/m³ at the three sites. The highest concentrations of ΣPAHs were found in samples collected between December and February, while the lowest concentrations were detected in samples taken from June to August. Trend analysis suggested that most of the PAHs were decreasing at the Point Petre site located on the shore of Lake Ontario, while only a few PAHs were showing increasing trends at all three sites. Our exposure assessment suggested that the lifetime lung cancer risks associated with inhalation of PAHs were within the acceptable range (less than one in a million according to USEPA) at the three Canadian Great Lakes sites.

TP171 Analysis of Floating Oil Exposed to Ultraviolet Light Under Different Environmental Conditions
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Oil spills in the environment are subject to many weathering processes that alter the chemical and physical properties of oil. The process of photo-oxidation is now known to be a much larger contributor to weathering than previously thought. Products formed during the photolysis of oil have been shown to be more polar, and potentially more soluble in water. Understanding how oil weather under solar irradiation can improve modeling of the fate and transport of oil during spills. The aim of this study is to examine the chemical and physical changes that occur in floating oil that is exposed to ultraviolet light (UV-A) under different environmental conditions. Laboratory exposures of floating oil (Louisiana Sweet Crude) were prepared in beakers of seawater on an orbital shaker platform, with treatments consisting of either UV-A or fluorescent light (12h light/12h dark) and manipulations of various environmental factors (temperature, wave energy and/or strength of irradiation). Samples for chemical analysis were collected at different time points (6h, 24h, 48h, and 7d) and the oil was photographed to examine physical changes. Changes in chemical composition of the oil were analyzed by gas chromatography mass spectrometry and liquid chromatography tandem mass spectrometry. Preliminary results indicate that there are physical changes occurring in oil exposed to UV light as opposed to fluorescent light. Oil exposed to UV light became more viscous and formed “tar-ball” like substances whereas oil exposed to fluorescent light remained less viscous and more sheet-like. Additional chemical analyses will explore the relationship between the observed physical changes and chemical composition of the oil and examine if and how environmental factors relate to changes in chemical composition/weathering results. Results from this study will be used to improve models that forecast the fate of floating oil in the environment.

TP172 Influence of Photolysis on Rice Herbicides in Irradiated Water-Sediment Systems
M.A. LaNasa, E.N. Vebrosky, Louisiana State University / Department of Environmental Sciences; K. Armbrust, Louisiana State University / Environmental Sciences

Quizalofop (PROVISIA(R), ASSURE(R)) is a pro-herbicide that was recently approved for application on rice crops in Louisiana. Louisiana rice fields are a unique system in terms of environmental factors that could influence herbicidal behavior different than observed in other regions of the United States. Farmers often rotate rice and crawfish harvest on an annual or bi-annual rotation. Increased agricultural runoff and Louisiana's proximity to the Gulf of Mexico allows for the possibility of these herbicides to be transported through aquatic systems such as marshes and bayous into the Gulf of Mexico. Due to these additional influences, its chemical behavior and environmental fate need to be determined in order to better identify any negative environmental impacts. The purpose of this investigation is to determine the role photolysis has on the degradation and water-sediment partitioning of the herbicide. Irradiated water-sediment experiments will be conducted using an Atlas SUNTEST XTL + environmental chamber to produce a lab-simulated system that mimics sunlight in South Louisiana and includes rice field sediment. Both freshwater and seawater are to be used in the analysis due to saltwater intrusion and the close proximity to estuarine systems for rice fields. Samples will be placed under dark and light conditions, with water and sediment samples extracted and analyzed at 0, 2, 4, 8, 24, and 48 hours by HPLC. Preliminary results show that Quizalofop has the capability to undergo photo-degradation due to its UV-light absorption spectrum, and it has a photolysis/ hydrolysis half-life of 31.8 hours in deionized water. Quizalofop P-ethyl, an herbicide derivative of Quizalofop, degrades rapidly in deionized water, with a photolysis/hydrolysis half-life of 2.9 hours. Understanding the environmental fate of Quizalofop and its capacity to undergo photo-degradation is important in determining the persistence and efficacy of this herbicide in South Louisiana rice fields.

TP173 Lab and field-based determination of microbial and photo-degradation rates of 2,4-dichlorophenoxyacetic acid
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The herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) is used in Wisconsin as a treatment for invasive Eurasian watermilfoil. However, the degradation rate and resulting lifespan of 2,4-D can vary widely, with complete degradation observed to range from 70 to 150 day, potentially increasing risk for off-target effects to fish and aquatic plants due to unintended long exposure times. We investigated the microbial and photochemical degradation of 2,4-D in aquatic environments using lab-based
microcosms and irradiation studies in combination with large field campaigns to monitor 2,4-D loss following whole-lake herbicide treatments to determine the controls on 2,4-D degradation in aquatic systems. Initial microcosm results suggest sediment is important to driving 2,4-D degradation, with complete removal of 2,4-D observed in microcosms with sediment but not 2,4-D loss in water-only microcosms. Loss rates in microcosms with sediment varied based on previous treatment history. Lakes with previous 2,4-D exposure had a half-life of 20 days vs. 70-100 days for non-previous exposed lakes, suggesting increased microbial degradation in response to repeat exposures of 2,4-D. While microbial degradation appears to be faster than photochemical degradation, both direct and indirect photochemical degradation occurred, suggesting lakes that experience extended periods of 2,4-D (such as lakes that have not been exposed to 2,4-D previously) may be more susceptible to photo-degradation than lakes that have been previously treated with 2,4-D. We expect field data collected Summer 2019 will relate water clarity, littoral zone area, abundance of genes associated with 2,4-D degradation, and extent of stratification in 8 different lakes to 2,4-D degradation rates. These results will be used to determine 2,4-D degradation rates to optimize the application of 2,4-D to Wisconsin lakes and support decision making that promotes healthy native plant and fish populations while attempting to protect and eradicate invasive pests.

**TP174 Methods for pesticide extraction from leaves: Comparing Accelerated Solvent Extraction (ASE) and Energized Dispersive Guided Extraction (EDGE)**

_A.D. Kinross, K.J. Hageman, Utah State University / Chemistry & Biochemistry; W.J. Doucette, Utah State University / Utah Water Research Laboratory_

As part of a project designed to generate leaf-air partition coefficients for pesticide fate modeling, we compared two automated instruments for extracting pesticides from plant leaves (alalfa and citrus leaves). Pressurized liquid extraction (PLE) has been widely used for extracting pesticides and other organic contaminants from a variety of environmental matrices. While considered one of the most effective and solvent efficient extraction methods available, PLE extraction vessels are often expensive and leak prone. Recently, CEM Corporation introduced the Energized Dispersive Guided Extraction (EDGE) automated extraction system that claims to combine PLE and dispersive solid phase extraction. The EDGE system is a potentially faster, more robust alternative to traditional PLE instruments. This project compared extraction efficiency of the Thermo Scientific Dionex Accelerated Solvent Extractor (ASE) and EDGE for 20 target pesticides from plant leaves. For comparability, the same critical operating parameters (e.g. extraction temperature, solvents, and in-cell cleanup sorbent amounts) were used for both systems. In-cell cleanup sorbents (Florisil and graphitized carbon black (GCB)) were used to reduce the levels of interferences due to lips and chlorophyll in the sample extracts. The percent recovery for the 20 spiked pesticides had a range of roughly 30-110% from both the ASE and the EDGE. The percent recoveries between individual compounds showed that only six had significantly different percent recoveries when comparing the ASE and EDGE extraction methods. For these six compounds, the ASE had higher percent recovery than the EDGE. When comparing citrus vs. alfaalfa, there were no significant differences in ASE extractions for individual compounds and there was only one compound that had a significant difference in the percent recovery when extracted on the EDGE and the percent recovery was higher from citrus leaves. Overall, the extraction methods are comparable. The main advantage for the ASE is that the percent recoveries are statistically higher (9.8-16.5%), but only for 6 of the 20 pesticide. Sample preparation and extraction times are shorter for the EDGE and fewer system errors occurred during extractions. Both systems used roughly the same amount of solvent. Currently, we are comparing recoveries from actual field samples using both extraction systems.

**TP175 Application and quantitative accuracy evaluation of GC/MS target screening analytical method for agricultural chemicals in raw and ground water**

_N. Kobayashi, NIH; Y. Tsuchiya, National Institute of Health Sciences; S. Takagi, Osaka Institute of Public Health; Y. Ikarashi, National Institute of Health Sciences_

Many agricultural chemicals in raw water and tap water are monitored by many of water suppliers in Japan, however, Japanese official analytical methods for the agricultural chemicals in drinking water are generally complicated. Therefore, we need more simple and efficient analytical method for agricultural chemicals, in order to ensure the safety of drinking water. In the present study, we have developed a target screening analytical method for agricultural chemicals by gas chromatography/mass spectrometry (GC/MS). Then we applied the analytical method to measure concentrations of agricultural chemicals in raw water and tap water in Japan. The target compounds of the present study are 176 agricultural chemicals, which are the “Complimentary Items” in tap water in the Japanese Waterworks Act. We have prepared and measured the standards solutions of all the agricultural chemicals by GC/MS, then, information of retention time, mass spectrum, and calibration curve of each agricultural chemicals was restored to our database. We used anthracene-d10, 9-Bromoanthracene, and chrysene-d12 as internal standards for GC/MS measurement. The sample preparation method is the same as the Japanese official analytical method released by the Ministry of Health, Labour and Welfare. 500 mL of water samples were concentrated to 1 mL by a solid phase extraction method. We have collected 108 raw water samples and 5 ground water samples in the 21 prefectures in Japan during May to September 2018, and then we apply the GC/MS target screening analytical method using the developed database. As a result, 52 agricultural chemicals were detected from the raw water samples. No agricultural chemicals were detected from ground water samples. Regarding to the most of detected agricultural chemicals, analytical results by GC/MS target screening analytical method were within the range of half to twice compared to those by official analytical methods. Therefore, we judged that the GC/MS screening analytical method we have developed in the present study was applicable to the analysis of agricultural chemicals in drinking water. In order to expand this GC/MS target screening analytical method as a standard analytical method of drinking water in Japan, we will conduct the validity test of the analytical method among other examination organizations.

**TP176 Development of an LC-MS-based Method to Study the Fate of Nanoencapsulated Pesticides in Strawberry Plants**

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Nanoencapsulation has opened up promising fields of innovation for pesticides and plant protection products. Pesticide monitoring traditionally relies on the analytical methods developed and validated for “conventional” formulations. Because of their interaction with the nanoparticle, the environmental fate and the analytical approach could differ from conventional pesticides. In the present study, an analytical method was developed with the objective to detect/quantify two pesticides, oxazystrobin and bifenthrin, in strawberry plants treated with either a nanoencapsulated or a “conventional” formulation. For this purpose, a modified QuEChERS extraction method is applied for the extraction of active ingredients from different homogenized plant tissue samples (fruits, leaves and roots). Stable isotope-labeled standards were spiked prior to extraction. The sample extracts were analyzed by liquid chromatography coupled to mass spectrometry with time-of-flight analyzer (LC-QToF-MS). The method was applied to both spiked and incurred samples. Method detection limits, linearity, recoveries, precision and matrix effects were assessed for both the nanoencapsulated and
“conventional” pesticides. Some preliminary results for a controlled exposure experiment are presented to illustrate the fate, uptake and distribution of nanoencapsulated pesticides in treated strawberry plants.

**TP177 Evaluation of Pesticide Exposure of Agricultural Workers to Chlorothalonil in Green Pepper Field Trials**

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The purpose of the study was to evaluate the dermal and inhalation exposure of agricultural workers through mixing, loading and application of the pesticide on fields of green pepper (10 field trials). Two types of formulations such as wettable powder and suspension concentrate for chlorothalonil were used to estimate exposure rate, and which were diluted about 600 times and 1000 times, respectively. They were uniformly sprayed to the crops using a power sprayer. The whole body dosimetry (WBD) method was applied as an exposure method and following application, outer and inner clothing were cut into various parts such as forearm, upper arm, chest/stomach, back, hip, thigh and shin, then analyzed by GC-MS/MS. The analytical method was validated in triplicate for all samples prior to analysis of each field sample, resulting in a recovery range of 85.6 to 110.4% with RSD.

**TP178 Exposure of rural farmers in Benue State Nigeria to pesticides results in several health issues**

*P.C. Ezeobi*, Benue State Hospitals Management Board / Environmental Monitoring Unit

In Nigeria, organochlorine pesticides (OCP) are most times used in the control of pest (birds, insects, rodents) during agricultural activities. The mismanagement of these chemicals results in different environmental and health issues among the farmers. Therefore, this study was undertaken to evaluate the health problems associated with use of OCP among rural farmers in Benue State, Nigeria. The evaluation was done with interview, laboratory experiments and statistical models. About 150 farmers attending hospital for a particular were selected for the interview. Also about 75 more persons were selected from health workers in the state. The health issues include bad vision and several respiratory disorders. The outcome of the study indicated that the health risks depend on the sex, age and the cultural practice. The highest risked groups were the pregnant women with several reported cases of pesticide intoxication. The next target groups were the uneducated farmers. The outcome of this investigation suggests that the precaution should be taken when pesticides are used in farm operations.

**TP179 In vitro Evaluation of Potential Hepatotoxicity Induced By Detergent-Processed Cassava Product (fufu) on Wistar Rat (Rattus norvegicus)**

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Potential toxic effects of cassava-based products on humans have been established. The recent use of detergent in processing cassava into food products such as fufu (a local delicacy Nigeria), may exacerbate its toxic effect. This study determined the hepatotoxicological effect of detergent-processed fufu on Wistar rat. The liver is a heterogeneous organ which is involved in detoxification of xenobiotics and is highly susceptible to injury from these substances. With the increase in chronic diseases among the Nigeria growing population, there is need to look beyond pathogenic and infectious diseases and focus on public health nutrition. Rat models were used in assessing the degree of damage caused on the haematological and hepatological parameters. Graded concentrations (7.5mg/L, 15mg/L and 22.5mg/L) of detergent was used in fermenting cassava for making the fufu which was used in the study. Wistar rats were given 7 feeding treatments (TRT): TRT I - positive control (commercial rat feeds only); TRT II - positive control (fufu only); TRT III - negative control (detergent only), TRT IV - designated control (Fufu bought from the open market), TRT V - VII (fufu plus graded concentrations of detergent). Liver marker enzymes were assayed in the plasma and liver homogenate, blood parameters were also analysed after four weeks of treatment. The 96 hr-LD50 value obtained was 21.00 mg/L. The water intake of the exposed rats reduced significantly. This could suggest that detergent stimulated the pathway that exerts an inhibitory drive on water intake, or alternative, that the detergent blocked thirst inducing pathways. Levels of marker enzymes such as Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), and Alkaline phosphatase (ALP) were increased significantly across all the detergent treatment groups and TRT II and IV, while plasma ALP only increased in TRT III. No significant difference was observed in the liver homogenate except in AST which showed increase across all treatment groups except group VIII. There was no significant difference in the blood parameters across all groups. The consumption of detergent-processed fufu poses a high risk to the liver as evident in the photomicrographs with various degree of hepatocellular injury to the liver.

**TP180 Use of a zebrafish model to identify anti-convulsive properties of phyto-cannabinoid extracts**

*C.E. Murr*, Louisiana State University / AgCenter; *C.C. Green*, Louisiana State University / Renewable Natural Resources

Epilepsy is a neurological disorder that effects approximately 65 million people worldwide. While no drug can prevent the development of epilepsy, several compounds that the limit the severity of epileptic seizures have been identified. The clinical use of phytocannabinoids for the treatment of neurological disorders has increased in recent years, as they have been shown to have strong neuroprotective and anticonvulsive properties. The goal of this research is to use zebrafish (*Danio rerio*) as a model organism to identify the anticonvulsive properties of phytocannabinoids to provide insight for their potential use as anti-epileptic drug. Epileptic-like seizures were induced by exposing seven-day-post-fertilization zebrafish larvae to a 10mM pentylenetetrazol (PTZ) solution for 10 minutes. Larvae were then exposed to either cannabidiol (CBD), cannabinol (CBN), tetrahydrocannabinol (THC), or tetrahydrocannabivarin (THV) at concentrations of 0.125, 0.25, 0.5, or 1mg/L for 90 minutes. After the 90-minute cannabinoid incubation, larvae were individually placed into wells of a 48-well plate, and movements were recorded for 10 minutes using a DanioVision recording chamber. The total distance each larva moved during the 10-minute recording period was measured using Ethovision XT software. Larvae exposed to CBD exhibited significantly reduced seizure behavior across all concentrations, displaying movements similar to those seen under control conditions. These findings suggest that CBD is effective in reducing PTZ-induced seizure behavior. Investigations of potential anti-seizure properties of CBN, THC, and THV are ongoing in addition to determining their acute toxicity in larval zebrafish. It is anticipated this research will potentially support a larger body of work as production and use of phytocannabinoids increases.

**TP181 Arsenic-inhibited caudal fin wound healing is mitigated by treatment with estradiol in larval zebrafish**

*S. Dresler*, Northern Arizona University / Biological Sciences

Arsenic is a toxic natural metalloid found in ground and surface waters globally. Although drinking water standards are in place by the Environmental Protection Agency (EPA), many regions of the Southwest United States have reported water sources above these standards. Arsenic has numerous potential detrimental effects on health outcomes including increased risks for cancers and diabetes. Furthermore, arsenic interferes with estrogen signaling processes. In vitro models of wound healing demonstrate that arsenic also inhibits wound healing and that estradiol ameliorates the effect of arsenic. In order to determine whether these effects translate into an in vivo system, larval zebrafish were used to investigate the effects of arsenic and estradiol on wound healing. Zebrafish
are an ideal model for studying tissue regeneration because they can fully regenerate an amputated caudal fin in just a few days (2-3 days). At 24 hours post-fertilization, larvae were exposed to either control solution (0.3x Danieau’s), or arsenic at 0.1 μM, 1.0 μM, or 10 μM. The caudal fins were amputated 48 hours post-fertilization, 1 nM estradiol was added to treatments, and they were imaged every 24 hours for 3 days post-amputation. We conducted traditional morphometrics on images using ImageJ. Our measurements included body length, tail width, and tail area. We hypothesize that arsenic exposure at environmentally relevant concentrations will decrease caudal fin healing and 1 nM 17-β estradiol will promote healing in vivo. Tail regeneration was significantly diminished in the 10 μM arsenic treatment compared to controls, which were nearly healed. The addition of estradiol post-amputation restored tail regeneration to the control levels. Our next steps are to determine the underlying molecular pathways associated with arsenic-induced inhibition of wound healing and whether these are the same pathways through which arsenic acts to ameliorate this effect. In conclusion, environmentally relevant levels of arsenic inhibit wound healing and estradiol ameliorates the effects of arsenic in an in vivo model.

**TP182 Arsenic-inhibited wound healing is mitigated by estradiol**

B.L. Pinto, Northern Arizona University / Center for Bioengineering Innovation; O.R. Lujan, T.A. Bardsley, Northern Arizona University / Biology; C.R. Proper, R.S. Keller, Northern Arizona University / Biological Sciences

Cutaneous wound healing is a complex process that involves several physiological and molecular changes surrounding the damaged skin tissue. Environmental contaminants that impede wound healing place injured individuals at risk for infection and co-morbidities, while compounds that enhance healing limit these risks. Inorganic arsenic inhibits wound healing, and steroid hormones, such as estrogen, increase the rate and capacity for wounds to heal. Therefore, contaminants such as arsenic that interfere with estrogen signaling may impede healing, and estradiol treatment may ameliorate these effects. The broad goal of this research was to understand the risks of contaminant exposure and the potential for amelioration through local, non-systemic estradiol treatment. The current studies utilized a scratch (wound) assay and PrestoBlue(R)-CyQUANT Direct(R) combination fluorescent assay to elucidate the impact of arsenic on cellular migration, metabolism and viability in primary human dermal fibroblast cells (hDF). Additionally, gene expression from both wounded (scratched) and unwounded hDF cells +/- arsenic and estrogen was analyzed via RNAseq. Results demonstrate that cellular migration is delayed when fibroblasts are exposed to arsenic at time of wounding. However, arsenic pretreatment for 24 hours prior to wounding led to a 20-fold decrease in the effective dose that delays wound healing. These findings suggest that individuals chronically exposed to arsenic-contaminated water sources may experience delayed wound healing at lower arsenic doses compared to exposure at the time of wounding. Arsenic exposure decreased cellular metabolism and DNA content of viable cells in a dose-dependent fashion with increasing arsenic concentrations. RNAseq analysis data corroborated cell viability assays, suggesting that arsenic decreases the expression of many genes involved in the cell cycle potentially leading to impaired wound healing. Lastly, treatment with estrogen in the wound assay resulted in a mitigation of the negative effects of arsenic, indicating that estrogen may be interacting with arsenic while promoting cellular migration. Our findings are among the first to describe the deleterious effects of arsenic on wound healing, and the potential to mitigate these effects through the use of the estrogen hormone. This research may lead to translational treatments for arsenic-contaminated wounds in populations who do not have access to uncontaminated water resources.

**TP183 Evaluating Alternatives for Monitoring Mercury in Fish Tissue: Fish Biopsy Punch Versus Homogenized Whole Fillet Samples**

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Investigating the bioaccumulation of contaminants in fish continues to be an important area of research necessary for human health protection and risk communication associated with fish consumption. Recently, biopsy punch (or fish plug) sampling is being applied in some fish monitoring programs as a more cost-effective alternative to obtain contaminant data (mercury data in particular) than the routine approach of removing, homogenizing, and analyzing entire fillets. EPA's Office of Science and Technology within the Office of Water is conducting a Fish Plug Evaluation Study to address the fundamental question of comparability between fish fillet plug sample versus homogenized whole fillet tissue results for mercury, i.e., to determine if fish plugs are a reliable surrogate for traditional whole fillet sampling and analysis. Secondarily, the study addresses the applicability of fish fillet plug sampling and analysis for conducting assessment monitoring associated with EPA's 300 ng/g (wet weight) fish tissue-based mercury water quality criterion. Initiated in June 2017, the Fish Plug Evaluation Study involved collecting six target species of fish commonly consumed by humans from three Great Lakes (i.e., lake trout, Chinook salmon, and walleye) and three mid-Atlantic rivers (i.e., smallmouth bass, largemouth bass, and blue catfish). A total of 10 specimens of each of the six species were used to prepare fish tissue samples including 5 replicate field plug samples, 5 replicate laboratory plug samples, and 5 replicate samples of homogenized fillet tissue (prepared in the laboratory) to produce a total of 900 samples for mercury analysis. The 15 replicate fillet samples from each of the 60 fish were analyzed individually. EPA used Analysis of Variance (ANOVA) to test the comparability of mercury results from field-extracted fish plugs, lab-extracted fillet plugs, and homogenized whole fillets. Study results are being used to determine if fish plug sampling and analysis can be applied as a technically comparable alternative to homogenizing and analyzing whole fillets for mercury, as well as to highlight any differences among the three tissue sample types across fish species.

**TP184 The Influence of Metal Exposure on Plumage Coloration in Several Songbird Species**

S. Chiparus, Eastern Michigan University / Biology

Heavy metals are found naturally in the environment but can be elevated beyond normal levels due to anthropogenic activities. Heavy metals continue to pollute many ecosystems in spite of emission control measures, potentially due to historical exposure or the continued expansion of human development. Organisms exposed to metal pollutants may be negatively impacted if fitness is reduced. Carotenoid-based bright plumage in many songbird species is thought to be a visual cue to potential mates - signaling high fitness levels. This is because bright plumage may reflect efficient foraging for diet-dependent carotenoids and/or the ability to allocate carotenoids to plumage coloration as opposed to anti-oxidant protection. Studies have shown a decline in carotenoid-based coloration along metal pollution gradients, and an increase in melanin patch size with increased metal exposure. We will relate plumage coloration characteristics of several songbird species, both from urban and rural locations in Southeast Michigan, to feather mercury levels. Identifying negative impacts of pollutants on wild animals is important for understanding the consequences of anthropogenic activities on wildlife.
TP185 Investigation Of The Relationship Between Potentially Toxic Metals (PTMs) Concentration In Soil And Plants Along Major Highways In Lagos, Nigeria

A.B. Sodiq, University of Lagos / Pure and Applied Chemistry

The possibility of bioaccumulation of potentially toxic metals (PTMs) by edible plants especially those grown along highly trafficked highways poses a threat to humans. This study investigated the levels of PTMs in soil and plants along six major highways in Lagos, Nigeria. The PTM concentrations in the soil and plant were determined by atomic absorption spectrophotometry (AAS) after digestion with aqua regia. Also the physicochemical parameters of the soil were determined by the appropriate standard methods. The results of the analysis showed that lead (Pb) had concentration which ranged from of 14 - 58 mg/kg with a mean of 25.02 mg/kg ± 14.29 for soil the samples and a range of 9 - 42 mg/kg (23.94 mg/kg ± 14.04) for plant samples. Nickel (Ni) and Copper (Cu) had concentrations ranging from 0.03 - 2 (0.61 mg/kg ± 0.43) and 0.3 - 2 mg/kg (0.28 mg/kg ± 0.46) respectively for the soil samples. The levels of Ni and Cu were below detectable limit in the plant samples. The study showed that consumption of edible plants sourced from farms along highway could be a threat to human health due to the possible levels of PTMs that they could contain.

TP186 Spatial and Temporal Variability of Selenium in an Urban Watershed in Colorado

S. Parvey, GEI Consultants, Inc. / Ecological Division; S. Skigen-Caird, GEI Consultants, Inc. / Ecology; S.P. Canton, GEI Consultants, Inc. / Ecological Division

Colorado has extensive areas with underlying geology that contributes to elevated selenium concentrations in ground and surface waters. Selenium in these regions can be mobilized through erosional processes and groundwater leaching. Selenium data were collected by several stakeholders to determine potential sources of selenium in the South Platte River in an urban area south of Denver, Colorado given the unexplained presence of selenium at concentrations exceeding the state water quality standards in this segment. To evaluate sources of selenium, samples were collected from four mainstem South Platte River sites, 13 tributary sites, and 3 discharges. The tributary sites were largely free from any point source discharges. In addition to dissolved selenium, sulfate was also measured, as increased concentrations of this parameter are postulated to decrease bioavailability, bioconcentration, and toxicity of selenate. Additionally, selenium and sulfate are often found together at elevated concentrations when originating from natural geologic sources. Seasonal patterns related to precipitation and possible dilution were observed at many locations, particularly at sites with elevated selenium concentrations. Five of the seven tributary sites that exceeded the chronic selenium standard were located in the portion of the watershed with drainages originating in the highlands southeast of the South Platte River, suggesting that this region may be a source of selenium. Several lines of evidence indicate that the elevated selenium concentrations are likely the result of natural or human-induced uncorrectable conditions resulting from selenium bearing strata - specifically marine shales. The highly variable selenium concentrations observed in the tributaries that were located in adjacent gulches provided insight to the elevated selenium concentrations in the South Platte River. These data were used to develop site-specific ambient-based water quality standards for selenium in tributaries to the South Platte that were ultimately adopted by the Colorado Water Quality Control Commission and approved by the Environmental Protection Agency. Spatial and temporal studies as such will assist with site-specific selenium criteria development in other regions with naturally occurring selenium and may help inform study design for additional investigation such as evaluation of fish tissue concentrations in these regions.

TP187 Determination of Oxybenzone, Sulfamethoxazole, and Clofibrate in Water, Sediment, and Fish from Galveston Bay and Clear Creek Areas

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Environmental chemical contaminants have been of major concern as they can cause adverse health effects in single or multiple forms — even at trace levels. They are derived from different activities; and they include pesticides, personal care products, pharmaceuticals, and byproducts of various industrial processes. The contaminants often referred to as contaminants of emerging concern (CECs) are of growing awareness and concern because of their possibilities of interacting with biological systems to cause serious health issues. CECs are used daily and are continuously released into the environment via various waste streams. Galveston Bay and Clear Creek receive waters from several sources including runoffs which may contain a significant number/concentration of contaminants with a high possibility of human exposure. The potential adverse effects of the contaminants on humans, human environment, and the ecosystem can range from acute to chronic and are of significant importance. This study analyzed the presence of selected CECs: oxybenzone, sulfamethoxazole, and clofibrate in the water, sediment, and fish samples from the Galveston Bay and Clear Creek areas. Samples were collected from the identified locations, extracted using standard protocols, and analyzed using high-performance liquid chromatography coupled with an ultraviolet/visible detector. Results quantified, and bioaccumulation calculated. The results showed the presence of the contaminants in the samples analyzed. The concentration of oxybenzone in water and sediment samples were 1.85 ± 0.82 and 1.30 ± 1.55 ppm respectively. Oxybenzone in fish tissues/organisms was 38.49 ± 14.64 ppm, this is 2,081% and 2,961% its concentration in water and sediment samples. Clofibrate was detected at a concentration of 0.45 ± 0.31 and 2.28 ± 3.76 ppm in water and sediment samples. Its concentration of 7.76 ± 2.46 ppm found in the fish tissues/organisms is 17 and 3 times more than the levels in water and sediment. Sulfamethoxazole was below detection limits. Thus, the results revealed that oxybenzone and clofibrate are present in the locations analyzed and they bioaccumulate in fish tissues/organisms with a high probability of biomagnification in higher animals. Oxybenzone has a higher bioaccumulative capacity and may produce more toxic interactions. The data from this research is an impetus for the continuous monitoring of the levels of CEC in the Galveston/Clear Creek areas bodies of water and the aquatic environment.

TP188 Phthalates and other industrial compounds in San Francisco Bay water

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San Francisco Bay is the largest estuary on the west coast of North America, drains approximately 40% of the state of California, and is surrounded by a dense urban population. These features make the region an excellent laboratory to study anthropogenic contaminants. The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) supports strategic studies of contaminants of emerging concern (CECs). A pilot study in 2017 analyzed 22 Bay water samples for ten phthalates and eight additional industrial compounds, including two benzotriazoles, two benzoazinones, two trimellitates, bis(2-ethylhexyl) adipate, and 3,5-di-tert-butyl-4-hydroxybenzaldehyde. These compounds have broad uses, including as ingredients in plastics, cleaning and personal care products, hydraulic fluids, lubricants, and corrosion inhibitors. Findings from this study will provide a more robust understanding of the industrial compounds present in water bodies near urban centers, as well as the risks they may pose to humans and aquatic life.
TP189 Analytical method validation aiming for glyphosate determination in surface water samples by ion chromatography

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Agrochemicals usage is directly proportional to the population increase and crops expansion. In this way, man has always sought alternatives to combat natural adversities. Herbs have been eliminated by herbicides application, but some compounds do not show enough efficiency due weed resistance. As a result, glyphosate has become the most widely used herbicide in the world for the control of a broad spectrum of plant organisms that grow as a "pest" in various crops. Its main degradation products are aminomethylphosphonic acid (AMPA) and the amino acid sarcosine. Due to its chemical properties, in evidence its zwitterionic character, glyphosate analysis and its degradation products in environmental matrices has been more easily performed by ion chromatography aimed at trace analysis. The present work optimized the analytical method described by Amarante Jr., et al., (2003) that apply ion chromatography for the determination of glyphosate and AMPA with ion exchange resin and conductivity detection. Chromatographic conditions were: Metrosep A Supp 7 ion exchange column, 250x4.0 mm; Flow 0.8 mL min-1; Oven temperature 45°C; Conductivity detector with self-regenerative suppression (MSM); Conductivity ~ 1μS cm-1; 200 μL injection volume with Metrohm's 858 Professional automatic sampler; Mobile phase: Eluent A (1.0 mmol L-1 of sodium carbonate and 15 mmol L-1 of sodium hydroxide) and Eluent B (15 mmol L-1 of sodium carbonate). Those conditions were determined during the method optimization. Validation parameters studied were: selectivity, precision, accuracy, limit of detection (LOD) and limit of quantification (LOQ), during recovery studies. Linearity of the work concentration range was investigated with analytical curves between 50 and 500 μg L-1. Recoveries were obtained between 95.6% and 99.6%. LOQ were 28 and 75 μg L-1, to Glyphosate and AMPA, respectively. LOD were 9 μg L-1, to the herbicide, and 25 μg L-1, to its degradation product. Evaluated parameters assure that the investigated method can be aplyed for this contamination monitoring, taking into account the current Brazilian legislation of these pesticides in natural waters.

TP190 Efficient extraction of estrogen receptor-active compounds from environmental surface water via a hydrophilic PEG-based molecularly imprinted polymer

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We report an efficient screening procedure for selectively detecting compounds that are actively bound to estrogen receptor (ER) in environmental water samples using a receptor-mimic adsorbent prepared with a molecularly imprinted polymer (MIP). To mimic the recognition ability of ER, we improved the typical MIP preparation procedure by using a hydrophilic matrix with a polyethylene glycol (PEG)-based crosslinker and a hydrophobic monomer to imitate the hydrophobic pocket of ER. An optimized MIP prepared with methacrylic acid as an additional functional monomer and estriol (E3), an analogue of 17β-estradiol (E2), exhibited highly selective adsorption for ER-active compounds, such as E2 and E3, with significant suppression of non-specific hydrophobic adsorption. This indicates that the novel MIP-based adsorbent provided low hydrophobicity and highly selective adsorption towards ER-active compounds in comparison with typical hydrophobic adsorbents. The prepared MIP was then applied to the screening of ER-active compounds in sewage samples. The fraction concentrated by the MIP was evaluated by in vitro bioassay using the yeast two-hybrid (Y2H) method and liquid chromatography-quadrupole time-of-flight mass spectrometry (LC-Q-TOFMS). Compared to an authentic adsorbent or styrene-divinylbenzene (SDB)-based resin, the fraction concentrated by the MIP showed the 120% ER activity in the Y2H assay, and total peak volume was decreased to 25% in LC-Q-TOFMS. Furthermore, a few ER-active compounds were identified only from the fraction concentrated by the MIP, while no ER-active compounds could be determined from the fraction by the SDB-based resin due to the ion suppression under high levels of hydrophobic compounds. These results implied that the newly developed MIP effectively captured the ER-active compounds without capturing most of non-ER-active compounds.

TP192 Identification of groundwater pollution sources using artificial compounds as marker

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Nitrate nitrogen pollution in groundwater have been confirmed all over the world. Its pollution results from infiltration of nitrogen-rich water. Examples of point sources include livestock waste and domestic wastewater, and non-point sources include use of nitrogen fertilizers in agricultural activity. It is necessary to identify pollution sources in order to take appropriate measures. In many researches, major ion composition and/or element stable isotope ratios of N and O in groundwater have been used as markers for identifying nitrate nitrogen pollution sources. In this study, artificial compounds consumed in daily life, livestock, and agriculture were attempted to use as markers to identify nitrogen pollution sources, as a novel approach. Artificial compounds which can characterize domestic wastewater, livestock waste, and agriculture are suitable for markers. Additionally, the artificial compounds possessing high water solubility and high consumption are preferable. In this study, ten artificial compounds were selected for marker candidates; two artificial sweeteners (acesulfame and sucralose) for domestic water markers, three veterinary drugs (sulfamethoxazole, sulfadimidine, and sulfadimethoxine) for livestock waste markers, and five neonicotinoids (dinotefuran, acetamiprid, clothianidin, thiacloprid, and imidacloprid) for agriculture markers. Groundwater samples were collected from 63 sites across Saitama prefecture, Japan. The marker candidates were extracted from the water samples by solid phase extraction, and then determined by LC/MS/MS. The detection ratios of marker candidates were as follows: acesulfame (61/63), sucralose (50/63), dinotefuran (38/63), clothianidin (21/63), imidacloprid (18/63), and sulfadimethoxine (2/63). Sulfadimidine, acetamiprid, and thiacloprid were below the detection limits (0.7 ng/L). Dinotefuran concentrations were found to be high in a farming area. It seems that dinotefuran was infiltrated from farming lands, and detected in groundwater samples. In the area, the use of nitrogen fertilizer has been also high, and nitrate nitrogen pollution of groundwater has been occurred. Therefore, it is possible that nitrogen infiltration from the farmland have caused the nitrate nitrogen pollution of groundwater. Dinotefuran possessing a high detection rate and infiltration from farmland might be used as an agriculture marker. Relationships between the other marker candidates and nitrate nitrogen pollution is under analysis.

TP193 Occurrence and Fate of Synthetic Phenolic Antioxidants in Various Canadian Wastewater Treatment Processes

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Synthetic phenolic antioxidants (SPAs) are of emerging concern due to their potential environmental risks. However, the environmental occurrence and fate of SPAs are poorly understood. In this study, 13 SPAs were analyzed in 70 liquid and 21 solid samples collected from 12 wastewater treatment plants (WWTPs) to investigate the distribution and composition profiles of these contaminants in different wastewater treatment processes in Canada. The concentrations of total SPAs were in the ranges of 71 - 3193 ng/L in influent, less than method quantification limits (MQLs) - 520 ng/L in effluent, and 479 - 4794 ng/g in biosolids (dry weight (dw)). SPAs were effectively removed (e.g., median for total SPAs >75%) from the liquid stream in most WWTPs except for one aerated lagoon and two
primary treatment sites with low removal efficiency (median 26%-43%) for 4-tert-octylphenol (4-OP). These results indicated that wastewater effluent is a vector for some SPAs, including the endocrine disruptor 4-OP to aquatic environments in Canada. The mass balance approximation suggested the major removal mechanisms of these contaminants from the liquid stream in WWTPs are sludge sorption/separation and degradation. Future research should evaluate the environmental risks of SPAs associated with land application of biosolids and investigate the occurrence and fate of the degradation products of SPAs.

TP194 Water quality of raw and treated water in rural areas of the Colombian Caribbean grouped through Cluster analysis
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The water quality of the water used was evaluated using the Water Quality Index proposed by the CETESB - Brazil (IAP) composed of the toxicological index (ISTO) and a water quality index (ICA). This index was applied to drinking water samples or sources of raw water supply in the Colombian Caribbean region in the towns of Mahates, San Joaquin, Malagana and San Basilio de Palenque and Mandinga. The physical and chemical parameters, heavy metals, microbiological parameters (total coliforms and Escherichia Coli) and pesticides (organochlorine and organophosphorus compounds) used in the region for agriculture and livestock were determined. The samples were grouped taking into account the type of source and through a statistical analysis of Clusters. It was observed that the groundwater showed a high hardness and in the surface waters a high turbidity. In turn, microbiological contamination was found in water supplies and aqueducts, as well as Fe, Cr and Ni levels in water supplies, and Pb and Ni in drinking water samples higher than those allowed by both quality indexes. The statistical analysis also showed that these groups presented common characteristics that allow them to be grouped and analyzed in a different way, taking into account the type of source. The analyzed samples showed critical and in some cases higher IAP in the drinking water samples than in the raw waters. This research allowed us to study the contamination that affects water supplies and aqueducts in this region to provide environmental authorities with the necessary information to establish strategies and regulations to reduce the risks of water contamination.

TP195 Volatile Organic Compounds in Porewater from Protected Wetlands in Mexico - The Effect of Physicochemical Parameters
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The Ramsar Convention integrated a list of wetlands of international importance based on their biodiversity. Mexico ranks second in the world in terms of the number of sites included in the Ramsar list with 142 wetlands. The aim of this study was to obtain information on potential threats to the protected species present in two Ramsar wetlands located in different regions, associated with the presence of pollutants recognized as toxic to humans: volatile organic compounds (VOCs), which are generated by anthropogenic activities. Trihalomethanes (THMs) are produced by the association of organic matter with bleach residues, while BTEX (benzene, toluene, ethylbenzene and xylenes) are linked to fuel, paints and other solvents. Selected sites differed in their geological, climatic, demographic and socioeconomic characteristics, in order to investigate physicochemical influence on VOCs behavior: “Lerma wetland,” located in central highlands of Mexico at 2,600 m above the sea level, with a mean annual temperature of 12 °C, and “El Palmar,” a coastal wetland of the Yucatan Peninsula, with a mean annual temperature of 26 °C. Sampling devices allowed to collect both water column and sediment porewater samples to construct concentration profiles. At each site, samplers were placed in two points with different intensity of anthropogenic activities (high H and low L). BTEX and THMs were determined by headspace solid phase micro-extraction (SPME) and analyzed by GC-MS. Even if they were present in most samples, measured levels of VOCs were quite low, demonstrating that both wetlands are not polluted by these molecules. However, THMs presented concentrations relatively equivalent between sites, in the water column and in porewater, whereas BTEX levels were higher in porewater samples of Lerma wetland. The cleanest site was found to be L-site of El Palmar. Most of the profiles presented an increase of the concentration with the depth in the porewater, implying a possible accumulation process within the solid phase of the sediments. Chloroform and toluene were the pollutants found with the highest levels in both wetlands. Ethylbenzene and xylene profiles were highly correlated. Redox potential, conductivity/salinity and temperature profiles were quite different between the four sites; however, none of them presented a clear impact on VOC’s fate. In particular, porewater samples from El Palmar H-site were statistically equivalent to most of Lerma samples.

TP196 Identifying Naturally Sourced Benzene at a Tier 3 Risk Assessment Property in Trenton, Ontario
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In southern Ontario, oil and gas deposits are associated with limestones and shales. Oil compounds such as benzene, are formed from the decay of organic matter subjected to heat and pressure after burial of the sediments. Elevated concentrations of benzene (up to 140 µg/L) were identified in groundwater during a Phase Two Environmental Site Assessment (ESA) at a commercial property in downtown Trenton, Ontario. The property had historically been occupied by a retail fuel outlet, an automotive repair garage and a dry-cleaning facility, and was redeveloped in 2010 with a slab on-grade commercial building and associated parking lot. Preliminary field investigations identified the Site as a shallow soil property underlain by Verulam (Sherman Fall) Formation limestones and calcareous shales. The benzene that was measured in shallow groundwater at the site was preliminarily attributed to the presence of the former fuel tanks. Shallow, intermediate and deep bedrock monitoring wells were subsequently installed in an attempt to horizontally and vertically delineate the benzene impacts in groundwater, but to no avail, as concentrations increased by between one and greater than two orders of magnitude with depth. The results suggested that elevated benzene concentrations were unlikely to be the result of anthropogenic activities, but rather were due to the presence of fossiliferous limestones and calcareous shales underlying the Phase Two Property. Following consultation with the Ontario Ministry of the Environment, Conservation and Parks (MECP), a multiple lines of evidence approach, including a rock leaching procedure, characterization of local formation waters, and depth profiling of benzene with saline groundwater parameters was conducted, and a Tier 3 Risk Assessment is underway at the property. This phenomenon of naturally occurring benzene and related compounds in certain Ontario sedimentary rocks is well known amongst Ontario sedimentary geologists; however, literature on the topic is limited and the information has yet to be translated by the MECP into regulatory protocols for completing Tier 3 Risk Assessments for the purpose of obtaining Records of Site Condition. These conditions will surely be encountered with greater regularity as development in shallow bedrock environments east of the Greater Toronto Area continues; therefore, an improved understanding of the implications for Tier 3 Risk Assessments is essential.

TP197 AhR activity of brominated disinfection by-products of parabens in the river water
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Parabens are used as preservatives in pharmaceuticals and personal care products (PPCPs). Parabens react with aqueous chlorine, which is used in disinfection processes, and readily leads to the formation of halo-genated parabens. The present study involved measuring brominated paraben concentrations in the Kitakami River, north Japan, which flows
through urban areas (sites K1 and K2) and mixed areas of residential and agricultural land (K3-K10) using the LC-MS. The major STPs were located at upstream from sites K2, K4, K5, and K10. Aryl hydrocarbon receptor (AhR) agonist activity was also assessed using a yeast (YCM3) reporter gene assay. Dibrominated methylparaben (Br2MP), ethylparaben (Br2EP), propylparaben (Br2PP), butylparaben (Br2BP), and benzylparaben (Br2BnP) and monobrominated benzylparaben (Br1BnP) were detected in 25-100% of river samples during the sampling period from 2017-2018 at median concentrations of 8.1-28 ng/L. Dibrominated paraben concentrations were comparable to those of dichlorinated parabens reported in our previous study in the central Pacific region of Japan. In the yeast assay, 12 of the 18 compounds exhibited AhR activity (activity relative to β-naphthoflavone, RA; 4.4x10-4-7.1x10-1). All monobrominated parabens exhibited greater activity than their parent parabens, however further bromination reduced or eliminated their activity. To assess the contribution of active compounds, median concentrations during 2017-2018 obtained from the chemical analysis were converted to BNF eq. by multiplying their corresponding RA values. The values of Σ BNF eq. of parabens were up to 150 pM; Br2MP and Br1BnP had the high BNF eq. among the active components. Contributions of parabens were also high at upstream sites (K1-K3) around urban areas, but low at the lower downstream sites, suggesting that the STPs are potentially a major source of brominated parabens into the Kitakami River. We have found novel aspects of brominated parabens originating from PPCPs.

**TP198 AhR-mediated effects of dioxins on liver in 3D co-culture system and Zebrafish embryo**

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Evidence on the association between the aryl hydrocarbon receptor (AhR) and liver fibrosis has been reported. Dioxin is thought to exert its biological and toxicological effects primarily by binding to AhR and recent studies suggest that chronic exposure to low doses of dioxin induced liver fibrosis development in mice. However, a high throughput method for predicting liver fibrosis of dioxins is sparse. Here we examine the feasibility of 3D liver micro tissue system and zebrafish embryos to identify the liver toxicities of dioxins. Three typical dioxins (TCDD, BaP, PCB126) and the hepatotoxic chemical –Thioacetamide (TAA) were chosen to test their liver toxicities in these two platforms. In this study, we decided to use specific gene markers indicating liver fibrosis (e.g., col1α1; αSMA), albumin ELISA assay and immunohistochemistry to examine if four compounds could induce liver fibrosis in 3D liver micro tissue system and zebrafish embryos. Four compounds induced cytotoxicity in monolayer cultures of HepaRG cells, i1ERT-HSC cells and THP-1 cells with 7-day treatment, but only TAA and BaP were observed in 3D micro tissues system with 14-day treatment. RT-qPCR analysis from micro tissues showed that liver fibrosis gene markers were up-regulated by TAA and BaP, with col1α1 down-regulated by PCB 126, while there was no significant change induced by TCDD. Immunostaining results also suggested that col1α1 and αSMA proteins expression of micro tissues treated with BaP increased. Further, albumin ELISA assay indicated that TAA and BaP caused liver damage with decreasing albumin compared with the controls. In zebrafish embryos experiments, these chemicals showed different apical endpoints. TAA disrupted zebrafish embryos’ hatch, with an IC50 of 1.803nM, while PCB 126 induced serious malformations with an EC50 (30.8nM), such as yolk sac oedema, pericardial oedema and bent spine. The half-lethal doses of BaP (39.8nM) could be calculated. In addition, it was observed that BaP at a low dose level could induce liver damage of zebrafish embryos by histology analysis. In summary, our data suggested that 2D monolayer cell culture was more sensitive than 3D micro tissues system in testing chemicals’ cytotoxicity, while liver fibrosis caused by TAA and BaP could be detected in 3D micro tissues system. When zebrafish embryos were treated with chemicals from 8hpf to 120hpf, development toxicity of chemicals could be observed, but it was not easy to identify liver fibrosis.

**TP199 Geographical distribution and temporal trends of organohalogen compounds in finless porpoises from Seto Inland Sea and Omura Bay, Japan**

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Persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane and its metabolites (DDTs), polybrominated diphenyl ethers (PBDEs), and hexabromocyclododecanes (HBCDs) are known to be highly accumulated in cetaceans which are at the top of the marine food webs. Previous studies reported that concentrations of POPs in marine mammals have not significantly decreased, although those in environmental samples have been following a decreasing trend. In addition, cetaceans are known to accumulate natural organohalogen compounds such as methoxylated PBDEs (MeO-PBDEs) at the same level as POPs. These compounds have POPs-like chemical structures and are suspected to have similar environmental fate. This study aimed at elucidation of the recent levels, geographical distribution, and temporal trends of POPs and POPs-like compounds in finless porpoises (Neophocaena asiaeorientalis) from Seto Inland Sea and Omura Bay, Japan. Blubber samples (n = 89) of adult male finless porpoises stranded between 2000 and 2017 in Seto Inland Sea and Omura Bay were analyzed for PCBs, PBDEs, MeO-PBDEs using GC-MS, for DDTs, chlordane compounds (CHLs), hexachlorobenzene (HCB) and hexachlorocyclohexanes (HCHs) using GC-MS/MS and for HBCDs using LC-MS/MS. The target organohalogen compounds were detected in all the blubber samples, indicating the widespread contamination in Seto Inland Sea and Omura Bay. Interestingly, concentrations of PCBs, PBDEs, HBCDs, and HCB in the specimens from Seto Inland Sea were significantly higher than in the specimens from Omura Bay, while higher concentrations of natural organohalogen compounds were found in the Omura Bay specimens. A number of samples from Seto Inland Sea contained very high concentrations of HBCDs, suggesting specific pollution sources. In the Seto Inland Sea specimens, concentrations of DDTs, CHLs, and HCHs followed a significant decreasing trend from 2000 to 2016, but no significant changes were observed for PCBs, PBDEs, HBCDs, and HCB, indicating on-going exposure of finless porpoises to these compounds. In the Omura Bay specimens, no significant changes were observed from 2005 to 2017 for any compounds. Possible reasons could be unfavorable dispersal of contaminants from the highly enclosed bay and/or a short survey period. In both study areas, there were individuals with higher PCB concentrations than the level reported to cause immunotoxicity in harbor seals.

**TP200 Polychlorinated biphenyl congener analysis of regional wildfire-dominated air samples collected during summer 2017 in Spokane, Washington**

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Summer of 2017 was an intense wildfire season for the Pacific Northwest. As part of an atmospheric deposition study for polychlorinated biphenyls (PCBs) in Spokane, Washington, several air samples were analyzed for PCB congeners and particulate matter size 2.5 microns. The air samples were collected as 24-hour composites with Polyurethane foam/XAD-2 during three different days between August 29th to September 6th, 2017. PCB congener patterns were nearly identical in all the samples suggesting that the PCBs released during wildfires smoke may be similar even with differing levels of PM2.5.
TP201 Atmospheric dust: how does transport influence reactivity?
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Over one billion tons of dust are emitted into the atmosphere each year. This dust can then be transported across the globe, including to urban areas, where pollutants have the potential to partition to its surface. Because of its photocatalytic properties, dust can catalyze the photochemical oxidation of pollutants, thereby influencing their fate in the atmosphere. Since larger dust particles sediment more quickly, only smaller dust particles are transported over longer distances. Because the composition of dust is size-dependent, this implies that its photoreactivity may also change with transport. However, to date, no studies have explored this possibility. In this study, we investigated the effects of transport on dust chemistry by using the production of hydroxyl radical as an indicator of dust photoreactivity. In our system, the hydroxyl radical is too reactive to be measured directly; therefore, we instead used 1-propanol as a molecular probe to quantify its production. With our optimized method, we quantified hydroxyl radical production by size-fractionated dust samples from Niger, Alaska, Cape Verde, and Edmonton, where size fractionation was used to simulate the gravitational settling effects of dust transport. Our results provide new insights into how dust reactivity changes with atmospheric transport and have implications for the atmospheric lifetimes of dust-associated pollutants.

TP202 Potential of Conductive Soil Particles to Enhance Direct Interspecies Electron Transfer (DIET) for Methanogenic Organic Acid Degradation
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Anaerobic digestion (AD) is an attractive bioprocess for organic waste treatment as it proffers a clean source for energy generation and environmental remediation. However, the process over the years has suffered from limited applicability due to the prolonged lag phase, being easily influenced by environmental changes and substrate-induced inhibition. Several studies are ongoing for AD process optimization. Direct interspecies electron transfer (DIET) is a syntrophic association characterised by electron transfer between two microbial species in contact with each other. Enhancing DIET efficiency between acetogens and methanogens invariably enhances methane generation and the overall efficiency of AD. Several conductive particles such as graphite, activated charcoal and haematite have been used in the past with great success to “hardwire” microbes for DIET. However, there are no reports on the use of soil particles for DIET, as they are ubiquitous, cheap and silicon derivatives (semiconductor). To this end, this study was aimed at investigating the potential of soil particles for enhancing DIET. Conductive clayey particles (CCP) were chosen from 5 different soil types after a conductivity assay (77.33 ± 1.12 µS/m) and were assessed for DIET enhancing ability. Different setups with varying concentrations of activated charcoal were used as positive controls whereas a setup without any additives was the negative control. The setup with CCP (40 g/L) gave the highest methane yield (3496.60±105.10 mL/g) and production rate (223.11±7.00 mL/g/d), which corresponds to an enhancement of 44.7% and 38.5% respectively when compared to the negative control. Activated charcoal (1.5 g/l) resulted to 25.6% overall yield and production rate enhancement which was consistent with findings from literature. There was no significant difference between the production rate of CCP and the positive control. The linear regression equation for production rate plot of the clayey particle (40 g/L) was modelled to y = 0.0325x + 232.45, while the negative control was y = -3.3859x + 188.18. Comparing their gradients suggests a sustained stability and delayed decline in production rate of the clayey setup. Hence, CCP, a representative of soil particles, has the potential to enhance DIET for anaerobic digestion. There is a need for further studies to unravel the mechanism of DIET enhancement by CCP and to further explore this novel approach.

TP203 Characterization of Recycled Tire Crumb Rubber Used on Synthetic Turf Fields in the United States
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Crumb rubber from recycled tires is widely used as an infill material in synthetic turf fields which has raised issues concerning potential exposures. However, recycled tire crumb rubber is a complex material which presents challenges when evaluating potential exposures (i.e., what is in the material as well as how people are actually exposed). As part of U.S. Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds, researchers collected recycled tire crumb rubber samples from across the U.S. (nine tire recycling plants; 25 outdoor and 15 indoor synthetic turf fields) and characterized the samples for chemicals (with a total of over 3000 analyses) as an initial step in characterizing exposure. Multiple analytical methods were applied to characterize particle size, metals, volatile (VOCs) and semi-volatile organic compounds (SVOCs). Particle size analysis used a sieve method to generate seven particle size fractions for each sample, ranging from ≤ 0.063 to > 4.75 mm. Twenty elements were measured by microwave acid digestion and ICP-MS analysis. Forty-nine PAHs, phthalates, thiizoles, amines, and other SVOCs were measured by solvent extraction with GC/MS/MS and LC/TOFMS analyses. Releases of SVOCs and thirty-one target VOCs (including BTEX chemicals, formaldehyde, styrene, and 1,3-butadiene) from tire crumb rubber were measured by dynamic emission chamber testing at 25°C and 60°C. Suspect screening and non-targeted analyses were applied to tentatively identify additional VOCs and SVOCs associated with the material. Bioaccessibility of metals was measured using simulated gastric fluid, sweat plus sebum, and saliva at 37°C. When compared to previous studies, the mean concentrations measured for most metal and SVOC chemicals were similar. While many chemicals are present in recycled tire crumb rubber, exposure may be limited based on what is released into air or biological fluids, but this needs confirmation. For the microbial analysis, all tire crumb rubber samples collected from the 40 synthetic turf fields tested positive for a universal bacterial gene (16s rRNA) at levels similar to those found on household products. Results from this research (and the follow up exposure characterization which is underway) improves our understanding of the potential for human exposure to chemicals associated with recycled tire crumb rubber material used on synthetic turf fields.

TP204 Analysis of Exhaust Gases of 3D printers and Odors from Modeled Objects
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3D printers are widely used in various fields (e.g., prototype modeling, aerospace industry, medical technology) in recent years. Little information concerning with the health and safety effects of 3D printers and their product has been reported. To investigate the safety of 3D printing systems, we analyzed exhaust gases from several 3D printers and outgases from modeled objects. In this study, material extrusion type and material jetting type 3D printers using resin materials were applied. We analyzed the gases and outgases using GC/MS and HPLC. Uncured residual monomers and its reaction products including aldehydes were detected. Gas compositions were differed by the modeling method and using materials of 3D printers. It should be noted that residual monomers and aldehydes were specific odorous compounds for the evaluation of 3D printing.
systems. The each analyses data give us characteristic information, which we can use for development and optimization of the 3D-printer instruments, ink materials, the designs and the printing procedures.

**TP205 Using Mud to Clear the Waters: Use of a Sediment Geochemical Marker to Derive Nitrogen Standards for Coastal Waters**

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Despite significant study and improvements in modelling and measurement, direct quantitative relationships between increased inputs of nitrogen to coastal water bodies and environmental effects are difficult to obtain, making the task of setting standards for nitrogen loading to such water bodies problematic. Part of the problem in obtaining better relationships is the complex combination of factors that influence various effects of nitrogen at any one time / observation. Molybdenum (Mo) in sediments can be used as a geochemical marker of periods of hypoxia in bottom waters overlying those sediments. Reaction with sulfide in pore waters of sediments underlying hypoxic waters precipitates Mo present in seawater, a process that acts as a chronometer of the period the bottom waters are hypoxic. The longer time period encompassed by sampling sediments integrates the effects of nitrogen loading over long time periods (years) and may thereby reduce variability due to other shorter-term factors that affect the occurrence and severity of hypoxia (e.g., precipitation / river inflow, wind speed and direction). Mo was measured in surface sediments of coastal waters in Narragansett Bay (RI, USA). Multiple sampling sites were selected within and among the estuaries, so that the sites would be evenly distributed over the full range of expected normalized loading. The resulting estimates of frequency of hypoxic bottom waters correlated strongly with estimates of nitrogen inputs derived from a nitrogen land-use model, normalized for hydrodynamic characteristics of the water bodies. The strong relationship between normalized nitrogen loading and frequency / duration of hypoxia can then be used in a statistical / reference condition approach to set a standard for nitrogen loading to coastal water bodies to prevent / limit the occurrence of hypoxia.

**TP206 Identification of key lipids and proteins associated with cold tolerance in Arctic char Salvelinus alpinus**

*Y. Gong, C. Wang, J. Tang, S. Su, University of Saskatchewan / Toxicology Center; P.D. Jones, University of Saskatchewan; J. Giesy, University of Saskatchewan / Department of Veterinary and Biomedical Sciences*

The Arctic char (Salvelinus alpinus) is a cold-water fish with a circumpolar distribution, and few other freshwater fishes are found at such high latitudes. Fish forced to live at temperatures higher than their natural range show reductions in growth, reproduction, and are susceptible to disease. Global climate change puts the Arctic region at the greatest risks and threatens the survival of Arctic char populations in nature as well as the Arctic char farming industry. In the present study, juvenile Arctic char were labeled individually, and survival, growth, and food consumption were recorded to evaluate fitness changes in response to different water temperatures. Advanced mass spectrometry-based multi-omics technologies, including lipidomics, metabolomics, and proteomics, were applied and integrated to identify essential lipids and proteins associated with cold tolerance in Arctic char. Network analysis of lipid and protein dynamics was also employed to get insights into how Arctic char adapt to temperature changes and how these crucial lipids and proteins interact with each other. This data could benefit both population-based conservation initiatives for native Arctic char populations as well as the Arctic char farming industry by facilitating the development of robust broodstocks.

**TP207 Lowering of the Concentration Range of the Ready Biodegradability Method OECD 301F**

*D. Koch, S.P. McLaughlin, Smithers Viscent, LLC / FATE; K. Malekani, Smithers Viscent, LLC / Environmental Fate and Metabolism*

The OECD 301F Guideline ‘Manometric Respirometry Test’ has been a standard method in determining if a test substance is ‘readily biodegradable’ for several decades. If a test substance exposed to a dilute inoculum generally comprised of activated sludge achieves 60% biodegradation equivalent to 60% of its organic carbon being converted to CO2 within a 10-day window (once reaching 10% CO2 evolution) during the 28-day test, the test substance can be labeled ‘readily biodegradable’. However, based on the method in its current form with starting concentrations at 100 mg/L, some compounds that could potentially be biodegradable may fail this test if they are inhibitory at this relatively high concentration which may be above many compounds’ Predicted Environmental Concentrations (PEC). A 301F study design was modified in this experiment by conducting the prescribed test with one of the standard reference substances, sodium benzoate, but at lower than guideline concentrations. This was conducted to determine the sensitivity of the test method at much lower and more environmentally relevant concentrations. The concentrations used in this experiment are 100, 10, 5, 2 and 1 mg/L. The results will demonstrate if the method is appropriate at concentrations of 1/1, 1/10th, 1/20th, 1/50th, 1/100th of the lowest test concentration of 100 mg/L currently stated in the OECD 301F Guideline.

**Creating Pathways to Restoration in the Great Lakes: Addressing Beneficial Use Impairments in Areas of Concern**

**TP208 Phytoremediation of an Anthropogenically Salinized Wetland in the Great Lakes Region**

*A. Litalien, Royal Military College of Canada / Chemistry and Chemical Engineering; B. Zeeb, Royal Military College / Chemistry Chemical Engineering Dept*

Soil and freshwater salinization are growing issues worldwide but of particular interest in the Great Lakes Region. Anthropogenic sources of salinity such as road salt and industrial wastes like cement kiln dust (CKD) can release salts into the environment at concentrations that are harmful to plant, benthic and aquatic life. Salt tolerant plants known as recrethohalophytes can remove salts from soil, excrete them on their leaf surfaces and dilute them within the air column. Native recrethohalophytes have been used to stabilize and extract salts from a marshland adjacent to a CKD landfill site at a cement manufacturing plant in Bath, ON, preventing entry of harmful ions into a stream that feeds into Lake Ontario. In soils with 4 mg Cl/g, S. pectinata can extract up to 26 g of Cl/m² and distribute a portion of the excreted salt over a region of land greater than 20 km² allowing deposition concentrations to fall well below background soil chloride concentrations. This effectively dilutes the chloride concentrations to those that are not only harmless, but potentially beneficial to plant and animal life. This study demonstrates that plant based strategies utilizing recrethohalophytes can sustainably remove salts accumulated in soil and prevent their leaching into freshwater bodies.

**TP209 Restoring sites in human-dominated systems: What is the reference point, which stressors dominate, and how to determine beneficial uses?**

*G.A. Burton, E.C. Cervi, University of Michigan / School for Environment and Sustainability; W.H. Clements, Colorado State University / Fish, Wildlife and Conservation Biology*

Most Superfund, Areas of Concern and contaminated sites are in heavily human-dominated watersheds. These often are near the mouths of rivers and/or harbors where industrial and municipal outfalls, stormwater runoff, and agricultural runoff constituents are deposited in quiescent zones. This plethora of chemicals is primarily attached to fine particles which then
form the dominant substrate habitat and are surrounded by shorelines comprised of armored walls with few vegetated zones, high boating activity, and high flow regimes. The multitude of contaminant sources in the watershed cannot be managed realistically, given the many business and public interests. Global change is resulting in increasing habitat degradation, agricultural and urban runoff and extreme flow events. What then are realistic reference conditions for comparing and setting remediation goals that apply at present and in the future? Is it okay to leave toxic sediments in-place after remediation? Is recolonization after remediation by a pollution tolerant benthic community acceptable? Should habitat enhancement be required to support improved benthic and fish communities? Can upstream and local stressor sources be significantly reduced? We provide a framework for ecologically sound remediation targets, utilizing realistic assessment methods to document goals are attained in human-dominated systems where stressor loadings will continue and likely increase.

Water Treatment Technologies for Removal of Emerging Contaminants and Biological Methods to Measure Effectiveness

TP210 Assessment on the Environmental Safety of Advanced Oxidation Water Treatment System (AOS)

Y. He, City University of Hong Kong / School of Energy and Environment; G. Goss, University of Alberta / Biological Sciences; L. Patterson-Fortin, R. Smith, BioLargo Water, Inc.

The Advanced Oxidation System (AOS) is a water treatment technology for bacterial disinfection and contamination remediation. The AOS can effectively remove bacterial and organic contaminants from water through the electrochemical manipulation of potassium iodide salt, electrolysis, and expanded graphite adsorption. Iodine acts as the primary disinfectant in the system. Evidence shows formation of additional iodinated and oxidative species, which may contribute to the disinfection and decontamination achieved by the AOS reactor. However, the formation of reactive oxygen species and potential secondary oxidative species may pose additional hazards to aquatic organisms living in the receiving water affected by the post-treatment effluent. The effect of exposure to AOS treated waters, especially the long-term effect on aquatic ecosystem receptors (fish, invertebrates) is a commonly raised subject of concern, and thus requires further investigation to demonstrate both efficacy and safety of this process. To examine the long-term effects of AOS treated water, a 21-day chronic daphnia exposure, a 96-hour acute zebrafish embryo exposure, and a 14-day chronic rainbow trout exposure, were conducted, with treated and untreated municipal wastewater effluent (MWE) spiked with model organic contaminants, benzo[a]pyrene and 17β-estradiol. The results indicated AOS treatment significantly reduced the adverse effects caused by exposure to MWE and model organic contaminants to baseline levels in daphnia (reduced fecundity), zebrafish embryo (elevated ERod activity), and rainbow trout (elevated plasma vitellogenin). Overall, this study demonstrated that AOS treatment is a promising and environmentally friendly technology for wastewater treatment.

TP211 Use of ozonation and sand filtration during drinking water treatment and implications for nanoplastic particle removal


Microplastics have been recently detected in bottled drinking water as well as in drinking water sources. Studies addressing the fate and removal of nanoparticles during drinking water treatment are currently lacking. Ozonation is a key treatment step in modern drinking water treatment plants due to its excellent disinfection and oxidation properties. Therefore, we evaluated the impact of ozone treatment on the physicochemical properties of three types of nanoplastics in terms of morphology, surface charge and particle aggregation state. The effect of rapid and slow sand filtration in terms of nanoplastic breakthrough taking into account the influence of the flow rate, grain size and particle roughness was also evaluated. Two plastic particles, a rough polyacrylonitrile/polyurethane co-polymer (PAN/PS) and a smooth polyacrylonitrile particles (PAN), were synthesized and showed a hydrodynamic diameter of 215 nm (PDI:0.077) and 150 nm (PDI:0.043), respectively, in agreement with the diameter derived from transmission electron microscopy (TEM) images. Commercially available 100 nm polystyrene spheres represented the third plastic particle (PS). In individual batch experiments, the plastic particles were reacted with ozone (0.5, 1 and 5 mg/L) in either buffered-DI H2O or in a lake water (used as a source of drinking water for the city of Zurich, Switzerland). After the ozone treatment in the experimental media, the hydrodynamic diameter of the particles suspended in buffered-DI H2O and lake water increased in the range from 253–409 nm, 550–620 nm and 116–150 nm for PAN/PS, PAN and PS, respectively. All the plastic particles kept a negative surface charge once suspended in the experimental media, but, after ozonation, the Z-Potential decreased from -20 to -30 mV for particles suspended in the buffered-DI water and from -14 to -17 mV for particles suspended in the lake water. Initial results from TEM investigations of particles which underwent ozone exposure revealed a very similar size and surface structure as observed for the pristine particles. Thus, ozonation does not appear to either fragment plastic particles nor dramatically change their surface charges. Whether more subtle changes on the surface properties are induced by the ozone treatment is currently under investigation. Results from sand-packed column experiments will be presented during the meeting.

TP212 A Simple Polydimethylsiloxane (PDMS) Sponge for the Removal of Environmental Organic Contaminants

B. Ng, Florida International University / Chemistry and Biochemistry; N. Quinete, NC State University / Florida International University / SERC; P. R. Gardinali, Florida International University / Chemistry & Biochemistry and SERC

Water quality affects all of us daily: through the water we drink from the tap, shower and swim in, and use to irrigate crops and plants with. Due to everyone sharing the same relative space, air and water, environmental impacts are concentrated in smaller areas, including waterways. Large amounts of pollution enter urban waters from a variety of sources, such as industrial discharge, residential/commercial wastewater, trash and polluted stormwater runoff from urban landscapes. As urban communities often share centralized water sources, this pollution creates both environmental and public health hazards such as lower drinking water quality and bodies of water that are not safe for recreational use. Water scarcity is a serious and growing issue worldwide, there is a need for clean and safe water supplies. Polydimethylsiloxane (PDMS) is a polymer based material with high absorptive properties that has been increasingly used as a passive environmental sampler for persistent organic compounds. PDMS sponges have been previously used for the selective absorption of oil from water. In this study, we have made a simple PDMS sponge to be tested for the removal of emerging environmental organic contaminants from aqueous matrices. The PDMS sponge was made using a simple, minimal preparation procedure using commercially available PDMS pre-polymer and curing agent applied to a sugar negative template. This resulted in an environmentally friendly technology for wastewater treatment.

G. Goss, University of Alberta / Biological Sciences; L. Patterson-Fortin, R. Smith, BioLargo Water, Inc.

The Advanced Oxidation System (AOS) is a water treatment technology for bacterial disinfection and contamination remediation. The AOS can effectively remove bacterial and organic contaminants from water through the electrochemical manipulation of potassium iodide salt, electrolysis, and expanded graphite adsorption. Iodine acts as the primary disinfectant in the system. Evidence shows formation of additional iodinated and oxidative species, which may contribute to the disinfection and decontamination achieved by the AOS reactor. However, the formation of reactive oxygen species and potential secondary oxidative species may pose additional hazards to aquatic organisms living in the receiving water affected by the post-treatment effluent. The effect of exposure to AOS treated waters, especially the long-term effect on aquatic ecosystem receptors (fish, invertebrates) is a commonly raised subject of concern, and thus requires further investigation to demonstrate both efficacy and safety of this process. To examine the long-term effects of AOS treated water, a 21-day chronic daphnia exposure, a 96-hour acute zebrafish embryo exposure, and a 14-day chronic rainbow trout exposure, were conducted, with treated and untreated municipal wastewater effluent (MWE) spiked with model organic contaminants, benzo[a]pyrene and 17β-estradiol. The results indicated AOS treatment significantly reduced the adverse effects caused by exposure to MWE and model organic contaminants to baseline levels in daphnia (reduced fecundity), zebrafish embryo (elevated Erod activity), and rainbow trout (elevated plasma vitellogenin). Overall, this study demonstrated that AOS treatment is a promising and environmentally friendly technology for wastewater treatment.
compounds in order to evaluate the applicability of PDMS sponges in the remediation of contaminated water bodies. The manufactured PDMS sponge has shown to be a reusable, scalable adsorbent material that can be shaped and introduced to multiple sampling and cleaning applications.

TP213 Endocrine Disruptor Chemical Removal using Modified Chitosan in Water Treatment

X. Solimando, A.F. Rich, M. Cunningham, Queen’s University; P. Champagne, Queens University / Civil Engineering

Endocrine disruptor chemicals (EDCs) are micro pollutants that interfere with endocrine systems, leading to developmental, reproductive, neurological and immune disruptions. EDCs arising from domestic, agricultural and industrial activities migrate through water into our ecosystem. However, no processes that target EDC removal in drinking water or wastewater treatment have been developed, exposing individuals to potentially harmful compounds. This work describes the development of a method involving modified biopolymer particles for the selective capture of EDCs. Bio-sourced selective beads to adsorb EDCs from water by simple contact were developed and tested, contributing to a long-term goal that ensures EDC-free drinking water is feasible. Chitosan (CTS) is a natural polysaccharide derived from industrial food-processing industry waste (crustacean exoskeleton, fungi, etc.). In this study, CTS is modified by grafting synthetic polymers, using free radical polymerization, to enhance its ability to bind to EDCs in water. In order to tune the properties of the CTS, a variety of synthetic monomers were investigated. Spherical particles (beads) were then prepared with grafted CTS via aqueous precipitation method. After a chemical crosslinking step (preventing the particles from being redissolved in water) the beads were dispersed in contaminated water for EDC capture. The study focused on the adsorption of Bisphenol A because it is the most produced (5000 ktons/year) and the most detected synthetic EDC in water at this time. It was noted that after grafting CTS with synthetic polymer, its binding ability with BPA was enhanced. As an example, it has been shown that the grafting of poly(4-vinylpyridine) on CTS increased its BPA sorption ability from 25 to up to 75%.

TP214 Effect of UV radiation types on photodegradation and toxic effects of Triton X-100

E. Jho, D. Yoo, Hankuk University of Foreign Studies / Department of Environmental Science

Various chemicals including pesticides, surfactants, and wetting agents are widely being used in agricultural practices. Uses of these chemicals can lead to environmental pollution, particularly water pollution. Previous studies focus more on the fate of active ingredients in pesticide formulation; however, there are other ingredients in pesticide formulation that may be as toxic as the active ingredients. Surfactants are included in pesticide formulation to enhance the performance of active ingredients. Therefore, the surfactants applied on agricultural land with other agrochemicals can eventually reach nearby water bodies and become pollutants. One way of naturally removing water pollutants is photodegradation. Thus, this study investigated how a surfactant in water are photodegraded and how the toxic effects are changed during the course of photodegradation. Different types of UV radiation (i.e., UV-A, UV-B, and UV-C) were used to degrade Triton X-100 dissolved in water, and the changes in the toxic effects before and after photodegradation were determined using bioluminescent bacteria. With UV-A, the Triton X-100 removal was 25% within 35 d, while with UV-B and UV-C Triton X-100 removals of 81% and 96%, respectively, were achieved within only 24 h. The toxic effects were also changed after photodegradation. The toxic effects were greater with the UV-C-radiated sample that the others. This may be explained by the generation of intermediate products. The possible generation of intermediate products is being analyzed using NMR spectroscopy. This study shows that toxic effects may increase with photodegradation of Triton X-100 in water, so the inert ingredients of pesticide formulation other than active ingredients may also need to be managed and regulated.

TP215 Estrogen composition varies in effluents discharged from various secondary municipal wastewater treatment plants in Ontario

N. Srikanthan, L. Bragg, H. Dhiyebi, University of Waterloo / Biology; S. Smyth, Environment Canada / Water Science Technology Directorate; M.R. Servos, University of Waterloo / Biology

Emerging contaminants in municipal wastewater have been a growing concern for several years. Recent changes to the Federal Wastewater Systems Effluent Regulations (WSER) in Canada require all wastewater treatment plants (WWTPs) to be operating with secondary treatment or equivalent by 2020. Infrastructure upgrades across the country will improve the quality of final effluent discharged into the receiving waters. These treatment upgrades are targeted at “deleterious substances,” which could include contaminants of emerging concern, such as pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs). These compounds have become more prevalent in effluent discharges and have been associated with adverse impacts on aquatic life downstream of WWTP outfalls. Natural and synthetic estrogens are potent EDCs that have been linked to intersex in fish. This study compares the concentration and composition of estrogens in influent and final effluents from nine WWTPs in southern Ontario with varying levels of secondary treatment. Samples were collected using cooled 24-h composite samplers and extracted using solid phase extraction. The samples were analyzed using both a biological assay (yeast estrogen screen) for total estrogenicity and chemical analysis (LC-MS/MS) for specific hormone concentrations. Results show that across the various treatment plants the relative composition of the raw influent is fairly consistent and predominantly composed of the natural estrogen, estrone. After treatment there is a significant reduction in estrogenicity and a change in the relative composition of the estrogenic chemicals, which differs across the treatment plants. WWTP processes are very site specific, therefore studying the fate and composition of estrogenic compounds at various plants can provide insight into processes influencing the removal and biotransformation of these compounds, and whether they need to be specifically targeted for additional removal.

TP216 Adsorption of HIV and AIDS related drugs from environmental wastewaters using a nanofibers

T. Kebede, UNISA / Chemistry

Emerging contaminants can be defined as synthetic or natural compounds which have now been discovered or suspected to be present in the various aquatic environment and causes known adverse ecological and human health effects. One of the most utilized emerging contaminants are pharmaceuticals and personal care products, such as antibiotics, non-steroidal anti-inflammatory drugs (NSAIDs), antidepressants, sedatives or contraceptives and b-blockers and antiretroviral drugs. Among them, antiretroviral drugs are the most utilized in South Africa than any nation in the fight against HIV/AIDS, with an approximate figure of 2150 880 receiving ARVs. This condition contributes to the presence of the compounds in the environment at a greater extent. However, their release to the environment is not regulated and they are not routinely screened for their presence in water, sediment or tissue. As a result, in South Africa HIV and AIDS-related drugs have been detected in surface water, waste water, river water and dam water. This evidently proofs that our wastewater treatment plant is not designed to effectively remove such contaminants. They are mainly designed to remove solids, dissolved organic matter and nutrients from wastewater. Thus far, some conventional treatment methods have been used for the removal of HIV and AIDS-related drugs, including activated sludge, trickling filters and anaerobic pond; however, they are inefficient of removing these drugs. In this project, the nanofibers from Moringa seed extracts were used, since nanomaterials have advantages over the others due to significantly improved physicochemical properties. From the result, it was observed that the removal efficiency of the nanofibers was in the range of 65 - 85% for 14 drugs.
TP217 Removal of Micropollutants from Wastewater by Immobilized Laccase on Hollow Silica Embedded Plastic Packing Reactor

G. Yüksel, University of Sherbrooke / Civil Engineering; D. Okutman-Tas, Istanbul Technical University / Environmental Engineering; H. Cabana, University of Sherbrooke / Civil Engineering

Over the last years, laccase-based processes have gained interest in water and wastewater treatment, unfortunately, there are many economic and large-scale operating challenges associated with the use of free enzymes in full-scale systems. Consequently, the large-scale application of laccases in bioremediation necessitates immobilization/insolubilization of the biocatalysts to enhance their operational stability and reusability in the treatment of wastewater. This research aims at optimizing the immobilization condition of the laccases of Pleurotus dryinus on hollow silica embedded plastic packing, to characterize the resulting biocatalyst and used it in a packed bed reactor for the elimination of trace organic contaminants. The resulting biocatalyst will be used in a pilot scale packed bed bioreactor in order to remove pharmaceutical active compounds from municipal wastewaters. Through these solid catalysts, approximately 10 L volume packed bed reactor will be operated to treat a local wastewater treatment plant effluent. During reactor operation; laccase activity and selected pharmaceuticals removal efficiency will be monitored. The preliminary batch test results already showed that immobilized laccases silica packing helped to improve stability and reusability of the enzyme. According to laccase immobilization optimization, 6% glutaraldehyde concentrations was optimal to activate the packing for laccase immobilization. During optimization process, pH 5.5 conditions was applied for activation by glutaraldehyde and enzyme loading. The stability of the laccase-based biocatalysts is also examined under pH 3.5 and 5.5. The residual activity is also monitored with 10 cycles of uses over a 4-month period. Also, the preliminary tests performed with the free laccase from P. dryinus have highlighted the high potential of this enzyme for the elimination of trace organic contaminants such as acetaminophen. The proper design of a packed bed reactor has been ensured long term and continuous treatment of PhACs from wastewater treatment plant effluents.

TP218 Pharmaceutical exposures in a temperate region wastewater effluent-dominated stream: Muddy Creek, Iowa

H. Zhi, University of Iowa / Civil and Environmental Engineering; D.W. Kolpin, US Geological Survey / Central Midwest Water Science Center; L.R. Iwanowicz, US Geological Survey / Leetown Science Center; R. Klaper, University of Wisconsin, Milwaukee / School of Freshwater Sciences; E. Meade, University of Wisconsin, Milwaukee / School of Freshwater Sciences; S.M. Meppelink, US Geological Survey / Central Midwest Water Science Center; M. Powers, The University of Iowa / IHR-Hydrosciences & Engineering; J. Quin, G.H. LeFevre, University of Iowa / Civil and Environmental Engineering

The increasing use of pharmaceuticals has translated to a corresponding increase in concern over their potential impacts on ecosystem and human health worldwide. An important environmental pathway for such pharmaceutical exposure is via wastewater treatment plant (WWTP) discharge as incomplete removal of pharmaceuticals during wastewater treatment can potentially effect aquatic and terrestrial organisms. Small effluent-dominated streams represent an ideal scenario for evaluating and predicting aquatic responses to pharmaceuticals as such chemicals are continually discharged into these less diluted systems. To this end, Muddy Creek, a small (22.5 km²) effluent-dominated temperate region stream that flows through the town of North Liberty, Iowa, was selected as a field laboratory for this study. Although the population serving the North Liberty WWTP is small (18,500 people), it is the second fastest-growing city in Iowa. To determine spatial and temporal trends in pharmaceutical exposures, four sampling sites were selected for this study: (1) approximately 100 m above the WWTP outfall, (2) the WWTP outfall, (3) approximately 100 m below the WWTP outfall, and (4) approximately 5 km downstream of the WWTP outfall. From September 2017 to August 2018, water samples were collected on a biweekly basis and analyzed for 13 pharmaceuticals by the University of Iowa and collected monthly and analyzed for 110 pharmaceuticals by the U.S. Geological Survey. The top 13 pharmaceuticals in terms of concentration accounted for over 85% of the overall chemical mass measured in the collected environmental samples. The total concentration of the top 13 pharmaceuticals ranged from 2,550 to 37,800 ng/L in the WWTP outfall. The parent-to-product ratios for five pharmaceuticals were calculated spatially and temporally as a measure of differential attenuation. Bench experiments are being conducted in the laboratory to elucidate transformation kinetics including photolysis, sorption, and biodegradation of targeted pharmaceutical mixtures. Ongoing and future efforts will relate pharmaceutical results to fish exposure and bioluminescent yeast estrogen assays to better understand potential environmental impacts from pharmaceutical exposures.

TP219 The Removal of silver nanoparticles from aqueous samples using milled activated charcoal

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The environmental impacts of silver nanoparticles (AgNPs) is now of interest due to their incorporation in numerous nano-functionalised consumer products. Products include; medical devices, food contact materials, paints and textiles. The incorporation of AgNPs into these products presents potential risks to the environment as AgNPs may be released throughout the products lifetime from manufacturing to end-of-life disposal. Activated charcoal, Norit(R) CA1 (Sigma-Aldrich), a commonly used filter material, was investigated as a potential material to capture AgNPs from water samples. Initial investigations used 100 ppb samples of 25 nm PVP coated AgNPs (nanoComposix) in water generated with Milli-Q water. These samples were exposed to the charcoal for 20 hours after which the change in silver concentration was measured using ICP-MS. The removal efficiency of the charcoal was improved by milling the charcoal. The processed charcoal was then exposed to samples containing AgNPs as in initial tests. Initially approximately 10% of the silver was removed from the water samples using the unaltered activated charcoal granules. The capture of the AgNPs was improved using the milled charcoal, with a capture efficiency of 94% at concentrations of 10 ppb. This study found that increasing the surface area of the charcoal increased the silver reduction in the samples. Further a procedure was developed allowing the silver captured by the charcoal to be quantified using a HCl leaching procedure.

TP220 Release of Silver Nanomaterials from Textiles: Generating weathered nanoparticles for toxicity testing

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Engineered nanomaterials (ENMs) are artificially created objects that have at least one dimension between 1-100 nm and can exhibit physico-chemical properties different from their bulk material counterparts. Textiles often contain silver nanomaterials to take advantage of silver’s antibacterial properties, which prevent odour in textiles during use. Recent research has shown that silver nanomaterials (AgNMs) are released from textiles during their active life cycle which can pose a risk to microbial communities in environmental systems. The objective of this study is to develop representative methods for the artificial wearing of silver-containing textiles which will be compared to data from previously performed true wearing scenarios. The experimental set-up involved the physical stretching of silver-treated textiles with a 3D printed apparatus inspired by techniques used in the textile manufacturing industry. Following physical pre-treatment, textiles were washed in a detergent solution at parameters closely mimicking typical laundry conditions. Wash water samples were analyzed through a combined suite of
characterization techniques including: SP-ICP-MS, size fractionation via filtering, SEM/EDX, DLS and XRF. It was found that artificial wearing of the textile had a significant effect on the concentration (~60% increase) and the size morphology (higher percentage of smaller particles) of silver released during a first wash cycle, when compared to an unworn textile. It was also found that wash solutions made with deionized water resulted in a higher silver release (~85%) when compared to tap water wash solutions. This indicates silver release characteristics could vary geographically based on the water chemistry of the area. Future plans include the incorporation of artificial sweat, further exploration of the relationship between water chemistry and silver release, and investigations into silver-release mechanisms. Successful development of an artificial wearing method will lend itself to use in ecotoxicity studies, which currently use pristine materials that are not necessarily representative of realistic exposures.

TP221 The fate of pristine and weathered silver nanomaterials from commercial products in subsurface planted wetland mesocosms

A. Farooq, Royal Military College of Canada; V. Gagnon, D. Patch, Royal Military College of Canada / Chemistry and Chemical Engineering; D. O’Carroll, University of New South Wales / Civil and Environmental Engineering; K.P. Weber, Royal Military College / Chemistry and Chemical Engineering

Due to their antimicrobial properties silver nanomaterials (Ag NMs) are frequently employed in a variety of industrial and consumer products such as clothing and personal care products among others. Due to their abundance, Ag NMs are predicted to be released into the aquatic environment, via treated wastewater effluent, at concentrations, which may cause potentially toxic effects. However, current research focuses on the effects of pristine ENMs rather than those released from commercial products. The fate and effects of nanomaterials release from commercial products in the environment, such as wetlands, are largely unknown. Wetlands ecosystems have an innate ability to transform a wide range of pollutants into harmless by-products mainly through their microbial communities and could be impaired by the release of Ag NMs. This project aims to examine the fate and effect of both pristine and weathered Ag NMs in twenty-four batch-fed subsurface flow wetland mesocosms, planted with Phalaris arundinacea; twelve intensified with artificial aeration and twelve non-aerated. The experiment consisted of four design types including a positive control, a negative control, a pristine Ag NM and an artificially weathered Ag NM exposure, all conducted in triplicate. Two separate in situ exposures were conducted and monitored using a characterization suite consisting of five assessment categories (water quality, hydrological, microbial, plant health, and NM assessment) to profile the impacts on treatment performance and microbial function. Finally, the overall fate of silver within the mesocosms was determined through the destructive sampling of the constructed wetland biofilm, plant roots, and aboveground plant biomass. The analysis of microbial activity for the aerated and non-aerated CW systems illustrated no discernible difference between the silver treatments and their respective controls indicating that the CW systems are quite robust when exposed to Ag NMs at environmentally relevant concentrations. Silver removal kinetics were tracked in the CW systems for both exposures, which revealed that the aerated CW systems remove the Ag NMs more rapidly than the non-aerated systems. Total silver data from the deconstruction indicates that the highest concentrations of silver were located in the gravel-associated biofilm; in particular in the 30-60 cm layer. In the long term, this accumulation may reach a concentration that could be toxic to the microbial communities.

TP222 Investigation of the effectiveness of an electrochemical treatment train process for treatment of synthetic and real municipal stormwater

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The pollution caused by contaminants carried in anthropogenic-based wastewaters is of increasing concern as they impact ecosystem and human health. Contaminant sources include municipal and industrial wastewaters, agricultural runoffs, and stormwaters. For example, stormwater contaminants may include suspended and dissolved solids, polyaromatic hydrocarbons, heavy metals, fecal coliforms, among others. Many stormwaters systems, such as those in the Canadian prairies, have numerous untreated stormwater outfalls into receiving waters making the collection and treatment of these waters challenging logistically and economically for municipalities. BioLargo Water Inc., an Alberta based company has developed a wastewater treatment technology, the Advanced Oxidation System (AOS). In collaboration with BioLargo Water and through NSERC Engage Plus Funding, our research goal is to create a simple, effective treatment process that can be viable for use in multiple outfall locations such as those found in Saskatoon, Saskatchewan. The AOS is a type of electrochemical treatment that uses oxidative species that can be used to effectively treat contaminants in stormwaters with iodide and chloride showing potential to be valuable for creation of potent oxidative species. Thus, it is important to determine the concentrations and locations of these species in an AOS-type reactor to assess the reactor performance and to optimize the treatment conditions. Spectrophotometry was used to determine the concentration of chloride and iodide oxidative species within the AOS reactor. These species include chlorate, chlorite, and hypochlorite for chloride; and periodate and iodate for iodide. After success in initial experiments, the AOS reactor is currently being assessed in a treatment process train that includes a standard pre-treatment step for removals of solids prior to entering the AOS reactor. This treatment train will be tested and optimized for the treatment of synthetic and actual stormwater samples from Saskatoon outfalls during the spring and summer of 2019. The findings of this research will lead to the production of an effective stormwater treatment train process that can be useful for municipalities that currently release contaminated stormwater without treatment into receiving waters. This is treatment is going to be needed in the face of existing and potential stormwater effluent regulations as are currently being assessed in Canada and beyond.

TP223 Direct and indirect photodegradation of triclosan in wetland

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Triclosan is an antimicrobial agent incorporated into many household products, such as soaps, detergents, and toothpaste. Triclosan is ubiquitously found in the aquatic environment, potentially toxic, and readily bioaccumulated. Passive water treatment systems, such as wetlands, have shown potential to reduce triclosan pollution. This study investigated three factors that affect the aqueous phototransformation of triclosan in wetlands, i.e., pH, nitrate concentration and dissolved organic carbon (DOC) concentration, using a three-parameter three-level Box Behnken experimental design. The effect of pH on triclosan phototransformation was tested given its pKa of 8.2 is close to typical wetland pH. Further, nitrate and DOC concentrations were selected as common surface water photoinducers capable of promoting the formation of reactive species. Both the direct and indirect phototransformation of triclosan followed pseudo first-order kinetics. The results showed that the kinetic of direct phototransformation increased as the pH increased. The Box Behnken Model analysis revealed that pH and DOC significantly affected indirect phototransformation rates. At pH 6 (pH < pKa), an increase in DOC concentration did not significantly change the kinetic constant; whereas, at pH 8 and 10 (pH > pKa), the highest phototransformation rates were obtained with the lowest DOC concentrations. Both direct and indirect phototransformation experiments formed several phototransformation products, including 2,4-dichlorophenol, a known toxic compound. At pH 6, phototransformation products were continuously formed and accumulated; whereas at pH 8 and 10, the products were formed and depleted. The results showed that minimal changes in classical wetland design would be needed to sustain triclosan removal by phototransformation, even though larger pH values would result in faster triclosan phototransformation and lower by-product accumulation.
TP224 Removal of triclosan by the green alga Euglena gracilis
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Triclosan is an antimicrobial agent that is incorporated into many household products, such as soaps, detergents, and toothpaste. A fraction of the triclosan contamination that reaches the sewage treatment plant remains uncaptured and is then released into the aquatic environment where it can be further transformed into toxic products. Constructed wetlands can be effective water treatment systems for emerging contaminants by promoting adsorption, plant uptake, phototransformation, and biotransformation of chemicals. Algae develop naturally in constructed wetlands and lagoons, and are even used in high-rate algal ponds to treat wastewater.

However, to date, little is known about the role of algae on trace organic contaminant removal. This study used the green alga Euglena gracilis to investigate the reaction mechanisms that control triclosan removal in wetland water, autoclaved wetland water, Euglena medium, and Milli-Q water. The study was done in 1-L Erlenmeyer flasks containing 600 mL of algae spiked with triclosan. Samples were taken on day 0, 3, 7, 14, and 21 to quantify the concentration of triclosan and its transformation products. The algae was also subjected to three different light conditions: white, red, and absence of light. The red light control was conducted to inhibit triclosan phototransformation while maintaining algae growth, thereby promoting conditions where biotransformation - if any - would dominate.

TP225 Mechanisms of Pharmaceutical and Personal Care Product Removal in Algae-Based Wastewater Treatment
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The widespread distribution of pharmaceuticals and personal care products (PPCPs), in particular in the built environment, has led to increased concern about their potential to affect human and ecosystem health. In this research, we investigated the role of algae species Scenedesmus obliquus and Chlorella vulgaris in governing PPCP transfer and transformation mechanisms in algae-containing environments. Lab-scale algal bioreactors were created under various conditions of light, water matrix, and sterilization method to isolate and elucidate reaction mechanisms affecting carbamazepine, ibuprofen, gemfibrozil, and triclosan. The parent compounds and their potential transformation products were analyzed in both the water and algae phases. The results showed that ibuprofen was primarily biotransformed thanks to synergistic relationships between the algae and the bacteria. Ibuprofen biotransformation products such as hydroxy-ibuprofen, carboxy-ibuprofen, and 4-isobutyratechol were detected in several samples. In all the reactors exposed to light, triclosan underwent both phototransformation and biotransformation. Triclosan biotransformation took place in Scenedesmus obliquus, as demonstrated by the presence of triclosan-O-sulfate in the algae extracts. No evidence of significant carbamazepine and gemfibrozil transfer or transformation was observed under the experimental conditions tested. These results suggest that microalgal-bacterial consortia can facilitate PPCP transformation in algae-based passive water treatment systems.

TP226 Evaluating the efficacy of native halophytes in the phytoextraction of road salt (sodium chloride) from contaminated soil
E. Mann, Queens University / School of Environmental Studies

Salt from the soil in a process known as phytoextraction. Salts taken up from the soil are stored in the above ground biomass, and by harvesting this plant material salts can be removed from the site before they accumulate to toxic levels or leach into groundwater. This study investigated the ability of three native halophytes: Atriplex canescens, Atriplex patula, and Atriplex hortensis to remove sodium chloride from contaminated soil. Both field and greenhouse studies were completed in order to determine survivability in roadside areas, and Na+ and Cl− extraction ability. The Atriplex spp. accumulated 41-64 mg Cl/g dry weight (DW), and 18-55 mg Na+/g DW when grown for a two- month period in soil spiked with NaCl to realistic levels. Salt content in separate shoot components (seeds, stem, leaves) was determined in order to provide further insight on phytoextraction processes. In all three Atriplex species, the leaves had the highest salt concentration, followed by the seeds (bracteoles included), with the lowest concentrations found in the stem. A column study was also completed to investigate the movement of road salt through soil during the spring melt. The results from this study will be presented and discussed. This research aims to inform remediation and management practices for salt-contaminated soil in order to reduce the environmental impact of road salting.

TP227 Nature-based solutions: The use of a floating wetland system as an alternative to effluent’s treatment

Conventional physicochemical methods for effluent treatment are expensive and the resulting discharge can still be harmful to the environment. Thus, alternative ecotechnologies that are low cost such as constructed wetlands (CW) are a solution traditionally used. A variant from CW is the Floating Wetland Treatment (FWT) that uses a floating structure that allows the formation of a root mat to bioremediate polluted waters. The aim of this study was to evaluate the efficiency of a FWT system in the removal of pollutants from a real effluent. The search for a low cost-effective technology is crucial especially in developing countries such as Brazil, considering that around half of its sewage effluent is released into water bodies without any treatment. So, this challenge could be minimized by the application of an ecotechnology through phytoremediation. The current study performed three experiments with triplicates, using effluent from the Federal University of Rio Grande do Sul. It was considered three tanks with macrophytes (M) and its respective controls (with no plants) (C). Water quality parameters analyzed were total nitrogen, total phosphorus, conductivity, pH, color, and turbidity. Inflow and outflow event were quantified to verify pollutant removal and also to compare the treatments (M vs. C). According to PERMANOVA, macrophyte tanks were more efficient than controls in the effluent polishing considering the parameters analyzed in all experiments (p=0.001). There was also a significant difference between inflow and outflow considering both treatments (p=0.001). The results also suggest that control tanks presented some efficiency, which may have occurred by interactions such as photo-oxidation processes and/or the presence of algae proliferation, that might also have acted as phytoremediation agents. Further analysis is being performed evoking ecotoxicological assays and metal quantification for these effluents. As an overall conclusion, FWT is a good alternative to effluent’s treatment, although its action alone is not enough to fit legislation’s requirements. The relevance of this study encompasses collecting more information regarding the efficiency of FWT along with bringing a new insight for the potential to be achieved for effluent treatment in developing countries.
TP228 Do Vegetated Treatment Systems “Treat” OPEs by Evapotranspiration?
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Organophosphate esters (OPEs), compounds used as flame retardants and plasticizers, are found at high levels in urban areas worldwide. Rodgers et al. (2018) previously found that wastewater treatment plants (WWTPs) were the largest pathway for OPE emissions from the city of Toronto to Lake Ontario, accounting for ~70% of total loadings for six of the most abundant compounds. Chlorinated OPEs (Cl-OPEs), which are examples of persistent and mobile organic compounds (PMOCs), have low removal through traditional WWTPs. The Oro Loma Horizontal Levee is a subsurface flow wetland located next to San Francisco Bay, California, designed as a pilot system to treat nitified secondary domestic wastewater effluent. The Oro Loma system has high evapotranspirative flows and a residence time of about two weeks, which may allow for better treatment of PMOCs like Cl-OPEs than conventional WWTP processes. Some Cl-OPEs have KOW values in the optimal zone for uptake by plant shoots through the transpiration stream and have been shown to accumulate in the shoots of wheat plants. We hypothesize that Cl-OPEs are removed from the WWTP effluent through transpiration, thus reducing loading in the final effluent. We are developing a continuous, dynamic multimedia model of the system to investigate the distribution and fate of OPEs in the Oro Loma system. Our “Subsurface Sinks” multimedia model is based on the activity concept so as to be broadly applicable to trace organic contaminants commonly found in WWTP effluent, including pharmaceuticals and other compounds that ionize in water. The model consists of 8 compartments, including a detailed 3-compartment model of plant roots used to predict plant uptake from water. We are evaluating the model against measured OPE water concentrations taken at multiple points along the Oro Loma system. Preliminary measured OPE concentrations from the Oro Loma Horizontal levee confirm the presence of OPEs in the Levee effluent at detectable concentrations. Preliminary model results indicated that the topsoil compartment tends to accumulate CI-OPEs through uptake to the plant compartment and subsequent litterfall and plant death, while non-Cl-OPEs are transferred to the soil compartments through sorption to soil particles and lipids in plant roots. Overall, our results indicate that the large evapotranspirative flows in the Oro Loma Horizontal Levee provide higher removal of Cl-OPEs from the WWTP effluent than would be predicted for sorption alone.

TP229 Multi-tracer Experiment in a Bioretention Cell to Study the Transport of Trace Organic Stormwater Contaminants
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Bioretention cells are a widely applied urban low impact development (LID) strategy focusing on the infiltration and treatment of stormwater runoff. These cells have been shown to effectively remove contaminants such as suspended solids, dissolved nutrients and trace metals in field and laboratory studies, though with variable efficiencies. Limited research has probed the fate of emerging trace organic contaminants in bioretention cells, especially under field conditions. Although present in low concentrations in the environment, these contaminants have raised increasing concerns recently due to their toxicity and persistence. To fill this knowledge gap, we performed a tracer experiment at a bioretention cell site to obtain in situ field data at a high time-resolution with the goal of investigating the underlying transport, transfer and transformation mechanisms of various stormwater trace organic contaminants. A tracer mixture containing bromide, rhodamine WT, nitrate, phosphate, benzotriazole, and four organophosphate esters (OPEs) was injected as a pulse at the inlet of a bioretention cell located north of Toronto. Outflow samples were collected at different time points and analyzed to generate tracer breakthrough curves for these compounds. The results were modelled to obtain important parameters including recovery rate, mean residence time and variance for each compound, as well as hydraulic efficiency of the bioretention cell. The results showed that the bioretention cell had a short retention time of less than 2 hours. The calculated effective volume ratio was 0.39 suggesting the presence of dead volume and/or preferential flow paths. The recovery rate was 95% for the water tracer bromide, and 35 and 51% for nitrate and phosphate, respectively, indicating removal of these nutrient species. Recovery of benzotriazole was 71%, consistent with this compound sorbing poorly to soil. Given the short retention time that is typical of conventional bioretention cells, biotransformation and plant uptake of the contaminants were likely limited. This field tracer experiment produced valuable information on the performance of the bioretention cell in mitigating trace organic chemicals. These results demonstrated the need to use new design strategies to effectively sorb or transform these contaminants, such as increasing the retention time, incorporating soil amendments, and selecting specific plant species for better treatment performance.

TP230 Production of extracellular lipase expressed by Aspergillus flavus isolated from crude oil polluted soil for remediation of contaminated water
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For enhanced production of lipase by a novel fungal strain: Aspergillus flavus, optimization of selected environmental conditions and fermentation medium were performed using response surface methodology and factorial design. The results from factorial design reveal that agitation, substrate concentration, temperature and pH were the crucial elements affecting the production of lipase. The optimum medium conditions obtained for lipase production using response surface methodology were agitation 150 rpm, substrate concentration of 2.75 v/v, temperature of 45 °C and pH 8.5. This model was authenticated by replicating the experiment under the established conditions, which led to maximum expression of lipase by the organism 5.05 U/mg (predicted response 4.91 U/mg), hence substantiating the reliability of the model. Unexplored Aspergillus flavus strain isolated from crude oil contaminated soils was used for this study. This study underscores the capability of Aspergillus flavus, for lipase production and highlights the practicability of response surface methodology for the optimization of environmental conditions and fermentation medium for enhanced production of lipase.

TP231 Investigation of the Phototransformation Processes of Benzotriazole in Surface Waters Using Compound-Specific Isotope Analysis Approach
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Benzotriazole is widely used as an antifreeze, a corrosion inhibitor, and the production of fungicides and pharmaceuticals. As a result, it is frequently detected in urban runoff, wastewater, and receiving aquatic environments. Benzotriazole does not adsorb significantly onto surfaces and is typically resistant to biodegradation. In addition, hydrolysis is not expected due to the lack of hydrolysable functional groups. Aquatic direct and indirect phototransformation of benzotriazole can be the major transformation pathways in surface waters. However, to date, little research
Compound specific stable carbon isotope analysis of semi-volatile substituted chlorobenzenes coupled with solid phase microextraction

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Compound specific isotope analysis (CSIA) is an established technique to assess the origin and fate of volatile organic pollutants in the environment. The isotope ratio of contaminants mainly changes as a result of the formation and breaking of chemical bonds. This effect has been exploited to distinguish between destructive and non-destructive in situ processes. However, the application of CSIA for semi-volatile organic compounds, such as amino- (NH2-) and nitro- (NO2-) substituted chlorobenzenes are limited due to the difficulty to extract sufficient analyte mass from the liquid sample matrix. In this study, we developed a CSIA method coupled with the solid phase microextraction (SPME) technique using a divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) adsorbent fiber to determine the δ13C signature of the selected chlorinated anilines and chlorinated nitrobenzenes. The effect of different SPME factors on the isotope fractionation of the selected compounds was evaluated using the design of experiments (DoE) methodologies. Initially four SPME factors, i.e. extraction time (30-70 minutes), extraction temperature (50°-90° C), desorption temperature (200°-260° C), and agitation during extraction (200-500 rpm) were evaluated using a two-level fractional factorial DoE to screen the factors most affecting the isotopic fractionation of the compounds. The second step consisted of identifying the values of the most influential parameters found in the screening design using a composite surface response DoE. The concept of desirability function was used to minimize the isotope fractionation while maximizing the analyte signal amplitude in the isotope ratio mass spectrometer (IRMS). Next, the isotope fractionation due to the potential sorption competition for the SPME adsorption sites was evaluated within the linear range of the analyte mass in IRMS. The limits of detection (LOD) and the linearity for C isotope by the SPME technique were determined for each compound, and the trueness of the measured isotopic signature was evaluated by comparing the δ13C values determined by SPME-GC/IRMS and elemental analyzer IRMS (EA/IRMS). Finally, the applicability of the developed method was demonstrated using contaminated groundwater samples. The developed SPME technique has the potential to apply CSIA for the remediation of groundwater contaminated with the selected semi-volatile compounds.
Relationships Between the Bioaccumulation of Organic Chemicals in Aquatic and Air-Breathing Organisms

TP234 In vitro biotransformation in fish and mammals: Differences and similarities
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Historically, the globally accepted model for determination of bioaccumulation has been fish and bioaccumulation assessment has been driven by the octanol-water partition coefficient ($K_{OW}$). The ECHA guidance document on PBT/vPvB assessment, released in 2017 (Chapter R.11), includes the octanol-air partition coefficient ($K_{OA}$) to extend the screening criteria to air breathing organisms. However, biotransformation can be a key factor and can strongly impact the extent to which hydrophobic chemicals accumulate in aquatic and terrestrial organisms. Accounting for biotransformation in bioaccumulation assessment is of importance for very hydrophobic and poorly volatile chemicals because for such chemicals even low rates of biotransformation can dominate the overall chemical elimination process. Hence, there is a need to develop methods for bioaccumulation assessment that include biotransformation. Standardized methods using fish liver hepatocytes and S9 sub-cellular fractions have been approved by the OECD to quantify the metabolic turnover of chemicals under in vitro test conditions in fish. Similar methods have been developed and applied to mammalian species for decades, e.g., pharmaceutical development. This work summarizes preliminary explorations of similarities and differences in biotransformation rates obtained from various in vitro systems in fish and mammal species. An extensive literature search was performed to review and compile existing data of intrinsic hepatic clearance measured in vitro in fish, rodents and humans reveal satisfying interspecies correlation $R^2 > 0.5$. The statistical distribution of experimental responses shows that data of intrinsic hepatic clearance measured in different species are comparable and cover the same range of values. Based on these preliminary and encouraging findings, future analyses and applications of the datasets are outlined.

TP235 Comparing trophic magnification of perfluoroalkyl substances in an avian terrestrial food-web to aquatic food-webs
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Several types of legacy persistent organic pollutants (POPs), such as organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs), and emergent POPs like perfluoroalkyl substances (PFASs) are released from many sources into the environment and negatively impact exposed wildlife. Protocols to assess bioaccumulation of these persistent chemicals within terrestrial systems are far less developed compared to aquatic systems. Consequently, regulatory agencies in Canada, the USA, and the EU currently use only aquatic information to assess bioaccumulation potential of chemicals. However, studies have shown that some chemicals that are not bioaccumulative in aquatic food-webs do biomagnify in terrestrial ones. To better understand the bioaccumulation behaviour of chemicals in terrestrial systems, we assessed the biomagnification of POPs and PFASs in a terrestrial food-web that included an avian apex predator, the Cooper’s Hawk (Accipiter cooperii). Over 100 samples were collected from an urban food-web including hawk eggs, songbirds, invertebrates, and berries. We estimated the trophic position of each organism using stable isotope analysis of $δ^{13}C$ and $δ^{15}N$ signatures. We analyzed the samples for concentrations of PCBs, OCPs, and PFASs listed on the Government of Canada’s Chemicals Management Plan. Trophic magnification factors (TMFs) were determined for contaminants that were detected at appreciable levels in all of the biota samples (>50%). We compared our terrestrial TMFs to those observed in aquatic food-webs. TMFs of PFASs ranged from 13.02 – 86.19, indicating PFASs are readily biomagnifying. TMFs reported in aquatic food-webs for PFASs were 4 – 20 times lower than the terrestrial TMFs we estimated.

TP236 Bioaccumulation and Biotransformation Databases for Organic Compounds in Birds
D. Kuo, City University of Hong Kong / Architecture and Civil Engineering

Robust experimental data and field observations are indispensable in advancing bioaccumulation and biotransformation science in birds as they constitute the basis for establishing regulatory guidelines, conducting risk assessment, and developing mechanistic prediction models. This project reviewed and compiled bioaccumulation and biotransformation data of organic compounds from primary experimental sources, covering both legacy and emerging organic pollutants. Over 15,000 bioaccumulation and biotransformation data entries (~1,000,000 filled cells of information) were compiled following a critical review of over 300 studies and reports. These included some 400 organic on close to 300 wild avian species and domestic breeds. Data were reviewed for their quality and subsequently organized under four differently themed databases: main, metabolic pathway, field survey, and enzymatic activity. The main database carried key bioaccumulation metrics and toxicokinetic parameters, as well as reported pharmacokinetic parameters and biotransformation rate constants. The field survey database qualitatively documented the availability of tissue-specific measurements in various birds under field exposed conditions. The metabolic pathway database provided basic availability information on metabolic pathway and number of metabolites reported. The enzymatic activity database summarized the type of biotransformation-relevant enzymatic activities reported for different substrate compounds in the presence (or absence) of organic compounds. Data characterization and preliminary explorative data analyses were conducted on these 4 databases. Preliminary findings in this on-going review effort will be highlighted.

TP237 Refining bioaccumulation screening of neutral hydrophobic organic chemicals in air-breathing organisms from in vitro liver S9 biotransformation assays

The use of in vitro biotransformation assays followed by in vitro-in vivo extrapolation (IVIVE) is of increasing importance in bioaccumulation screening to reduce in vivo bioaccumulation testing. Recently, the Organisation for Economic Co-operation and Development (OECD) has developed test guidelines (No. 319B) to determine the in vitro intrinsic clearance of a test chemical using the substrate depletion approach in incubations with liver S9 of rainbow trout (RT-S9). Given the demands of bioaccumulation screening for air-breathing organisms, there is a need for mammalian bioaccumulation screening protocols involving in vitro approaches. This study reports on the development and testing of a screening approach for bioaccumulation assessment of neutral hydrophobic organic chemicals in air-breathing organisms using rat liver S9 biotransformation assays. It is based on the OECD RT-S9 protocols with modifications to provide all the information needed to conduct IVIVE for the purpose of bioaccumulation assessment. Modifications include the
determination of the unbound fraction (fu,inc) of the test chemical in the incubation, which is not included in current RT-S9 protocols. We illustrate that fu,inc can be estimated using a composition-based approach by including lipid and protein analysis of rat liver S9, or measured experimentally in the bioassay along with the depletion rate constant constant using a solvent-free passive-dosing approach. Results show good agreement between model estimated and experimental fu,inc values. Results further indicate that an in vitro depletion rate constant in a rat liver S9 greater than 0.3 d-1 is sufficient to negate biomagnification in rats.

**TP238 The Bioaccumulation Assessment Tool (BAT): Case studies for the assessment of bioaccumulation of chemicals in both air-breathing and aquatic organisms**

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Persistence, Bioaccumulation and Toxicity (PBT) assessments are carried out by many regulatory programs such as REACh, TSCA, CEPA, and CSCL. These assessments aim to identify the hazards and risks posed by chemicals to the environment and human health. There is a wide variety of available data describing the bioaccumulation and biotransformation of neutral and ionic chemicals in both aquatic and terrestrial organisms. The freely-available Bioaccumulation Assessment Tool (BAT) was developed to aid the collection, evaluation and integration of various lines of evidence (LOE) with available toxicokinetic (TK) information and related B classification criteria in both aquatic and terrestrial biota. It is a platform designed to aid decision-making using a quantitative weight of evidence approach. Recent work has extended the capabilities of the BAT to robustly assess bioaccumulation in air-breathing organisms and invertebrates. The BAT is used to integrate physical-chemical properties and estimates of biotransformation in fish and mammals with measured and/or estimated bioaccumulation metrics (bioconcentration, bioaccumulation, biomagnification and trophic magnification factors, i.e., BCF, BAF, BMF and TMFs). Within the BAT framework is a generic environment with both aquatic and terrestrial food webs as well as simulated laboratory models used to estimate these B-metrics. Experimental, field and in silico LOE are evaluated for reliability, based on data quality assessment methods derived primarily from OECD testing guidelines. Output from the BAT includes a summary of the results, relevance and reliability scoring of input data; these are presented in concise tables, figures and in a generated PDF report. We provide an overview of the BAT and demonstrate its application with two case studies. The first example illustrates the aquatic-based bioaccumulation results for a typical B chemical. The second example is for a chemical which shows bioaccumulation potential in terrestrial ecosystems, but is not screened in as potentially B for aquatic systems because of its low octanol-water partition coefficient. This work demonstrates the value of considering bioaccumulation in non-aquatic organisms for regulatory purposes by employing a tool that allows the user to consider a breadth of available empirical and modelled information for assessing bioaccumulation.

**TP239 Application of Toxicokinetic Models to Simulate Organic Chemicals in Air-breathing Animals for B assessment**

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Bioaccumulation assessment (B) for regulatory purposes has traditionally relied upon data for aquatic organisms (fish) and a partitioning property referenced to water (i.e., octanol-water partition coefficient, KOW). OECD guidance for laboratory testing with fish is available and widely accepted (OECD 305) and there is a relative abundance of empirical data characterizing bioaccumulation potential in fish (i.e., bioconcentration factors, BCF). The abundance of empirical data has supported the development, evaluation and application of several approaches to simulate BCFs in fish including Quantitative Structure Activity Relationships (QSARs) and mechanistic bioaccumulation (toxicokinetic) models. Food web bioaccumulation models have also been developed to simulate bioaccumulation potential in the field (e.g., bioaccumulation factors, BAFs and biomagnification factors, BMFs). These tools can be used to support regulatory activities such as PBT assessment and exposure/risk assessment. Regulatory guidance from the European Chemicals Agency (ECHA) now includes B screening threshold criteria for air-breathing organisms linked to KOW and the octanol-air partition coefficient (KOA) (e.g., Chapter R11: PBT/vPvB Assessment). Unlike the situation for fish, there is no standardized test for bioaccumulation assessment in air-breathing organisms (e.g., laboratory rats and mice). However, a wealth of toxicokinetic data has been generated using mammals for other regulatory purposes (e.g., pesticide registration). These tests are frequently single dose studies (intravenous, oral bolus) and their interpretation for B assessment is less obvious compared to fish BCF data. The objective of this study was to develop and apply one- and multi-compartment toxicokinetic models (1-CoTK and PBTK respectively) to simulate the behaviour of organic chemicals in laboratory animals for interpretation in the context of B assessment. As a case study, the models were applied to laboratory test data for several organic compounds of interest and their performance assessed. Different sources of data characterizing biotransformation (e.g., in vitro S9 data, QSARs) were considered to parameterize the models and demonstrate the key role of this process in mitigating bioaccumulation potential. The results are then interpreted with respect to bioaccumulation assessment in air-breathing organisms.

**UVCB Risk Assessment: Venturing Into Another Dimension**

TP240 A linear regression model for predicting sigma profiles

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Linear regression models can be very useful for predicting chemical properties with high environmental significance. Quantitative structure-activity relationships (QSARS) and linear free energy relationships (LFERs) are examples of linear regression type models often used in environmental science to predict properties such as partition ratios or biotransformation half-lives. Sigma profiles are chemical properties which estimate the distribution of charges over the molecule's surface area. An example is shown for ethanol in Figure 1a. Andreas Klamt has shown that sigma profiles can be used to characterize any chemical or mixture of chemicals and used this as the basis for developing the quantum mechanics-based COSMO-RS theory. COSMO-RS has been implemented into the software COSMOtherm for predicting chemical properties such as partition ratios, solubilities, vapour pressures, Henry's law constants (HLCs), and others. In this study, a multi-parameter linear regression (MRE) model has been developed using HLCs as descriptors in order to predict sigma profiles of chemicals. Predictions can be made for pure chemicals or for mixtures of unknown or variable composition (UVCBs). Sigma profiles are then indirectly input into COSMOtherm in order to predict chemical properties such as partition ratios. A sigma profile for ethanol predicted using this MRE model is shown in Figure 1b. Figure 1: A) left: Shows the sigma profile of ethanol. B) right: A predicted sigma profile of ethanol which was generated using the MRE in this study. Partition ratios were predicted for a group of 250 neutral organic compounds in an ethanol/water medium as well as for a 'predicted ethanol'/water medium and these partition ratios were graphed against each other, shown in Figure 2. Graph of partition ratios in a 'predicted ethanol'/water medium vs. in an ethanol/water medium and regression statistics. RMSE = 0.29. This process was repeated for all 49 test chemicals giving an average RMSE of 0.49 log units for predicted partition ratios. These results are promising for using experimentally determined HLCs (which can be converted from vapour pressure) to characterize relevant properties of environmental media, especially for UVCB substances.
TP241 An Approach to Estimating the Aquatic Risk of Complex Petroleum Substances Following Wastewater Treatment

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Petroleum substances are considered to be substances of Unknown or Variable composition, Complex reaction products or Biological materials (UVCBs), consisting of 10’s to 1000’s of individual components in variable proportions, the majority of which are hydrocarbons. These substances are used in many different industrial, commercial and consumer applications, and may be released to wastewater that eventually undergoes wastewater treatment (WWT). The physical and chemical properties of each individual component affect its removal in wastewater treatment processes, resulting in changes in the relative proportion of individual components of the substance post-treatment. This leads to two issues for an ecological risk assessment: 1) removal rates for WWT being dependent on the initial composition of the substance; and 2) a potentially different hazard profile of the UVCB substance post-treatment compared to pre-treatment. An approach was needed to estimate the removal of petroleum UVCBs and resulting changes in composition in order to appropriately develop predicted environmental concentrations (PECs) and estimate hazard of the substance released to the environment after WWT. The Ecological Assessment Division (EAD) of Environment and Climate Change Canada uses a model, PETROTOX, which can estimate the toxicity of a petroleum substance if some details of its composition are known. Therefore, EAD wanted an approach to estimate WWT removal of petroleum substances which could be used with PETROTOX. An approach was developed that combined the library of hydrocarbon representative structures and mapping scheme of structures to hydrocarbon blocks found within PETROTOX with wastewater removal models to estimate the removal of hydrocarbon components during WWT. This approach was then used to estimate the total removal rate of the substance, which was used to estimate the PEC, and the post-treatment composition, which was entered into PETROTOX to estimate hazard. The PEC and hazard were then compared to determine risk. Overall risk decreased due to the removal of petroleum constituents during WWT. However, the modeling analysis indicated that the composition of the UVCBs shifted, which affected the hazard differentially dependent on the specific petroleum substance. The approach is described, and the impact of assumptions (e.g., block size in PETROTOX) and compositional data resolution on the results are discussed.

TP242 Analyzing complex mixtures for bioaccumulation potential using the trout in vitro metabolism assay (OECD TG 319A & B): A case study, fir (pine) oil

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Bioaccumulation potential determination using the bioconcentration factor (BCF) is used widely by regulatory agencies (e.g. REACH, ECHA) for the PBT (Persistency, Bioaccumulation and Toxicity) criteria in risk assessment of chemicals. Biotransformation of chemicals is a key component in order to determine if a chemical is enzymatically degraded by organisms in the environment and impacting environmental and human health. We are utilizing the recently approved OECD TG 319A and 319B trout in vitro metabolism methodology to assess the bioaccumulation potential of fir (pine) oil. The objectives of the present study are several-fold: a- determine the metabolism of pine oil by assessing biotransformation of 9 main components (alpha-pinene, beta-pinene, camphene, carene, limonene, terpinolene, borneol, bornyl acetate, and caryophyllene) in a Natural Complex Substance (NCS) b- compare these results with a recent in vivo benchmarked fish dietary study of the same fir oil mixture that has been undergoing in McLeod’s laboratory at the Stockholm University c- compare the in vitro biotransformation of the components in the NCS mixture and individually. In our animal alternative methodology in vitro study we are utilizing rainbow trout liver S9 and cryopreserved hepatocytes. The analytical method has been optimized in order to separate and resolved the main components of this mixture for accurate analysis. In addition, individual components have been used to match the identity of the components in the complex mixture of fir oil. These individual components will also be assessed in a subsequent phase of the study for in vitro metabolism using the same TG 319A and 319B and compare the results with the behavior of each component in the mixture. The in vitro metabolic assay is a powerful tool that can be used to determine BCF of test chemicals and also provides data to build the database information on fragrance materials for fish metabolism and modeling. In addition, this in vitro methodology offers the great advantage and flexibility of varying factors at the cellular level in order to obtain a more realistic scenario of the chemicals-enzyme interactions (e.g. inhibition, induction) which is not possible utilizing in vivo methodologies.

Estimating Environmental Hazard and Risks from Exposure to Perfluorinated and Polyfluorinated Alkyl Substances (PFAS): Outcome of a Focused Topic Meeting

TP243 An Evaluation of the Acute and Chronic effects of PFAS in avian species to derive threshold values

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Perfluoroalkyl substances (PFAS) are synthetic fluorinated organic compounds that can be released into the environment during manufacturing processes, from commercial products and applications, or indirectly via oxidation of precursor molecules containing fluoroalkyl chains. Currently over 3,000 PFAS have been identified in environmental biotic and abiotic media that can include perfluoralkyl carboxylates (PFCAs), perfluoralkyl sulfonates (PFSAs), perfluoralkyl phosphonic acids (PFPA) and fluorotelomer alcohols (FTOHs). Recently, PFAS have received increased attention in federal and state monitoring programs that have primarily focused on aspects related to human exposure and health. Ecologically, numerous studies have demonstrated the bioaccumulation of PFAS into aquatic organisms and avian and mammalian wildlife, however the significance of these data relative to the risk they pose to wildlife is difficult to ascertain due to the lack of ecotoxicity data. This issue is especially relevant for avian species where few laboratory studies have been conducted and of which most have focused on either perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA). To address this issue, we have conducted a review of avian laboratory studies and field studies with a focus on apical endpoints (survival, growth and reproduction) and other indices of health including immunological and neurological endpoints. Field studies with avian species that relate exposure to potential adverse health outcomes will be discussed taking into account both direct effects of PFAS on avian populations, and confounding factors (study design, endpoint selection and presence of additional chemical classes) that influence interpretation of results. Finally, these data will be evaluated relative to their potential utility in deriving scientifically useful and defensible toxicity reference values (TRVs) along with insights into what is still needed to provide a greater understanding of potential risks that PFAS pose to wildlife.

TP244 Ecological Assessment Challenges/Data Gaps for Short-Chain (C4-C7) Perfluoroalkyl Substances and Long-Chain (C9-C20) Perfluoroalkyl Sulfonic Acids

J. Kurias, Environment and Climate Change Canada / Department of Environment and Climate Change

Risk assessments conducted under the Canadian Environmental Protection Act, 1999 for perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA) and long-chain (C9-C20) perfluoroalkyl
carboxylic acids (PFCAs) have concluded that these substances are harmful to the environment. Concerns raised internationally that short-chain (C4–C7) perfluoralkyl substances (PFAS) and long-chain (C9–C20) perfluoralkyl sulfonic acids suggest that these substances have similar ecological impacts as PFOA and PFOS. These substances are not manufactured in Canada but are found in Canadian biota/environment. There are significant ecological assessment challenges including data gaps for these substances. Environment and Climate Change Canada is presently developing a report outlining data gaps and their relevance to the evaluation of ecological risk to encourage data generation. Some key points include: Air-breathing marine/terrestrial mammals and birds are the species most bioaccumulative for PFAS and of most ecological interest; Short-chain PFAS toxicity values ranged from 110 to 20 250 mg/L in fish, daphnia and algae. Similar results were seen for PFOA, PFOS, and long-chain PFCAs; Obtaining ecotoxicity data for marine/terrestrial mammals is difficult given the large number of substances to test and large body sizes. New approach methodology can be helpful to evaluate toxicity if links from molecular/cellular level can be made to a mode of action or gross effect (i.e., reproduction, growth & development), and if modes of action are conserved across species (if so, which modes of action and for which species) to allow for read-across to marine/terrestrial mammals, birds or saltwater fish; PFAS bioaccumulation based on fish, daphnia and algae alone cannot be used to reliably predict food web bioaccumulation for marine/terrestrial mammals or birds; Species differences result in different rates of bioaccumulation making extrapolations between species and between PFAS chain length difficult; Short-chain PFAS and long-chain PFAS are QSAR-difficult. Estimates of log Kow or using log Kow of neutral species can result in unreliable bioaccumulation predictions. Some bioaccumulation models incorporate key characteristics of PFAS (i.e., ionizing and preferential protein partitioning). However, model results remain unreliable as training sets are based on freshwater fish, few empirical data or use either protein-partitioning or lipid-partitioning, but not both.

**TP245 Fluoropolymers are ‘benignly persistent’, analytically distinct PFAS that pose no hazard to human or environmental health**


In order to protect public health and the environment, efforts to restrict/regulate PFAS must focus limited resources on those that pose the greatest risk. Exposure pathways, physical, chemical and toxicological properties, and valid analytical methods are needed to identify and regulate appropriately. The recent legislative definition of “PFAS” is overly broad and includes fluoropolymers satisfying the OECD Polymer of Low Concern (PLC) criteria, as well as drugs, pesticides, veterinary drugs and those PFAS listed or recommended for listing as Persistent Organic Pollutants. This definition is not adequate for grouping for hazard assessment, risk management, regulation, monitoring or analyses. Presented here is a science-based approach for prioritizing efforts to better understand PFAS toxicity to inform regulatory decision-making. Tables comparing the properties of the polymeric and non-polymeric PFAS categories and the five PFAS classes response to each type of analytical method are presented. Also presented is a proposal to designate one or more specific PFAS subclass as “PFAS of concern” and exclude polymers that meet OECD PLC criteria. Toxicity data, physical/chemical/thermal properties and residuals demonstrate that fluoropolymers that are PLCs are not bioavailable, toxic, or bioaccumulative. They have little to no water solubility or volatility and pose a low risk of environmental mobility. They are stable/persistent and do not degrade in biota or the environment, nor do toxic substances leach from them, even under exaggerated extraction. This fluoropolymer data has been approved by global regulatory authorities for commercial permanently implanted cardiovascular medical devices. Fluoropolymers that are PLCs are “benignly persistent” PFAS that do not pose a hazard to human or environmental health. They are a distinctive PFAS class that can be analytically differentiated by readily available, reliable, and reproducible methods. Accordingly, “benignly persistent” PFAS should not be the focus of limited resources to protect public health.

**TP246 Modeling of Potential PFAS Leaching from Land Applied Biosolids to Groundwater**

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One source of potential concern for the entry of PFAS into the environment is the land application of biosolids. Biosolids, often from municipal wastewater treatment facilities, are most often applied to agricultural land to provide nutrients required for plant growth. Due to the ubiquitous nature of PFAS in our society, their presence in wastewater biosolids is often detected at variable concentration levels. Understanding the limits to the concentrations of PFAS in land applied biosolids that are required to be protective of groundwater sources for drinking water is of high importance. Screening level approaches for estimating PFAS concentration limits in agricultural soils have been largely derived from contaminated sites, which assume a very different conceptual model than a biosolids application to cropland. The use of inappropriate models in deriving regulatory concentration limits on PFAS in biosolids has the potential to result in mismanagement of biosolids as a beneficial resource. An approach to modeling the leaching of two common PFAS chemicals, PFOA and PFOS, was developed based on contaminant transport modeling used by USEPA in the regulation of agriculturally applied pesticides. The Pesticide Root Zone Model (PRZM) predicts surface runoff, erosion, and leaching of chemicals applied at the land surface, and accounts for sorption/desorption and multiple degradation processes when relevant. The PRZM model was applied to evaluate the potential for PFOA/PFOS leaching to groundwater in Maine, and to estimate biosolids concentration limits required to protect groundwater resources. A spatial analysis of cultivated cropland and pasture/hayland in Maine was conducted to identify four representative soils in these areas, ranging from sandy low water holding capacity soils to clay high water holding capacity soils. These four soils were used to parameterize the PRZM model using Maine specific weather and crop growth parameters. An ensemble of model simulations, evaluating a range of sorption characteristics (Kd), groundwater depths, and biosolids application rates, provided data that allowed for better informed determination of the relationships between PFAS concentrations in land applied biosolids and their presence in groundwater.

**TP247 Perfluorooctanesulfonate (PFOS) induces apoptosis of neuronal cells via NMDA receptor-mediated ERK pathway**

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Perfluoroalkyl compounds (PFCs) may pose a potential risk of neurotoxicity. Perfluorooctanesulfonate (PFOS) is one of the major PFCs found in humans. PFOS is one of the major PFCs detected in serum samples taken from the general population as well as in umbilical cord and breast milk. Serum level of PFOS in children has been reported to be greater than adults. Many studies have demonstrated that the early exposure to environmental chemicals increases the risk of neurodegenerative diseases such as Parkinson’s disease in later life. This raised a concern over their health effects. While PFOS is known to induce neuronal cell death, its mechanism remains unclear. In this study, the effects of PFOS on neuronal cell death were examined using PC12 cells as a model of dopaminergic neuron to understand the underlying mechanisms. The treatment with PFOS reduced cell viability in a dose-dependent manner. PFOS increased cell apoptosis which was measured by caspase-3 activity and TUNEL staining. MK801, a NMDA receptor antagonist, reduced PFOS-induced apoptosis. PFOS increased the activations of ERK1/2, JNK and p38 MAPK with different temporal modes. The treatment with PD98059, an ERK inhibitor, significantly reduced apoptosis, whereas SB203580, a p38 MAPK inhibitor, had no effect. JNK inhibition by SP600125 significantly increased apoptosis. PFOS exposure also
increased ROS formation, which was completely blocked by antioxidants, Trolox or N-acetylcysteine (NAC). However, neither Trolox nor NAC reduced PFOS-increased apoptosis, suggesting that ROS may not be a critical mediator for PFOS-induced apoptosis of cells. These results have demonstrated that PFOS induces the apoptosis of dopaminergic neuronal cells via NMDA receptor-mediated ERK pathway. Our results may contribute to understanding cellular mechanisms of apoptosis and identify target molecules for assessing the risk of PFC-induced neurotoxicity.

TP248 Uncertainties in Conducting Ecological Risk Assessments for PFAS Compounds
S.M. Jones, GHD
PFAS compounds have received a great deal of attention in recent years. Whereas strides have been made in analytic technical, advances in our knowledge of toxicity, particularly to ecological receptors, have lagged behind. Because PFAS compounds are known to bioaccumulate and biomagnify in aquatic food webs, regulatory agencies at the federal, provincial, and state levels are requiring ecological risk assessments (ERAs) to evaluate risk to aquatic life and upper trophic level ecological receptors that forage on aquatic prey. Due to absence of a robust database on the ecotoxicity of PFAS, there is a high degree of uncertainty in evaluating risk to ecological receptors, and subsequently, identifying risk management measures. For example, few studies have identified toxicity reference values (TRVs) for avian receptors, with values differing by orders of magnitude among taxonomic groups and feeding guilds. This presentation will discuss the variability in ecological screening guidelines for freshwater and marine water, sediment, soil, and biological tissue from jurisdictions in Canada, Australia/New Zealand, and other countries. Variability in bioaccumulation factors (BAFs), biota sediment accumulation factors (BSAFs) and TRVs for avian and mammalian wildlife will also be presented. Measures to reduce uncertainties in ERAs will be discussed.

Ecological Risk Assessment: What Matters and Prioritization of Resources

TP249 Assimilation of Ash-Related Arsenic and Selenium Contamination in Bubbling Mayflies - Why Tissue Collection for Food Chain Evaluations Matter
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Benthic invertebrates provide an important food source to aquatic and terrestrial wildlife and, in contaminated water bodies, they also can contribute to the transfer of contaminants from sediments into the aquatic and terrestrial ecosystems. This study focuses on the assimilation of arsenic (As) and selenium (Se) from coal ash into the nymph stages of the common and widespread burrowing mayfly Hexagenia bilineata and compares the measured tissue concentrations to predicted tissue concentrations using literature-derived bioaccumulation factors. Depurated and non-depurated Hexagenia nymphs were collected annually from 2009 to 2017 at up to 11 sites and were analyzed for As and Se. Mean levels of As in Hexagenia tissue ranged from 0.58 to 4.67 mg/kg-dw in depurated individuals and from 2.3 to 19.0 mg/kg-dw in non-depurated tissue. Estimated concentrations of As in tissue based on literature-based bioaccumulation factors and regression models varied widely and both over- and underestimated As tissue concentrations, whereas predicted As tissue concentrations for non-depurated tissue consistently underestimated measured As tissue values. Mean levels of Se in Hexagenia ranged from 3.0 to 9.6 mg/kg-dw in both depurated and non-depurated individuals. Estimated Se tissue concentrations calculated from a literature-based bioaccumulation factors underestimated Se tissue concentrations at low sediment concentrations and overestimated Se tissue concentrations at high sediment concentrations. Differences between measured and predicted tissue concentrations suggest that site-specific conditions may affect the assimilation rates of metals. Differences may also reflect species-specific uptake given that literature-based bioaccumulation factors and models are often based on multiple invertebrate species. Therefore, standard bioaccumulation factors may not accurately predict the contribution of some contaminants to upper trophic level consumers that feed on these organisms. This presentation highlights the importance of understanding uncertainties of key parameters in ecological risk assessments and how collecting site-specific tissue measurements of representative invertebrate species in wildlife diets can alter predicted risk outcomes.

TP250 Ecological Risk Assessment of Heavy Metals from Informal E-waste Processing in Alaba International Market, Lagos, Nigeria
A.A. Adebayo, A.O. Ogunkeyede, Federal University of Petroleum Resources / Environmental Management and Toxicology; O. Oshibanjo, Basel Coordinating Center for Africa / Department of Chemistry, University of Ibadan
Informal electronic waste (e-waste) processing is a crude method of recycling, which is on the increase in Nigeria. The release of hazardous substances such as heavy metals (HMs) into the environment during informal e-waste processing has been a major concern. However, there is insufficient information on environmental contamination from e-waste recycling, associated ecological risk in Alaba International Market, a major electronic market in Lagos, Nigeria. The aims of this study were to determine the levels of HMs in soil, resulting from the e-waste recycling; and also assess associated ecological risks in Alaba international market. Samples of soils (334) were randomly collected seasonally for three years from fourteen selected e-waste activity points and two control sites. The samples were digested using standard methods and HMs analysed by inductive coupled plasma optical emission. Ecological risk was estimated using Ecological Risk index (ER), Potential Ecological Risk index (RI), Index of geoaccumulation (Igeo), Contamination factor (CF) and degree of contamination factor (Cdmg). The concentrations range of HMs (mg/kg) in soil were: 16.7-11200.0 (Pb); 14.3-22600.0 (Cu); 1.90-6280.0 (Ni), 39.5-4570.0 (Zn); 0.79-12300.0 (Sn); 0.02-138.0 (Cd); 12.7-1710.0 (Ba); 0.18-1310.0 (Cr); 0.07-28.0 (V), while As was below detection limit. Concentrations range in control soils were 1.36-9.70 (Pb), 2.06-7.60 (Cu), 1.25-5.11 (Ni), 3.62-15.9 (Zn), BDL-0.56 (Sn), BDL-0.01 (Cd), 14.6-47.6 (Ba), 0.21-12.2 (Cr) and 0.22-22.2 (V). The trend in ecological risk index was in the order Cu>Pb>Ni>Zn>Cr>Ba>V. The potential ecological risk index with respect to informal e-waste activities were: burning>>dis mantling>>disposal>>stockpiling. The index of geo accumulation indices revealed that soils were extremely polluted with Cd, Cu, Pb, Zn and Ni. The contamination factor indicated that 93% of the studied areas have very high contamination status for Pb, Cu, Ba, Sn and Co while Cr and Cd were in the moderately contaminated status. The degree of contamination decreased in the order of Sn>Cu>Pb>>Zn>Ba>Co>Ni>V>Cr>Cd. Heavy metal contamination of Alaba international market environment resulting from informal e-waste processing was established. Proper management of e-waste and remediation of the market environment are recommended to minimize the ecological risks.

TP251 Geospatial approaches to increasing the ecological relevance of chemical risk assessments
For several decades, the prospective risk assessment of chemicals has followed a generic approach of comparing estimated exposures to toxic thresholds designed to be protective of all species (i.e., assessing exposure to the most sensitive species assumed to be located anywhere the chemical may occur in the environment). This approach does not recognize geographic patterns of species distributions or acknowledge that particularly sensitive species may not occupy potentially exposed habitats. Therefore, risk assessments could be overly conservative and restrictive for some uses of chemicals. Approaches for making spatially explicit assessments of chemical exposure are relatively advanced but this is not the case for mapping and assessing ecological data. However, geo-referenced
ecological data appear to be increasingly available at spatial resolutions applicable to chemical risk assessment, potentially facilitating enhanced environmental relevance of such risk assessments. In 2017 a Task Force was initiated by European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) to assess the capability of making chemical risk assessments using available geospatially referenced chemical exposure, ecological receptor and ecosystem services data. Two case studies were developed to illustrate the potential to assess geo-referenced risks to ecological receptors in fresh water and terrestrial environments exposed to i) a chemical used in consumer cleaning products discharged via municipal WWTPs across the EU and ii) a range of representative active ingredients used in plant protection products on selected crops in Germany. After initially compiling a catalogue of available geo-referenced ecological data for Europe, geo-referenced exposure concentrations were derived by combining accessible chemical use and fate data with conventional exposure models. However, use of many ecological data sets over a pan-European range proved problematic due to data access issues, limited geographic coverage and unreliable quality. Nevertheless, several suitable ecological data sets were accessed after making specific requests to various organizations within national authorities and these were integrated with the exposure maps. The results of these case studies give an indication of the potential value of making geo-referenced chemical risk assessments as well as the limitations to current capability.

TP252 Modifying the Ecological Risk Assessment Framework for Managing Environmentally Sensitive Sites
L. McDonald, J. Kirk, B. Hard, M. Whelly, ARCADIS Canada, Inc.; L. Tam, ARCADIS Canada, Inc. / Environment

Point Pelee National Park (PPNP) in southern Ontario includes Middle Island and a mainland portion which is a triangular sand spit formation extending 10 kilometres into Lake Erie. PPNP is located at the centre of two central migratory flyways and provides habitat critical for hundreds of species of migrating birds and insects. PPNP protects a mosaic of ecosystems located in the most biodiverse natural region in Canada, the Carolinian ecozone. 70 COSEWIC-listed (Committee on the Status of Endangered Wildlife in Canada) species are currently found in the park, including 60 federally protected Species At Risk (SAR), as per Schedule 1 of Species at Risk Act, with three SAR found only on Middle Island. The majority of the mainland PPNP is marshland, with remaining 30% composed of dry forest, swamp forest, beach, and savannah habitat. Numerous investigations have documented a variety of contaminants of concern (COCs) in both aquatic and terrestrial media. The objective of the risk assessment (RA) for mainland PPNP was to more accurately represent unacceptable risks to all ecological receptors beyond the capacity of traditional RA models with the goal of more precise characterization of site-specific bio-transfer of contaminants to ecological receptors. This will allow better estimation of exposures and risk for the species that require protection. Given the biodiversity of the park and presence of many SAR, wildlife vertebrate sampling was not advisable, and a more unique approach was recommended. Arcadis developed a site-specific Conceptual Site Model (CSM) in conjunction with Parks Canada Agency (PCA) to more accurately demonstrate the ecological food web interactions and refine recommendations. Arcadis has recommended sampling a variety of primary producers and invertebrates being consumed by SAR to better understand the transfer of COCs from soil, sediment, and water. In particular, the diet of certain SAR required extensive research of receptor characteristics not typically modelled in RAs. Other potential tools may include field surveys related to bio-magnifying compounds and population health assessments. The RA, currently in draft, will enable federal custodians to better understand rates and spatial patterns of COC uptake and transfer within the park to determine whether risk management and/or remediation is appropriate and how it can be implemented most effectively at PPNP, where and if required, to protect this biodiverse ecosystem.

TP253 Practical Advancements in Endangered Species Risk Assessment Efficiency
S. Teed, Intrinsik Corp.; M.E. Kern, Waterborne Environmental, Inc. / Ecotoxicology Risk Assessment; J.L. Cowles, NovaSource / Tessenderlo Kerley, Inc. / Product Safety

With the release of the Environmental Protection Agency (EPA) and National Marine Fisheries Service (NMFS) organophosphate case studies for endangered species risk assessment, it became clear that the methods used in the biological evaluations and biological opinion need refinement for identifying risk to listed species and the critical habitat on which they may depend. With hundreds of pesticide registration actions annually, and more than 1,660 species listed under the Endangered Species Act, it is critical to be able to conduct a scientifically defensible risk assessment efficiently with limited time and resources. However, confidence must be high that the listed species or the critical habitat on which they depend can readily be identified as being not at risk, or at potential risk. The recently released EPA revised method for developing biological evaluations addresses some aspects of these short comings, by recognizing early in the problem formulation process that some listed species will not be exposed to a pesticide for a variety of reasons (e.g., they are extinct or extirpated; only found on federal lands). However, there are many possible additional considerations that matter, can be accounted for, and may vary on a pesticide by pesticide basis. These include label restrictions, simple spatial refinement, specific fate/behavior characteristics, listed species life history information, known and previously evaluated pesticide tolerances, and other factors. In a CropLife America funded project, these practical advancements are being identified and evaluated for use in the problem formulation process. In this presentation, the carbamate pesticide carbaryl is used to evaluate the impact of these factors on the endangered species risk assessment process, along with examples from other chemistries to more clearly show their utility.

TP254 Utilization of a Web-Based Tool ChemTHEATRE in Exposure and Risk Assessments for Chemicals
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A huge number of monitoring data on chemicals in various environmental and biological specimens have been reported in scientific journals. However, comprehensive, public repositories to store such valuable data set of the chemicals do not exist; researchers are forced to spend lots of time and cost in collecting and utilizing the published data, when modelling environmental behavior and fate of, and performing the risk assessment for, the chemicals of interest. Therefore, we have launched a platform to register and visualize the monitoring data of environmental contaminants, named ChemTHEATRE (Chemicals in the THEATRE: Tractable and Heuristic E-Archive for Traceability and Responsible-care Engagement) in 2016. To date, data described in more than 87 projects have been registered on the platform. Users can find e-archived chemical concentration data in the environmental and biological specimens each with associated metadata such as sampling date and location, species, and biometrics, and can download them in text files. Bridging ChemTHEATRE to AIST-MeRAM (Multi-purpose Ecological Risk Assessment and Management Tool) storing chemical property and/or hazard/toxicity information provides us high accurate and transparent assessment of ecological risk of chemicals. AIST-MeRAM can output the results of exposure and risk assessments very easily and quickly just importing the text file containing monitoring data exported from ChemTHEATRE. Much effort is currently being devoted to visualizing e-archived data sets, and enhancing available data-model interfaces to
Bayesian Network Applications for Environmental Risk Assessment and Adaptive Management

TP255 A stochastic framework for estimating freely dissolved concentrations: Implications of variance in observed sediment-porewater partitioning

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The use of passive sampling to quantify freely dissolved and bioavailable contaminants (Cfree) in sediment porewater has led to innovative management strategies. However, variance in contaminant partitioning strength in natural systems remains, in many cases, an intractable problem due to a complex environmental conditions. When solid-phase contaminant concentration (Ctotal) is known but direct porewater measurements are not available, variance in sediment-porewater partitioning (KTOC) translates to variance in estimated porewater contaminant concentrations. The variance in estimated C-free has important implications for comparisons to risk-based thresholds. We propose a framework in which a range of Cfree exposure estimates are stochastically paired with effects data, providing a transparent way of quantifying the risk of Cfree exceeding a threshold. The proposed stochastic framework uses passive sampling-derived variance in KTOC as the basis for a continuous estimate of the probability that Cfree will exceed a threshold along a continuum of Ctotal. Our results show that passive sampling-derived KTOC distributions differ markedly among the studies included in our analysis, and that risk curves derived from KTOC distributions depend on the scale of variance present in the partitioning distribution. KTOC probability distributions can be updated for a specific site based on additional site-specific passive sampling-derived porewater measurements. Bayesian analyses can be used to adjust distributions to reflect knowledge of site-specific conditions without the need for wholesale resampling. For assumed parametric KTOC distributions, we apply Bayesian updating to estimate the number of samples needed to quantify site-specific model parameters based on case studies from two contrasting environmental conditions. The proposed methods have applicability beyond sediment contaminant partitioning and advance the basis for understanding and quantifying uncertainty associated with risk management decisions.

TP256 A short introduction to the application of Bayesian networks in ecological risk assessment and decision making

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Bayesian networks (BNs, also known as Bayesian belief networks) are a means of describing cause and effect using directed acyclic graphs where the interactions between the nodes are described using conditional probability tables. That is a way of saying that there are nodes (steps in a cause-effect model), which are connected by lines of influence, and the interactions are described using probability tables that take into account all possible combinations of inputs to generate the probability distributions for each possible outcome. Bayesian networks inherently incorporate uncertainty and can use wide varieties of data, from precise determinations of molecular interactions to expert elicitation. Since 2010 a number of papers have been published on the use of BNs to evaluate management options, to evaluate risk, to provide a more quantitative framework for the relative risk model, and to become a part of adaptive management. At the 2017 SETAC NA (Sacramento) and the 2018 SETAC EU (Helsinki) this sessions included presentations by developers and users of Bayesian networks to estimate risk, calculate the outcomes of management alternatives and the use of such techniques to make policy decisions. The topics included large scale risk assessments, BNs in QSAR models, the use of BNs to build quantitative adverse outcome pathways, sustainable management of large scale systems, and the management of environmental resources. This session will include presentations integrating the use of pesticides and synthetic biology, multiple stressors, and other applications. The question will be where do we go now that the use of Bayesian networks is part of the mainstream of risk assessment and decision making.

TP257 Risk Assessment Framework for Gene Drive Technology: Example in Integrated Pest Management

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As of June 2019, there has been no ecological risk assessment which incorporates synthetic biology stressors and potential impacts into a multiple-stressor/multiple-endpoint model. To start developing a framework for this risk assessment scenario, the Relative Risk Model (RRM) was employed in the context of environmental applications of gene drive technology, which aims to spread engineered genes through populations of organisms with relatively short generational times. A conceptual framework and Bayesian Network were constructed for a pest management scenario of non-indigenous mice on the South Farallon Islands. Potential ecological, toxicological, spatial, and temporal influences were incorporated into the Bayesian Network, which quantitatively relates variables using causal knowledge. Two management scenarios are discussed for mouse eradication in the Farallonones: the first is the “Preferred Alternative” put forth by the United States Fish and Wildlife Service (USFWS) in a recent environmental impact statement. The second is deployment of gene-drive-modified mice, which are intended to spread female sterility through the wild non-indigenous mouse population. Integrated pest management, a management goal with the purpose of minimizing the use of chemical pesticides, is discussed in the context of these two potential management strategies, taking into account the possibility of interactions between gene-drive mice and chemical pesticides. The National Academies of Science, Engineering, and Medicine’s (NASEM) report on gene drives outlines a “phased testing pathway” for potential deployment of gene drive organisms into the environment. This testing pathway is discussed in the context of its relation to the risk assessment process and with the scope of developing lab and field experiments for gene drive development. An example of dose-response toxicity data analysis in the context of uncertainty, probability, and gene-drive factors was also outlined to give an example of what experimental design considerations should be accounted for in a risk assessment, as well as a discussion of experimental and modeling assumptions. Additionally, needs for future work is discussed in the context of parameterizing a risk assessment model that incorporates synthetic biology stressor and impact variables in a probabilistic manner.

TP258 A Bayesian network approach for estimating distribution parameters with detected and non-detected environmental concentration data

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Environmental data often contain non-detects that can bias a data or exposure analysis if mishandled, such as by substituting artificial point
values for the non-detected data. Bayesian analysis is infrequently used with environmental concentration or exposure distributions for handling non-detected data but can incorporate more of the uncertainties for data and parameters than conventional methods. An approach that relies on Bayesian networks for handling non-detects was developed to estimate the parameters of probability distributions built with environmental concentration data. Multiple reporting limits can be used to accommodate the non-detected data and uncertainty ranges can be input to detected data, if useful and appropriate. The approach requires identifying initial prior probability distributions for the distribution parameters and the ranges or point estimates for detected or non-detected data. The uncertainties from the data are propagated to the distributions for parameters using Bayes theorem. The output environmental concentration distribution from the posterior probabilities for the parameters then includes uncertainties from both the parameters and concentration data. We briefly demonstrate the creation of a distribution of environmental concentrations and discuss the application of the Bayesian network distributions in temporal Bayesian learning. Bayesian hypothesis testing, benchmark exceedence calculations, and causal risk-based modelling. The Bayesian network approach to constructing an environmental concentration distribution may be more labor-intensive than classical and other Bayesian approaches as it requires prior probability distributions for parameters and additional time to construct the graphical components of the model. But the Bayesian network approach potentially provides a rigorous and flexible way of including uncertainties from non-detected data and distribution parameters.

TP259 Adaptive management framework and Bayesian network analysis for regional climate change assessments

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Understanding and planning for climate change is a complex systems problem that is interdisciplinary and requires place-based and impact-specific management practices for communities to become resilient to a changing environment. The greater Charleston Harbor region of South Carolina is highly susceptible to the projected impacts of climate change due to low lying geography, a strongly bimodal socioeconomic spectrum, and invaluable coastal ecosystem services. Using Charleston as an example community, this presentation discusses the application of the Bayesian Network-Relative Risk Model for a system-level, community-focused risk and resilience assessment that aims to enable community involvement in the assessment of and planning for climate change-induced severe weather events, more extreme temperatures, and sea level rise. For climate change assessment, be it for vulnerability, risk, or resilience, to be both contextually and geographically relevant, and be able to foster local commitment to feasible solutions, a holistic assessment approach must 1) employ community-based and community-participatory research methods that acknowledge and treat the community members as collaborators, rather than subjects for observation, 2) integrate regionally-relevant data from disparate disciplines and data sources, and 3) evaluate community-centered solutions through the measurement of qualitative and quantitative resilience metrics that are assessed through the community lens. Effective vulnerability, risk, and resilience assessments do not exist independent of a decision-making framework, such as the adaptive management framework. Adaptive management is an iterative decision-making process that formalizes the qualitative social values (e.g. cultural, well-being) of a community given governing social constraints (e.g. economic resources, legislation) such that relevant management options can be quantitatively evaluated against each other such that system uncertainties are reduced. When paired with Bayesian network analysis, the assessment process within the adaptive management framework allows assessors and decision-makers to parameterize and operationalize system attributes and processes that affect stakeholder endpoints of concern/value. Bayesian network analysis is ideal for such research as it integrates data from diverse sources and probabilistically quantifies spatially explicit risk, thus supporting nuanced decision-making through scenario-based management options.

TP260 Bayesian network model for risk assessment based on fish embryo testing: A probabilistic weight-of-evidence approach

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Reduction of animal testing wherever possible is requested by EU Directive on the protection of animals used for scientific purposes (2010/63/EU). Fish Embryo Toxicity (FET) testing can be an alternative to using juvenile fish in acute toxicity testing. However, FET data are currently not accepted as a replacement to juvenile fish acute toxicity data for regulatory purposes such as REACH, without sufficient weight of evidence (WoE). The development of a WoE approach for FET data has been recommended by the European Chemicals Agency to significantly reduce the number of animals required for hazard assessments of chemicals. We propose a Bayesian network (BN) modelling approach for quantifying the lines of evidence demonstrating the relationship between FET data and juvenile fish toxicity results. The purpose of the proposed BN model is to integrate information from large ecotoxicological and physico-chemical datasets, and apply it in a WoE approach to predict fish acute toxicity of chemicals from data on fish embryo toxicity testing in combination with other predictive information. The model has been developed from data on fish embryo and juvenile acute toxicity in combination with other information for more than 200 chemicals. The BN predicts the toxicity level of each chemical to juvenile fish by combining information in four pathways: (1) fish embryo toxicity, (2) physical and chemical properties, (3) toxicity to fish of other chemicals in the same category, and (4) toxicity to other species (algae and Daphnia). The conditional probability tables are quantified either by frequencies of observations or by expert judgement. The current version of the model predicts the correct toxicity interval for 65-80% of the tested chemicals, depending on the criteria for data quality. We aim to improve the model performance by training the model with a larger dataset and by identifying the chemical categories for which the model has high accuracy. This BN model can be used to assess the risk of various contaminants to fish based on fish embryo toxicity data in combination with other available information without the need to perform fish acute toxicity testing. The current version of the BN model has also been implemented as an online tool for testing and demonstration. More generally, this study demonstrates how a WoE approach for predicting risk to unmeasured endpoints can be quantified as a BN model.

TP261 Using structured decision-making-stakeholder engagement to integrate community values with scientific understanding for better decision-making

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By the early 1970’s, the state of the environment in the United States had been degraded to the point that the public was raising greater concerns about litter and debris, contaminated waters, beach closures, rivers catching on fire, and deteriorating air quality to their elected officials demanding something be done to address these very visible environmental problems. With the creation of the USEPA, rapid progress was made to address and fix the most egregious and readily tractable environmental pollution problems. While it made sense to address these ‘low hanging fruit’ problems, in the background were many less easily defined (i.e. “wicked”) problems that needed addressing. Such problems were not readily solved by technical solutions and regulations alone due to inter-related socio-economic and environmental constraints. The multi-disciplinary nature of such problems necessitates methods and means to include community stakeholder values to inform management objectives and performance metrics, combined with technical/scientific expertise
for integrated assessment and evaluation of proposed solutions. DASEES (Decision Analysis for a Sustainable Environment, Economy and Society) is a web-based tool predicated on the precepts of decision analysis, aimed at enabling users to better formulate, assess, evaluate, and communicate issues, solution results and trade-offs to address complex problems. The DASEES user-interface provides a suite of tools for structuring and analyzing environmental management problems, that are accessible and understandable to a broad range of stakeholder expertise. DASEES is designed to capture stakeholder provided information and integrate scientific data and expertise, in a transparent and inclusive approach to develop and evaluate solutions. Alternative evaluation, (the stakeholder-derived valuation of data/science-driven metric assessments), is presented through 1) Consequence Tables suitable for more rapid screening evaluations where there is minimal uncertainty, and 2) Bayesian network evaluations where there may be more uncertainty and/or a need to better characterize important socio-ecosystem causal linkages to metrics.

Using Ecological Risk Assessment Frameworks to Determine the Risk of Marine Debris to Marine and Freshwater Ecosystems

**TP262 Alternative Approaches for Estimating Ecological and Human Health Risk of Exposure to Marine Plastics in Data Poor Regions**

B. Polidoro, Arizona State University / School of Mathematical and Natural Sciences; T. Lewis, E. Murphy, Arizona State University

Across the globe, macro and micro sized plastics are increasingly found in marine, freshwater, and terrestrial environments. As a consequence, plastic particles have been shown to incorporate into the food chain, as documented by their presence in humans and in a wide variety of aquatic organisms. However, standardized and/or comprehensive studies on the potential toxicological impacts or adverse outcomes associated with macro or micro plastic ingestion, or other forms of exposure, are widely lacking for the vast majority of species, including humans. As a result, it is difficult to apply a standard risk assessment framework. Based on current projects across the Pacific, two different approaches for estimating risk from ingestion of plastics are presented. In American Samoa, a more traditional, screening-level hazard quotient approach is being employed to estimate potential ecological and human health risks associated with consumption of seafood containing microplastics and other associated contaminants. In the Philippines, a macro and micro plastic assessment of relative risk is being conducted for more than 2,000 marine species, based on life history traits in combination with probability of exposure. Through presentation of preliminary results, the pros and cons of these two different approaches are discussed, including their relevance and application for assessing individual, population and ecosystem risks in data poor regions and developing nations.

**TP263 Risk From Microplastics Exposure To Blue Crab Larvae In Delaware Bay And Its Adjacent Coastal Shelf**

J. Cohen, T. Kukulka, A.o. Mason, A. Internicola, University of Delaware

Plastic marine debris is an emerging pollutant of concern both regionally and globally, with microplastics in particular receiving increasing attention. Microplastic marine debris may present serious hazards to individual marine organisms; however, the impact of microplastics at population, community, and ecosystem scales has yet to be systematically studied through risk analyses. Here, we present a risk assessment framework for understanding microplastics effects on an ecologically and commercially important species: the blue crab, Callinectes sapidus. We are using this approach to test whether microplastic marine debris exposure during larval development in the coastal ocean impacts blue crab survival and recruitment to mid-Atlantic estuaries. Our risk assessment framework includes: (1) determination of spatial and temporal distribution of both microplastics and C. sapidus zoae/megalopae in shelf water of the mid-Atlantic Bight based on a high-resolution hydrodynamic numerical model focusing on the region offshore of Delaware Bay, with field sampling for both microplastic and crab larvae guiding the modeling effort; (2) development of concentration-response functions for mortality and growth upon time-integrated microplastic exposure in C. sapidus zoae/megalopae in the laboratory; and (3) quantification of microplastic exposure risk to C. sapidus zoae/megalopae by analyzing microplastic exposure based on results from distribution modeling (1) and adverse responses functions (2). We are employing ecological risk models at the individual and population levels. This ecological risk assessment will result in a decision making tool for resource managers in the mid-Atlantic region currently evaluating the impact of microplastics on this economically and ecologically important species.

**TP264 Using the commercially valuable black sea bass (C. striata) as a model to assess the risk of microplastic pollution across multiple life stages**

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Microplastics have emerged as a global threat to aquatic ecosystems. Coastal and estuarine waters that serve as critical habitats for commercially important fish species are susceptible to microplastic pollution due to their proximity to terrestrial inputs and tidal processes that provide favorable conditions for accumulation. As such, we explored the occurrence and effects of microplastic exposures on the commercially valuable black sea bass (Centropristis striata). Fish were exposed in the laboratory to virgin and contaminated microplastics across larval (10-14 dph), early juvenile (50-60 dph), and late juvenile (320-330 dph) life stages. Larval fish obtained more plastics from their prey, and juvenile fish from some treatments appeared to have a decrease in immune response and increased respiration at high plastic concentrations. Other measured effects of the laboratory microplastic exposures include condition index, hepatosomatic index, gene expression, and chemical desorption into fish tissues. Wild-caught adults were also analyzed to investigate the potential effects of microplastic ingestion on individual hepatosomatic index and condition factor. A major goal of this work was to examine the consequences of these individual-level exposures and effects on overall population dynamics. Thus, we used weight-of-evidence approaches to integrate data collected across different life stages, and also use empirical data supplemented with data from similar fish species to parameterize an integral projection model (IPM). This approach is commonly used in fishery stock assessments. We quantified the effects of exposures to a range of microplastic concentrations, accounting for both population persistence and population variability. Model predictions indicate that microplastic exposure may have longer-term effects on population variability. The projected effects will elucidate the degree to which microplastic pollution affects a commercially valuable species across several life stages, highlighting the need for more commercial fishes to be considered in risk assessment.
Site-Specific Risk Assessment of Soils Impacted by Petroleum Hydrocarbon Mixtures: State of Science and New Approaches

TP265 Developing Site-Specific Petroleum Hydrocarbon Guidelines for a Site in the Taiga Ecozone: Initial Research and Development Stages

L. Eastcott, Imperial Oil Limited / Environmental & Property Solutions

Imperial Oil is currently progressing remediation and reclamation at the Norman Wells operating field (the Site). Remediation work includes excavating soils to meet the Canadian Council of Ministers of the Environment (CCME) environmental quality guidelines. A large portion of petroleum hydrocarbon (PHC) affected soils are amenable to bioremediation, and where possible these soils are treated on-site biocells. However, in some cases the residual PHC Fraction (F3) concentration is the limiting factor, as concentrations remain above CCME eco-contact guidelines. There is some uncertainty around application of the CCME guidelines for eco-contact under Site conditions because of the manner in which they were derived. Toxicity testing was done using agronomic species and earthworms that are not native to or not present in subarctic areas where the Site is located. In addition, the toxicity testing was carried out with fresh crude oil or oil distillates, and not the specific PHC composition of weathered and/or biotreated soils. Thus, Imperial Oil has undertaken to develop Site-specific guidelines for the soil eco-contact pathway using toxicity testing under CCME protocols, which is an option within the regulatory framework of the Northwest Territories for management of contaminated sites. The intent is to assess the toxicity of Site soils to native plant species and a number of invertebrate species using conventional organism toxicity testing, and potentially reduce bioremediation times while providing the same level of protection. The process of developing these risk-based guidelines has involved a number of phases of Research & Development (R&D) work in collaboration with government and academic research teams. The work began with initial field surveys undertaken approximately 10 years ago to identify plants native to the region and to characterize plant root length and invertebrate communities and distributions with depth in soil at the Site. We will share results and lessons learned from the initial R&D stages, and summarize work that is currently ongoing.

TP266 Developing site-specific petroleum hydrocarbon (PHC) guidelines for a site in the Taiga Ecozone

A. Pang, Queen’s University / Environmental Studies; B. Zeeb, Royal Military College / Chemistry Chemical Engineering Dept; A. Rutter, Queen’s University / School of Environmental Studies

Current Canada-wide petroleum hydrocarbon guidelines are derived from toxicity tests using species commonly found in the temperate region, which may misrepresent actual risk scenarios in colder subarctic sites where these species do not reside. Additionally, the toxicity tests were performed using either fresh crude oil or specific sub-fractions of crude oil that do not accurately represent sites contaminated with weathered petroleum hydrocarbons (PHCs). Hence, generic Canada-wide guidelines may be too conservative for a site contaminated with weathered PHCs in subarctic areas and may lead to over-management of northern sites, with measures such as excessive excavation of site soils. Where site conditions significantly modify exposure and risk scenarios, the Canadian Council of the Minister of the Environment (CCME) allows for the derivation of site-specific PHC guidelines. Toxicity tests were conducted following Environment Canada’s biological test methods but with modified summer climate conditions (17°C for 20h Light / 14°C for 4h Dark) for five plant species and four soil invertebrates native to the subarctic ecoregion. For species not listed in Environment Canada’s test methods, similar test protocols were developed. Fine- and coarse-grained reference and contaminated soils were collected and homogenized for testing. Preliminary range-finding tests were conducted using dilutions of contaminated soil mixed with reference soil to determine a concentration range at which the plants and soil invertebrates are being affected. For plants, the endpoints evaluated were root and shoot length and percent emergence. Mortality rate and reproduction were evaluated for the soil invertebrates. Following the range-finding tests, definitive tests were conducted to verify results. The outcome of this research will assist in the derivation of site-specific PHC guidelines for the site in the subarctic ecoregion. Findings and evolving alternative toxicity tests will be discussed during the presentation.

TP267 Evaluating the effectiveness of select biomimetic passive sampling methods for estimating the toxicity of petroleum contamination in soils

R. S. Koster, Royal Military College; A. Rutter, Queen’s University / School of Environmental Studies; B. Zeeb, Royal Military College / Chemistry Chemical Engineering Dept

The derivation of site-specific remediation guidelines for contaminated sites often requires the use of labour-intensive and time-consuming toxicity tests using indicator organisms. The toxicity of petroleum hydrocarbon (PHC) contamination to soil-dwelling invertebrates has been correlated to the bioaccessible fraction of the hydrocarbon mixtures dissolved in soil pore water. Chemical analytical methods that mimic biological uptake (biomimetic methods) of contaminants from soil pore water can be used to estimate the toxicity to organisms without the need for costly toxicity testing. A selection of biomimetic passive sampling methods, including polyoxymethylene (POM) and solid-phase microextraction (SPME) were compared using contaminated field soils of various concentrations. The test soils for this comparison were characterized using standard chemical extraction methods for total PHCs and individual constituents (e.g. volatile organic compounds, and alkyl/aryle-polyaromatic hydrocarbons) as well as total organic carbon, which is known to affect bioaccessibility. The selected passive sampling methods will be used to determine the bioaccessible soil pore water concentrations of total PHCs and individual compounds known to contribute substantially to the toxicity of PHC mixtures such as alkyl- and oxy-polyaromatic hydrocarbons. Each passive sampling method will be evaluated based on consistency, time commitment, resource use, labour requirements, and correlation to toxicological results from concurrent studies. Preliminary results will be discussed in the presentation.

TP268 Acute Toxicity of Water Accommodated Fractions (WAFs) of three Nigerian Crude Oils to Clarias gariepinus (Burchell, 1822)

H. Omogoriola, Nigerian Institute for Oceanography and Marine Research / Fishery Resources

Oil industry activities such as exploration, transportation, storage, use and disposal, as well as oil spills are sources of major contamination problems in Niger Delta, which have significant deleterious effects on aquatic organisms. The objective of this study was to report LC50 values obtained from acute toxicity tests on the African Catfish, C. gariepinus exposed to Water Accommodated Fraction (WAF) -heavy (Ebo), light (Meji) and medium (Erha) crude oils. Acute toxicity concentrations of 0%, 2%, 4%, 6% and 8%, 0%, 15%, 20%, 25% and 30% and 0%, 40%, 60%, 80% and 100% were used to determine the 96h Lethal Concentration (LC50) of heavy, light and medium crude oils respectively. The analysis of variance (ANOVA) showed that there was a significant (p<0.05) differences in the quantal response of C. gariepinus to different concentrations of the various crude oil types at 24, 48, 72 and 96 hours exposure. These results showed that 96LC50 values for heavy, light and medium crude oils on C. gariepinus were 0.028 mg TPH/1, 0.177 mg TPH/1 and 0.742 mg TPH/1 respectively. The 96LC50 of WAF showed that the heavy crude oil was six times more toxic than light and twenty six times more toxic than medium and on toxicity categorization, the heavy, light and medium crude oils were very highly toxic, highly toxic and highly toxic on C. gariepinus. Based on the acute toxicity tests, heavy with lower API (< 22.30C) gravity was more toxic than other crude oils on C. gariepinus. All crude oils are toxic to aquatic organisms especially the fish; their discharge into the water bodies during crude oil exploration, transportation, storage and even sabotage should be discouraged to protect the environment.
TP269 Organic carbon normalization and relevance of species assemblages for soil ecological risk assessments of petroleum hydrocarbon-contaminated soils

A. Gainer, SNC-Lavalin / Soil Science, Toxicology; N.S. Hogan, University of Saskatchewan / Department of Animal and Poultry Science and Toxicology Centre; K.E. Bresee, Intrinsic Corp.; S. Siciliano, University of Saskatchewan / Department of Soil Science

Sediment toxicity studies and ecological risk assessments on organic contaminants routinely apply organic carbon normalization to toxicity data; however, no studies examine its potential for use in soils with petroleum hydrocarbon (PHC) contamination. Limited studies in soil ecotoxicology assess the influence of species assemblages used in species sensitivity distribution curves provided influenced more by soil cation exchange capacity. Incorporating organic carbon into species sensitivity distribution curves provided a higher level of protection to soil dwelling receptors in low organic carbon normalization into species sensitivity distribution curves provided influenced more by soil cation exchange capacity. Incorporating organic carbon normalization into species sensitivity distribution curves provided a higher level of protection to soil dwelling receptors in low organic matter soils as well as reduce the variability of PHC soil toxicity data. Soil remediation guidelines derived for protection of soil dwelling organisms using a diverse species assemblage provided similar levels of protection as guidelines developed with test species specific for remote, forested land uses in Canada. We conclude that: (i) Canadian hazard concentration values for PHC contamination of soils should be revisited as they may not be protective and (ii) that soil PHC guidelines for protection of soil dwelling organisms should be expressed as carbon normalized values.

TP271 Post clean-up analysis of crude oil contaminated agricultural soil at Emede Isoko south local government of Delta state, Nigeria

A.O. Orgukevede, Federal University of Petroleum Resources / Environmental Management and Toxicology; A.A. Adedayo, Federal University of Petroleum Resources Effurun Nigeria / Environmental Management & Toxicology

Emede community in Isoko South local government of Delta state, Nigeria has had a fair share of oil spillage from pipeline leakage. After many years of clean-up by the multinational oil company that owns the pipeline, crude oil is visible on the soil surface of the agricultural area. Hence, the major farm products (cassava and maize) from the farmlands or grazing of goats on plants are of serious concern. This research seeks to examine the concentration of the petroleum hydrocarbon in the soil and Cyperus rotundus (Nutgrass) (indigenous plant on the farmland) at uncultivated farmland in Emede town. Four sampling points were picked at random based on the dark grey colour intensity of the soil surfaces. The surface soil (0 - 15 cm) and subsoil samples (15 cm - 30 cm) were collected using soil auger at same sampling points where Cyperus rotundus were picked. The soils analysed for the following parameters: pH, total organic soil and total petroleum hydrocarbons (TPHs), while TPHs is the only parameter analysed in plants samples. The results of soils sample revealed that the values of TOC ranges from 13.26 ± 1.21 to 19.23 ± 1.21 for surface soil and subsoil samples were 18.13 ± 1.30 to 22.11 ± 4.20. The gas chromatograph-flame ionisation detector (GC-FID) result of the surface soils TPH ranges from 7463.62 ± 8.26 to 37201.30 ± 4.47 mg/kg while subsoil 32368.31 ± 5.32 to 81115.36 ± 48.21 mg/kg. The shoot samples result ranges from TPH 2866.23 ± 5.75 to 15636.52 ± 2.78 mg/kg, and roots values were 1915.06 ± 4.47 to 51448.80 ± 2.78 mg/kg. These soil TPH results were higher than the intervention limit of 5000mg/kg set by the Department of Petroleum Resources (DPR). The nut grass results were very high, and they can find their way into the food chain through goats (common animal within the community) grazing on them. Crude oil contains benzene and toluene that can cause aplastic anaemia, acute leukaemia, bone marrow abnormalities, DNA strand breaks, nausea, weakness, confusion, and at high doses leads to unconsciousness and even death. It further contains 32 polycyclic aromatic hydrocarbons, which includes benzo(b) fluoranthene that is carcinogenic. The cassava tuber products may be harmful to Emede people because it can absorb crude oil. This research revealed that the agricultural area requires urgent remediation.

Pesticides and Pollinators: Assessing Potential Risks at Colony and Population Level

TP272 Pollinator Research Task Force: Overview of Accomplishments and Upcoming Projects

V.J. Kramer, Corteva Agriscience / Ecotoxicology; B. Sharma, FMC Corporation / Global Regulatory Sciences

Research on pollinators is an active area of scientific inquiry. However, there is a paucity of research devoted to improving the fundamental aspects of pesticide risk assessment for pollinators. The Pollinator Research Task Force (PRTF) was formed in 2015 by a group of US pesticide registrants to facilitate improvement in pollinator risk assessment paradigm jointly created in 2014 by the United States Environmental Protection Agency (USEPA), Health Canada Pest Management Regulatory Agency and the California Department of Pesticide Regulation. The research projects conducted by the PRTF are developed in collaboration with the USEPA insuring relevancy to pollinator risk assessment needs in the United States, while remaining cognizant of and generally applicable to regulatory issues regarding pollinators globally. This presentation will summarize completed, ongoing and planned PRTF projects. Completed and published projects include: a ring-test of improvements to the honey bee larval repeat-dose test methodology, a literature survey and analysis of the relevance of guttation water as a potential source of pesticide exposure to honey bees, and; results of an international workshop on non-Apis exposure pathways. Completed projects that are in the manuscript submission/review phase include: a literature review and analysis of honey bee colony-level consumption of pollen and nectar and of nectar consumption by nectar foragers particularly; Monte Carlo model development and evaluation of nectar consumption by honey bee nectar foragers, and; a literature review and analysis of pesticide active ingredient acute toxicity to honey bees compared to formulated product toxicity. PRTF projects that are in progress include: evaluation of the BEEHAVE model parameterized to North American conditions for prediction of over-wintering survival of honey bee colonies; refinement, standardization and ring-test of the “Toxicity of Residues on Foliage: RT25 Test;” and laboratory evaluation of alternative solvents for use in honey bee larval tests. Outlines for future research projects will also be presented.

TP273 Honey bee risk assessment: Are two larval studies better than one (2019 update)?

M.A. Feken, Syngenta / Ecological Risk Assessment; S. Hinarejos, Sumitomo Chemical Agro Europe / AgroSolutions Division International; R. Hummel, Landis International Inc.; V.J. Kramer, Dow Agro Sciences LLC / Ecotoxicology; B. Neill, DuPont Crop Protection; D. Schmelch, Bayer Crop Science; R. Singh, BASF Corporation / Ecotoxicology

After the publication of the Guidance for Assessing Pesticide Risk to Bees (USEPA, PMRA, CDPR 2014), USEPA began requesting a suite of honey bee Tier 1 laboratory toxicity studies to support registration and the registration review process of new and currently registered crop protection chemicals, respectively, including the 8-day acute, single exposure and the 22-day chronic, repeat exposure larval toxicity studies. For the acute larval study design (OECD Test Guideline 237), the primary goal is to determine the LD50/LC50 following a single exposure to a test chemical (on Day 4) and mortalities are evaluated on days 5-8 of the larval developmental phase. In contrast, in the 22-day chronic larval study design (OECD Guideline No. 239), honey bee larvae are exposed to the test
chemical on Days 3-6 with mortality recorded on Days 4-8 during the larval phase, on Day 15 during the pupae phase, and on Day 22 during adult emergence. Given the 22-day larval study design covers all phases of honey bee brood development up to adult emergence and the larval endpoints LD$_{50}$/LC$_{50}$ can be calculated, the European Food Safety Authority (EFSA) only requires the 22-day larval study to derive larval endpoints for their bee risk assessments. However, USEPA requires the acute, single exposure study to calculate a dose-based endpoint (i.e., LD$_{50}$) that can be incorporated into the current screening-level risk assessment model (i.e., BeeREX). In 2018, a preliminary review of LD$_{50}$/LC$_{50}$ endpoints from both study designs indicated that similar endpoints (< 2x difference) are derived based on dose (i.e., LD$_{50}$) for both study types but lower endpoints (greater sensitivity) are typically derived in the repeat exposure design when based on concentration (LC$_{50}$). Likewise, converted daily dose (e.g., LDD$_{50}$) endpoints from the repeat exposure designs are often lower (40% where >2x lower) than single exposure endpoints. Additional data (approximately 50 studies total) have been incorporated into this most recent evaluation to further corroborate or refute our previous finding. If confirmed, we propose that the acute, single exposure study design should not be required considering the 22-day larval study provides the necessary larval endpoints required for Tier 1 bee risk assessments.

**TP274 The utility of a weight-at-emergence endpoint in the 22-day larval assay for a pollinator risk assessment**

B. Sharma, FMC Corporation / Global Regulatory Sciences; D. Schmehl, Bayer Crop Science; J. Collins, F. Abi-Akar, Waterborne Environmental Inc

USEPA has identified the 22-day honey bee larval assay as a Tier 1, screening-level toxicity study for assessing pesticide risk to bees. This repeat-dose larval study is based on the Organization for Economic Co-operation and Development Guidance Document 239, and methodology provided by Schmehl et al.(2016). During this study, first instar larvae are transferred from healthy colonies to grafting cells (day 1) and treated diet is administered between days 3 and 6. Survival is assessed at multiple stages of the test: daily between days 4 and 8 for larvae; day 15 for pupae; and day 22 (emergence time) for adults. However, at the request of the USEPA, adult weight at emergence has also been included as a study endpoint. The Pollinator Research Task Force (PRTF) is conducting an endpoint evaluation to compare the sensitivity of adult weight at emergence to that of the survival endpoint in this study design. A database was developed based on anonymized study data from PRTF member companies, as well as applicable studies from the open literature. The compiled data were evaluated both empirically and statistically with regard to endpoint sensitivity. Statistically significant effects based on survival and adult weight at emergence were compared. No- and Lowest-Observed-Effect Dose (NOED and LOED) values, as well as 50% lethal and effect dose (LD$_{50}$ and ED$_{50}$) values were also compared between the endpoints. Coefficients of variation (CVs) were compared graphically and statistically to quantify the variability in each metric and determine significant differences. A pairing structure was also used to assess correlation, which could be graphed and statistically analyzed. This presentation outlines the methods used during this project, the results of the endpoint analyses, and concluding findings on the endpoint sensitivity comparison between survival and adult weight at emergence.

**TP275 Comparisons of Neonicotinoid Residue Data When Considering Potential Exposures to Pollinators**


Historically, data has been sparsely available to quantify the concentrations ("residues") of pesticides in food matrices relevant to honey bees, (i.e., pollen and nectar). As part of the registration review of the nitroguanidine-substituted neonicotinoid insecticides (imidacloprid, clothianidin, thiamethoxam, and dinofuran), registrants submitted data to the U.S. Environmental Protection Agency (EPA) on neonicotinoid concentrations in pollen and nectar for a variety of crops and application methods. Registrants also submitted data for other matrices that could potentially be used as surrogates for pollen and nectar (e.g., anthers, flowers). Each neonicotinoid active ingredient has its own set of registered crops and corresponding rates and methods, leading to many possible chemical-crop-application scenarios to consider when assessing potential honey bee exposures. To understand potential influences of geographic location on residues, studies for the same crop and application scenario were carried out at multiple locations. Since residue data were not available for every crop and application scenario registered for a single neonicotinoid, EPA analyzed residues for the same chemical and application method to determine potential bridging among crops (i.e., whether residues in floral matrices of one or more crops are suitable surrogates for an entire crop group). In addition, EPA analyzed residues for the same crop and application method (e.g., foliar applications to cotton) among different neonicotinoids to determine the potential for bridging across neonicotinoids. We summarize the available residue data, provide comparisons across chemicals and crops, and describe the scientific justification for extrapolating residue data among neonicotinoids, crops, and plant matrices when assessing risks to bees.

**TP276 Quantifying insect pollinator exposure and effects from pesticides for risk and impact assessment**

E. Crenna, European Commission - Joint Research Centre / Directorate D - Sustainable Resources, Bioeconomy Unit; P. Fantke, Technical University of Denmark / Quantitative Sustainability Assessment Division; O. Jolliet, University of Michigan

Pollinator populations are suffering significant declines worldwide. The use of agricultural pesticides has been identified as one of the main contributing causes. The impact pathway associated with pollinators' exposure to pesticides, however, is currently missing in various assessment frameworks, including comparative risk screening and life cycle impact assessment (LCIA) to characterize various impacts contributing to damages on humans, ecosystems and natural resources associated with product and service life cycles. To address this gap, we developed a model to quantify field exposure of honey bees—chosen as most relevant pollinator species—to pesticides and related potential ecotoxicity impacts. As exposure metrics, we defined bee intake and dermal contact fractions for oral and dermal exposure, respectively. We tested our model to characterize bee impacts of two pesticides, namely lambda-cyhalothrin (insecticide) and boscalid (fungicide) applied to oilseed rape. We observed that dermal contact and oral intake fractions vary according to the specific type of forager honey bees, with the highest dermal contact fraction of 1.27x10^-5 kg dermal contact/kg applied found in pollen foragers for the fungicide boscalid, and the highest intake fractions of 3.21x10^-5 and 1.90 x10^-5 kg oral intake/kg applied found in nectar foragers for both boscalid and lambda-cyhalothrin respectively. Hive oral exposure fraction is higher than forager oral exposure fractions in both pesticides. For boscalid it is 7.4 to more than 100 times higher, while for lambda cyhalothrin it is 2.1 to 32.4 times higher than the intake fraction of foragers. We observed a higher impact of the insecticide, being the impact score two orders of magnitude higher compared with the fungicide, and the impact per unit application three orders of magnitude higher. Overall, nectar foragers are the most affected forager type for both pesticides, emphasizing the oral pathway dominating overall bee exposure. Considering the in-hive exposure, CFs for hive bees are up to two orders of magnitude higher than CFs of foragers for boscalid, and at least twice the CF of foragers for lambda-cyhalothrin. This is based on the assumption of the same toxicity between adults and larvae. This model and the calculation of bee intake fraction constitutes an important first step toward integrating pollinator impacts in risk screening and LCIA, whereas we also identified areas of further model refinement to fully operationalize our approach in comparative frameworks where quantifying impacts on pollinators is relevant.
TP277 Assessing the uptake of pesticides from soil by ground-nesting solitary bees
S. Rondeau, D. Willis Chan, N. Raine, University of Guelph / School of Environmental Sciences

Risk assessments of the impacts of pesticide exposure are currently only tested on social honeybees as the model pollinator species. However, honeybees are atypical of most bee species in their ecology and life history and may be more resilient to pesticide exposure than solitary bees. While research on the impact of pesticides on pollinators typically focusses on the consumption of contaminated pollen and nectar, exposure may also occur via nesting materials and sites, such as leaves, wood or mud. As more than 70% of all bee species nest underground, prolonged contact with contaminated soil may represent an important yet overlooked route of pesticide exposure. While female ground-nesting bees are repeatedly exposed to soil during nest excavation and maintenance, larval stages experience long-term contact exposure as they develop underground. In most ground-nesting bee species, however, the nest cells in which bees develop are thought to be lined with a water-resistant lining that may reduce larval exposure to pesticide residues from soil. The extent to which these linings actually prevent exposure is an important research gap to be addressed. Here we report results from a new method developed in our laboratory to study squash bees (Peponapis pruinosa) under ecologically-realistic conditions used for the first time to evaluate the uptake of three widely used pesticides (imidacloprid, boscalid, difenoconazole) by adult female and developing larvae of this agriculturally important ground-nesting solitary bee. Mated female squash bees were introduced into mini hoop houses (meshed enclosures) containing zucchini plants as sources of pollen and nectar. Bees were allowed to nest in contaminated or uncontaminated bare soil. Samples of bees (adults and larvae) and soil were then analyzed for pesticide residues, allowing us to calculate an uptake factor for each pesticide. We predict uptake will occur for all pesticides tested, with a positive correlation between uptake levels and pesticide lipophilicity. These results will allow us to determine whether pesticide residues in soil can be taken up by the most vulnerable developmental stages of ground-nesting bees, and the extent to which residues can accumulate in bees. Our semi-field exposure paradigm represents a valuable addition to the field of bee ecotoxicology research, by providing a novel tool to study ground-nesting bees under semi-controlled, yet environmentally-realistic, conditions.

TP278 Nest bundles used to characterize agrochemical exposure to native pollinators near cattle feed yards and row crop agriculture
E. Peterson, Texas Tech University / Environmental Toxicology; C. Tomlinson, Texas Tech University / Plant and Soil Science; P.N. Smith, Texas Tech University / Environmental Toxicology

Insect pollinators are declining worldwide due to a variety of factors such as habitat loss, disease, non-native species, and pesticides. However, knowledge of specific agrochemicals present in the environment is still incomplete. Beef cattle feed yards and row crop agriculture are the foremost agrochemical end-users in the Southern High Plains of the United States. In an effort to characterize agrochemicals availability in this region and potential risk to pollinators, phragmites reed nest bundles were deployed alongside beef cattle feed yard boundaries and row crop agriculture. Nest bundles were installed prior to pollinator emergence in February and collected in November, to span an entire field season. Reeds were opened to determine which cavity nesting insect species were present and reed cell matrices (mus, feces, leaves, pollen, and larvae) were analyzed via liquid chromatography mass spectrometer for agrochemicals commonly used in this ecoregion. Initial screening of reed matrices revealed a variety of agrochemicals including thiamethoxam, imidacloprid, clothianidin, dicrotophos, diazinon, malathion, ivermectin, and boscalid. Over 60% of mud caps and larvae from reeds located near feed yards contained agrochemical concentrations above the limit of detection. Native bee monitoring strategies like that used in this study may allow for more accurate determination of agrochemical distributions in the environment and enhance assessment of risk among native pollinators.

TP279 A semi-field tunnel study using the common eastern bumble bee (Bombus impatiens)
L. Richardson, J. Hanzas, Stone Environmental, Inc. / Agrochemical Fate and Exposure; S. Perez, Adpen Laboratories, Inc.

Ecological risk assessment is a key component of the regulatory process required for registration of crop protection products in the US and elsewhere. The western honey bee (Apis mellifera) is the established test organism for assessing pesticide exposure risk to pollinating bees, yet there is concern that it is not a suitable surrogate for other bees in all circumstances. Accordingly, efforts are underway in Europe to adapt honey bee test methodologies for two types of native bees, bumble bees and mason bees. The buff-tailed bumble bee (Bombus terrestris), a test species in Europe, may not be imported to North America, meaning that such risk assessment studies will have to be conducted here using a species native to the area, the common eastern bumble bee (B. impatiens). To address this need, in 2019 we are conducting a higher-tier field study with B. impatiens. Adapting semi-field study guidelines for honey bees (e.g., EPPO 170 and OECD 75) and benefiting from similar work with B. terrestris in Europe, we grew 3 hectares of the bee-attractive plant curly phacelia (Phacelia tanacetifolia) on a Vermont, USA farm. We constructed 18 caterpillar tunnels, each 60 m², above the crop, and at the onset of flowering, introduced one commercial B. impatiens colony to each tunnel. Six replicate tunnels were randomly assigned to each of three treatments: a negative control where plants were sprayed only with water, and low and high concentration applications of the insecticide dimethoate. Following applications made with a handheld spray boom, analytical samples will be collected to verify application rates, nectar and pollen residues, and realized dietary exposure to bees. After 14 days of confinement to tunnels, all colonies will be moved outside to forage on untreated floral resources. The primary endpoint to be quantified is number and mass of new gynes (queens) produced by colonies. In addition, we are collecting data on production of male offspring, worker mortality, foraging behavior, and colony growth. Our work is novel in that it is the first fully-replicated semi-field tunnel study to be conducted using B. impatiens, a key component of future risk assessment research for non-Apis bees in North America. We anticipate that our methods and results can guide future efforts to develop a standard test paradigm to assess risk of crop protection products to bumble bees.

Understanding Risks from Exposures to Per- and Polyfluoroalkyl Substances (PFAS)

TP280 A Framework for Assessing Bioaccumulation and Exposure Risks of Per- and Polyfluoroalkyl Substances in Threatened and Endangered Species
B.C. Kelly, Simon Fraser University / Civil & Environmental Engineering; F. Gobas, Simon Fraser University / Resource & Environmental Management

For several decades, the U.S. Department of Defense (DoD) widely used aqueous film forming foams (AFFF) formulations for training and operations related to fire suppression. These AFFF formulations contained relative high quantities of perfluorooctane sulfonate (PFOS), as well a range of other of per- and poly-fluoroalkyl substances (PFAS). The objective of the present study is to develop a framework for conducting scientifically sound risk assessments for PFAS in T&E species at these sites. The study involved (i) a comprehensive literature review of physical-chemical properties, bioaccumulation metrics and environmental concentrations, (ii) development of a risk assessment framework for assessing PFAS bioaccumulation and exposure risks in T&E species and (iii) application of the proposed framework to select AFFF-impacted DoD sites. The proposed approach utilizes a combination of field-based
measurements and bioaccumulation modeling to evaluate exposure in T&E species. Toxicity reference values (TRVs) are derived from conventional toxicity assay data for surrogate test species, as well as in vitro assay data (e.g., ToxCast assays). A chemical activity-based approach is utilized for exposure and effects characterization, where chemical activity (a, unitless) in a given medium is determined as the ratio of the concentration (C, mol/m³) and the corresponding solubility (S, mol/m³) of the chemical for a given phase or compartment (i.e., a = C/S). T&E species with habitat ranges overlapping AFFF-impacted DoD sites included the Bog Turtle (Clemmys muhlenbergii), Northern Long-Eared Bat (Myotis septentrionalis), Red-cockaded Woodpecker (Picoides borealis) and E. Massasauga Rattlesnake (Sistrurus catenatus). For sites with relatively high PFAS concentrations risk quotients (RQs) of PFOS for T&E species often exceeded 1. For sites with relatively low concentrations, RQs of PFOS for T&E species were generally well below 1. Omnivorous and carnivorous birds, mammals and reptiles are shown to exhibit a higher degree of PFAS bioaccumulation and hence exposure risk, compared to aquatic organisms at a given site. Lastly, key uncertainties and knowledge gaps related to bioaccumulation behavior and exposure assessment of PFAS will be highlighted and discussed. This study will help guide future research efforts and risk assessment initiatives related to exposure of legacy PFAS in T&E species at AFFF-impacted sites.

**TP281 Assessing the effect of Per- and Polyfluoroalkyl Substances on the expression of epigenetic machinery-associated genes in the placenta**

*J.T. Bangma, UNC Chapel Hill / Marine Biomedicine and Environmental Sciences; J. Szilagyi, C. Meakin, University of North Carolina at Chapel Hill / Environmental Science and Engineering; J. Reiner, National Institute of Standards and Technology; T. Manuck, University of North Carolina / OB/GYN; R.C. Fry, University of North Carolina at Chapel Hill / Environmental Science and Engineering*

Per- and poly-fluoroalkyl substances (PFAS) are a group of chemicals that have been widely used in stain repellents, paints, protective coatings, and firefighting foams. While some of these chemicals, including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), have been discontinued in the United States, their persistence in the environment and continued use internationally make them a toxicological concern. Moreover, hexafluoropropylene oxide dimer acid (HFPO-DA, ammonium salt with trade name: GenX), a modern replacement for PFOA, and continued use internationally make them a toxicological concern. As demonstrated with 8:2 fluorotelomer alcohol (FTOH), these intermediates can form covalent adducts with cellular proteins. Consequently, identifying the protein targets of these compounds is paramount to elucidating their toxic mechanisms of action. To this end, we have developed a proteomics method for the identification of proteins covalently modified by PFAS. Our method combines solid phase fluoruous separation (FSPE) and a modified nanoliquid chromatography gradient with existing proteomics infrastructure for the identification of targets via high-resolution mass spectrometry-based shotgun proteomics. When applied to the analysis of tryptic bovine serum albumin peptides modified with a cysteine reaction fluoruous tag, our FSPE enrichment enables a 30% increase in the number of identified fluoruous-modified peptides. Likewise, our modified proteomics gradient was able to compensate for the increased hydrophobicity of fluoruous-modified peptides and we report a two-fold increase in detected fluoruous-modified peptides over traditional proteomics gradients. We then applied our method to investigate the protein targets of 8:2 FTOH in rat liver S9 fractions. As our described methodology can only enrich PFAS-modified peptides, we combine the downstream analysis with a traditional proteomics analysis of the unmodified flow-through fraction to identify 8:2 FTOH adducts at both the peptide and protein levels. Our developed method will help to better understand the toxic mechanism of 8:2 FTOH. Lastly, we will discuss our plans to identify PFAS with structurally unknown peptide modifications for a better understanding of the toxic mechanisms of action for numerous, structurally varied, PFAS.

**TP282 Development of a Chemical Proteomics Method for the Enrichment and Identification of Poly- and Per-Fluorinated Covalently Modified Proteins**

*D. Hall, J. Han, S. Joudan, H. Peng, University of Toronto / Department of Chemistry*

Per- and poly-fluoroalkyl substances (PFAS) are not only environmentally ubiquitous and capable of significant bioaccumulation, but can often undergo biotransformations into more reactive, and toxic, intermediates. As demonstrated with 8:2 fluorotelomer alcohol (FTOH), these intermediates can form covalent adducts with cellular proteins. Consequently, identifying the protein targets of these compounds is paramount to elucidating their toxic mechanisms of action. To this end, we have developed a proteomics method for the identification of proteins covalently modified by PFAS. Our method combines solid phase fluoruous separation (FSPE) and a modified nanoliquid chromatography gradient with existing proteomics infrastructure for the identification of targets via high-resolution mass spectrometry-based shotgun proteomics. When applied to the analysis of tryptic bovine serum albumin peptides modified with a cysteine reaction fluoruous tag, our FSPE enrichment enables a 30% increase in the number of identified fluoruous-modified peptides. Likewise, our modified proteomics gradient was able to compensate for the increased hydrophobicity of fluoruous-modified peptides and we report a two-fold increase in detected fluoruous-modified peptides over traditional proteomics gradients. We then applied our method to investigate the protein targets of 8:2 FTOH in rat liver S9 fractions. As our described methodology can only enrich PFAS-modified peptides, we combine the downstream analysis with a traditional proteomics analysis of the unmodified flow-through fraction to identify 8:2 FTOH adducts at both the peptide and protein levels. Our developed method will help to better understand the toxic mechanism of 8:2 FTOH. Lastly, we will discuss our plans to identify PFAS with structurally unknown peptide modifications for a better understanding of the toxic mechanisms of action for numerous, structurally varied, PFAS.

**TP283 PFOA induces liver and serum dyslipidemia in a humanized PPARα mouse model fed an American diet: A risk assessment relevant model**

*W. Heiger-Bernays, T.F. Webster, Boston University / Dept Environmental Health; T. Hyytyläinen, Orebro University; C. Boston, J.J. Schlezinger, Boston University School of Public Health / Department of Environmental Health*

Americans are exposed daily to mixtures of perfluoroalkylated substances (PFAS) in their drinking water, food, air, dust in their homes, and direct use of consumer products. Increased concentrations of serum total cholesterol and low density lipoprotein cholesterol (LDL-C) are among the best supported outcomes by epidemiology studies. Dyslipidemia (elevated tri-glycerides, decreased high density lipoprotein cholesterol) and increased serum LDL-C are major contributors to cardiovascular disease, the leading cause of mortality in the US. Despite evidence that human PFAS exposure is associated with dyslipidemia, these effects of PFAS have received little focus as a basis for risk assessment, largely due to the lack of a suitable animal model. Notably, the European Food Safety Authority has proposed Tolerable Daily Intakes for PFAS based on epidemiological data. Mechanisms by which PFAS cause lipid-disrupting metabolic effects are not well understood, but given their structural similarity to fatty acids, interaction with human peroxisome proliferator activated receptor α (PPARα) is a logical molecular initiating event. PPARα is an essential mediator of cholesterol and lipid homeostasis. Moreover, polymorphisms in human PPARα are associated with changes in serum cholesterol. Thus, PPAR activation is relevant and important as a likely PFAS mechanism of action. Humanized PPARα mice were exposed to PFOA in drinking
water (8 µM) for 6 weeks and fed a custom diet based on “What we eat in America.” Serum was analyzed for ALT by activity assay, triglycerides by UHPLC/QTFMS, and cholesterol by enzymatic assay. Liver was collected, weighed and analyzed for triglycerides by chemical conversion to glycerol. Liver lipidome was analyzed by UHPLC/QTFMS. Liver mRNA expression was determined by RT-qPCR. Perfluorooctanoic acid (PFOA) exposure in drinking water (8 µM) for 6 weeks resulted in a serum PFOA concentration of 78.8 ± 5.4 µg/ml, a level approximately 4-fold higher than serum levels found in fluorochemical workers. PFOA exposure increased liver mass, increased lipid content, perturbed the lipidome and induced PPARα target gene expression. PFOA increased serum triglycerides and total cholesterol, while also perturbing the serum lipidome. Sex-dependent effects were evident. A literature-based analysis of effects of PFOA on serum triglyceride and cholesterol across multiple mouse models suggests a non-monotonic dose response. The humanized PPARα mouse model fed an American diet is an important new model for examining PFAS-induced dyslipidemia to prioritize PFAS of concern for human risk assessment.

**TP284 PFOA Physically Targets >500 Lipid-Interacting Proteins as Revealed by Chemical Proteomics**

*J. Sun, H. Peng, University of Toronto / Department of Chemistry*

Perfluorooctanoic acid (PFOA) has been reported to induce diverse toxicities such as lipid homeostasis. While several potential protein targets of PFOA including peroxisome proliferator-activated receptor alpha (PPARα) have been reported, but the vast majority toxicities of PFOA was found to be mediated via PPARα-independent pathways. In this study, a chemical proteomics method was developed to identify the protein targets of PFOA by employing photo-reactive palmitic acid probe. >500 lipid-interacting proteins were detected by quantitative proteomics, by spiking lipid probe to HepG2 and HEK293 cell lines, two major bioaccumulation organs for PFOA. In-gel fluorescence was adopted to characterize the protein targets of PFOA, and dose-dependent (30, 160, 800 µM) competition was observed. Particularly, all >500 lipid-interacting proteins were competed by PFOA at the highest concentration (800 µM). Quantitative proteomics was performed on two lower concentrations, and >100 proteins were physically targeted by PFOA at medium concentration (160 µM), while only ~20 proteins were targeted at low concentration (30 µM). The proteins targeted at low concentration were enriched in several pathways including mitochondria fatty acid beta-oxidation. Several proteins including acetyl-coenzyme A synthetase were purified in E. coli and their interactions with PFOA were validated by thermal stability assay. This study reported, for the first time, that PFOA could physically target hundreds of proteins, which provides an important mechanistic basis to understand their toxicities. The unbiased method also provides a unique opportunity to investigate the potential toxicities of other PFAS such as PFOA/PFOS replacements.

**TP285 Polymeric PFAS: Advances in Toxicology, Grouping Criteria, Essential Uses and Alternatives Assessment**

*S. Korzeniowski, BEC; J. Bowman, FluoroCouncil*

Per- and polyfluoroalkyl substances (PFAS) is a term that describes a wide and diverse array of chemistry containing carbon and fluorine. It is noteworthy that the chemistry and properties are vastly different across the various PFAS categories and classes. The primary focus of this presentation will be on polymeric PFAS including both fluoropolymers and side-chain fluorotelomer-based polymers. We will describe why fluoropolymers should be regarded as polymers of low concern and provide clear compelling examples of essential uses. Moreover, robust criteria for PFAS grouping will be proposed and discussed considering mode of action, potential for toxicity, critical toxicological endpoints, human and animal half lives, bioavailability, bioaccumulation and biomagnification. Recent advances pertaining to side-chain fluorotelomer-based polymers will be described including degradation, toxicity, fate, transport and water treatment. This presentation will summarize a number of these critical and significant advances and present the results in the context of the overall risk in using the subject fluoropolymer-based products. In addition, we will discuss decision criteria to help in the assessment of alternatives (risk vs. exposure vs. hazard vs. precaution), as well as the true value-in-use including some critical end use examples. The decision criteria will include persistence, mobility, end-use need (concept of essential use), function, precaution, toxicity, performance and emission control amongst the various elements.

**TP286 Machine learning approaches to inform classification of toxic impacts of diverse PFASs**

*W. Cheng, University of Pittsburgh; C.A. Ng, University of Pittsburgh / Civil & Environmental Engineering*

Recent estimates of the diversity of per- and polyfluoroalkyl substances (PFAS) suggest more than 4700 different substances and technical mixtures may have been used in processes and products, potentially resulting in environmental release and human and wildlife exposure. As the extent of environmental contamination with PFAS becomes apparent, the lack of available data on the properties and potential toxic impacts of the vast majority of these substances is a major concern to scientists, regulators, and impacted communities. At the same time, high throughput screening (HTS) has become increasingly common in risk assessment for chemicals used in a wide variety of products and applications. As a consequence, databases of HTS data for chemicals are growing in scope and coverage of the universe of chemicals. In this study, we seek to exploit existing chemical hazard classification databases to develop machine learning based models for PFAS effects. In this talk, we will first present an analysis of coverage of PFAS chemicals in two important chemical activity databases: the PubChem Bioassay database (PCBA), and the EPA’s ToxCast database. First, we evaluate the number of fluorinated substances (containing at least one CF2 group) present in PCBA and ToxCast, as well as all substances that fall under the definitions of PFASs set out in OECD’s 2018 report. We then assess the overlap between the PFAS found in the OECD database (the subset of the 4730 substances for which a SMILES code could be found or defined). Finally, we use the fluorinated substances found in the PCBA and ToxCast databases to develop a set of machine learning models of PFAS activity. We optimize and validate their performance, and use them to predict biological activity (active/inactive classification) of the non-overlapping PFASs in the OECD database. We discuss what structural features and potential bioactive pathways emerge from this analysis and the implications for identifying and prioritizing PFAS effects.

**TP287 Effects of Chronic Dietary Exposure to Aqueous Film Forming Foam on Japanese Quail (Coturnix japonica)**

*S.J. Bursian, M. Crawford, J. Link, Michigan State University / Animal Science; M. McCarty, M.F. Simcik, University of Minnesota / Division of Environmental Health Sciences*

Aqueous film forming foam (AFFF) containing perfluoralkyl substances (PFAS) has been used by the Department of Defense for over 40 years for fire-fighting and emergency response activities. This has resulted in contamination of ground and surface water, soil and biota near relevant military bases with perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) as well as other PFASs. In order to develop an avian toxicity reference value for these chemicals, the effects of a 3M AFFF formulation (containing primarily PFOS with a lesser concentration of PFOA and other PFAS) on egg production, embryo development, hatchability and chick survivability and growth were determined in Japanese quail (Coturnix japonica). Hatching Japanese quail were raised on 6 dietary concentrations of AFFF for 140 days (0, 2.1, 5, 11, 19, and 21 µg/g feed). At 4 weeks of age, 16 male/female pairs were assigned, within treatment, to breeding/laying cages (1 pair per cage). At 8 weeks of age, photoperiod was increased gradually to induce the females to start laying eggs at 10 weeks of age. Eggs were collected daily, set weekly and incubated for 18 days for the following 10 weeks. Hatchlings were fed uncontaminated feed for 2 weeks and then euthanized and sampled for blood and liver. Unhatched eggs were opened to determine stage of development. At the
end of 10 weeks of egg collection, the adult quail were euthanized to collect blood, liver and kidneys. Results indicated that dietary exposure of Japanese quail to 3M AFFF had an adverse effect on egg production, hatchability, chick survivability and chick body weight. There were significant histological changes in the liver and kidney, but these changes were not dose-dependent. Of the endpoints evaluated, chick survivability was determined to be the most sensitive. EPA benchmark dose software was used to determine the dose at which chick survivability was decreased by 20%. A daily dose of 0.58 mg PFOS/kg body weight/day derived from 3M AFFF could pose a threat to avian wildlife.

TP288 Chronic Toxicity in Northern Bobwhite Quail Exposed to Perfluorooctane Sulfonate (PFOS) or a 2:1 Mixture of PFOS and Perfluorohexane Sulfonate (PFHxS)

N.M. Dennis, Texas Tech University / Environmental Toxicology; M.L. Dennis, A. Karpjanapiboonwong, S. Subbiah, S. Lasee, Texas Tech University / Department of Environmental Toxicology; T.A. Anderson, Texas Tech University / Environmental Toxicology

Per- and polyfluoroalkyl substances (PFAS) are a broad class of environmentally persistent chemicals that include thousands of synthetic organic molecules which are potentially toxic. There is a lack of terrestrial toxicity data on individual PFAS for comprehensive risk assessment and therefore a lack of data to inform regulations of these chemicals. We utilized a common avian species (Colinus virginianus) with known chemical sensitivity and amenability to laboratory conditions to perform sub-chronic (90-day) toxicity studies via oral exposure to perfluorooctane sulfonate (PFOS) and a simple mixture of PFOS and perfluorohexane sulfonate (PFHxS) (2:1) at three increasing and environmentally relevant concentrations (0.1 ppb, 1.0 ppb, and 20 ppb). Adult bird survival was 92% over the 90 days with only one death possibly treatment related (Female: 1.0 ppb PFOS). Our endpoints included: average number of eggs laid, hatch success rate, average day of arrested embryo development, adult weight change over the 90-day exposure, chick weights (hatch, 7-day, and 21-day), and chick survival rate. We calculated individual adult daily doses from amount of water consumed during the studies, then sought to determine if any dose-response relationships existed among these variables. After the 90-day exposure, adult doses varied 1.38 ± 0.06(10-5), 1.28 ± 0.10(10-4), and 2.62 ± 0.08(10-3) mg/Kg body weight (bw) for the PFOS study and 1.34 ± 0.06(10-5), 1.36 ± 0.09(10-4), and 2.70 ± 0.13(10-3) mg/Kg bw for the mixture study. Average egg production (69 ± 2 eggs) was statistically similar among treatments (p = 0.70). Hatching success ranged from 48 to 72% and was significantly associated with treatment (p = 0.009). The average day of arrested embryo development was significantly different among all treatment groups (p << 0.001). There was no treatment effect on adult weight change overall, however, females gained significantly more weight in both the 0.1 ppb PFOS and 20 ppb PFOS treatments than in the 20-ppb mixture treatment (p = 0.04, p = 0.01). Chick hatch, 7-day, and 21-day weights were all unequal among treatments (p << 0.001, p = 0.001, p = 0.001), respectfully. Chick survival from hatch to 21 days ranged from 91 to 99% and was not significantly associated with treatments (p = 0.10). Completion of this study fulfills gaps in chronic toxicity data necessary for establishing toxicity reference values (TRVs) used to better estimate ecological and human health risk.

TP289 Environmental Risk Assessments for PFAS Contaminated Sites; The Role of the Total Oxidizable Precursors Analysis

H.L. Lord, Bureau Veritas Laboratories / Scientific Services; P. Benvenuto, Bureau Veritas Laboratories / Mississauga Operations; T. Obal, Bureau Veritas Laboratories / Corporate

Background/Objectives. Per- and polyfluorinated alkyl substances (PFAS) are ubiquitous, persistent, anthropogenic chemicals that bioaccumulate in both humans and biota. An understanding of the toxicity of certain PFAS such as perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and several of their shorter carbon-chain analogues has developed in recent years. In response, along with a recognition of the wide presence and environmental impacts of these compounds, contaminant guidelines for selected PFAS in environmental matrices have been introduced in many jurisdictions. While significant effort has been focused on identifying priority impacted sites and delineating PFAS contamination extent, an additional consideration expected to influence risk assessment efforts is the potential for in situ oxidative transformation of PFAS precursor compounds to the currently reported PFAS of concern. At many sites, the pool of potential precursor compounds is large and poorly characterized. As a result it is difficult for stakeholders to quantify, assess or mitigate the potential risk posed by the presence of these precursor compounds. Approach/Activities. In 2012 Erika Houtz and David Sedlak of the University of California, Berkeley published a laboratory-based oxidative conversion of PFAS precursors in water by persulfate thermolysis. By measuring a standard suite of PFAS from the same sample before and after oxidation, the presence of a potential PFAS precursor pool could be determined, and by extension, the potential magnitude of uncharacterized risk inferred. Bureau Veritas Laboratories (Bureau Veritas) has implemented the total oxidizable precursors (TOPs) assay as published for water samples. A parallel assay to measure the presence of PFAS precursor compounds (often referred to as PFAS “dark matter”) in contaminated soils and sediments has been developed and validated by Bureau Veritas. Results/Lessons Learned. During this presentation, we will share our experiences and “lessons learned” over the past two years of processing soil and water samples with the TOPs assay from multiple sites throughout North America, including:-Characterization of the types and magnitudes of additional PFAS compounds that are commonly seen with the assay; -Correlations between types of precursors observed and resulting new PFAS generated; -Examples of observed changes in toxic potential based on amount total PFAS normalized to relative toxicities of individual species.

TP290 Estimates and perspectives on the risk of PFAS to terrestrial and aquatic ecological receptors

A. East, Towson University / Environmental Sciences; R.H. Anderson, US Air Force / AFCEC; C.J. Salice, Towson University / Environmental Science & Studies Biology

Per- and polyfluoroalkyl substances (PFAS) have been detected in a wide variety of terrestrial and aquatic environmental samples as well as organisms. Estimating risk to ecological receptors, however, remains a significant challenge. One important challenge lies in identifying priority PFAS for research and risk assessment given the wide variety of existing PFAS. As well, there are generally a lack of toxicity data for most PFAS other than a few well studied chemicals (e.g., Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA)). From an exposure perspective, there is considerable variability regarding uptake and accumulation for terrestrial and aquatic receptors for even well-studied PFAS. To better understand the ecorisk landscape of PFAS, we used a large dataset of PFAS-contaminated soil and surface waters on DoD installations, available toxicity data for prominent PFAS, and uptake/accumulation estimates to explore the potential risk to ecological receptors. Careful analysis of the environmental data point to the prominence of mostly PFOS followed, in many cases, by perfluorohexane sulfonate (PFHxS). Hence, we used data for PFOS as our estimate of toxicity and because PFOS was the dominant PFAS (by an order of magnitude in some cases), we used maximum PFOS concentrations as a basis for exposure estimates. The analysis indicated that exposure and effects are relatively likely but the magnitude was organism- and location-specific. In aquatic systems, exceedance of the HC5 (50th percentile most sensitive species) was 26% and exceedance of the lower confidence level of the HC5 was 65%. These two estimates suggest that many aquatic sites may contain PFOS concentrations that exceed current toxicity thresholds. In terrestrial systems, we used two example avian species with different life histories. Time-on-site and life history had large effects on risk—pesticides, for example, were in exceedance in greater than 5% of sites at any level above 1% time-on-site while granivores were in exceedance at 5% of sites only when time-on-site was greater than 32%. Collectively, the data point to the potential for environmental concentrations of PFAS to result in exposures to ecological receptors that...
exceed current toxicity thresholds. However, there are considerable uncertainties regarding the toxicity of even well-studied PFAS such as PFOS. We are refining methods to better characterize ecological risk in light of the ambiguities and inconsistencies in PFAS toxicity data.

TP291 An evaluation of multiple approaches to derive threshold values for the protection of aquatic organisms exposed to perfluoroalkyl acids

J.L. Newsiedl, Ramboll / Environmental and Health Sciences

Perfluoroalkyl acids (PFAs) are synthetic fluorinated organic compounds that can be released to the environment during manufacturing processes, from commercial products and applications, or indirectly via oxidation of precursor molecules containing perfluoroalkyl chains. While PFAs have received increased attention in monitoring programs, the assessment of the potential risks PFAs pose to aquatic organisms is still being investigated. Currently, water quality values including predicted no-effect concentrations (PNECs) have been derived for several PFAs using two regulatory approaches, application of assessment factors (AF) to the “most sensitive” species, and species sensitivity distributions (SSD). Another less utilized approach is the application of models to establish PNECs that are based on ecological and toxicological principles. AQUATOX is an aquatic ecosystem model that incorporates environmental fate and trophic processes as well as toxicant lethal and sublethal effects that can be evaluated through food webs and ecosystems. In this study we evaluated the ecological risks posed by perfluorooctane sulfonate (PFOS) and perfluorobutane sulfonate (PFBS) using all three approaches in Lake Ontario. Laboratory acute and chronic toxicity data were used to derive PNEC values based on the AF and SSD approaches. For the model approach, PNECs were estimated as the lowest PFAS concentration resulting in non-significant changes in taxon-specific biomasses as compared to control results. Results showed that while the AF approach produced the most conservative PNEC for PFBS, the model approach produced the most conservative PNEC for PFOS. Uncertainties related to all three approaches will be discussed.

TP292 Reviewing Current Toxicity Literature to Evaluate Data to Support the Development of Draft PFOS and PFOA Aquatic Life Ambient Water Quality Criteria

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Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonate (PFOS) contamination of aquatic ecosystems is widespread. PFOA and PFOS are part of a broader group of polyfluorinated compounds, which are synthetic and have unique chemical and physical properties, including thermal stability, water and oil repellency, and surfactant properties. PFOA and PFOS were incorporated into a wide range of industrial and consumer products for decades until the production of PFOA and PFOS was phased out by their major global manufacturers in 2000 and 2002, respectively. However, both PFOA and PFOS are highly persistent in the aquatic environment and, therefore, still pose a potential risk. Acute and chronic effects to a relatively wide diversity of aquatic and aquatic-dependent taxa have been reported in the current toxicity literature for both PFOA and PFOS. Additionally, bioaccumulation of polyfluorinated compounds consisting of long carbon chains (generally eight or more) like PFOS, occurs through the aquatic food web. This presentation will provide an overview of current toxicity literature evaluated for data quality to support development of PFOA and PFOS aquatic life and aquatic-dependent wildlife effect values and will identify existing data gaps for aquatic and aquatic-dependent species.

TP293 A Novel Approach for Assessing Hazard Associated with Firefighting Foams

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A mixture of per- and poly-fluoroalkyl substances (PFAS) are found in most Class B firefighting foams used at O&G facilities. Past use of firefighting foams has resulted in the release of PFAS into the environment where they may mobilize and persist. Concern over potential health risks to humans and ecological receptors has generated substantial interest in developing next generation foams, such as short-chain (C6) and fluoro-free foams (3F), that potentially have more favorable risk profiles. As a critical first step towards quantifying the relative risks of these foam types, we developed hazard profiles following the general guidelines outlined in the GreenScreen for Safer Chemicals hazard assessment method. Constituents detected in at least one C6 foam included perfluorocarboxylic acids (PFCAs; C3-C8), 4:2, 6:2, and 8:2 fluorotelomer sulfonates (FTS); 4:2, 6:2, and 8:2 fluorotelomer thiiaoamido sulfonates (FITAoS); 4:2, 6:2, 8:2, 10:2, and 12:2 fluorotelomer sulfonamide betaines (FIsaB); and 4:2 and 6:2 fluorotelomer sulfonamido amines (FiSaAM) and 6:2 fluorotelomer thiohydroxy ammonium (FiTHN). The detection of long-chain PFAS was limited to one C6 foam sample and at orders of magnitude lower concentrations compared to short-chain PFAS. Similar classes of hydrocarbon surfactants were detected in both C6 and 3F foams and included alkyl sulfates, linear alkyl benzene sulfonates, alkyl ethoxy sulfates, linear alkyl ethoxylates, glucosides, cocamidopropyl hydroxysulfates, and alkyl amido dipropionates. A comprehensive literature review yielded varying amounts of toxicity data for the majority of PFCAs, 6:2 FTS, and 6:2 FiSaB including data for systemic mammalian toxicity, mammalian reproductive and developmental endpoints, and aquatic toxicity. However, for many detected fluorotelomers, toxicology study data gaps remain for parent compounds, expected degradation intermediates, and terminal products. In these cases, the longest chain PFCA that could form following fluorotelomer degradation was used as a surrogate. This approach facilitated the development of a hazard profile for each foam type. The proposed hazard assessment approach and results of this study can help to guide further research to address key data gaps on analytical chemistry standards and toxicology of complex mixtures present in current and future foam formulations.

TP294 Estimating PFAA exposure from consumption of vegetables grown in contaminated soils

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In 2017, the FDA conducted a study measuring per- and poly-fluoroalkyl substance (PFAS) concentrations in American foodstuffs. Among their results, they found concentrations of perfluorooctanesulfonic acid, a member of a sub group of PFAS know as per- and polyfluoroalkyl acids (PFAAs), in leafy greens as high as 1,000 parts per trillion; PFAAs have been known to bioconcentrate in plants grown in contaminated soils. The potential risk from consuming these plants is currently not well defined. Using a combination of our own research and literature data on plant uptake of PFAAs from soil, we developed an equation for predicting PFAA bioconcentration factors (BCFs) for plants grown in soils with a known percent organic carbon. This calculated BCF was then used with measured soil PFAA concentrations to estimate PFAA concentrations in harvested plants and the potential exposure to humans and animals consuming them. This equation could be a useful tool for estimating exposure to PFAAs in soils through trophic transport.
TP295 Development of Ambient Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoate (PFOA) Concentrations in Soil and Groundwater

H. Loso, AECON / Remediation; K. Schwach, AECON / Environmental Remediation; C. Wong, AECON / Modelling/Statistics Dept.

Poly-and perfluoralkyl substances (PFAS) are a group of emerging anthropogenic compounds that are environmentally persistent, ubiquitous, and are used in a wide variety of consumer products and industrial applications. Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) are two of the most studied PFAS and have been documented to be present in both abiotic and biotic media worldwide. Some risk-based screening benchmarks and preliminary remediation targets have been developed for selected PFAS and are extremely low. The combination of widespread prevalence and low screening levels introduces considerable uncertainty and potential costs in the characterization and remediation for PFAS at sites contaminated from known sources. Thus far, characterization of ambient (i.e. background) has been limited and the development of quantitative background threshold values (BTVs) have not been calculated that could be applied on a national or regional level. BTVs can be especially useful at sites in the initial characterization phase when site-specific background concentrations may not be well understood. This presentation compiles the available U.S. background datasets from primary literature and governmental publications and attempts to develop national and regional BTVs for soil and groundwater for PFOS and PFOA by using documented and well-established statistical procedures available in the environmental statistical literature and governmental guidance. The upper tolerance limit (UTL95-95) was selected as the BTV for this evaluation. The UTL95-95 is a value that represents the upper limit of a tolerance interval such that 95% of the observations from the background population will be less than or equal to that upper-limit value with a confidence coefficient of 95%. Availability of statistically-based BTVs provides for a better understanding of national and regional ambient levels of PFOS and PFOA in soil and groundwater, which may contribute valuable information to remedial project decision-making at sites throughout the U.S.

TP296 Development of Generic Risk-Based Soil Screening Values for Perfluoroalkyl Substances (PFAS) Applicable to Biosolid Amended Agricultural Lands

N.C. Garisto, ARCADIS Canada, Inc. / Risk and Radioactivity; E. Arbaban, ARCADIS Canada, Inc.; S. Dunn, ARCADIS

PFAS may be present in biosolid amended agricultural lands (BAAL). PFAS in such soil can enter the terrestrial agricultural food chain and result in human exposure. This study develops risk-based soil screening values (SSVs) protective of human health exposure to PFAS due to both direct soil contact and food consumption. The SSVs can be used as interim values for assessing soil quality at BAAL. We have followed the USEPA biosolids risk assessment (RA) guidance for the derivation of SSVs for three agricultural land uses: (i) Farm: a crop producing farm, where residents (i.e., farmers) consume local crops and store-bought meat; (ii) Ranch: a cattle ranch, where residents (i.e., ranchers) consume local meat and store-bought crops; and (iii) Mixed Farm and Ranch: a crop producing farm and ranch, where residents consume local crops and meat. The PFAS concentrations in seven groups of vegetables/crops were estimated using transfer factors (TFs) from literature studies on BAAL. The PFAS concentration in beef was modeled using feed to muscle TF and cattle’s daily dietary intake. The short chain PFAS (C4-C7) were not detected in the muscle tissue samples of the literature study, therefore, the human exposure to the short chain PFAS via beef ingestion was assumed to be negligible. The exposure to short chain PFAS via food was assumed to occur only through crop ingestion pathway. Generic human exposure characteristics were used. No irrigation was assumed. A hazard quotient target level of 0.1 was used to be consistent with up-to-date RA and to ensure conservatism. The SSVs were derived for perfluoroalkyl carboxylic acids (PFCAs) (C4-C14) and perfluoroalkane sulfonic acids (PFSA) (C4, C6, C8 and C10). The results indicate that the derived risk-based SSVs are more stringent for long chain PFCAs for a “Ranch” than for a “Farm” agricultural land use, while the SSVs for short chain PFAS (C4-C7) are more stringent for a “Farm” than for a “Ranch” land use. These observations are consistent with limited data on the chain length and functional group dependency of TFs for PFAS. Further studies are recommended to improve the understanding of short chain bioaccumulation potential in farm animals. As expected, the “Farm and Ranch” land use has the most restrictive SSVs. The concentration of PFAS in BAAL reported in the literature was compared to the derived SSVs. The soils meet the SSVs depending on the historical biosolids loading rates.

TP297 Employing the SeqAPASS tool to inform bioaccumulation potential of per- and polyfluorinated alkyl substances across species

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Per- and polyfluorinated alkylated substances (PFAS) are synthetic chemicals used in a variety of industrial applications and consumer products, notably fire-fighting foams and stain and oil repellents. Due to the ubiquitous nature of PFAS in the environment, they have been measured in tissues from species as diverse as whales, birds, fish, and even invertebrates, covering a range of trophic levels. The ability of these chemicals to bioaccumulate is largely due to protein binding, with both serum albumin in the blood and fatty acid binding proteins in the liver capable of important interactions. Due to the involvement of proteins in bioaccumulation, the US Sequence Alignment to Predict Across Species Susceptibility (SeqAPASS) tool was used to evaluate protein conservation and predict similarities and differences in bioaccumulation potential across species. This approach serves as a case study in using SeqAPASS for advanced in silico and chemical prototoxic evaluations. Level 1 of SeqAPASS compared human primary amino acid sequences for serum albumin and liver fatty acid binding protein (LFABP) to all other protein sequences that exist in publicly available protein databases. These results provide a line of evidence that serum albumin and LFABP are conserved across the majority of vertebrate species. Based on knowledge of amino acid residues identified as critical for the interaction of PFAS with LFABP, Level 3 of SeqAPASS was used to compare individual amino acids. From these results, two positions, 50 and 94, were identified as potentially important for differences in PFAS bioaccumulation due to the differences observed when comparing across taxonomic groups. For example, a substitution of phenylalanine at position 93 for threonine predicted that zebrafish may differ from human LFABP in interactions with PFOS therefore leading to potential differences in bioaccumulation. Results from SeqAPASS were then used to guide molecular homology modeling and molecular dynamics simulations to further evaluate species similarities and differences to predict potential for bioaccumulation of PFAS across species. Cross-species chemical proteomic studies will be used to confirm and expand upon in silico results. The contents of this abstract neither constitute nor reflect official policy of the USEPA.

TP298 Field-Based Terrestrial Bioaccumulation Factors for PFAS

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Human health and ecological risk assessments require data on the levels of contaminants in both the abiotic and biotic environments. If such data are missing in the biotic environment, it is often possible to derive them, using abiotic concentrations and Bioaccumulation Factors (BAFs). For many organic contaminants, it is possible to derive BAFs from their octanol-water partitioning coefficient (KOW). However, this method is not suitable for per- and polyfluoroalkyl substances (PFAS) compounds that are strong acids i.e., for perfluorooalkyl carboxylic acids (PFCAs) and perfluoroalkane sulfonates (PFSA). The PFCAs and PFSA typically exist in nature as anionic species and the KOW method is not relevant for such species. Furthermore, as many PFAS bind to proteins rather than...
to lipids, KOW would not be an appropriate measure of their bioaccumulation potential. Therefore, we derived terrestrial BAFs using field measurements. These measurements were used to assess the behavior of PFAS in the environment and develop an understanding of the main parameters that control the transfer of PFAS from the abiotic to the biotic environment. Co-located soil samples and the following terrestrial biota tissue samples were collected and analyzed for PFCAs (C4 -C14) and PFSAs (C4, C6, C8 and C10):(a) Terrestrial plants species: grass, leaves, forage, and berries; (b) Terrestrial invertebrates: earthworm BAFs were only calculated for parameters with detected concentrations in soil samples. The BAFs were developed for soil to terrestrial plants (BAFs-plant) and soil to earthworms (BAFs-earthworm). The derived BAFs-plant suggest a decreasing bioaccumulation potential with increasing chain length for both PFCAs and PFSAs, while the BAFs-earthworm increase with chain length for long chain PFCAs and decreases with chain length for PFSAs. These findings are consistent with previous studies. An exponential correlation was observed between PFOS and PFOA concentrations in plants and soil. A linear correlation was observed between the concentration of PFOS and PFOA in earthworms and soil. It is interesting to note that the calculated terrestrial BAFs were within an order of magnitude of literature values. These derived regression models can be applied to estimate the concentration of these parameters in plants and earthworms, providing the soil concentrations are known for these parameters and are within the range applied in the derivation of field based BAFs.

TP299 Development of a marine PFAS bioaccumulation model


Per- and polyfluoroalkyl substances (PFAS) are a broad class of widely produced anthropogenic chemicals that have been detected in ecosystems globally. As a chemical class, PFAS are often referred to as bioaccumulative substances. However, mechanisms driving uptake and accumulation in aquatic food webs for various PFAS are still poorly understood. Here we present a new food web bioaccumulation model for PFAS that is based on both phospholipid partitioning and serum protein binding in tissues. Our research goal is to develop a generic model that can help inform biotic monitoring and risk assessment guidance for PFAS. We parameterize the model to two marine food webs: 1) North Atlantic pilot whales and their prey, and 2) a highly polluted coastal estuary (Charleston Harbor). We will present results comparing modeled and field-measured PFAS concentrations and discuss physical and chemical factors driving accumulation in biota. These results will include a quantitative assessment of contributions to variance in model results, including sensitivity analyses that are used 1) to assess the impact of uncertainty in literature-derived partitioning coefficients and 2) to infer the relative importance of active protein transport. We will also present results of a novel assessment of the bioaccumulation potential of unidentified organofluorine.

TP300 Accumulation of Per- and Polyfluoroalkyl Substances in Fish Downstream of a Fire-fighting Training Area and Determination of the Risk to Human Health


Environmental investigations completed for the fire-fighting training area (FTA) of an airport (the Site) identified elevated concentrations of per- and polyfluoroalkyl substances (PFAS) in surface water and sediment in a river that flows across the Site. PFAS are persistent and can bioaccumulate in fish, representing a potential risk to people that may consume fish from the river. The objectives of the study were to: (1) collect and analyze fish tissues from the river to assess the bioaccumulation of PFAS; (2) derive Site-specific fish tissue guidelines for PFAS protective of human health; and (3) compare the measured fish tissue concentrations to the derived fish tissue guidelines to determine if the concentrations of PFAS in fish pose a health risk to people consuming fish from the river. Fish tissues were collected from the river from locations downstream (i.e., exposure areas) and upstream (i.e., reference areas) of the FTA. Surface water and sediment were primarily impacted by perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorohexanoic acid (PFHxA). PFHxS, PFOS and perfluoropentanoic acid (PFPeA) were detected in muscle tissue collected downstream of the FTA, with PFOS dominating PFAS uptake. Fish tissue guidelines protective of human health were derived for all PFAS analysed in fish tissues using receptor characterizations, exposure and toxicity assumptions recommended by Health Canada or based on Site-specific information. The derived fish tissue guidelines for the most sensitive receptor (toddler) ranged from 11 ng/g (for perfluorodecanoic acid [PFDA], perfluorododecanoic acid [PFDoA] and perfluoroundecanoic acid [PFUnA]) to 6883 ng/g wet weight (for perfluorobutanoic acid [PFBA]). Except for PFOS, maximum measured muscle tissue concentrations of PFAS in rainbow trout, creek chub, rock bass and white sucker were below the fish tissue guidelines derived for a toddler. For PFOS, the maximum measured concentration in rock bass of 232 ng/g wet weight was greater than the derived fish tissue guideline of 138 ng/g wet weight, suggesting that concentrations in rock bass may pose a health risk to people consuming fish from the river. Fish consumption advisories were recommended to address the potential risk. The fish consumption advisories will be developed in collaboration with the Ministry of the Environment based on their analyses of splits of the fish tissue samples collected from the Site.

TP301 Biotransformation and Bioconcentration of 6:2 and 8:2 Polyfluorooalkyl Phosphate Diesters in Common Carp (Cyprinus carpio)

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Polyfluorooalkyl phosphates esters (PAPs) are widely used in a variety of commercial products and detected in many aquatic organisms. To investigate their bio-accumulation and transformation in fish, common carp (Cyprinus carpio) were exposed to 6:2 and 8:2 diPAP in water. Several degradation products, including fluorotelomer unsaturated carboxylic acids (6:2 and 8:2 FTUCA), 5:3 and 7:3 fluorotelomer carboxylic acids (5:3 and 7:3 FTCA), perfluorooalkyl carboxylates (PFCAs) were identified in the carp liver. In addition, several phase-II metabolites, such as glutathione- and glucuronide-conjugated compounds were detected in the carp bile. 8:2 diPAP displayed lower accumulation potential than 6:2 diPAP probably due to its relatively large molecular size. However, 8:2 diPAP experienced more extensive transformation and produced more phase I metabolites than 6:2 diPAP, with higher transformation rate of 8:2 diPAP (6.78-14.6 mol%) compared to 6:2 diPAP (0.49-0.66 mol%). The in vitro incubation with the liver S9 fraction confirmed that biotransformation of 6:2 and 8:2 diPAP took place in the carp liver. Further analyses of enzyme activities indicated that acid phosphatase (ACP) could be involved in mediating phase I while glutathione S-transferase (GST) involved in phase II metabolism of 6:2 and 8:2 diPAP in carp.

TP302 Development of a Risk Framework for Threatened and Endangered Species potentially exposed to PFAS on military installations


Per- and polyfluoroalkyl substances (PFAS) are emerging contaminants of concern on many DoD sites. As such, there is growing interest regarding the potential effects of PFAS to public and environmental health, as
well as concern from the DoD regarding liability under federal statutes such as the Endangered Species Act (ESA). ESA requires federal agencies to ensure that any actions conducted by that agency are not likely to jeopardize the continued existence of threatened and endangered species including their respective habitat. Given the lack of information concerning the potential risk of PFAS to T&E species on DoD lands, we are developing a spatially-informed framework to conduct screening-level risk assessments for listed species on DoD installations. Using Joint Base McGuire-Dix-Lakehurst (JB MDL) as a model installation, percent of PFAS-impacted habitat per species was estimated using geospatial analysis by overlaying the areas of impacted soil/surface water with species-specific habitat (landscape layer(s)). Additionally, to determine if there are specific, at-risk taxa based on dietary preferences we developed a GIS layer that extrapolates transport of PFAS from the release location and overlaid this with taxa-diet landscape layers and found that species with insectivorous dietary preferences likely experience increased PFAS exposure. Currently, we have preliminary data for the screening-level risk assessment for Osprey and the Northern Pine Snake (both state listed in NJ) at JB MDL. These preliminary estimates indicate that osprey and snakes may be exposed to 0.003 and 0.03 - 2.15 mg PFOS/kg/d, respectively. The working Toxicity Reference Value (TRV) for avian and reptilian species is 0.021 and 0.2 mg/kg/d, respectively. Taken together, the high exposure estimate of 2.15 mg/kg/d at a former fire training area on the installation would likely pose a risk to Pine Snakes. Importantly, many assumptions are built into these screening-level risk estimates and there are critical uncertainties (i.e. fish tissue concentrations vs whole body) that we identify as data needs.

TP303 Guidance for Assessing the Ecological Risks of Threatened and Endangered Species at Aqueous Film Forming Foam (AFFF)-Impacted Sites

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Per- and Polyfluoroalkyl Substances (PFAS) have been widely used in numerous applications since the 1950s, including aqueous film forming foams (AFFFs) used for fire suppression at airports, firefighting training facilities, and other industrial locations. PFAS are routinely-detected in a wide variety of environmental media impacted by AFFF, and have prompted regulatory focus on exposures and risks. Many AFFF sites host ecological habitat or, due to the offsite transport potential for PFASs, PFAS-impacted AFFF sites may affect nearby and downgradient habitats. As part of a Strategic Environmental Research and Development Program project, a guidance document was developed to provide a current state-of-the-practice overview of methods, practices, and key data gaps for assessing the potential for risks from exposure to PFAS for threatened and endangered (T&E) species at AFFF-impacted sites. The guidance is intended to provide clear guidance to quantitatively evaluate ecological risks and enable site managers to make defensible, risk-based management decisions using the best available information and approaches. The key objectives are: 1) to provide a framework for the evaluation of T&E species during ecological risk assessments (ERAs) at AFFF-impacted sites; 2) to provide the reader with an understanding of the specific T&E species or general feeding guilds typically expected to be considered most at risk at AFFF-impacted sites; 3) to provide the reader with recommended parameters (exposure factors, toxicity reference values [TRVs], uptake factors) to perform a food web model-based ERA for wildlife T&E species; and 5) to provide the reader with a recommendation of key data gaps and uncertainties when evaluating T&E species at AFFF-impacted sites. Several hundred toxicity values and over 1000 bioaccumulation parameters were assessed in the guidance review effort, resulting in 150 recommended values for use in ERAs. In addition to providing a review of the available literature and recommendations for ERA parameters, the guidance reaches the following key conclusions: 1) ERAs for AFFF sites are feasible; 2) off-site habitats are most at risk; 3) aquatic habitats are critical to address; 4) terrestrial habitats may be important at some sites; 5) risks from mixtures is uncertain; and 6) the exposures and effects of many PFAS-constituents in AFFF are unknown.

TP304 Selection of Toxicity Reference Values (TRVs) for Use in Ecological Risk Assessment of Threatened and Endangered Species at AFFF Impacted Sites


As part of a Strategic Environmental Research and Development Program project, a guidance document was developed to provide a current state-of-the-practice overview of methods, practices, and key data gaps for assessing the potential for risks from exposure to Per- and Polyfluoroalkyl Substances (PFAS) for threatened and endangered (T&E) species at AFFF-impacted sites. A key part of this guidance focused on a state-of-the-science review of Toxicity Reference Values (TRVs) for use in ecological risk assessments of avian and mammmalian wildlife. Over 70 regulatory and peer-reviewed documents were reviewed for both mammalian and avian toxicity studies (lethality, growth, and reproductive endpoints) for 18 target PFAS, primarily the environmentally-stable perfluoroalkyl acids (PFAAs). To reflect a high level of conservatism for T&E species (consistent with general USEPA T&E ecological risk assessment guidance), TRVs from exposure doses associated with an absence of statistically detectable differences in effects from controls (termed no observed effect level [NOEL] values) were prioritized. Doses associated with ecologically adverse effects (No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs) were also highlighted where available. Each wildlife toxicity study was reviewed and scored on a 10-point scoring system modified from USEPA Ecological Soil Screening Level (Eco-SSL) review approaches. The overall TRV selection process considered several different aspects of each study including duration of exposure, endpoint, and magnitude of the TRV to ensure a robust and, a conservative value was selected for each PFAS. Recommendations were identified for 11 mammalian TRVs and 2 avian TRVs for use in ecological risk assessment. In addition to providing recommended PFAS wildlife TRVs, the guidance also identifies critical data gaps for PFAS lacking robust TRVs and highlights cases in which further research is warranted.

TP305 Selection of Bioaccumulation Metrics for Use in Empirical PFAS Food Web Modeling for Threatened and Endangered Wildlife Species


As part of a Strategic Environmental Research and Development Program project, a guidance document was developed to provide a current state-of-the-practice overview of methods, practices, and key data gaps for assessing the potential for risks from exposure to Per- and Polyfluoroalkyl Substances (PFAS) for threatened and endangered (T&E) species at AFFF-impacted sites. A key part of this guidance focused on a state-of-the-science review of bioaccumulation metrics (e.g., bioconcentration factors, bioaccumulation factors, biota-sediment accumulation factors, etc.) for use in empirical bioaccumulation modeling to estimate concentrations of (PFAS) in diet items of threatened and endangered (T&E) wildlife species. Organic carbon-water partitioning coefficients (Koc) values were also reviewed, as these values can be critical components in PFAS bioaccumulation and fate modeling. Over 1000 bioaccumulation parameters in over 100 regulatory and peer-reviewed documents in aquatic and terrestrial food webs were reviewed for 18 target PFAS, primarily the environmentally-stable perfluoroalkyl acids (PFAAs). After compilation, metrics and studies were reviewed to provide recommended values for each PFAS (where available), resulting in a final compilation of 82 bioaccumulation values for predicting uptake by aquatic biota and 35 bioaccumulation values for predicting uptake by terrestrial biota.
Selection of recommended values followed a pre-determined approach, including preferential selection of values from laboratory studies using PFAS-spiked media, concentrations determined at steady state, and use of standardized testing organisms, resulting in robust values with a high level of conservatism for modeling bioaccumulation exposures to T&E wildlife species. The resulting recommended bioaccumulation metric values can be applied to measurements of PFAS in abiotic media to estimate concentrations in plants, terrestrial invertebrates, benthic invertebrates, pelagic invertebrates, and fish. In addition to providing recommended bioaccumulation factors for PFAS, the guidance also identifies critical data gaps for PFAS lacking robust bioaccumulation factors and highlights where further research is warranted.

TP306 Framework for Assessing Risks to Threatened and Endangered Aquatic Life at PFAS Impacted Sites

J. Arblaster, J.M. Conder, E. Larson, Geosyntec Consultants; C.P. Higgins, J.B. Brown, Colorado School of Mines / Civil and Environmental Engineering

The United States Department of Defense is one of the primary stewards of Threatened and Endangered (T&E) species on Federal lands. As part of a Strategic Environmental Research and Development Program (SERDP) project, guidance on the current methods for assessing risks to T&E aquatic life from exposure to per and polyfluoroalkyl substances (PFAS) was developed. To evaluate risks to aquatic T&E species, over 50 laboratory aquatic toxicity studies on PFAS were reviewed. To reflect a high level of conservatism for T&E species, no observed effect concentrations (NOEC) or 10% effective concentrations (EC10) were compiled for U.S. resident species and reviewed for inclusion in a Species Sensitivity Distribution (SSD) for PFOS and PFOA (other PFAS met minimum data requirements for SSDs). A total of 82 NOECs for freshwater aquatic species and 14 NOECs for marine aquatic species were included in SSDs for PFOS and PFOA. One percent and five percent hazardous concentrations (HC1 and HC5) were calculated from the SSD using USEPA guidance. HC1 values for PFOS were 0.56 µg/L and 2.57 µg/L for freshwater and marine species, respectively. HC5 values for PFOS were 5.8 and 7.7 µg/L for freshwater and marine species, respectively. The HC1 and HC5 value for PFOA were 537 µg/L and 1,110 µg/L for freshwater species, respectively (data were insufficient for marine species). HC5 values are typically accepted as protective thresholds for aquatic life. Based on the inclusion of NOEC values as the basis for the SSD, the HC5 values reported here are expected to represent conservative thresholds for evaluating risks to aquatic T&E species and aquatic life.

TP307 Case Study: Risk-based remedial criteria for per- and polyfluoroalkyl substance (PFAS) contamination in soil and groundwater in Ontario

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A case study on a fire site in southern Ontario is presented and highlights challenges encountered during environmental evaluation work and the undertaking of a risk assessment wherein risk-based criteria were derived as remedial goals for per- and polyfluoroalkyl substances (PFAS), e.g. perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). The fire occurred at an industrial property and was extinguished using a water and aqueous film-forming foam (AFFF) mixture, likely containing PFAS. Suitable containment of douse water was not achieved, and the runoff discharged to a neighboring property. Following the fire, subsurface investigations were conducted to delineate and remediate off-site fire-related impacts. The results indicated that PFOS and PFOA concentrations of up to 0.01 µg/g and 0.0028 µg/g, respectively, were present in soil. In groundwater, PFOS and PFOA concentrations of up to 0.12 µg/L and 0.24 µg/L, respectively, were also detected. In the absence of generic Site Condition Standards (SCS) in Ontario, a risk assessment was conducted to derive site-specific risk-based remedial criteria for PFAS contamination in both soil and groundwater. The challenges for risk assessors included, but are not limited to, 1) adequate identification of PFAS substances of concern; 2) selection of appropriate screening criteria and toxicity data; 3) managing the evolving science of PFAS toxicity; 4) defining uncertainties in a space with very limited regulatory consensus; and 5) recommending risk management of PFAS contamination protective of both human and ecological receptors. The human health risk assessment of PFOS and PFOA relied upon toxicity reference values (TRVs) provided by the United States Environmental Protection Agency and Health Canada, and the ecological risk assessment of PFOS relied upon toxicity benchmarks provided by Environment and Climate Change Canada. The final risk-based criteria in soil were 0.01 µg/g for both PFOS and PFOA, and a risk-based criterion in groundwater, of 0.07 µg/L for total PFAS, was also recommended. This case study showcases the approach adopted at a fire site in southern Ontario in consultation with provincial regulators, and the measures taken to ameliorate environmental and liability risk associated with PFAS contamination in soil and groundwater. The challenges encountered during the risk assessment of PFAS contamination at this fire site are relevant to similar sites across Canada.

TP308 Per- and Polyfluoroalkyl Substances (PFAS) Regulatory Values for Soil in the Context of Background Concentrations

C. Faith, K. Hathaway, Barr Engineering Co.

PFAS regulatory values for soil are being set below one part per billion (ppb) in several jurisdictions. At the same time, recent regional and global background studies have detected PFAS in soils at background levels exceeding one ppb. The methods used and considerations given to set the PFAS regulatory values for soil vary greatly between agencies including recent regulatory directives from certain agencies to evaluate the potential for PFAS to leach from soils using Synthetic Precipitation Leaching Procedure (SPLP). The presentation will compare and contrast established or proposed PFAS regulatory values for soils, how these values have been developed, causes for variability in these values and how these values relate to background levels. A compilation of hypothetical groundwater protection values, based on the methods used by various regulatory agencies, will be also be presented. The information presented will illustrate the relevance of background PFAS levels in the investigation and risk assessment at PFAS-impacted sites.

TP309 A review of four per- and polyfluoroalkyl substances to inform surface water standards in New Hampshire

M. Rardin, NH Department of Environmental Services / Permitting and Environmental Health Bureau; J.M. Ali, New Hampshire Department of Environmental Services / Environmental Services

Per- and polyfluoroalkyl substances (PFAS) have a long history of global industrial use, but their persistence in ecosystems and bioaccumulation within organisms and their environments pose risks to human and environmental health alike. In 2018, the State of New Hampshire was tasked with developing a plan for the regulation of four PFAS (perfluorooctanoic acid [PFOA], perfluorononanoic acid [PFNA], perfluorooctanesulfonic acid [PFOS], and perfluorohexanesulfonic acid [PFHxS]) in its diverse surface waters. The objective of this project was to review PFAS toxicity data relevant to the protection of aquatic life and human-health-based surface water criteria. This information will be used to make recommendations to the state regarding surface water standards, and most importantly, will delineate what further research is needed to support a more formal recommendation. A systematic literature review was conducted to collect data relevant to the state’s designated uses. These designated uses include but are not limited to: fish and shellfish consumption, aquatic life integrity, human recreational use, and a source of drinking water. After consideration of these designated uses and the current research on chemical, biological, and toxicological impacts of PFAS in surface water, fish consumption has been determined to be the driver of surface water standards. This is due to markedly different toxicokinetics between humans and most studied aquatic organisms, which is summarized in this poster. Therefore, using fish consumption as the main determinant of surface water standards will not only protect human
health, but will be sufficiently protective of wildlife. This work has direct applications to the challenging issues unique to New Hampshire—as well as other states—looking to establish surface water standards for PFAS. Additionally, this work can provide a broader scope of existing PFAS data which can inspire further PFAS research projects within the fields of academia and industry.

**Systematic Review for Robust Reporting and Evaluation of Environmental Toxicology Data for Risk Assessment**

**TP311 Combining best practices in Weight of Evidence and Systematic Review**

*G.W. Suter, US Environmental Protection Agency / ORD/NHEERL*

Environmental assessments often require inference by combining multiple pieces of evidence. Conventionally, this has been done by weight of evidence (WoE), but too often this process has consisted of informal narratives. Better practices for WoE are guided by Hill’s, or equivalent, considerations. Recently, more structured and transparent WoE processes have been developed by the USEPA and others. In parallel, clinical medicine developed Systematic Review (SR) as a more structured and transparent approach, including meta-analysis. As developed by the Cochrane Collaborative, SR combined a systematic review of the literature with meta-analysis of the extracted data. More recently, SRs for human health hazard assessments (e.g., OHAT) have adapted and expanded methods to include qualitative methods. The best practices from WoE and SR can be identified by distinguishing two steps: assembling the evidence and making the inference. SR is characterized by a structured process of searching, screening, and extracting formation from the literature. WoE has focused less on the literature review but has, in some cases, formalized the generation of sets of new evidence. Inference processes are more heterogeneous. If only one type of evidence is used (e.g., rat carcinogenicity tests), some version of meta-analysis can be used. If multiple types of evidence are used (e.g., laboratory tests, mechanistic studies, mesocosm tests, field observational studies, or models), some version of WoE must be used. The SETAC community should consider how best to make SR and WoE fit for our purposes. One approach is represented by our framework for making inferences in environmental assessment that combines best practices in WoE and SR. Depending on the case, it may direct the assessor to a classic SR with meta-analysis of assembled data, or to a transparent and structured WoE with the evidence assembled in a rigorous and transparent manner.

**TP312 Comparing apples to pomegranates: Development of toxicology-based systemic review criteria using evidence integration techniques: TCE case study**

*M.S. Johnson, T.E. Sussan, US Army Public Health Center / Toxicology*

Development and derivation of toxicology-based criteria are rarely straightforward. This process often requires systematic review using data collection for different purposes, integrating a wide range of endpoints from diverse study designs, and searching for patterns of corroboration, biological plausibility, coherence, and dose-response relationships. Despite the direct applicability of human data to criteria derivation, rarely are there opportunities for application of specific human environmental data, primarily because of imprecise exposure estimates, assumptions and confounding factors. Here we present a framework for evaluating epidemiological, controlled in vivo, mechanistic/in vitro and computational evidence that can help in toxicology criteria development. We begin with a documented systematic review of the literature according to precise problem formulation guidelines, followed by sorting of data into either controlled laboratory in vivo, mechanistic/in vitro, or epidemiological/field data categories. Strict weight of evidence criteria are used to assess controlled in vivo data that includes an assessment of risk of bias. Epidemiological and in vitro data are used to help inform points of departure or human-equivalent concentrations that are system-based. Bayesian uncertainty factors are then employed to develop preliminary criteria, and these values are again compared with epidemiological data to support for the toxicity reference values.

**TP313 Identifying and Curating Ecologically- Relevant Toxicity Data with the ECOTOXicology Knowledgebase Literature Search and Review Processes**

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The ECOTOXicology Knowledgebase (ECOTOX, https://www.epa.gov/ecotox/) is a nationally and internationally recognized source of curated single-chemical toxicity data for aquatic life, terrestrial plants, and wildlife. This publicly available database provides private industries, federal and state regulators, and researchers with a cost-effective, non-duplicative means of locating high-quality ecological effects data to support chemical decision making. Through its 30+ year history, ECOTOX has developed systematic and transparent procedures to conduct comprehensive literature searches, title/abstract screening to identify references that meet ECOTOX applicability and initial acceptance criteria (e.g., ecologically-relevant species, verifiable CASRN, endpoint and control reported), and data extraction of all pertinent study and effects information (e.g., species, chemicals, test methods and conditions, toxicity results). Currently, the ECOTOX Knowledgebase includes data for more than 11,000 chemicals from over 48,000 references, with additional data uploaded quarterly. This well-established protocol is completed for 35-50 chemicals each year, as requested by various Program Offices. Some recent data updates were: a) Aluminum for EPA’s Office of Water, b) Uranium for the Office of Land and Emergency Management, c) Ziram for OCSP’s Office of Pesticide Programs, d) Decabromodiphenyl ethers for the Risk Assessment Division in the Office of Pollution Prevention and Toxics, and e) over 250 per- and polyfluoroalkyl substances (PFAS) for the Office of Research and Development and others. The curated data within ECOTOX can be searched and refined by 19 parameters (e.g. Species, Chemical, Effect, Control, Year, etc.), with customized output selections from over 100 data fields for users’ specific applications. These data results are readily available for use in scoping reviews, evidence mapping, systematic reviews, risk assessments, and regulatory decisions. Updated and enhanced functionality was recently added to the ECOTOX user interface, with interactive queries and data visualization capabilities; and efforts are on-going to enhance the interoperability with other databases and tools such that environmental regulatory agencies, the regulated industry, and researchers can more effectively and efficiently search and use existing toxic effects data. This abstract does not necessarily reflect USEPA policy.

**TP314 The Evidence Ecosystem: Present and Future Innovations For Systematic Review Automation**

*I. Stefanison, P. O’Brien, J. Tetzlaff, Evidence Partners*

Today’s systematic review software evolved from the need to automate the many manual tasks involved in conducting a review. Reviews are process intensive and data heavy, but, until recently, the ecosystem of tools to support them have been unsophisticated, inefficient and prone to error generation. Further, they failed to provide the level of transparency and reproducibility expected in reviews. Recent innovations have allowed many parts of the systematic review process to be automated to varying degrees, to the point that an entire electronic ecosystem now exists for evidence generation and curation. These evidence ecosystems enable unstructured text to be converted to structured data that can easily be searched, analyzed, and re-used. In addition, artificial intelligence is increasingly being used to accelerate and enhance the screening, classification, quality assessment, and data extraction processes, with enormous potential for even greater impact in the near future. This overview of the emerging evidence ecosystem will highlight the various technologies and
tools currently available as well as new developments on the horizon that allow for more efficient, higher quality, human-in-the-loop conversion of unstructured content into structured, high quality evidence.

**TP315 Harnessing literature-based evidence to support nutrient criteria development in rivers and streams: Applying systematic review**

C. Ridley, US Environmental Protection Agency / Office of Research and Development; M. Bennett, US Environmental Protection Agency / Region 5; S. Lee, K. Schofield, US Environmental Protection Agency / Office of Research and Development

Eutrophication from nitrogen and phosphorus pollution is a major stressor of freshwater ecosystems globally. Despite recognition of this problem by scientists and managers, qualitative and quantitative synthesis of scientific evidence is still needed to inform nutrient-related management decisions and policies, especially for streams and rivers. We conducted systematic reviews of the literature on nutrient stressor-response relationships and potential confounding environmental factors to support identifying, managing, and restoring aquatic resources impaired by eutrophication. We asked two questions: (1) What are the responses of chlorophyll-a (chl-a), diatoms, and macroinvertebrates to total nitrogen (TN) and total phosphorus (TP) concentrations in lotic ecosystems? (2) How are these relationships affected by other environmental factors? Consistent with best practice in systematic review, we published our review protocol before the review began and established data searching, screening, extraction, and evaluation methodologies to increase transparency and reproducibility and reduce bias. Our preliminary results are based on ~300 publications (screened from >20,000 initial search results) that document quantitative stressor-response relationships between relevant nutrients and endpoints around the world. Overall, we found that chl-a has stronger relationships than diatoms or macroinvertebrates to nutrients. This confirms a common understanding in stream ecology that autotrophic indicators are better predictors of nutrient enrichment. However, certain macroinvertebrates show broadly consistent responses to both TN and TP: burrowers, chironomids, and dipterans show consistent positive responses, while coleopterans, plecopterans, and EPT index show consistent negative responses. For studies that report relationships between chl-a and both TN and TP, those that show a strong response to TN also tend to show a strong response to TP. This reconfirms the importance of controlling both nitrogen and phosphorus to limit eutrophication. When completed, our dataset will be publicly available via an interactive database to facilitate user-driven data exploration and analysis. Disclaimer: Views expressed are the authors’ and not views or policies of the USEPA.

**TP316 Systematic review criteria used in polychlorinated biphenyl fish toxicity meta-analysis for ecological risk assessment and injury determination**


The legacy of environmental contamination by polychlorinated biphenyls (PCBs) continues even decades after their production ban. We conducted a meta-analysis on mortality, growth and reproductive toxicity thresholds of PCB-related effects on fish to facilitate assessment of potential impacts on aquatic life (Berninger and Tillitt 2019 Environ Toxicol Chem 2019;38:712-736). The goal of the meta-analysis was to evaluate data on PCB-induced toxicity in fish and develop tissue concentration-based thresholds useful for ecological risk assessments and injury assessments. A strategy for data retrieval, extraction and analysis was initially developed based on our objectives. We developed and documented a set of six criteria to identify appropriate primary data for inclusion into or exclusion from the meta-analysis. The rationale for these criteria were clearly defined to be consistent with the quantitative nature of the meta-analysis. A data extraction protocol, including predetermined data fields for each data type and worksheets were developed. Key data fields were lowest observable adverse effect residue (LOAER) concentrations for mortality, growth impairment, and reproductive impairment, and the corresponding effect levels (% of controls). This presentation details the planning, conduct and reporting of our systematic review of PCB-induced toxicity thresholds in fish.

**TP317 A meta-analysis of acute toxicity tests in fish**

H. Pluegg, N. Das, Verisk 3E / Safer Chemical Analytics; J. Kostal, George Washington University

Very little information is available regarding the overall statistical variability of the universe of acute fish toxicity tests, a necessity for its use in the regulatory community. Add to this the need for comparative data for computerized in silico modelling of acute fish toxicity, and the need for a meta-analysis becomes ever clearer. Based on publicly available data we obtained acute fish toxicity tests; approximately 70,000 results for 7400 chemicals. As the quality of the data (entry) varies widely; data cleanup and normalization are essential. The data were filtered to eliminate duplicates (from multiple entries), implement quality control parameters and standardize exposure/test duration and taxonomy. The resulting databases were separated into a number of component/sub-databases. The sub-databases include o A 10% subsample to determine statistical stability o Chemicals for which the raw number of LC50 assays exceeds 50 (N 180 chemicals!) o Specific data bases for chemical classes e.g. metals Based on preliminary data analysis we determined that data, i.e. LC50’s (for select chemicals), even at n=100 were not normally distributed. Given that many evaluations in ecotoxicology use normally distributed statistical methodologies, this already identifies a major problem. We thus focused on non-normal distribution based statistics i.e. using geometric means, which assume a log-normal data distribution. In order to demonstrate log-normal vs normal data distribution we used simple parameters such as mathematical mean, median and geometric mean, the latter of which tend to converge when a log-normal distribution is present. Graphical analyses were also performed, again in order to demonstrate typical data distribution. We calculated these statistics including a geometric mean confidence interval for all of the databases including many of the individual chemicals. Selected classes e.g. metals were analysed. Species-specific analyses were performed to determine relative sensitivity. We evaluated the ratios of effects based on various standard exposure times e.g. 24 vs 96 hours. Novel and highly sophisticated uncertainty analyses of the same data are presented elsewhere.

**TP318 Recommended versus inappropriate procedures for the interpretation of histopathology data from environmental toxicity studies**

J.C. Wolf, EPL, Inc.

Histopathology is a key endpoint for many environmental toxicological bioassays, as it can provide information relevant to hazard identification, risk assessment, the elucidation of disease mechanisms, monitoring of contaminant remediation efforts, and the general health of animal test subjects. Additionally, morphologic tissue changes can serve as critical links between initiating molecular events and apical effects in adverse outcome pathways. Despite the long established use of this venerable endpoint as a research tool, published recommendations concerning the appropriate collection, interpretation, and reporting of histopathology data for hypothesis-based ecotoxicological challenge studies are not widely available. In particular, issues arise when attempts are made to convert descriptive microscopic findings and semi-quantitative ordinal categorizations of lesion severity to quantitative data. Increasingly evident in the literature are papers in which the histopathology data are reduced to numerical index values per organ type and test organism. Although seemingly scientific, this inherently biased approach relies on a variety of unsupported assumptions and statistically invalid mathematical calculations. More importantly, because they promote the recording of numerous unrelated finding types, many of which are incidental to the study outcome, index systems are highly prone to the generation of false positive and false negative results. One very real danger is that inaccurate conclusions resulting from such analyses will be used in characterizations of hazard or risk to establish policy. This presentation will illustrate...
the shortcomings of index systems, and then describe an algorithmic, weight-of-evidence approach for the recording, interpretation, and statistical analysis of histopathology data from toxicological studies that utilize fish as test subjects.

TP319 Microplastic Soil Pollution: Key Knowledge Gaps and Research Needs
I. Bamgbose, Gradient

In recent years, microplastics have become emerging persistent contaminants of increasing concern with ecological consequences. Microplastics (plastic particles < 5 mm in size) are a diverse heterogeneous group of particles that differ in size, shape, color, and have chemical composition with specific densities that come from many various sources. Despite the ever increasing scientific documentation on the widespread presence, fate, and ecological adverse effects of microplastics in aquatic environments (marine and freshwater), their fate and impact on the soil ecosystem still remains largely unexplored. Soils are essential components of terrestrial ecosystems that experience strong pollution pressure. Soils have widely known to be sinks for various organic and inorganic contaminants and potentially sinks for microplastics. Given the paucity of information about microplastics in soil, the poster aims to assess the state of science in the exposure and effects assessment of microplastics in soil by drawing from the marine and freshwater literature to summarize current understanding of microplastics in soil, identify knowledge gaps, and suggest future research priorities.

Poster Only: Policy, Management and Communication

TP320 A study of chemical accident cases for determination of the restoration endpoint
S. Lee, E. Jho, Hankuk University of Foreign Studies / Department of Environmental Science

The number of chemical substances distributed in Korea is about 45,000 to 50,000, among which 43,500 kinds are registered as existing chemical substances, and 200 to 400 new chemical substances are reported every year. When chemical accidents break out, there will be huge impacts on human and environment, and there have been several large spill accidents in Korea. Assessment of the effects of chemical accidents is mostly based on human risks, but assessment techniques that take into account the impacts of ecosystems such as water quality and soil are very important. In addition, it is very important to determine the endpoint of the disaster due to the chemical accidents. In developed countries such as the United States and the United Kingdom, emergency response plans for chemical accidents and various guidelines for environmental pollution are available. However, there are only few studies on domestic chemical accident response regulations. Therefore, recognizing international chemical regulatory trends is very important for safe maintenance and development of the domestic chemical industry. In this study, the present situation of domestic and foreign spill accidents and regulations on restoration of chemical accidents are studied, compared, and analyzed to contribute towards determining the endpoint of disaster recovery considering the aquatic ecosystem.

TP321 Development of contaminated site management decision support program based on human health risk in Republic of Korea
K. Yang, K. Kim, M. Lee, Korea Environment Institute / Environmental Assessment Group; J. Kim, Greencos Inc; K. Nam, Seoul National University / Department of Civil and Environmental Engineering

In the Republic of Korea, contaminated site management has been based on the total concentration of contaminant in the soil and its removal to meet the soil regulatory level. The concept of ‘risk’ assessment for contaminated site was introduced about 20 years ago, and the relevant guidance was prepared about 10 years ago with the revision of related law. However, risk-based contaminated site management is still not a common practice. The major reasons are the technical difficulties of determination of exposure factors, lack of a consensus of risk mitigation practices, and the absence of guidance on risk-based site management strategy. The project developing guidance on detailed technical risk assessment process and method, and how to build risk-based management strategy for contaminated site is underway. This study included in the project is for developing software to support risk managers of contaminated site when they assess human health risk and make a risk management plan. The main features of the software are statistical analysis of site survey results, determination of human health risk, and decision support. Statistical analysis tool includes sample size determination, goodness-of-fit test, and 95% upper confidence limit determination. Human health risk assessment tool includes default exposure factors and toxicity values, simple estimation of exposure concentration of contaminant in environmental media (i.e., groundwater, fugitive dust, outdoor and indoor vapor), and risk determination. Decision support tool includes cleanup goal determination to meet target risk level, determination of area of concern, geospatial analysis including creation of concentration, risk, area of concern maps. The software is developed in Microsoft .NET Framework using C#. For statistical analysis tool, R programming language was used. R codes for sample size determination, goodness-of-fit test, and 95% upper confidence limit determination were written based on ‘EnvStats’ which is R package for statistical analysis of environmental data, and connected with C#.

TP322 Pesticide use in Colombia and future policy needs in the sustainable agriculture framework
J. Gallego Zapata, J. Olivero-Verbel, University of Cartagena / Environmental and Computational Chemistry Group / School of Pharmaceutical Sciences

Agriculture is among the greatest contributors to environmental pollution in developing countries due to the high dependence on pesticides and their misuse. Achieving the food security goals involves the sustainable management of agroecosystems and the assessment of the risks of agrochemicals. Hence, the increasing use of pesticides requires policies and regulatory actions aimed to minimize the impact on human and environmental health. The objective of this study was to examine the trends in pesticide use in horticultural systems in Colombia, emphasizing on environmental issues, health risks, policies, and regulations. The analysis was carried out using data from official databases and the recent literature. In this country, the agricultural production is rising as a result of a growing national and international demand, a process linked to an increase in pesticide use, in particular organophosphates, carbamates, pyrethroids, neonicotinoids, and azoles. An average of 4.6 kg of pesticides is applied annually per hectare, resulting in 14588 tons of fungicides and bactericides, 9401 of insecticides, and 30038 of herbicides. It was found that there are more than 500 different active ingredients, which are commercialized as individually or mixtures formulations in 2292 officially registered products. Some of them are prohibited in the European Union, United States, and China, among others. Despite the fact that there are general regulations for the production, transport, storage, and application of pesticides, recent studies highlight health and environmental concerns. Genotoxicity and neuronal disorders related to pesticides have been reported in rural communities, as well as accidental and self-inflicted poisoning. In terms of environmental impact, few local studies have been conducted; however, pesticides have been found in water, soils, and foods. The different field application approaches used for agrochemicals are also of great concern for human and environment health, demanding attention from the national government. The results suggest that to reduce human and environmental health risks from pesticide use it is necessary to insist on sustainable agriculture. Policies should be focused to improve institutional capacities to provide support to smallholders, increase environmental monitoring strategies to obtain more reliable data on pesticide exposure, protect vulnerable groups, in particular women, and update the regulations for high toxicity pesticides.
TP323 The Use of Flow Studies in Arid West Streams to Determine Impacts on Downstream Waters

S. Skigen-Caird, GEI Consultants, Inc. / Ecology; S. Pargee, GEI Consultants, Inc. / Ecological Division; B. Bertelmann, GEI Consultants, Inc. / Ecology; S. Struck, J. Kurz, P. Staub, Geosyntec Consultants, Inc. / Environmental

When developing permit limitations for sites in Colorado the State considers both the water quality standards for the receiving stream and next downstream segment in order to ensure protection of the designated uses. Where it is determined that effluent has reasonable potential to reach the downstream waterbody, the downstream segment water quality standards must be considered. The more restrictive limitations are adopted in the permit to protect the uses of both the immediate receiving waterbody and downstream waterbodies. Sites discharging effluent to ephemeral and intermittent stream systems can present unique challenges for regulators. If reasonable potential exists, permit writers will incorporate the more stringent standards of downstream waters, no matter the distance between discharge and perennial waterbody, and it is then the responsibility of the discharger to prove otherwise. GEI Consultants, Inc. (GEI) and Geosyntec Consultants, Inc. (Geosyntec) collaborated to design and implement a flow study appropriate to determine whether discharge into an ephemeral stream bed would reach downstream perennial waters. For this study we evaluated discharge rates from three outfalls of particular concern, surveys were then conducted to characterize both the existing conditions as well as the extent of flow generated by active discharge. Conditions were documented pre- and post-discharge, as well as for one outfall not yet active but being considered for future permitting. Pre-discharge data collected for each drainage included: precipitation data, underlying geology and soils, surface water condition/type and flow rate, dominant vegetation type, and substrate composition. Post-discharge data collected for each drainage focused on documentation of flow lines from point of discharge to the point at which flow terminated. Field conditions and flow data from each outfall were then input into the U.S. Environmental Protection Agency’s Stormwater Management Model (EPA SWMM, v. 5.1.013) to assess whether flows would reach downstream perennial waters under varying conditions. The results from both field and associated modeling efforts will be presented with a particular focus on presenting alternative compliance strategies for arid environments.

TP324 Fish Tissue Monitoring Recommendations for Implementation of the Environmental Protection Agency’s 304(a) Freshwater Aquatic Life Selenium Criterion

K. Kesler, US Environmental Protection Agency / Office of Science and Technology; L. Guenzel, US Environmental Protection Agency / Office of Wetlands, Oceans, and Watersheds; J. McLaughlin, US Environmental Protection Agency / Office of Science and Technology

The 2016 304(a) recommended freshwater chronic selenium criterion for aquatic life is composed of four criterion elements, two fish tissue elements (egg-ovary and whole body/muscle) and two water column criterion elements (monthly average exposure for toxic and lentic waters and intermittent exposure). This criterion is the Environmental Protection Agency (EPA)’s first tissue-based criterion for the protection of aquatic life. To support the implementation of this criterion, the EPA is developing Technical Support for Fish Tissue Monitoring for Implementation of EPA’s 2016 Selenium Criterion. This document would provide recommendations and considerations for designing a fish tissue monitoring plan for the assessment of the selenium criterion and for the development of site-specific water column criterion elements. It would provide information to help states and authorized tribes decide which fish species it should target for sampling, which type of fish tissue to sample (egg-ovary, whole body, or muscle), how to collect fish samples (individually or as composites), and what to consider when selecting sampling locations. In addition, it would provide considerations for how to utilize existing tissue monitoring programs that are typically designed to assess human health risks. Lastly, this document would present information on analytical chemistry methods and data analysis. One of the recommendations that is unique to this criterion is the recommendation to collect egg-ovary samples for assessments. While states and authorized tribes have considerable discretion when selecting the fish tissue type to be used in their sampling protocols, EPA recommends sampling egg-ovary for assessment of the selenium criterion, if possible, and this document would provide monitoring considerations specific to egg-ovary sampling. This document is being developed in tandem with three other documents that address recommendations for the implementation of the selenium criterion, including for criterion adoption, National Pollutant Discharge Elimination System permitting, and Clean Water Act sections 303(d) and 305(b) assessments, listings, and total maximum daily loads. The views expressed in this abstract are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

TP325 Envisioning an International Validation Process for New Approach Methodologies

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After 30 years of discussions within the global toxicology community, New Approach Methodologies (NAMs), such as in vitro, in silico, and ‘omics-based approaches, still lack the standardized protocols and procedures that govern conventional in vivo testing methods routinely used to test the human and environmental risk of chemicals. Questions about the validity of NAMs compel their proponents to envision a validation process that could bolster the trust of the toxicology community and increase the acceptance of NAMs for regulatory purposes. To generate expert evaluations of options for the validation of NAMs, we conducted a Delphi study - a group communication process that solicits expert judgments through iterative questioning and feedback - with 13 expert panelists from government, industry, and non-governmental organizations in Europe and North America. To aid and accelerate the validation of NAMs, our panelists emphasize the development of common data collection, reporting and sharing procedures for new test methods, along with the improvement of knowledge about new test methods in the regulatory community. Both solutions suggest the need for a common regulatory science infrastructure that would enable toxicology stakeholders to generate and share the benefits of collaboration amongst themselves. Ranking novel testing approaches from the most to the least beneficial and easily implemented within a 3-year timeline, our panelists prefer the Ecological Thresholds of Toxicological Concern (eco-TTC), followed by fit-for-purpose validation, Integrated Approaches to Testing and Assessment (IATA), adverse outcome pathways (AOPs), and the replacement of existing assays with new standardized tests. However, our experts reach no consensus on implementation in risk management, as some favor flexibility, whereas others wish for more structure and less interpretation. This may reflect the broader lack of consensus on the best way to validate NAMs internationally. Our study highlights the need for stakeholders to rally around a shared collaboration infrastructure based on trust across many sites - laboratories, regulatory agencies, contract research organizations, chemical producers, and the public. To build this trust, stakeholders need to agree on what matters (content in relation to context), how it is communicated (data format), and how it is measured (metrics). This work supports the EcoToxChip project (www.ecotoxchip.ca).

TP326 The importance of a legislative framework; linking science to decision making in climate change mitigation and adaptation

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Climate change phenomenon has motivated an extensive body of research across a diverse array of topics including ecological niche theory. A lot of debate or scientific papers have appeared in several journals or News papers concerning climate change with some governments
viewing it as a political weapon while some as a myth. The overwhelming lines-of-evidence now has necessitated the call for approaches or actions that will mitigate or check climate change which is now known to be global in nature. Since avoidance of environmental harm and compensation for environmental damage are incorporated in sustainable principle, certain measures should be put in place to deal with or minimize the effects climate change. As such adaptation and mitigation should encompass a legal framework that will support or help in translating or giving insight on the complicated scientific principles and results for the lay public and non-scientific community or managers. This may ameliorate some of the challenges in linking science to decision-making. Essentially scientific data on climate change need to be consolidated, sorted and transformed into meaningful recommendations for influencing management decisions without losing the accuracy of the findings. However, this should be supported by a legal framework for policy making so that there is little chance of misconstruing the intent of the science. Substantive involvement of all disciplines and stake holders is needed for successful communication of results and actions but apart from the involvement of a communication expert, a legal framework which may facilitate a two-way push and pull of dialogue is vital; it may protect managers and decision-makers in a the manner they convey the scientific report where there are speculations and possible consequences of management decisions that should be made on the basis of what may not be clear or unknown. Hence in this work milestone for a legal framework that may lead to the foundations on which today’s climate change policy could be based is discussed. It is hoped that the hypothesis so derived if successfully implemented will engender an effective mechanism that could integrate information into a sound foundation for welcome decisions on climate change mitigation and adaptation.

TP327 Safer chemicals and materials: Exposing values in green design tools
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The sustainability and health issues of everyday materials are increasingly provoking public debate. Pervasive problems such as the toxicity of commonly used chemicals raise questions about the contributions of designers and engineers, alongside lawmakers and consumers, to creating potential solutions. Technology and design professionals, as well as policymakers, are turning to new tools to operationalize material sustainability goals: “green design tools” are assessment methods and frameworks that help to structure decision-making about chemicals and materials with environmental health concerns in mind. Tool developers (including NGOs, scientists, governments and industry groups) play an important but largely uninvestigated role in mediating technical knowledge in sustainable production initiatives. We argue that green design tools are a way for designers, engineers, and policymakers to operationalize an ethics of sustainable materials. Using toxics issues in the building industry and the green building movement as a case study, we consider specific examples of green design tools that focus on chemicals and materials: the GreenScreen for Safer Chemicals, Pharos, and the Health Product Declaration. We analyze how these tools encode ethical reasoning and instill their developers’ particular perspectives and values. We also examine how the tools are adopted and debated by an extended network of stakeholders. We find that key points of conflict reveal contested values in relation to the ethical questions that the tools are trying to address.

TP328 Themes and Typologies in Supply Chain Sustainability Management and Reporting in the Information and Communication Technologies (ICT) Industry
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The growth of the information and communication technologies (ICT) industry has increased its environmental and human health impacts globally. However, we have limited contextual and empirical understanding of how sustainability management practices have developed in the ICT industry, as well as the role of public and private policies. Based on existing theoretical and empirical research in sustainable supply chain management (SSCM) literature, we use content and interview analysis to identify the main themes, specific practices, and attitudes towards risks by ICT companies. We collect over 2000 annual sustainability reporting data from the Global Reporting Initiative (GRI) Database, the largest global sustainability reporting database and supplemented it with in-person semi-structured interview of managerial personnel in the ICT industry. To analyze emerging themes in ICT supply chain sustainability management, we use machine-based text analysis tool Structural Topic Modeling (STM) to identify themes that are frequently reported by companies. In addition, we built a classification model to predict if ICT companies’ sustainability management practices are driven by risk or non-risk factors using machine-learning approach LASSO to categorize the ICT companies. Based on preliminary analysis, we observe that companies from certain geographic regions have high correlation in their reporting semantic use. The emerging themes reported by ICT companies include 1) finance and performance; 2) management and service; 3) employee and operation; and 4) accountability and risk. Lastly, machine learning methods such as LASSO can be applied to classify corporate sustainability reporting typology. However, small hand-labeled sample size results in low recall rate.

TP329 ScienceBites: An Online Blog Network and Community for Early-Career Scientist Writers
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Early career scientists (graduate students and postdoctoral researchers) in STEM fields are an untapped source of very enthusiastic science writers, eager to share their research stories with the broader public. However, they often lack confidence in communicating with broader audiences, and they may have difficulty finding training resources to guide them in honing messages for non-experts, or platforms where they can publish their non-scientific writing. The ScienceBites family of blogs (astrobites.org, oceanbites.org, envirobites.org, chembites.org, and many others) provide a platform to connect early-career scientists with non-expert audiences by sharing compelling, bite-sized research summaries in a wide variety of scientific fields. At the ScienceBites blogs, these scientist writers regularly publish articles translating recent research articles in their field into engaging blog posts written for broad audiences, with undergraduate students specifically in mind. ScienceBites is working to form a centralized online hub to aggregate work from early-career scientists writing at many different Bites Sites, and to provide support and advice to students looking to start new Bites Sites in additional disciplines. When our website is launched, we also plan to disseminate free online resources that will help to train new Bites writers and other science writers to communicate effectively with non-experts. Here, we will introduce SETAC attendees to our growing network of science blogs, which currently features 14 websites in 3 languages. We will also summarize what we have learned this far about creating engaging science blogs, outline our future plans to grow ScienceBites, and provide information for any graduate students interested in joining an existing site, or starting a new one!
Multiple Stressors and Their Impact in Complex Ecosystems Within and Across Ecosystem Boundaries

TP330 Microbial Metatranscriptomic Investigations Across Contaminant Gradients of the Detroit River
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It is well documented that microbial assemblages in sediments respond to exogenous anthropogenic contaminants via alterations in community structure and cell function. However, how these processes proceed in fresh water ecosystems across pollution gradients is unclear, particularly with regards to holistic microbial gene expression. The advancement of culture-independent, meta-omic techniques is bridging this research gap by enabling whole transcriptome-level sequencing of microbial samples collected at contaminated sites, adding to the understanding of bottom-up ecosystem responses to pollution. This approach was applied to sediments collected from the Detroit River; a region with a complex history of industrialization, urbanization and agricultural land use. Previous sediment surveys and modelling have delineated the river into contaminant zones based on concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and metals, and comparative microbial metatranscriptomics was performed on sediments sampled within these regions. Differential gene expression analysis revealed that microbial function varied from natural to contaminated sites, with legacy-polluted sediments showing increased catabolic and anabolic cycling associated with nitrate reduction, methanogenesis, and beta-oxidation, despite decreases in community alpha-diversity. Transcripts involved in cell gluconeogenesis and polyester synthesis also showed high abundance in contaminated zones, along with increased expression of stress response genes and genetic transfer mechanisms. Aromatic cleavage genes were detected, but in low abundance across the contaminant gradient. These results suggest that microbial communities within the Detroit River exploit unique pathways to derive and store energy through the degradation of legacy organic contaminants and contribute to ecosystem services at work in the benthic environment.

TP331 Effects of the co-presence of the anionic surfactant sodium lauryl ether sulphate and pesticide chlorpyrifos on a natural soil microbial community

Chlorpyrifos (CPF) is an organophosphate insecticide currently used in agricultural practices characterized by a P-O-C linkage. Natural biodegradation can play an important role in its environmental removal; the main metabolite due to its hydrolytic processes is 3,5,6-trichloro-2-pyridinol (TCP). Surfactants are able to solubilize hydrophobic contaminants through their incorporation into the hydrophobic core of micelles in solution, improving the bioavailability of pesticides for natural microorganisms. Sodium lauryl ether sulphate (SLES) is an anionic surfactant widely used in excavation industry, as it is the main component of foaming agents used as lubricants. SLES residual concentrations can occur in the spoil materials reusable as by-products for different environmental purposes, including its mixing to agricultural soils. To date, no studies have been carried out on the interactions between SLES and CPF in soils. The aim of the present study was the evaluation of the persistence and bioavailability of both the anionic surfactant SLES and the pesticide CPF when they simultaneously occur in an agricultural soil. CPF and SLES half-lives (DT50s) were evaluated and the soil natural microbial community were also studied. For this purpose, various soil microcosms were treated with only SLES (70 mg/kg) or only CPF (2 mg/kg) or with both SLES and CPF; moreover, uncontaminated soil were used as microbiological controls (Con). At selected times (0, 7, 14, 21, 28d) soil sub-samples were collected for chemical and microbiological analysis. SLES was analysed by the Methylene Blue Active Substances (MBAS) method, while the pesticide CPF and TCP with a GC-MS, preceded by a Pressurised Liquid Extraction (PLE) from soil. Microbiological analyses were performed in order to assess microbial abundance (DAPI counts), cell vitality (live/dead method), dehydrogenase activity and structure (ELFA analysis). The results showed that both CPF and SLES concentrations decreased during the experimental time, but their halving times were not significantly affected by the presence of the other compound. On the other hand, the formation of TCP was favoured in the co-presence of SLES. In presence of both compounds, the microbial populations were more active and abundant, however the presence of the pesticide caused a shift in the microbial community structure, favouring the Gram-negative bacteria, main responsible of its degradation.

TP332 A multidisciplinary approach for evaluating fate and effects of mixtures of emerging compounds on aquatic and soil ecosystems

Aquatic and terrestrial organisms are continuously being subject to chronic exposures by mixtures of xenobiotics that can affect the population dynamics. A multidisciplinary approach, combining microbiology, ecotoxicology and chemistry makes it possible to assess direct and indirect effects of mixture on natural ecosystems. The natural attenuation capacity of ecosystem versus emerging contaminants such as pharmaceuticals, pesticides and surfactants was studied in microcosms containing natural water and soil samples (comprising the autochthonous microbial communities). The biotic and abiotic degradation of each pollutant alone or in mixture was evaluated comparing the chemical persistence in microbiological active versus pre-sterilized microcosms. At the same time, changing in microbial community structure and functioning, (e.g. loss or inhibition of bacterial populations which could be involved in key ecosystem functions), were also assessed. Non-treated microcosms were used as microbiological controls. The analytical determinations (GC or LC-MS/MS) of the xenobiotic residues in the soil/water over the experimental times period (0d, 7d, 14d, 21d, 28d), made it possible to assess both their half-lives (DT50) and transformation product formation. At the same time, microbiological parameters, related to functional (microbial activity and vitality) and structural (abundance and phylogenetic composition) characteristics of the microbial autochthonous communities, were analyzed. Finally, the effects of the multi-contaminated environmental matrix were also evaluated using standard target species by ecotoxicological bioassays. Ecotoxicological tests on the model organisms V. fisheri (water) and H. incongruens (soil), made it possible to assess the toxicity of both target compounds and un-target products, which may not be detected by chemical analysis. This work reports and discuss the overall chemical, microbiological and ecotoxicological data get from various microcosm experiments, showing the different knowledge obtained by this multidisciplinary approach.

TP333 The effects of the neonicotinoid pesticide imidacloprid and temperature on an ecological relevant springtail (Collombola) species
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Springtails (Collombola) play an important role in decomposition and the cycling of nutrients and energy in soil ecosystems, and provide good soil quality needed for the production of food. Although a non-target species, Collombola suffer sub-lethal and lethal effects from exposure to pesticides used on crops. The agricultural pesticide group neonicotinoids are used to protect crops against grazing insects, and is applied widely and heavily worldwide. When applied, commonly more 90% of the pesticide enters the soil from the crops. In addition to pollution has also climate change been identified as a major threat to the natural environment. Effects of pollution and temperature may interact to produce
unpredictable, potentially synergistic, negative responses. Our aim was to study the effects of the neonicotinoid imidacloprid and temperature on an ecologically relevant Collembola species. A major part of the available toxicological data is on the standardized test species, which have parthenogenetic reproduction and usually only found in very special habitats. By comparison, the sexual species Hypogastrura viatica is widely distributed in temperate and Arctic coastal habitats. We exposed $H. \text{viatica}$ to the neonicotinoid imidacloprid through their ambient environment (soil) at two temperatures, and observed the physical effects and mortality, and life history traits such as time and size at reproduction, and egg production. The animals were exposed to 7 concentrations of imidacloprid between 0.01 to 100 mg/kg dry soil, in addition to the control (0 mg/kg dry soil). The exposure lasted 35 and 26 days, before the animals were kept in a clean environment for 60 and 45 days, respectively for 15 and 20°C; i.e. physiological age. We determined lethal effects of imidacloprid already at the low concentration of 0.01 mg/kg dry soil, and increasing mortality with increasing concentrations. The animals did not recover when moved to a clean environment. The mortality was higher at 20°C compared to 15°C, while egg production of surviving animals and subsequent hatching size did not differ between treatments. However, Collembola exposed to higher concentration of imidacloprid started reproduction later. Understanding the responses in life history traits when exposed to multiple stressors can lead to better extrapolation of results from laboratory studies to field conditions. This is essential to improve ecological risk assessment.

TP334 Ecological Legacy of DDT Archived in Lake Sediments from Eastern Canada

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Past forest management practices led to widespread aerial application of insecticides, such as DDT, to North American forests. Lake basins thus provide an important archive of inputs and aquatic responses to these organochlorines. We used dated sediment cores from study lakes in multiple watersheds in New Brunswick, Canada, to provide a regional perspective on this legacy stressor in remote lake ecosystems. Peak sedimentary levels of p,p'- and o,p'-DDT (ΣDDT) and breakdown products ΣDDE and ΣDDD occurred during the 1970s to 1980s. Sediments exceeded probable effect levels (PELs) by ~450 times at the most impacted lake. Modern sediments in all study lakes still contained levels of DDTs that exceed PELs. We show that aerial applications of DDT to eastern Canadian forests likely resulted in large shifts to primary and secondary consumers within several lake food webs. Modern pelagic zooplankton and benthic invertebrate communities are now much different compared to those present before DDT use, suggesting that a regional organochlorine legacy may exist in the modern food webs of many remote lakes in watersheds where DDT was applied widely.

TP335 Predation-controlled populations are more vulnerable to stressors than food-controlled populations

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Stresses on ecological systems can result in species population declines and even extinctions. Detecting stressor impacts at the population level is consequently very important but challenging due to the natural variability of populations, and the large spatiotemporal scales that are needed to detect changes in population dynamics. Therefore, stressor impacts are frequently measured at individual and sub-individual levels. However, methods are needed to extrapolate from effects on individuals to impacts on populations because population-level impacts are not necessarily proportional to individual-level responses. Scaling from individual- to population-level impacts is challenging because a stressor can impact the survival, growth, and/or reproduction of an individual, as well as how individuals interact with each other and their environment. Population dynamics emerge from these individual-level interactions, often nonlinearly, as a result of positive or negative feedbacks. Closed populations are regulated through reproduction and death, both of which depend on the balance between bottom-up forces (e.g., food availability) and top-down forces (e.g., predation). Few studies consider both regulating forces when evaluating effects of stressors. Therefore, there is a pressing need for studies that systematically assess the stress responses of populations under top-down versus bottom-up control. We used an Individual-Based Model to infer population-level impacts of a hypothetical, sublethal stressor that can affect an individual’s metabolism (growth, reproduction, maintenance, or assimilation) in systems in which population size is controlled by different combinations of food availability and predation. Our results confirm that population-level effects increase with stressor intensity, and are rarely directly proportional to individual-level effects. However, we also found that population-level effects were greater when the stressor impacted assimilation, and when populations were predation-controlled. Our results suggest that individual-level measurements alone are insufficient for inferring population-level impacts of stressors, and that accurate inference hinges on insight into how populations are regulated. We suggest incorporating individual-level data into mechanistic models that take into account population regulation.

TP336 Can the SPrEcies At Risk of pesticides (SPEARpesticides) index selectively quantify pesticide impacts within artificial ecosystems?

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Pesticides are increasingly recognised as a threat to freshwater biodiversity, but their effects among co-occurring stressors and environmental gradients remain difficult to quantify. The SPrEcies At Risk indices designed for pesticides (SPEARpesticides) and corrected for use within mesocosms (SPEARpesticides-mesocosms), attempt to selectively quantify pesticide effects on communities among co-occurring stressors. We directly tested the efficacy of SPEARpesticides and SPEARpesticides-mesocosms, using 24 independent 1000L re-circulating outdoor mesocosms. We examined the effects of malathion, and other agricultural stressors, i.e. sediment, nitrate and phosphate, on stream invertebrate structure in an orthogonal pulsed design. Stream invertebrate communities were subjected to two pulses of sediment, nitrate and phosphate combined into one treatment (mimicking eutrophic conditions), and malathion (Pulse 1: 0.1 and 1ugL$^{-1}$; Pulse 2: 2.5 and 25 µgL$^{-1}$). SPEARpesticides failed to establish effects despite sensitive taxa declines during Pulse 1. In contrast, during Pulse 2 SPEARpesticides responded in the opposite direction in high pesticide treatments than expected. Both examination of species tolerances and the use of SPEARpesticides-mesocosms as opposed to SPEARpesticides help to correct this result. However, results identified that misclassification of taxonomic tolerances, low abundance, and low richness, especially in combination can cause unusual variation in SPEARpesticides indices. Simulation supports varying abundance, sample richness, sensitivity error, all cause declining index performance. We suggest the use of both multivariate and univariate (SPEARpesticides) analysis, accounting for co-occurring gradients both physical and chemical, coupled with experimentation and toxicity tests will best elucidate pesticide effects within complex freshwater systems.
TP337 Understanding Insect-Mediated Contaminant Flux: When, Where, and How to Look for Contaminant Export by Emergent Aquatic Insects

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The exchange of subsidies across the land-water interface is a key driver of community dynamics and ecosystem processes in both aquatic and riparian habitats as organic matter, nutrients, and animals flow across these systems. However, biological vectors can also transport contaminants across the land-water boundary. A classic example of contaminant-linked subsidies came from early studies of egg shell thinning in birds. In these studies, reproductive failure in piscivorous birds (e.g., eagles and pelicans) was linked to DDT exposure from consumption of fish that had accumulated in the aquatic ecosystem. Like birds, adult aquatic insects have been shown to transport significant quantities of contaminants such as PCBs out of aquatic environments, thereby linking aquatic contamination to terrestrial predators via a phenomenon called insect-mediated contaminant flux. Here, we present a decision-making tool to assess the likelihood of terrestrial risk via insect-mediated flux. This tool, named the Riparian Impact Test, integrates the technical science of the conceptual model into a step-wise series of four questions to aid risk assessors. We also discuss practical considerations for risk assessors, including how to best sample for insect-mediated contaminant flux at a specific site.

TP338 The effect of complex life histories on Hg accumulation and exposure in linked aquatic-terrestrial food webs


Many animals such as insects and amphibians have complex life histories that involve metamorphosis from an aquatic to a terrestrial life stage. Aquatic systems tend to concentrate contaminants such as mercury (Hg), so animals that accumulate Hg during their aquatic life stage are potential vectors of Hg transport to terrestrial ecosystems. Some amphibians are particularly interesting for assessing mercury flux from one system to the next because they feed on algae as tadpoles, do not feed during the process of metamorphosis, feed on aquatic and terrestrial insects as adults, then do not feed at all during hibernation which can last 7-8 months at high elevations. We measured total Hg (THg), methylmercury (MeHg), and isotopic composition (δ13C, δ15N) in chorus frogs (Pseudacris maculata) at two subalpine ponds (2775 and 2960 m elevation) in the Rocky Mountains in Colorado, USA. We sampled various life stages including spawning adults (‘starved’ adults just emerging from hibernation), eggs, tadpoles, metamorphs (recently emerged aquatic environment,) and mid-summer adults that remained and fed around ponds after spawning. We found large differences in MeHg concentrations and percent MeHg among life stages as a function of maternal transfer to eggs, diet switching, and catabolism during metamorphosis and hibernation. Starved spawning adults had the highest mean MeHg concentration (274 ng/g dry mass) of any life stage. Maternal transfer of mercury to eggs was minimal (22 ng/g) and remained low in tadpoles (36 ng/g) but roughly doubled at the metamorph stage (71 ng/g). This large increase was accompanied by a 33% loss of body mass during metamorphosis. Adults that remained around ponds during summer had concentrations roughly half (146 ng/g) that of the starved, spawning adults. The percent of MeHg and isotopic signatures also showed similar pronounced step changes across life history. Percent MeHg was high (~8%) for both adult life stages and remained high in eggs (52%) due to maternal transfer. After hatching, this percentage declined to only 23% in tadpoles and then doubled to 50% during metamorphosis. Isotopic signatures also changed substantially and abruptly between egg, tadpole, and metamorph life stages. Our findings show that key transition periods in animals with complex life histories are an important consideration in understanding environmental exposures to contaminants. Further, factors such as catabolism can dramatically alter the typical trajectory of trophic transfer and accumulation of contaminants such as mercury.

TP339 A Recommended Framework for a Great Lakes Early Warning System - Characterizing and Responding to Stressor Interactions

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The Science Advisory Board of the Canada/US International Joint Commission funded the development of a framework for a Great Lakes Early Warning System; a means to allow the Great Lakes scientific and management communities to “get ahead of the curve” in addressing emerging and anticipated issues before they threaten the ecological integrity of the Great Lakes - St. Lawrence River Basin. Toward that end, a multi-faceted approach consisting of a literature review, interviews, survey and Experts Workshop was taken to 1) identify and prioritize emerging and anticipated threats and stressors; and 2) develop a conceptual framework for a GLEWS to characterize these threats and stressors and link them to response actions. Project outcomes included the identification and prioritization of several dozen current, emerging and anticipated threats and stressors adversely impacting ecological integrity. In addition, structural and operational alternatives of a recommended framework were explored, with the recommended alternative being a distinct and formalized entity within the International Joint Commission structure. A related follow-on project examined the nature of interactions among priority stressors, noting that some approaches to multiple stressor impact assessment have assumed that impacts are additive. While synergistic stressor interactions have been hypothesized to further degrade ecosystem conditions within the Great Lakes, there is little documented evidence of non-additive effects of stressors, let alone ternary or quaternary stressor interactions. This project explored the potential for nonlinear effects and ecological changes associated with multiple interacting stressors. Outcomes included a characterization and prioritization of stressor interactions by 1) identifying and describing commonly documented stressor combinations; 2) describing the nature of non-additive effects; 3) identifying stressor combinations of greatest concern; 4) characterizing the strength of stressor interactions across different aquatic environments and scales; 5) assessing underlying data quality and strength of evidence; and 6) identifying and describing research, surveillance and monitoring needs. The development of a Great Lakes Early Warning System, coupled with an investigation into stressor interactions, has laid a foundation for more informed, science-based management of the Great Lakes system.

TP340 The Montreal Protocol and Kigali Amendment: Actions for a sustainable Earth

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Global problems need global solutions and there are few examples of successful actions leading to changes for the better other than the Stockholm Convention on POPs and the Montreal Protocol (MP) and the Kigali Amendment to the MP. Depletion of stratospheric ozone has serious consequences to humans and the global ecosystem. Under the MP (initiated in 1987), the release of ozone depleting substances (ODSs) has been successful in mitigating depletion of stratospheric ozone and thus contributed to a sustainable earth. The Kigali amendment has begun the process for mitigating the release of gases with global warming potential (GWP) that will reduce global warming. Under the leadership of the United Nations Environmental Programme (UNEP) all but two nations have become parties to the MP. This has come about because of overwhelming scientific evidence of depletion of stratospheric ozone, a detailed understanding of the mechanisms involved, and the resultant increased intensity of damaging UV-B at the surface of the earth. While UV-B is the primary...
Wildlife Ecotoxicology: Assessing Effects of Chemical Stressors at Multiple Scales

TP341 Elevated Persistent Organic Pollutant Exposure in St. Lawrence Estuary Belugas (Canada): Relationships with Lipid Profiles and Body Condition

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Exposure of St. Lawrence Estuary (SLE) belugas (Delphinapterus leucas) to elevated levels of persistent organic pollutants (POPs) was identified as environmental stressor that may contribute to affect SLE beluga health, and potentially be associated with certain causes of death in this endangered population. Several POPs (e.g., PCBs and PBDEs) are known to disrupt thyroid functions, lipid metabolism and ultimately alter body condition in mammals. However, limited information exists on the impact of contaminant exposure on energetic metabolism in cetaceans. The main objective of this study was to investigate the relationships between blubber concentrations of POPs (several flame retardants and organochlorines), lipid profiles (fatty acids, phospholipids, acylcarnitines) and body condition (scaled mass index) of SLE beluga males and females (n = 51; 1998 to 2016). A second objective was to investigate the linkages between these variables and the causes of death of these animals determined by necropsy. SLE female belugas that died as a result of dystocia were younger and were in better body condition than other females, whereas those that died by starvation had a lower body condition. SLE belugas that died from cancer exhibited greater concentrations of medium-chain fatty acids (C14:0, 16:0, and 18:0) compared to those that died from other causes. Concentrations of PCBs and organochlorine pesticides were 8- and 42-fold greater in male than female SLE belugas, respectively. Male and female belugas that died from bacterial infection showed the greatest PCB and organochlorine pesticide blubber concentrations, which could be explained by POPs exposure-mediated suppression of the immune system. SLE beluga females that died following dystocia, also exhibited the greatest polyunsaturated:monounsaturated fatty acid ratios that have been associated with metabolic disorders, oxidative stress, and lipid metabolism perturbation. Preliminary results of this study showed that energetic metabolism and general health of endangered SLE belugas is potentially affected as a result of their elevated POP exposure, which would warrant further investigation.

TP342 Effects of early-life stage exposure of double-crested cormorant embryos to 4 environmental chemicals on apical outcomes of regulatory relevance

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Environmental risk assessment is often challenged by a lack of toxicity data for ecological species of relevance. Although avian species are sensitive indicators of ecosystem health, toxicity data for many chemicals of ecological and regulatory concern are lacking. The overall goal of this research project was to employ an avian early-life stage toxicity test to determine the effects of 4 chemicals (benzo[a]pyrene [BaP], chlorpyrifos [CPF], ethinylestradiol [EE2], fluoxetine hydrochloride [FLX]), which are commonly detected in Canadian ecosystems and have well-characterized modes of toxic action. The chemicals were dissolved in DMSO and administered via air cell injection to fertilized, unincubated eggs collected from double-crested cormorant (DCCO) nests, at 3 nominal concentrations (BaP - 5, 0.5, 0.05 ng/g; CPF - 40, 4, 0.4 µg/g; EE2 - 33, 3.3, 0.33 µg/g; FLX - 30, 3, 0.3 µg/g) plus a solvent control. The highest concentration of each chemical was selected based on LD20 values from the literature and previous egg injection studies conducted by our group with Japanese quail (JQ) embryos. Liver tissue was collected from a sub-set of embryos at mid-incubation (day 14) for subsequent 'omics and analytical chemistry analyses, while the remaining embryos were examined on day 26 (1-2 days prior to hatch) for apical outcomes of regulatory relevance. Data are currently being analyzed to permit species sensitivity comparisons between JQ and DCCO. Ultimately, we aim to link 'omics endpoints with apical measures of regulatory relevance and demonstrate the utility of early-life stage toxicity tests as alternatives to traditional animal tests in the realm of chemical screening. The study supports the standardization of this early-life stage test in Canada and a large-scale Genome Canada project (EcoToxChip project; www.ecotoxchip.ca) aimed at transforming ecological risk assessment.

TP343 Health Assessment of Bighorn Sheep and Elk Populations on a Mine using GPS tracking and Tissue Sampling


In wildlife ecotoxicology studies, directly sampling chemical concentrations in individuals of free-ranging wildlife and monitoring their movements and diets provides an opportunity to identify population-level patterns of exposure and effects. This information can be used to inform remedial decisions. To assess effects from metals exposure to bighorn sheep populations that forage on a large mine and to elk populations that forage on the mine tailing facility, bighorn ewes and elk cows were captured. They were fitted with GPS collars to monitor herd foraging patterns on and off site for one year. Blood, hair and feces were collected from each collared individual to provide an indicator of metal uptake and overall health of each herd. Blood analyses included cell counts and biochemical parameters. The health of nearby reference herds was monitored at the same time through tissue collection. A dietary analysis of the elk herd for each season was conducted using DNA in feces. Tracking results indicate that bighorn sheep spent 13 to 22% of their time on the mine, depending on the season. They had elevated molybdenum levels in tissues but showed no indication of adverse effects on measured health parameters. Changes in exposure after mine reclamation were then predicted using landscape-scale habitat modeling. Planned reclamation will convert molybdenum exposure areas from waste rock piles to a seeded mine cover designed to transition to shrubland vegetation. Using innovative techniques, the habitat models predicted new home range contours and use patterns for post-reclamation populations. These models predicted that, after shrub development on the cover post-reclamation, bighorn sheep will spend approximately 16 to 20% of their time on the reclamation cover, which is similar to time spent on the mine prior to reclamation. Tracking results indicated that the elk herd foraged on the tailing facility 14% of the time. Tissue analysis indicated that elk had marginal copper deficiency in their blood and/or liver. However, the elk experienced no ill effects on their health as determined by a veterinarian and one necropsy.
TP344 Sublethal Effects of Neurotoxic Pesticides on Tropical Bats: from Cells to Behaviour

N. Sandoval Herrera, University of Toronto, Scarborough / Ecology and Evolutionary Biology; K.C. Welch, University of Toronto, Scarborough / Biological Sciences

Bats play vital roles in our ecosystems and economies as pest control agents, seed dispersers, and pollinators. Insectivorous bats, for example, control insect populations including agricultural pests. However, agricultural intensification and the consequent increase in pesticide use may represent an increasing threat to bat populations, thereby affecting the ecosystem services they provide. Some pesticides such as organophosphates (OPs) are highly neurotoxic for non-target organisms but have low persistence in the environment. Nevertheless, even low doses can impair essential processes such as immune function, locomotion, and cognition, threatening animal survival and its ecological function in a longer term. This study seeks to determine what sublethal effects of organophosphates have on bat physiology and behavior. We used an integrative approach to study the toxic effects of OPs on captive and wild bats. We measured multiple biomarkers in wild population roosting close to croplands in Mexico and Belize. We evaluated molecular (enzyme activity), physiological (metabolic rate, immune response) and behavioral (spatial memory) endpoints, aiming to extrapolate these responses across levels of biological organization. We present evidence of the suitability of some of these biomarkers to monitor wild populations and we propose a simple, yet sensitive behavioral test to evaluate spatial memory as an ecologically relevant behavior in bats. Understanding the sublethal effects of pesticides at different scales will enable to better predict the implications on bat populations and help to inform conservation strategies.

TP345 Micronucleus assay, a suitable tool to evaluate genotoxicity in wild bats

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Micronuclei were identified after a differential hematological staining as small, basophilic round inclusions inside the erythrocytes. We found that the bats from caves surrounded by commercial crops irrigated year-round have the highest number of MN, followed by bats from caves surrounded by seasonal crop lands, with bats from the cave proximal to deciduous forest having the lowest number of MN. We find evidence that MN assay is a useful biomarker for evaluating variation in genotoxic damage among wild animal populations.

TP346 Getting Buzzed: Use of Honey Bees (Apis mellifera) as an Alternate Model for Behavioral Effects of Alcohol Toxicity

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The current predominant model for examining effects of alcohol toxicity on behavioral and neurochemical outcomes in invertebrates is the fruit fly, Drosophila melanogaster. We propose that honey bees (Apis mellifera) have much to recommend them as a potential alternate organism to fill this research niche. Past research illustrates that honey bees readily consume alcohol, from both fermented nectar products, as well as in laboratory settings. Research into Drosophila has included both latent variables such as captive life span and general activity, as well as more controlled behaviors such as target oriented movement. In addition, the Drosophila literature has suggested a number of candidate genes which are affected by acute and chronic ingestion of alcohol. Past research in our laboratory, as well as genetic sequencing suggests that many of these genes are conserved in the honey bee genome. Here we present an initial assessment of the effects of chronic alcohol exposure on gross behavioral function and mortality in Apis mellifera ligustica.
**Advantages of Using Field Collected Invertebrates in Ecotoxicology and Ways to Standardize Their Collection and Testing**

WP001 Parallel Native Biota and Culturable Species Testing at EPA's Experimental Stream Facility

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The USEPA's Experimental Stream Facility (ESF) conducts meso-scale ecotoxicology studies that account for both structural and functional responses of whole stream communities to contaminants or other stressors. A macroinvertebrate community is established for each test by colonizing gravel baskets in field streams of the East Fork Watershed of Southwestern, Ohio where the ESF is located, and by allowing for recruitment from a continuous flow-through of natural river water over the course of each test, which are typically run for 90 days. Procedures have been developed for conducting parallel single-species exposure assays at the bench-scale using traditional test organisms and a culturable mayfly species, as well as using ex situ/in situ to the mesocosm formats that assess fish survival and fecundity and bivalve survival and growth. The 16 mesocosms of ESF are indoors and consist of a tiled run section (0.152 m W x 4.268 m L x 0.105 m D) that widens to a gravel riffle section (0.305 m W x 4.268 m L x 0.19 m D). They are intermediate size among studies reporting stream mesocosm results. Their set-up is unique for their size, with a high degree of engineering controls for continuous flow-through dose-response designs, yet fixed, chronic exposures to contaminants under conditions that quantifiably mimic real stream riffle/run habitat using standardized collection and measurement methods. With this framework of parallel native biota and standard test organism measures studies at ESF support the evaluation of proposed aquatic life criteria. This presentation will present the standardized methods used to colonize the mesocosms, measure biotic endpoints, physiochemical parameters and toxicity tests. In addition, present results on how single species toxicity tests compare with community responses.

WP002 Mesocosm testing of naturally colonized stream insect communities produces sensitive, reproducible, and ecologically-relevant effects concentrations


We conducted a series of 4 mesocosms tests using translocated, field-colonized insect communities that were exposed to 5 metals (Cd, 2X; Co, 1X; Cu, 3X; Ni, 2X; and Zn, 3X). Colonizations were for ~40 days using trays of pre-washed gravel placed in the same riffle of the same Colorado river in late summer or early fall depending on flow conditions. The 30-day exposures used 19-L buckets fitted with recirculating pumps to maintain a riffle-like current, and the buckets were set in chilled water baths to maintain suitable temperatures. Dilution water was trucked from the colonization site to the laboratory, and flow-through dosing was maintained by peristaltic pumps with about 2 volume replacements per day. The natural periphyton-based food web was maintained through grow lights, and no supplemental feeding was provided. In each test, the taxa richness ranged from about 23 to 35 taxa, and about 5 to 8 taxa were common enough to calculate concentration-response effect concentrations (ECs) in the same manner as in classic single-species tests. In most cases, repeated EC20 values varied within a factor of 2 to 3, although in one instance, the variability was almost a factor of 20. When ECs for the different species were overlain on published species-sensitivity distributions (SSDs) compiled from existing data, the ECs from the mesocosm testing nearly spanned the complete SSDs, ranging from the most sensitive to the most resistant ends of the distribution. This diversity of results appears consistent with patterns observed in metals-contaminated field settings. For the few insect taxa that were closely related to species that have been tested in single-species full life-cycle (FLC) tests, the 30-day larval survival endpoint was similar in sensitivity to the published FLC results. This suggests that the mesocosm larval ECs could be incorporated directly into aquatic life criteria or risk assessment datasets, much as fish early life stage (ELS) tests have long been used in lieu of far rarer and more difficult FLCs.

WP003 Why conduct rapid toxicity tests with field collected organisms?

B.J. Kefford, University of Canberra / Institute for Applied Ecology

Rapid toxicity tests are designed to determine the approximate sensitivity of many field collected species from specific ecological communities of interest. They aim to determine the approximate sensitivity of a large sample of species (10’s to about 100) to some chemical, chemicals or effluent, rather than the conventional practice in toxicity testing of more accurately determining the sensitivity of a smaller number of species. Rapid does not refer to the duration of exposure to chemicals but rather to the time and other resources per species tested. Rapid toxicity testing involves exposing field collected organisms to a chemical or a mixture of chemicals in the laboratory. To date these tests have used freshwater invertebrates and diatoms and marine invertebrates but in principle the approach could be extended to any group of organisms. Data obtained from rapid testing has been put to several uses. Species sensitivity distributions (SSDs) have been constructed with rapid test data from large sample of species (10’s to about 100) that represent specific communities of interest. Rankings of taxa’s sensitivities to chemical stressors have been developed with data from rapid tests which have then been used to construct, or modify, biomonitoring indexes, e.g. the diatom based SPEAherbicides index. Such indexes useful to interpret patterns in community structure along pollution and other gradients in field and mesocosm studies. Data from rapid tests has also been used to determine the ability of toxicity tests to predict the concentrations of chemicals that taxa inhabit in the field. Data from rapid tests conducted from species collected from multiple sites with different pollution histories has also been used to investigate pollution induced community tolerance (PICT). In this presentation, I will discuss how to conduct rapid tests, why conduct these tests and options for incorporating data from these tests into field and mesocosm programs.

WP004 Multiple biomarker responses and toxicity pathway analysis in snails Bellamyia aeruginosa exposed to tributyltin and triphenyletin in sediment

Q. Li, Tongji University / College of Environmental Science and Technology

Two organotin compounds, tributyltin (TBT) and triphenyltin (TPT) have been widely used as fungicides in agricultural activities and as ingredients of anti fouling paints since the 1960s. Sediments function as a secondary and significant source of TBT and TPT in aquatic ecosystems and may impose serious effects on benthic organisms and human health. Bellamyia aeruginosa (synonym: Sinotaia aeruginosa; Gastropoda, Caenogastropoda, Viviparidae) is a freshwater gastropod that is quite common throughout Chinese freshwater ecosystems and has great importance for human consumption. They are closely associated with surface sediments where they burrow in the upper layer and ingest particulate matter searching for the nutritive matter belonging to the sediment. In this study, the sub-chronic toxicity of sediment-associated TBT or TPT to snails Bellamyia aeruginosa at environmentally relevant concentrations was investigated. Multiple endpoints at the biochemical (EROD, SOD, CAT, protein carbonyl content and lipid peroxidation) were examined. High-throughput transcriptomic approach was applied to explore the toxicity mechanism of sediment-associated organotin compounds. TBT or TPT in sediment could result in induction of antioxidant defense system and oxidative damage in the hepatopancreas of B. aeruginosa after 28-d exposure. A transcriptomic profile of B. aeruginosa exposed to TBT and TPT was reported for the first time. CYP genes and EROD activity are sensible and reliable biomarkers, which could be an alternative tool.
in assisting reliable assessment of toxicity of TBT or TPT in sediment. Comparative pathway analysis revealed the alteration of steroid hormone biosynthesis and retinol metabolism in *B. aeruginosa* after 90-day exposure to sediment-associated TBT at the concentration of 2000 ng/g dw, which might affect both reproduction and lipogenesis functions. The ubiquitin proteasome system and immune system might be the toxicity target in *B. aeruginosa* after exposure to sediment-associated TPT for 90 days. The results offered new mechanisms underlying the toxicity of sediment-associated TBT and TPT.

**WP005 Diversity in toxicity testing - why field collected organisms are essential to the development of higher tier prediction tools for chemical assessment**

S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; G. Carr, The Procter and Gamble Company / Data & Modeling Sciences

Use of field collected biota for ecotoxicological testing has been a tradition in environmental toxicology before and since the days of Dr. Ruth Patrick’s river biological assessment teams probing responses of different trophic levels to systems perturbed by effluents in the 1940’s. The limitation of standard rearing, culturing, endpoint development and interpretation of responses to chemicals by lab-cultured organism has long been recognized as a shortcoming in chemical management. This eventually led to the use of microcosm and mesocosm approaches to supplement direct toxicity test investigations at the population level and also further emphasized the use of field-collected biota to understand extrapolation phenomena. In addition to micro/mesocosm studies as higher tier tools, ecotoxicologists also rely heavily on Species Sensitivity Distributions or SSDs for effects assessment. The limited nature of “standard test organisms” means SSDs are almost always heavily populated by “non-standard” field-collected biota subjected to chemical exposures to develop the sensitivity profiles for the chemicals. We recently developed a broad assessment of SSDs to understand roles of sample size on SSD characteristics and ways to address utilization of application factors. Both acute and chronic SSDs were assessed for 19 compounds and 22 individual data sets. Twenty data sets meet the commonly accepted criterion of a minimum of 10 species being represented across a range of phyla. Standard taxa were represented in all SSDs, although 4 instances occurred where standard algae and daphnids were absent. “Standard taxa” comprised 30% of the taxa and ranged from 2.4% (chlorpyrifos) to 50% (the anionic surfactant, HSAS) of species employed in the SSDs. Standard taxa and were only amongst the top two most sensitive taxa in only 4 cases. These observations demonstrate the essentiality of using field collected and non-standard species in ecotoxicological investigations. They are necessary to understand trophic-level tolerance patterns and trends (for example, photosynthetic organisms as being highly sensitive as a group to the zwitterionic surfactant, amine oxide). If field collected biota were not included in these assessments, fundamental linkages between standard taxa and mesocosm studies would also be more problematic.

**WP006 Probing Application Factors for SSDs - New Tools to Establish Robustness of SSDs with Adequate Biodiversity Present**

S.E. Belanger, Procter & Gamble Company / Global Product Stewardship; G. Carr, The Procter and Gamble Company / Data & Modeling Sciences

Application Factors (AF) are routinely applied in the extrapolation of laboratory aquatic toxicity data to ensure protectiveness from exposure to chemicals in the natural environment. The magnitude of the AF is both a scientific and policy decision; however, in any case should be rooted in scientific knowledge so as to not be arbitrary. Information rich chemicals are often subjected to Species Sensitivity Distribution (SSD) analysis, largely supplementing non-standard species with traditional ecotoxicity test species, to transparently describe certain aspects of assessment uncertainty. SSDs are normally subjected to much smaller AFs than screening information data sets. We describe here a new set of tools useful to assess the quality of SSDs. Twenty-two data sets and 19 chemicals representing agrochemicals, biocides, surfactants, metals, and common wastewater contaminants were compiled to demonstrate how the tools can be used. “Add-one-In” and “Leave-one-out” simulations were used to investigate SSD robustness and develop quantitative evidence for the use of AFs. Theoretical new toxicity data were identified for add-one-in based on the expected probabilities necessary to lower the HC5 (5th percentile Hazard Concentration) by a factor of 2, 3, 5 or 10. Simulations demonstrate the basis for AFs in the range of 1 to 5 for well-studied chemicals with high quality SSDs. Leave-one-out simulations identify that the most influential values in the SSD comes from the extremes of the sensitive and tolerant toxicity values. Mesocosm and field data consistently demonstrate HC5s are conservative further justifying the use of small AFs for high quality SSDs.

**Alternative Approaches to Animal Testing for Ecotoxicity Assessments: Exploring New And Novel Approaches**

**WP007 Identification of environmental causes of reproductive failure through high throughput chemical screening using yeast**

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The success of in vivo high-throughput chemical screens both to identify carcinogens and to discover effective therapies against cancer is well known. In contrast, very little has been done to employ this strategy to understand the toxicity of chemicals to the reproductive process although the consequences can adversely affect reproduction in this generation and result in birth defects and developmental disabilities in the next. An impediment to identifying and understanding the role of environmental chemical exposure is the prolonged delay between toxicant exposure and the manifestation of reproductive perturbations: when a pregnant woman is exposed to a reproductive toxin, the effects may only be seen in her offspring or generation after. As a result, there is a paucity of information on reproductive toxicity. Evaluation of reproductive toxicity has been most commonly performed using standard whole-animal rodent tests, which are costly, time consuming (years), require a large number of animals, and are typically not sensitive enough to capture the effects on gametes (egg and sperm), especially at the early stages of development. Here we describe a high-throughput screen to rapidly test a broad range of chemicals by incorporating an in vivo system using *S. cerevisiae* (budding yeast) to better capture a chemical’s effect on gamete production, a biological process known as meiosis. Our initial experiments using this yeast-based assay show that known mammalian reproductive toxicants (e.g. bisphenol A, triflumizole, fenarimol) can be positively identified by this assay suggesting that this assay could be an important aid in setting regulatory guidelines for chemical exposure particularly in regards to pregnancy and exposure to young children.

**WP008 A systematic approach to evaluate and utilize Molecular Initiating Events (MIE) for chemical classification**

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Mode of Action (MoA) determination is an important part of understanding toxicity to aquatic organisms in the context of risk assessment and as part of regulatory schemes to enable read-across, chemical categorisation
and prioritisation. With a lack of harmonisation of current chemical -fragment based approaches to be able to adequately classify the full commercial chemical space, coupled with a shift towards mechanistic based approaches, there is a need to better define classification approaches. The Adverse Outcome Pathway (AOP) concept has gained significant traction as a means to interpret apical toxicity endpoints mechanistically. An AOP is a systematic approach that links molecular and biochemical interactions to individual or population responses and thus provides an opportunity to base classification schemes around this framework. A first key component in AOPs is the Molecular Initiating Event (MIE), where both chemistry and biology are integral components. There is a recognised need to evaluate the confidence of all parts of the AOP notably the MIE, Key Events (KEs) and Key Event Relationships (KERs); whilst schemes are in place for KEs and KERs, they have not been applied to MIEs. The aim of this study was to develop a scheme for classifying chemicals in MIEs relevant to aquatic toxicity. Prior to collation of MIEs, a framework was established to evaluate the ‘quality’ of MIEs in terms of the underlying evidence. Information on structural qualities of the MIE target; the interaction; associated chemistry; taxonomic applicability; along with the sources and the type of data (e.g. in silico, in vivo, in vitro) corresponding to MIE/MIE target of interest were documented. This led to an extended list of identified MIE and MIE targets. The MIEs were organised in 3 classes based on the type of interaction. This facilitated the utilisation of the chemical domain of MIE/MIE targets as building units for the chemical space per class. The chemical structural criteria for class assignment along with transparency in taxonomic applicability, data source and quality, were coded in a KNIME workflow. This approach provides the user with an informed MIE prediction that can be potentially used in the application of the AOPs to better understand chemical classification and to predict toxicity across aquatic species.

WP009 An In Vitro Toolbox For Bioaccumulation
J. Heckelmann, E. Salinas, B. Birk, E. Fabian, C. Gomes, B. Hidding, B. van Ravenzwaay, BASF SE / Experimental Toxicology and Ecology; T. Braunbeck, University of Heidelberg / Centre for Organisational Studies

Bioaccumulation plays an important role in the risk assessment and environmental fate of chemical substances. The main source of information is obtained by vertebrate testing, although different in vitro methods can reduce the overall number of animals needed for bioaccumulation assessment. This project aims to establish an integrated in vitro toolbox to estimate bioaccumulation in fish in support of alternative methods to animal testing. The toolbox consists of two cell culture assays, a fish embryo BCF screening, and a PBTK (Physiologically Based Toxicokinetic) model. As gills represent the main uptake route for waterborne substances in fish, an in vitro barrier model with fish gill cells is utilized to determine the chemical uptake rate. This assay was characterized regarding, e.g., monolayer and tight junction formations and validated using chemicals with known in vivo bioaccumulation factors. Since the biotransformation of absorbed substances play an important role for their clearance and in turn for their bioaccumulation potential, the fish hepatocyte assay, according to the OECD TG 319A, is utilized as the second in vitro model in the toolbox. The third model for the toolbox, uses fish non-protected embryonic life stages (2010/63/EU) to establish lipid-corrected BCF values. The assay is performed at a reduced temperature to extend the embryonic life stage and allow sufficient time for uptake and elimination. Kinetic rate constants and bioconcentration factors of substances shall be determined in the fish embryo to compare the results with in vitro cell culture assays and known bioconcentration factors in adult fish. The fourth aspect of the toolbox incorporates the in vitro and fish embryo data well as data from other sources (e.g., physico-chemical properties) into a toxicokinetic model to elucidate the behavior of the substances in fish and predict bioaccumulation potential.

WP010 Non-lethal blood sampling from rainbow trout in the laboratory and in situ
S. Pollard, C.D. Tyson, Ontario Tech University / Faculty of Science; J. Guchardi, University of Ontario / Faculty of Science; J.C. Anderson, D. Simmons, Ontario Tech University / Faculty of Science

The use of humane methods in animal research is an internationally recognized priority, but few EEM programs use nonlethal methods with fish, and the ones that do are normally limited to behavior, morphology, and reproduction. Non-lethal blood sampling methods support the three R’s of humane experimental technique (Replacement, Reduction, and Refinement). Small tissue samples can be sampled from fish to measure exposure to contaminants; however, for understanding biological effects, tissue samples are often limited to only one type of physiological response. One of the advantages of blood, serum, and plasma is that these fluids contain protein, metabolites, and signaling information from all tissues and organs within the entire organism, which facilitates a systems-level understanding of whole organism health. Much to our surprise, we can find no published protocol or studies that outline procedures for effective and low-impact non-lethal blood sampling in fish. Thus, the goal of the present study was to determine the impacts and survival of larger bodied fish after sampling small volumes of blood. In our approach, we housed 80 rainbow trout (Oncorhynchus mykiss) purchased from a local hatchery in our flow-through aquatic facility (Ontario Tech U, Oshawa On). We then anesthetized using MS-222 and sampled 1 ul of blood per gram of mass from each fish. We tested three different post-blood sampling treatments on the puncture wound; application of a liquid bandage, a swab of betadine, a swab of the fishes own skin mucus, and then we compared these to fish where we performed no post-treatment (as a negative control). After blood sampling, fish were examined weekly for 5 weeks. Overall, we observed 90% survival among all treatments; the most effective approach was the negative control (100% survival), while the post-treatment with the largest impact on fish survival was the use of betadine (75% survival). Based upon these results, we repeated the blood sampling with no-post treatment using 20 rainbow trout (freshly purchased, not previously tested upon) in situ using suspended cages at a nearby freshwater lake, and monitored fish behavior and survival for 5 weeks post-sampling. In this presentation, we will present the detailed results of these combined studies and describe what we have determined to be the safest non-lethal blood sampling protocol.

WP011 Developmental Toxic Effects of Three Alternative Antifouling Biocide on non-target marine fish
J. Jung, Korea Institute of Ocean Science and Technology (KIOST) / Risk Assessment Research Center; Y. Choi, Korea Institute of Ocean Science and Technology / Risk Assessment Research Center; M. Kim, Korea Institute of Ocean Science and Technology / Risk Assessment Research Center; C. Hong, Theragen Etex Bio Institute Inc.; J. Kang, Korea Institute of Ocean Science and Technology / Risk Assessment Research Center

To compare the toxic effects of three alternative commercial biocides on pelagic nan-target fish embryos, we investigate the adverse effects of developmental malformation and transcriptome analysis using high-throughput sequencing (RNA-seq). Overall, three biocides produced a largely overlapping suite of developmental malformation including spinal curvature and tail fin defect. However, pericardial edema defects were shown specially in embryos exposed to Sea-nine 211(R). At 48 hours after exposure, frequency percentage of mortality was shown 100% of mortality in the exposure group of 100 µg/L for sea-nine 211(R). Those biocides may be ranked in the following order from highest malformation and mortalities; Sea-nine 211(R) > Irgarol 1051(R) > Diuron. In consistent with, the gene expression level relating to malformation including the heart formation was higher in embryonic flounder exposed to Sea-nine 211(R) than those of Irgarol 1051(R) and Diuron, but genes relating to fin malformation increased commonly in three biocides exposure groups. In the differential gene expression (DEG) profiles sensitive (fold change of genes with cutoff P< 0.05), genes associated with nervous system development and synaptic signaling have varied significantly in common
with three biocides exposure groups. Embryos exposed to Diuron were changed highly related to cellular protein localization, whereas, genes associated with immune system process were up-regulated significantly at embryos exposed to Irgarol 1051(R). Embryos exposed to Sea-nine 211(R) showed up-regulation in genes related to actin filament organization and embryonic morphogenesis. Gene expression profiles were also observed the different DEG network including muscle cell development, nervous system development and transmembrane transporter activity in embryos exposed to three different biocides. Overall, our study provides a better understanding of the overlapping and unique developmental toxic effects via RNA-seq analysis in embryonic flounder. The results could be suggested to construction of emerging biocide management guild line by determined the toxic effects on non-target marine organism.

Contaminant Mixtures in Food: How Did They Get There and Should We Be Concerned?

WP012 Patterns of mercury and metal and organic co-contaminants in marine fish and shellfish

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Fish consumption advisories have been established throughout the US for freshwater and coastal ecosystems. Most of the fish consumption advisories in the US are for mercury (81%), but significant numbers of others have been established for other metals and organic contaminants including polychlorinated biphenyls (PCBs) and their congeners, chlordane, dichlorodiphenyltrichloroethane (DDT), and others. Although the advisories are contaminant specific, humans are exposed to multiple contaminants through fish consumption. Past studies have focused only on individual contaminants, in particular mercury, without relating those exposures to others such as organic contaminants. Using publicly datasets in which multiple contaminants were measured in individual fish and shellfish samples, we examined the relationships between different contaminants (metals and organics) from the US Environmental Protection Agency’s National Coastal Condition Assessment (NCA) and the Mussel Watch Program of the National Oceanic and Atmospheric Administration. Our analysis of the NCCA, and Mussel Watch datasets utilized the covariate-adjusted Gaussian graphic model (GGM), which models the probability of co-occurrence between any two contaminants using imputation by chained equations and partial correlation. The final models for each of the available datasets reflect the co-occurrence between inorganic and organic contaminants, conditional on all covariates, allowing us to determine whether the interaction between some of the inorganic and organic contaminants is defined by certain environmental factors. Results from the network analysis are also compared to correlation analyses using pairwise comparisons. We examine the co-occurrence of mercury and organic contaminants in fish and shellfish in order to begin to evaluate the risk of human exposure to multiple contaminants posed by eating seafood and understand the processes related to their co-occurrence in aquatic organisms.

WP013 Advancing a Framework for Environmental Risk Assessment and Food Traceability Models for Global Food Safety

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Food safety has been a global issue, and has consequently been a recurrent epidemic in recent history despite the advancement in modern technology, equipment use and in the handling of foods and food products. Many advanced countries of the world have been so much challenged to this particular issue. Basically, no food is 100 percent free or safe from either microbiological toxin, chemical toxin and or both. But these sometimes occur in limiting amount that is tolerable and acceptable to be regarded as being ‘safe’. Nowadays, modern architectural systems has put in place some treatments such as the use of pesticides to control pests, veterinary drugs and other environmental and biotechnology techniques in order to increase crop yield and productivity to ensure food security and its advancement. Furthermore, food either processed or non-processed move from one location to the other, and there could be possible contamination along the chain. All these happen within the environment. Several methods has been applied in order to ensure the safety of foods which among them are the Hazard Analysis Critical Control Point (HACCP System) which is basically in the food processing industries to ensure safety. The HACCP system has long been seen to have limitations due to recent food revolutions. The food Traceability system has also been into application, but on the other hand has limitations also. It is therefore necessary to advance a framework between Environmental Risk Assessment (ERA) strategies to synergize with the food traceability models that will give more assurance to safety approach apart from the normal tracking systems. ERA has several interactions in regards to hazards, human population, and ecological resources. It describes human populations, ecological resources which are agents to measure the exposure potential that will define the uncertainties, adverse effects and associated risks. This will enable effective communication because of the human health risks and ERA. Nevertheless, it will also enable more advanced techniques into the findings to enhancing global food safety on a long-term based.

Life Stage-Specific and Multi-Generational Effects of Environmental Stressors in Fish

WP014 Effects of Low, Subchronic Exposure of Commercial 2,4-D Formulation on Early Life Stages of Native Wisconsin Game Fish Species

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Aquatic herbicides are used worldwide to eradicate nuisance and invasive plants despite limited knowledge of their toxicity to non-target organisms. 2,4-Dichlorophenoxyacetic acid (2,4-D) is a common active ingredient in commercial herbicide formulations, which triggers plant cell death by mimicking the plant specific hormone auxin. Application practices with 2,4-D commercial herbicides typically coincide with yearly freshwater fish spawning periods, exposing fish to xenobiotics at their vulnerable larval stages. However, the physiological impacts of 2,4-D on larval fish remain poorly understood, and hence, whether it may alter larval performance, fish populations, and ecosystem dynamics. We conducted a series of experiments to determine the effects of low concentrations (0.05, 0.50 and 2.00 ppm 2,4-D) of commercial amine salt herbicide formulation DMA(R)4IVM on the development and survival of nine freshwater fish species at various life stages. We observed reduced survival in embryo assays for 4 out of 9 species tested, reduced survival in 30-day larval assay for 4 out of 6 species tested, and no reduced survival in a 90-day juvenile assay in the 2 species tested. Altogether, the results indicate that the use of 2,4-D herbicide DMA(R)4IVM for weed control in aquatic ecosystems at current recommended concentrations (< 2 ppm whole lake; < 4 ppm spot treatment) could reduce fitness and survival of freshwater game fish species.
WP015 Life-stage-specific endpoints for estrogen disruptor screening in the zebrafish embryo

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New and improved approaches are needed to meet evolving regulatory requirements to evaluate ecotoxicity of chemicals worldwide, while at the same time reducing the use of laboratory animals. In this context, the fish embryo offers particular advantages since in several geographic regions, it is not protected under laboratory animals legislations. Additionally, an OECD test guideline for the Fish Embryo Acute Toxicity (FET) test (TG 236) is already available and can be used as a basis to add relevant exposure methods and biological endpoints for specific purposes. The use of fish embryos instead of adult fish can be considered from different perspectives. Either the fish embryo is used as a model for adult fish and adult endpoints are somehow translated and applied in embryos, or embryo-specific endpoints are studied. In this study we used endocrine disruptor screening in the zebrafish embryo as a case study and we investigated the potential of adding life-stage-specific exposure methods and endpoints. The presence of the yolk in early embryos results in an additional exposure route, corresponding to maternal transfer in a real-life scenario. We explored the use of micro-injection into the yolk as a way to dose chemicals, including hydrophobic compounds, to developing embryos. Although time- and dose-dependent estrogen receptor activation profiles were highly similar, we found evidence that the dynamics of molecular processes differed between micro-injection and the traditional aquatic exposure method, causing disruptions of development at distinct life stages and leading to different adverse effects. Adding a typical endpoint for estrogen disruption, vitellogenin protein levels, that is generally used in later life stages, was possible but seemed to provide limited sensitivity in embryos compared to adults or juveniles. Development is tightly regulated by hormones and thus highly sensitive to endocrine disruption. Here we show that neuromast development is indeed very sensitive to estrogen disruption, comparable to endpoints used in adult fish. In conclusion, when using fish embryos as alternatives to adult fish in toxicity testing, one can either choose to apply endpoints that are well-accepted in later life stages, or one can try to find new, embryo-specific endpoints, which may be more relevant and additionally may increase sensitivity.

WP016 Developmental stage at time of exposure is critical for observing toxicity effects in embryos of Atlantic cod exposed to dispersed crude oil

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The Atlantic cod (Gadus morhua) embryo is planktonic and floats in the water column near the surface for 2-3 weeks before hatching. This increases the potential exposure of the embryos to the dissolved phase of spilled crude oil, as well as possible surface slicks. There is growing evidence that exposure to contaminants during transient window of sensitivity critical to development could impart imminent lethality. The objective of this study was to characterize sensitivity to exposure of physically and chemically dispersed water accommodated fractions (WAF and CEWAF) of crude oil, during the fertilization, cleavage, blastulation, gastrulation, somitogenesis, pre- and post-hatching periods in Atlantic cod. Test concentrations (8) followed a log based dilution WAF (100%, 10.01%, and 1.0%) CEWAF (31.6%, 3.17%, 0.32%) stock, a dilution water control (seawater), and a dispersant control (Corexit 9500 applied at the same rate as the greatest test CEWAF concentration, based on a volume/volume percentage). Each concentration was replicated 3 times. Exposures were carried out in 25-mL scintillation vials, with 20 mL of exposure media, then after 24 hours the surviving organisms were transferred to 250-mL flasks until hatch. The exposures and subsequent monitoring were conducted in an environmental chamber, where temperature was maintained at 5+/−2°C with lighting for the entire test duration on a photoperiod of 16-hrs light and 8-hrs dark. Monitoring vessels were assessed for mortality and hatching daily, with 80% solution renewals every other day. Endpoints included survival, time to death, time to hatch, and assessment of developmental abnormalities using a modified blue-sac disease (BSD) index. Exposures at the beginning of the embryonic period and during the hatching window proved to be the most sensitive stages, showing a decreased percent hatch and an increase in BSD presentation respectively. Exposures during the middle of embryogenesis did not have a significant impact on hatching success.

WP017 Effects of early life-stage exposure to the novel brominated flame retardant, 1,2,5,6-Tetrabromocyclooctane, on reproductive capacity of zebrafish

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Brominated flame retardants (BFRs) that are added to many consumer products often are detected in aquatic ecosystems where they have the potential to cause adverse effects on organisms, including fish. The novel BFR 1,2,5,6-Tetrabromocyclooctane (TBCO) has recently been introduced to replace the major use BRF, hexabromocyclododecane (HBCD), and thus its environmental concentration is expected to increase. Little is known about adverse effects of TBCO on aquatic organisms. Based on previous studies with Japanese medaka (Oryzias latipes) it has been suggested that exposure to TBCO during early stages of development might impair oocyte meiosis, which would result in decreased reproductive capacity at sexual maturity. However, definitive studies have not been performed to address this potential effect. The objectives of the current study were to characterize the acute toxicity of TBCO to early life-stages of zebrafish (Danio rerio), investigate the molecular and biochemical mechanisms of toxicity, and determine whether exposure during early-stages of development might impact reproduction. Zebrafish embryos were exposed to a low, medium, or high concentration of TBCO within 30 minutes of fertilization until hatch and endpoints were measured over a five-day exposure. Exposure to TBCO increased mortality in a concentration-dependent manner that correlated with decreased heart rate. Exposure to low, medium, and high concentration resulted in 31.0, 58.3, and 71.0 % mortality, respectively. In comparison with the mean heart rate of control embryos, exposure to low, medium, and high concentration decreased heart rate by 20.8, 45.3, and 64.4 beats per minute, respectively. TBCO also increased the incidence of spinal curvature and uninfated swim bladders in a concentration-dependent manner. Incidence of spinal curvature among larvae exposed to low, medium, and high concentration decreased heart rate by 10.2, 59.6, and 96.5 % respectively. Similarly, incidence of uninflated swim bladders was 11.5, 65.2, and 93.6 %. Based on the mRNA abundance of genes important for the response to oxidative stress, the observed effects were not due to this mechanism of toxicity. Fish exposed to TBCO as embryos are currently being reared to sexual maturity in freshwater to examine reproductive capacity, including molecular (genomic and epigenomic) and biochemical processes that regulate oogenesis and gonad development and function.

WP018 Developmental exposure to venlafaxine suppresses growth in zebrafish

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Venlafaxine is a selective serotonin and norepinephrine reuptake inhibitor commonly prescribed to treat depression, anxiety, and mood disorders in humans. Due to excessive usage, this compound is commonly found in aquatic ecosystems globally, appearing in concentrations ranging from ng/L to µg/L. However, the consequences following developmental exposure to venlafaxine on non-target organisms are only beginning to emerge. We have previously shown that venlafaxine affects brain development and behavior in early life stage zebrafish (Danio rerio), but no studies have tested whether this drug
impacts growth. This is particularly critical, as programming changes due to early developmental venlafaxine exposure may alter growth trajectories. Here we tested the hypothesis that venlafaxine deposition in the embryo disrupts the endocrine growth axis leading to the suppression of postnatal growth in zebrafish. We injected zebrafish embryos between the 1-4 cell stage with either vehicle, 1 or 10 ng of venlafaxine. We followed the growth trajectory of zebrafish up to 60 days post-fertilization (DPF). At 60 DPF, fish were sampled for liver, muscle, and brain tissue, and assessed for basal cortisol levels, hepatosomatic index, and growth- and feeding-related molecular markers. There was significant reduction in body mass at 45 and 60 DPF in juveniles raised from venlafaxine-treated embryos. To assess if feeding is perturbed by the drug, we recorded food consumed over a 30-minute period in size matched fish at 120 DPF. Venlafaxine (10 ng) deposition in embryos reduced feed acquisition in adults. Venlafaxine did not affect basal cortisol levels, but disrupted the transcript abundance of genes involved in growth, including IGF-1, IGF-2, and leptin 1a in the liver. Overall, developmental exposure to venlafaxine suppresses growth, and this may involve endocrine disruption of the growth and feeding axis in zebrafish.

WP019 The sulfate metabolite of 3,3’-Dichlorobiphenyl (PCB-11) impairs Cypla activity and increases hepatic neutral lipids in zebrafish larvae (Danio rerio)

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3,3’-Dichlorobiphenyl (PCB-11) is a lower-chlorinated PCB congener that is a byproduct of diarylide pigment manufacturing, and both PCB-11 and its metabolites have been detected in human samples. Our previous research in zebrafish (Danio rerio) demonstrates that static exposures to 20 µM PCB-11 starting at 1 day post fertilization (dpf) can stunt liver growth, and in co-exposures with other aryl hydrocarbon receptor (Ahr) agonists, PCB-11 can inhibit Cypla function to either prevent or exacerbate cardiovascular and craniofacial malformations, depending on the co-exposure. In this study, we tested whether two prevalent PCB-11 metabolites, OH-PCB-11 and PCB-11-Sulfate drive these effects, as well as whether chronic single exposures to PCB-11 or the two metabolites result in increased hepatic neutral lipid accumulation. Wildtype AB embryos were statically exposed to 0.002-20 µM OH-PCB-11 or 0.2-20 µM PCB-11-Sulfate from 1-4 dpf using the live EROD bioassay to assess Cypla activity and morphological growth, and then co-exposed to these same concentrations with either of the Ahr agonists 5 nM 3,3’,4’,5-Pentachlorobiphenyl (PCB-126) or 100 µg/L Benz[a]pyrene (B[a]P). In a separate experiment, fish were also exposed daily to 0.2 µM of either PCB-11, OH-PCB-11, or PCB-11-Sulfate from 1-15 dpf and assessed for neutral lipid accumulation using Oil-Red-O staining. Our results show that 2 and 20 µM OH-PCB-11 was lethal, but fish exposed to 0.002-0.2 µM OH-PCB-11 and 0.2-20 µM PCB-11-Sulfate developed normally with low Cypla activity. In both co-exposure experiments, all co-exposure groups did not differ in morphological development as compared to their respective Ahr agonist control groups. However, 20 µM PCB-11-Sulfate significantly lowered Cypla activity for both PCB-126 and B[a]P, from 500% and 300% activity, respectively, to DMSO exposure group levels. In chronic exposure experiments, fish exposed to PCB-11-Sulfate had a significant 30% increase in lipid accumulation levels as compared to the DMSO exposure group. These findings indicate that an acute 20 µM concentration of PCB-11-Sulfate may affect Cypla activity in the presence of Ahr agonists, and that lower 0.2 µM chronic concentrations of PCB-11-Sulfate can increase hepatic neutral lipid accumulation in early development. Further studies to confirm Cypla activity via qPCR and to test chronic exposures in the presence of Ahr agonists would help better elucidate the effects of this environmental contaminant.

Behavioral Ecotoxicology in the Lab and Beyond: Incorporating Environmental Complexity and Relevance

WP020 Identification of Environmental Pollutants Impairing Escape Response in Fish Larvae by using the Vibrational Startle Response Assay

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Predation is one of the main sources of mortality of fish at all life stages, but particularly for fish larvae. Whereas escape response is a behavioral reflex promoting larval survival to predator’s strikes, unnecessary escape responses have a high energetic cost and increase the risk of predation. Therefore, habituation of this response to irrelevant stimuli results is also essential for larvae survival. In spite of the ecological relevance of this response, the potential effect of the different environmental pollutants present in surface water on fish escape response is largely unknown. Recently we developed and validated the Vibrational Startle Response Assay (VSRA), an automated in vivo assay for identifying chemicals impairing the escape response and its habituation in zebrafish larvae. Now, we have used this assay to screen a group of 25 environmental pollutants previously recognized as neurotoxic, at environmentally relevant concentrations. The results demonstrate that some of these compounds have a significant effect on the arousal an/or the habituation of the vibrational-evoked escape response. We are currently assessing the predictivity value of VSRA by analyzing if the identified positive hits show a significant decrease on the survival to dragonfly strikes, and some preliminary results will be shown.

WP022 Effect of two pesticides (chlorpyrifos and imidacloprid) on the avoidance behavior of earthworm (Eisenia fetida)


Pesticides are among the most widespread environmental contaminants. Chlorpyrifos (O,O-diethyl O-(3, 5, 6-trichloro-2-pyridyl) (CPF) is a broad-spectrum organophosphate insecticide characterized by a P-O-C linkage and it is toxic for aquatic and terrestrial organisms. Its mode of action is based on a rapid phosphorylation of acetylcholinesterase (ACHE), an important enzyme involved in the neurotransmission processes in organisms. Imidacloprid (1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylidineamine (IMI) is a systemic neonicotinoid insecticide used to control sucking insects in crops that impacts the nicotine acetylcholine receptors; recently it was restricted in Europe as responsible for harmful effects on bees. The earthworm Eisenia fetida was selected as test organism according to the OECD standard guidelines (OECD 2004); the organisms were bought from a vermicomposting company in the north of Italy and maintained at 20 ± 2°C before and during the test. Two section-chambers (210x110mm) were filled with 250 mg (dry weight basis) of soil substrate (OECD soil), prepared by mixing quartz sand, kaolin clay and sphagnum peat in the proportion 70: 20: 10%. The soil was then spiked with the pesticides and adult worms (300-600 mg, wet weight) with well-developed clitellum were randomly introduced into the soils. The organisms were exposed simultaneously to the soil samples spiked with the pesticide and to the control soil (without pesticides). After a test period of 48h, the position of the animals was determined. Five different concentrations of CPF and IMI (1, 5, 10, 20 and 50% of 14d-LC50) were tested in three replicates. Residual concentrations of pesticides were determined over time by GC/MS-MS for CPF and by LC/MS-MS for IMI, respectively. At the end of the exposition, for each replicate the net response (NR, expressed as percentage) on worm behavior was calculated as follows: NR = ((C -T)/10) x 100 where: C = sum of earthworm behavior observed in the control soil, T = sum of earthworm behavior observed.
in the treated soil; 10 = total number of earthworms per each replicate. Earthworms play an important role in agricultural soils, maintaining and improving soil structure and fertility. The avoidance behavior test resulted as an important screening tool in soil eco-toxicology, because it is a low-cost method, with very simple test design, and can provide an early warning signal for environmental protection.

WP023 Effects of Fluoxetine and Predation Risk Span Generations in a Freshwater Snail
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Appropriate anti-predator responses are critical for prey species; these responses to predation risk are governed in part by serotonergic signaling. Wastewater effluent commonly contains compounds that can influence the action of serotonin. Fluoxetine (FLX), the active ingredient of Prozac(R), is a selective serotonin reuptake inhibitor, which may affect serotonergic signaling in freshwater animals and thus alter their responses to predation risk. The objective of this study was to determine how predation risk and FLX interact to influence the phenotype of Physid snails across two generations. We applied six treatments with three levels of FLX (0 µg/L, 0.1 µg/L, and 1.0 µg/L) and two levels of predation risk (presence/absence of crayfish cue) to F1 snails and quantified the behavior, morphology, and reproduction of F2 snails. We found that both FLX and predation risk experienced by F1 snails influenced the behavioral responses of F2 snails to perceived predation risk. Given that FLX is ubiquitous in wastewater effluent, future studies should examine the influence of FLX on trophic interactions to obtain a clearer picture of the potential ecosystem effects of this pharmaceutical.

WP024 2,4-Dichlorophenoxyacetic acid containing herbicide impairs essential visually guided behaviors of larval fish
G. Dehnert, University of Wisconsin, Madison / Zoology; W.H. Karasov, University of Wisconsin, Madison / Forest and Wildlife Ecology; M. Wolman, University of Wisconsin, Madison / Integrative Biology

Aquatic herbicides are used worldwide to eradicate nuisance and invasive plants despite limited knowledge of their toxicity to non-target organisms. 2,4-Dichlorophenoxyacetic acid (2,4-D) is a common active ingredient in commercial herbicide formulations, which triggers plant cell death by mimicking the plant-specific hormone auxin. Application practices of 2,4-D commercial herbicides typically coincide with yearly freshwater fish spawning periods. This practice exposes fish to xenobiotics at their vulnerable larval stages. The full impacts of 2,4-D on larval fish remains poorly understood, and hence, whether it may alter larval survival, larval behavior, fish populations, and ecosystem dynamics. In the present study, we exposed embryonic and larval zebrafish (Danio rerio) to the active ingredient 2,4-D (pure 2,4-D) or a 2,4-D containing commercial herbicide DMA4(R)IVM (DMA4) and evaluated morphology, survival, behavior, and nervous system function. At 2,4-D concentrations producing no overt morphological defects during embryonic or early larval stages, we observed reduced survival throughout a 21-day larval assay (4-8 ppm DMA4 and 0.75-4 ppm pure 2,4-D). Notably, prey capture, a behavior essential to survival, was reduced in 2,4-D-exposed larval zebrafish (4-8 ppm DMA4 and 0.75-4 ppm pure 2,4-D) and yellow perch (Perca flavescens) (4-20 ppm DMA4). In zebrafish, 8 ppm DMA4 exposure reduced prey capture when exposure was restricted to the period of visual system development. Consistent with these results, larval zebrafish exposed to 8 ppm DMA4 showed reduced neural activity within the optic tectum following prey exposure. Together, our results suggest that 2,4-D alters the development and function of neural circuits underlying vision of larval fish, and thereby reduces visually guided behaviors required for survival.

WP025 Effect of Elevated Embryonic Incubation Temperature on the Temperature Preference of Juvenile Lake Whitefish (Coregonus clupeaformis)
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Lake whitefish (Coregonus clupeaformis) is an economically, and ecologically important species that has a wide distribution across Canada and Northern USA. Lake whitefish (LWF) spawn in shallow coastal areas in early winter, subjecting embryos to temperature fluctuations caused by thermal effluent discharged by coastal power stations. Previous research shows that LWF embryos incubated at 8°C experience increased mortality and altered metabolic/heart rate. They also display an “early hatch phenotype” exhibiting less developed body features, which may affect fitness during early development. Using a Loligo(R) shuttle box system, this study compares temperature preference (median occupied temperature) of juvenile LWF post-hatch, by exposing them to a range of temperatures and recording the behavioral response. Behavioral tests were optimized for a two-hour acclimation period (static) followed by two hours of data collection (dynamic). The temperature preference of LWF juveniles incubated at elevated temperatures (5°C, 8°C) will be compared to those incubated at the control temperature (2°C). Elevated temperature treatments are predicted to modify the temperature preference of juvenile LWF. The effect of body size, as a confounding variable, is being examined. The results of this study will be used to help inform management decisions on thermal effluent discharged into Lake Huron.

WP026 Developmental exposure to environmentally-relevant concentrations of four pesticides induces hypo- or hyperactivity in Delta Smelt larvae
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Behavioral tests can be a powerful tool for screening the neurotoxicity of compounds. Here we describe the development of a high-throughput system to evaluate contaminant impacts on the critically sensitive early-life stages of Delta Smelt (Hypomesus transpacificus), an endangered teleost species native to the California San Francisco Bay Delta (SFBD), USA. Leveraging the natural behavior of larval Delta Smelt, whereby they increase movement in bright light and decrease movement in the dark, we developed a test using a cycle of light and dark periods in a closed chamber, using light switching as a reliable stimulus to test hyper- or hypoactivity. Larval behavior was tracked using EthoVision software for total movement in each period. We used this test to evaluate the effect of four commonly used pesticides (bifenthrin, permethrin, fipronil, and chlorpyrifos) at environmentally-relevant concentrations, varying 100-fold in concentration. At 96 hours of exposure, all concentrations of bifenthrin caused hyperactivity during the light cycles in larval smelt compared to control. The highest concentration of permethrin caused hyperactivity in the light period at 48 and 72 h of exposure, and hyperactivity in the light period of 96 h of exposure. All concentrations of permethrin caused hyperactivity at 96 h of exposure in the dark periods. The highest concentration of chlorpyrifos caused hypoactivity in the dark periods at 48, 72, and 96 h, and hyperactivity in the light periods at 96 h of exposure. At 48 and 72 h of exposure, the highest concentration of fipronil caused hyperactivity in the light periods. These results indicate that this behavioral test is highly sensitive in determining the impact of
environments of high to varying crude oil concentrations prior to being tested for exploration, transportation, and disposal. Effects on predation, for example, can occur at much lower concentrations than mortality but also have the potential to alter the health of individuals and to impact inter-species interactions. The goal of this research was to better understand the role that neonicotinoids play in predator-prey interactions and how these might compare to results from published toxicity studies. For this research, we used the neonicotinoid pesticide, imidacloprid, as it was the first compound in the class to be developed and is still widely used. We have found that endpoints such as immobilization occur at concentrations that are not environmentally relevant, as a 48-hour acute D. magna acute immobilization test yielded an LC50 of 70.8 mg/L. Clearly, the use of D. magna may not be sufficient to inform toxicity values because of their relative tolerance. D. magna, however, may be an ideal candidate for a prey species in an essay to evaluate impacts of imidacloprid on predatory behavior. As an example, Odenate larvae will be used to develop an assay to determine the effects of environmentally relevant imidacloprid concentrations on predator efficiency. The LC50 from D. magna will be used to inform further experimentation with Odenate larva, a potentially more sensitive species. The ultimate goal of this research is to better understand the potential ecological effects of neonicotinoid pollution as a result of behavior alteration in sensitive predators.

WP028 Evaluating the behavioral sensitivity of two common larval fish models to changes in salinity
K.R. Scarlett, Baylor University / Environmental Science; B. Steele, Baylor University / Biomedical Studies; B.W. Brooks, Baylor University / Department of Environmental Science

Increased salinization of inland waters due to anthropogenic activity can lead to a wide variety of crucial ecological and economic environmental concerns. Elevated salinity can alter essential osmoregulatory mechanisms, physiological functions and species interactions in aquatic ecosystems. Herein, behavioral responses have been employed to examine environmental stress due to unique integrations of these effects among the physiology and ecology of an organism with the surrounding environment. Because changes in salinity gradients can alter environmental conditions, it is important to also understand how salinization may influence interactions in aquatic ecosystems. Using two common fish models, fathead minnow and zebrafish, we investigated changes in swimming activity during interchanging photoperiods with the exposure of different sodium chloride (NaCl) concentrations. Treatment levels examined were derived from the calculation of LC50 values for both species (60% LC50, 40% LC50, 20% LC50, 10% LC50, 5% LC50). Standardized (OECD FET, EPA WET) experimental guidelines were used for experiments with fathead minnow and zebrafish. Each organism was exposed for 96 hrs. to NaCl, before photomotor and locomotor responses were observed using a behavioral analysis software (ViewPoints). Following previously reported methods from our laboratory, behavioral observations occurred for 50 min., including 10 min. of acclimation, two 10 min. dark periods, and two 10 min. light periods. Zebrafish displayed more pronounced photomotor responses to changing photoperiods and more consistent statistically significant (p< 0.01, p< 0.05, and p< 0.1) behavioral changes at the highest salinity (60% LC50 or 5.786 g/L), though these responses depended on speed thresholds. Fathead minnows swimming behaviors were significantly affected primarily in the freezing and cruising speed thresholds; however, these responses were only significant (p< 0.01, p< 0.05, and p< 0.1) at the highest salinity treatment level (60% LC50 or 5.646 g/L). These results suggest that behavioral responses of fathead minnows are less sensitive to NaCl than zebrafish. Such information can be useful in understanding how changes in salinity gradients can alter locomotor behavior in combination with chemical and nonchemical stressors.

WP029 Addressing social complexity: Does a pharmaceutical pollutant affect dominance hierarchies in brown trout?
E. McCallum, Swedish University of Agricultural Sciences SLU; T. Brodin, Swedish University of Agricultural Sciences (SLU) / Department of Wildlife, Fish and Environmental Studies

Psychiatric pharmaceuticals (e.g., antidepressants, anxiolytics) in the environment have been gaining research attention because of their potential to modulate the behaviour and physiology of aquatic wildlife in a manner that may be detrimental for their fitness. The majority of studies to date have measured the behavioural and physiological effects of pharmaceutical compounds on individuals in isolated trials. Yet, animals often live with multiple conspecifics and take part in a variety of social interactions each day. To better understand how pharmaceutical contaminants affect animals in a more complex and realistic social setting, we exposed groups of four brown trout (Salmo trutta) to three treatments of a anxiolytic pharmaceutical commonly detected in municipal wastewater (oxazepam, benzodiazepine: 0 µg/L control, 1.5 µg/L low, or 30 µg/L high). We recorded aggressive interactions and the formation and stability of dominance hierarchies in these groups across five days. We expected exposed fish to be less aggressive and for dominance hierarchies to be less stable over time when compared to controls. Following behavioural trials, we sampled and analyzed plasma cortisol to determine if any exposure-related changes in aggressive behaviours were associated with reduced cortisol levels. Upscaling research to address the social complexity that animals experience in the wild is important for understanding the effects of pollutants in ecologically realistic scenarios.

WP030 Effects of crude oil exposure on teleost personality behaviors
A. Khursigara, University of Texas, Austin / Marine Science Institute; A. Esbaugh, University of Texas / Department of Marine Science

As a major aquatic environmental toxicant of concern, the impacts of crude oil exposure on marine fishes have been highly studied. However, much of this work has focused on oil-induced cardiotoxicity and the subsequent downstream impacts this may produce. Recent work suggests that neurological function is also impaired and may be just as sensitive as these cardiotoxic endpoints. Transcriptomics data from exposed larval fish showed that pathways related to neurological and cognitive function were severely disrupted, which was accompanied by a significant reduction in brain size. While there have been a few studies that have shown that acute oil exposures can reduce sociability and increase aggression in fish, there still remains a large gap in our understanding of the scope and significance of these alterations in behavior. The aim of this study was to not only investigate the potential impacts that oil exposure can have on individual personality traits, but the effect it may have on behavioral syndromes. Using the model species Danio rerio, fish were acutely exposed to varying crude oil concentrations prior to being tested for exploration,
activity, boldness, and sociability. Preliminary evidence suggests that oil exposure promotes a proactive archetype that coincides with reduced anti-predator behavior.

**WP031 Effects of the antihistamine fexofenadine on behavior and life-history of damselfly larvae is dependent on food availability**

T. Brodin, Swedish University of Agricultural Sciences (SLU) / Department of Wildlife, Fish and Environmental Studies; J. Fick, Umeå University / Department of Chemistry

Insects are the most abundant and diverse group on earth and a pivotal part of aquatic ecosystems. Recent reports show dramatic large-scale declines in insects and one factor suggested to explain this is pollution. Aquatic insects have been shown to bioconcentrate pharmaceuticals and also be affected by them behaviourally. Here I present new data on how behaviour and life-history of damselfly larvae is affected by the anti-histamine fexofenadine, and how this effects are affected by food availability. Larvae grew and developed faster without fexofenadine, but only under restricted food availability. This finding has implications for risk-assessments based on endpoints connected to life-history.

**WP032 Environmental nontargeted metabolomics of fish brains and other organs - can we scale from the lab to streams?**

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Behavioral alterations caused by presence of psychoactive compounds (e.g., pharmaceuticals, illicit drugs, pesticides, metabolites) in aquatic systems represent an emerging ecological issue that is not adequately assessed during regulatory risk assessments. Though there are number of laboratory studies providing evidence of diverse effects and potential adverse outcomes, upscaling subchronic laboratory experiments with single compounds (or simple mixture) to streams and other receiving systems in the field is challenging. We carried out a six month experiment with visible implant elastomer tagged wild brown trout restocked from a reference portion of a wadeable stream to a polluted reach. A WWTP effluent discharge, which contributed to 30% contribution to instream flow, affected part of the stream that is separated from upstream reference conditions in a downstream location with barriers to fish migration. We obtained useful information on concentration and bioaccumulation of psychoactive compounds across different exposure times and seasons, but this experiment design did not allow any evaluation of fish behavior. However, we have behavioral responses from laboratory studies with the same or similar species. We then employed LC-HRMS analysis to examine tissues from all laboratory and field specimens from exposures and controls. Sertraline was confirmed to highly bioaccumulate in brain tissues, and correlated with behavioral responses, unlike other substances accumulating in fish brains to a lower extent. However, nontargeted metabolomics of brain extracts showed significant changes among all groups (1, 3 and 6 months of exposure, and corresponding controls) in wild fish. When differences among controls in different seasons (postspawning, low activity and startup - 1, 3 and 6 months) were considered, we observed even more significant differences with exposed fish. Because it is difficult to separate markers of effect from compounds that were specifically observed to appreciably bioaccumulate, we applied specific markers obtained from laboratory studies of methamphetamine, citalopram, to examine whether similar responses exist under natural conditions. Such tissue specific metabolomics approaches appear promising for interpreting contaminant exposures during laboratory experiments and field observations. The study was financially supported by Czech Science Foundation (No. 16-06498S), the Ministry of Education, Youth and Sports of the Czech Republic - projects „CENAKVA“ (LM2018099), „CENAKVA Center Development“ (No. CZ.1.05/2.1.00/19.0380).

**WP033 The psychoactive pollutant fluoxetine compromises anti-predator behaviour in fish**

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Pharmaceuticals are increasingly being detected in aquatic ecosystems worldwide. Particularly concerning are pharmaceutical pollutants that can adversely impact exposed wildlife, even at extremely low concentrations. One such contaminant is the widely prescribed antidepressant fluoxetine, which can disrupt neurotransmission and behavioural pathways in wildlife. Despite this, relatively limited research has addressed the behavioural impacts of fluoxetine at ecologically realistic exposure concentrations. Here, we show that 28-day fluoxetine exposure at two ecologically relevant dosages done representing low surface water concentrations and another representing high effluent flow concentrations darters antipredator behaviour in Eastern mosquitofish (Gambusia holbrooki). We found that fluoxetine exposure at the lower dosage resulted in increased activity levels irrespective of the presence or absence of a predatory dragonfly nymph (Hemianax papuensis). Additionally, irrespective of exposure concentration, fluoxetine-exposed fish entered the predator ‘strike zone’ more rapidly. In a separate experiment, fluoxetine exposure reduced mosquitofish freezing behaviour common antipredator strategy following a simulated predator strike, although, in females, this reduction in behaviour was seen only at the lower dosage. Together, our findings suggest that fluoxetine can cause both non-monotonic and sex-dependent shifts in behaviour. Further, they demonstrate that exposure to fluoxetine at environmentally realistic concentrations can alter antipredator behaviour, with important repercussions for organismal fitness.

**WP034 Bisphenol S impairs learning behavior in adult female zebrafish by interfering with the ERK/CREB/BDNF pathway**

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Bisphenol S (BPS) is a chemical that is widely used in numerous consumer products including polycarbonate plastics, epoxy resins, and thermal receipt papers as a replacement for bisphenol A, which is a well-known xenoestrogen. Growing evidence shows that BPS can interfere with several neuroendocrine systems in animals. In this study, we investigated the effects of chronic exposure to environmentally relevant concentrations of BPS on learning and memory in adult female zebrafish. To determine the mechanisms underlying BPS neurotoxicity, we focused on the ERK/CREB/BDNF pathway, which is associated with the neurotrophic/neuroprotective effect of estrogens on the central nervous system. Adult female zebrafish were exposed to either vehicle (DMSO), estradiol (1ug/l), or BPS (1, 15 and 30 μg/l) for 120 days. Fish memory was assessed in the object recognition task and object placement task. To this end, fish were exposed to two identical objects for 15 min. After a 24 h delay (retention interval), subjects were allowed to explore an object identified from a reference portion of a wadeable stream to a polluted reach. A WWTP effluent discharge, which contributed to 30% contribution to instream flow, affected part of the stream that is separated from upstream reference conditions in a downstream location with barriers to fish migration. We obtained useful information on concentration and bioaccumulation of psychoactive compounds across different exposure times and seasons, but this experiment design did not allow any evaluation of fish behavior. However, we have behavioral responses from laboratory studies with the same or similar species. We then employed LC-HRMS analysis to examine tissues from all laboratory and field specimens from exposures and controls. Sertraline was confirmed to highly bioaccumulate in brain tissues, and correlated with behavioral responses, unlike other substances accumulating in fish brains to a lower extent. However, nontargeted metabolomics of brain extracts showed significant changes among all groups (1, 3 and 6 months of exposure, and corresponding controls) in wild fish. When differences among controls in different seasons (postspawning, low activity and startup - 1, 3 and 6 months) were considered, we observed even more significant differences with exposed fish. Because it is difficult to separate markers of effect from compounds that were specifically observed to appreciably bioaccumulate, we applied specific markers obtained from laboratory studies of methamphetamine, citalopram, to examine whether similar responses exist under natural conditions. Such tissue specific metabolomics approaches appear promising for interpreting contaminant exposures during laboratory experiments and field observations. The study was financially supported by Czech Science Foundation (No. 16-06498S), the Ministry of Education, Youth and Sports of the Czech Republic - projects „CENAKVA“ (LM2018099), „CENAKVA Center Development“ (No. CZ.1.05/2.1.00/19.0380).
significantly less time exploring the novel/moved object compared with the control group, indicating an impaired memory in fish. This was associated with a reduction in phosphorylation of ERK and CREB proteins and downregulation of the BDNF gene in the brain. Taken together, our results suggest that BPS affects fish memory in a dose-dependent manner and its effects are mediated through the ERK/CREB/BDNF pathway.

WP035 Perfluorooalkyl substances in Bluegill (Lepomis macrochirus) and its relationship to liver histology and swimming performance
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Per- and poly-fluorinated alkyl substances (PFAS) can be found in many household, industrial, and personal care products, including furniture, aqueous fire-fighting foam, and sunscreen. PFAS entered the environment through wastewater treatment plant effluent, leaching of fire-fighting foam into groundwater at application sites, and landfill leachate. Many recent studies have shown PFAS in surface waters and aquatic organisms around the world. PFAS levels are higher near contamination sources, such as Wurtsmith Air Force Base in Oscoda, Michigan, USA. Unexpectedly, PFAS levels have not biomagnified in Clark’s Marsh near Wurtsmith Air Force Base. Bluegill (Lepomis macrochirus) in Clark’s Marsh have higher PFAS levels than their predators, however, the reasons and effects of these high levels are unknown. To investigate these effects, Bluegill were sampled in Clark’s Marsh, Van Etten Lake, Lower Au Sable River, and Crooked Lake (Emmet County). Bluegill were individually tested for critical swimming speed, liver PFAS concentrations, and liver histology. The data collected was analyzed spatially and quantitatively to determine differences between PFAS effects at different sites and with different levels of PFAS. We hypothesize that higher PFAS levels will relate to higher amounts of vacuoles in liver tissue and a slower critical swimming speed. This research will help to determine how PFAS affects fish physiologically and behaviorally in environmentally relevant concentrations. Ultimately, this information will investigate how PFAS effects fish within an individual and potentially, an entire population.

WP036 Fish living near two wastewater treatment plants have unaltered behaviour and thermal tolerance but show changes in organ and tissue traits
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Municipal wastewater treatment plants (WWTPs) are a significant source of anthropogenic pollutants and can pose a serious environmental stressor on aquatic ecosystems. In this study, we examined whether living close to WWTPs disrupted behaviour, thermal tolerance; b>c< b>and gross morphology in two native freshwater fishes: bluegill (Lepomis macrochirus) and green sunfish (Lepomis cyanellus), and one invasive species, the round goby (Neogobius melanostomus). There were appreciable differences in behavior across species: green sunfish were the most active and exploratory and bluegill spent more time under shelter. However, there were no behavioural differences within any of the three species between the fish collected from contaminated sites downstream of the WWTPs compared to fish collected from less impacted reference sites. Upper thermal tolerance (critical thermal maximum, CTmax) also differed among species (green sunfish > bluegill > round goby), but CTmax was similar between fish from highly contaminated and fish from cleaner reference sites. Fish caught near WWTPs had larger body and liver masses, and higher haemocrit compared to fish caught from the reference sites. Our results suggest that fish in the wild have some capacity to cope with any disruptive effects of exposure to WWTP effluent on the underlying physiological determinants of behaviour or thermal tolerance.

Poster Only: Application of Metabolomics in Effect and Exposure Assessment of Environmental Stressors

WP037 Metabolomic Analysis of Neonates and Adult Daphnia magna Exposed to Acetaminophen
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As the pharmaceutical industry expands and the human population and longevity increases, more drugs are used and processed each day. Inevitably, these pharmaceuticals find their way into wastewater through human excretion and improper disposal. Thus, pharmaceuticals have been recently recognized as contaminants of emerging concern in aquatic environments. We investigated the impacts of acetaminophen - an over the counter drug that is frequently detected in wastewa - effluents and freshwater ecosystems - on the metabolic profile of neonate (less than 24-h-old) and adult (14-days-old) Daphnia magna. The study also investigates differences in Daphnia life stage on the sub-lethal toxicity of contaminants. Neonate and adult daphnids were exposed to 1, 5, or 10% of median effective concentration (EC50) of acetaminophen for 48 h. Following the exposure to sub-lethal concentrations, the metabolic profile of daphnids was investigated using targeted liquid chromatography-tandem mass spectrometry (LC-MS/MS) which measures 51 metabolites in D. magna. The result showed that acetaminophen changes the metabolome of both adult and neonate D. magna. However, the metabolic response of the two life stages differed. These observations at the molecular level might result in different manifestations at the organismal level. The results of the present study emphasize the importance of investigating the adverse impacts of environmental stressors, such as sub-lethal concentrations of acetaminophen, on different life stages of the receiving organisms.

WP038 1H NMR metabolomics applied to investigate metabolic changes from sub-lethal toxicity of disinfection by-products to Daphnia magna
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Daphnia magna is a keystone species often used in environmental metabolomic studies to assess the impacts of anthropogenic stressors in aquatic environments. Disinfection by-products such as haloacetic acids (HAAs) are routinely discharged into freshwater ecosystems. Using D. magna, a 48-hour sub-lethal exposure to dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), dibromoacetic acid (DBAA) and a mixture of equitoxicity of all three HAAs at varying sub-lethal concentrations, we investigated changes in the D. magna metabolic profile using 1H nuclear magnetic resonance (NMR) spectroscopy and multivariate statistics. Principal component analysis (PCA) showed statistically significant changes to the metabolome when D. magna was exposed to DCAA and to the HAA mixture. PCA scores plots of TCAA and DBAA resulted in a shift of the metabolome relative to the control but these were not significantly significant due to the large variation in D. magna responses. Quantification of metabolites found significant changes in proline, alanine and lactate. While other metabolite changes may not have been found to be significant, all of the 18 evaluated metabolites differed from the control. Pathway analysis showed that the chlorinated analogues (DCAA and TCAA) significantly disrupt the alanine, asparagine and glutamate metabolism pathways. Disruptions in this pathway could also alter other linked pathways such as the glycolysis and the citric acid cycle. For example, glutamate increases the rate of pyruvate transformation to alanine and is consistent with the observed changes in
alanine with exposure. Sub-lethal exposure to the mixture demonstrates an increase in metabolic changes which could suggest the presence of additive or synergistic interactions between the contaminants within the class. Sub-lethal exposure to HAAs alters the metabolism of D. magna and highlights the sensitivity of NMR-based metabolomics for detecting subtle perturbations to aquatic dwelling organisms.

WP039 Metabolic profiling of Daphnia magna sub-lethal exposure to phthalates using liquid chromatography tandem with mass spectrometry

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Phthalates are commonly used and added to plastics for flexibility, durability, and/or longevity. Due to their wide use in plastic products and the fact that they are not chemically bound to the plastic polymer, phthalates have been detected in a variety of aquatic and terrestrial ecosystems. *Daphnia magna* is a keystone freshwater organism, positioned at an intermediate level in many aquatic food chains, and is frequently used in ecotoxicological studies as a sentinel species for the toxicity assessment of pollutants. In this study, the *D. magna* metabolome is investigated to assess the sub-lethal toxicity of three phthalates (dimethyl phthalate, diethyl phthalate, and dibutyl phthalate). In a 48-h acute preliminary test, *D. magna* was exposed to a fraction of the concentration reported in the literature as EC50 (concentration that induces a response to a toxicant in half of the population) for the three phthalates. All organisms survived at the sub-lethal concentrations pertaining to 50%, 25%, 10%, and 5% of the respective EC50 values. *D. magna* was then exposed to the same concentrations of the three phthalates in a 48-h acute investigation. Targeted metabolite analysis by liquid chromatography tandem with mass spectrometry (LC-MS/MS) was used to quantify 51 metabolites that are linked to various biochemical pathways. Amino acids, nucleosides, nucleotides, neurotransmitters, and energy-related metabolites are among the 51 metabolites. Principal component analysis (PCA) was used to evaluate variations within the dataset for the different exposures relative to the control group. Metabolite changes were used in pathway analysis to ascertain which metabolic pathways were perturbed with sub-lethal exposure to dimethyl phthalate, diethyl phthalate, and dibutyl phthalate. This study highlights the sensitivity of metabolic profiling for measuring toxic responses to sub-lethal exposure. Given the ubiquity of phthalates in the environment, this information can provide a basic framework for potential ecosystem-level changes based on *Daphnia* health. Metabolomic profiling may also be used in ecosystem monitoring programs and provide insight into the overall environmental health.

WP040 Fenoxycarb Exposures Differentiate Metabolic Regulation at a Specific Reproduction Stage and Pairwise Metabolite Co-regulations in *Daphnia magna*

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*Daphnia magna* is a widely studied organism and is considered a model organism for metabolomic studies. The consistent asexual reproduction cycle is an attribute of *D. magna* and may result in metabolic variation of the species. However, to date, the reproduction stage information has not been considered in the design and data analysis of a comparative exposure study. This study examined if the consideration of reproduction stage provides an advantage to investigate comparative metabolic regulation in *D. magna*. Fenoxycarb was chosen as a model toxicant and *D. magna* was exposed to fenoxycarb for 1 and 12 days at the sub-lethal concentration 50 ng/L, which resulted in decreased neonate reproduction. 54 metabolites were quantified using liquid chromatography with tandem mass spectrometry and the measured metabolite concentrations were compared between the exposed and control groups. Two-way analysis of variance (ANOVA) results revealed that no metabolite concentrations were significantly differentiated by the fenoxycarb exposures. Otherwise, the time pattern comparison based on ANOVA-simultaneous component analysis showed a reversed time pattern of metabolite concentration regulation in the fenoxycarb exposures compared to the control. The reversed regulation pattern was only observed during reproduction stage 3, the last reproduction stage, but not during the other stages. Additionally, Pearson correlation analysis provided another aspect of fenoxycarb toxicity to *D. magna* that the pairwise correlations between metabolites are weaker in the fenoxycarb exposures compared to the control. Consequently, this study demonstrates the advantage of using reproduction stage information in *Daphnia* metabolomic studies and provides a new finding on the weakened co-regulation of pairwise metabolites with the fenoxycarb exposures.

WP041 Bacteria-endophyte enhanced phytotreatment of petroleum hydrocarbon-contaminated soil by *Nicotiana tabacum*

J.O. Anyasi, University of South Africa / Environmental Sciences

Pseudomonas parafulva is a bacterial strain isolated from an oil refinery discharge and capable of transforming various petroleum hydrocarbons. In order to evaluate the influence of a polycyclic hydrocarbon transforming ability of the bacterial strain on the phytoremediation of petroleum aromatic hydrocarbon (PAH), P. parafulvas Ros-1 was inoculated into tobacco plant. The tobacco plants were grown for 16 weeks with or without pyrene, chrysene, and perylene (500 mg/kg soil in each 1L pot) in non-sterile peat medium. Evidences were gained that P. parafulvas Ros-1 was present in high concentration in tobacco root tissues (3.1-8.9 _ 103 CFU g^-1_), while the strain was not detected in stem, leaves and rhizosphere. When tobacco was planted in uncontaminated medium, the phytotoxicity resulted in negative effects on the parameters tested which included biomass index, leaves and stem dry weight. However, there was stale effects on the plant. On the other hand, plants inoculated with the strain Ros-1 were much tolerant towards the phytotoxic effects of PAHs, in terms of root dry weight. Although the presence of plants acted as the main effective treatment for PAH dissipation (72-89%), the inoculum with Ros-1 strain lead to the highest PAH removal (up to 91%). In the present study, an environmental isolate with proper metabolic features was demonstrated to be possibly suitable as a plant endophyte for improving endophyte-assisted phytotreatment of petroleum hydrocarbon contaminated soil.

WP042 Fluorine incorporation into cellular lipids during growth of *Pseudomonas sp.* strain 273 with fluorinated alkanes

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Fluorinated chemicals are prevalent environmental contaminants, in particular per- and polyfluoroalkyl substances (PFASs). PFASs are recalcitrant and many have been implicated in disease, thus representing a substantial human health concern. The backbone of PFASs is both hydrophobic and lipophobic while the terminal head group is hydrophilic. Due to these unique properties PFASs interact with various biomolecules, including phospholipids. Not surprisingly, PFASs were found to partition into membranes and impact membrane function in human, animal and bacterial cells. Recalcitrance of PFASs is often explained by the remarkable strength of the carbon-fluorine bond; however, microbial enzymes exist that break carbon-fluorine bonds at neutral pH and room temperature. This study explores the metabolism of fluorinated alkanes by *Pseudomonas sp.* strain 273. This soil isolate utilizes 1-fluorodecanes and 1,10-difluorodecanes, as well as linear straight chain C5-C16 alkanes as growth substrates under oxic conditions. During growth with these fluorinated alkanes as the sole source of carbon and energy, mineralization occurred and the majority of fluorine in the growth substrates was recovered as inorganic fluoride, indicating enzymatic cleavage of carbon-fluorine bond. Strain 273 did not grow with monofluoroacetate.
as the sole substrate; however, monofluoroacetate was co-metabolized in the presence of decane as a primary substrate. Ultra-performance liquid chromatography (UPLC)-mass spectrometry (MS) based fatty acid analysis of extracts from strain 273 cells metabolizing 1,10-difluoredecane identified degradation intermediates (e.g., β-oxidation intermediates), including fluoroctanoate. Also detected were monofluorinated fatty acids with extended chain length, such as C18:1. Untargeted lipidomic analysis applied to strain 273 cells grown with 1,10-difluoredecane revealed that up to 91% of phosphatidylethanolamine and 87% phosphatidylglycerol contained fluoride. No fluorinated lipids were detected in strain 273 cells grown with decane in the presence of fluoride. Pseudomonas sp. strain 273 has the unique ability to defluorinate and mineralize α, ω-fluorinated alkanes and also to assimilate organofluorine into glycerophospholipids as constituents of the cellular membrane. The discovery of covalent incorporation of fluoride into fatty acids and cellular membrane structures has implications for human health and the fate of fluorinated chemicals in environmental systems.

WP043 Methamphetamine and brown trout (Salmo trutta fario): bioaccumulation and metabolome effects at environmentally relevant and higher exposure levels

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Methamphetamine (METH) is a strong psychostimulant detected in water from nanograms to low micrograms per liter, due to inadequate removal in sewage treatment plants. Previous research demonstrated that psychostimulants can impact non-targeted organisms because of their evolutionary conserved drug targets; however, little is known about impacts of illegal substances on aquatic life. This study aimed to examine effects of METH and its metabolite amphetamine (AMPH) after exposure to environmental (1 µg L⁻¹) and higher levels (50 µg L⁻¹) of METH for 35 days, following a 4 day depuration phase, using brown trout (Salmo trutta fario) as a model. Parent compound (METH) and its biologically active metabolite (AMPH) was analyzed in plasma, muscle, brain, kidney and liver. Tissue specific bioaccumulation levels followed the order kidney > liver > brain > muscle > plasma. Although a low bioaccumulation factor was observed (0.13 to 80), plasma concentrations of both substances was close to the therapeutic level in humans, suggesting potential adverse effects and highlight the necessity for additional studies. The metabolite (AMPH) was analyzed in plasma, muscle, brain, kidney and liver. Ventilation rate was significantly increased in the high exposure compared to controls and a lower environmentally relevant level of 1 µg L⁻¹. Results of nontargeted metabolomics for both groups showed changes in the pattern of biomarkers related to fat metabolism across the two groups, the aPOP (e.g. per- and poly-fluoroalkyl substances, PFAS) significantly correlated with aFAs and select downstream oxylipin metabolites. More advanced location-specific analyses on the bears and insights into the altered biological mechanisms and toxicology is underway.

WP044 Lipid Metabolomic Profiling in Polar Bears: Do Environmental Contaminants affect the Biomolecular Response of the Lipid Metabolome?

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WP045 Changes in Metabolomic Profiles of Drilling Platform Mussels

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Drilling platforms produce discharges containing complex mixtures of potentially harmful chemicals that can vary depending on factors such as the processing chemicals employed, local geochemistry and the specific composition of the oil and/or gas. This complexity contributes to the challenge of evaluating the potential impacts of platform discharges on the immediate environment. Metabolomics, a tool for measuring concentrations of large numbers of endogenous metabolites, provides a method for examining and monitoring the wellbeing of local populations and can potentially identify early changes in critical biological systems, acting as early warning indicators. This study looks at metabolite changes observed in wild mussel populations collected from platform pillars at varying distances and depths from the discharge pipes on 3 distinct drilling platforms. Mussels were collected from pillars representing 14 distinct locations covering all drilling platforms and 2 collection depths (0.5m and 12m). A targeted metabolomics approach was used to measure the concentrations of 222 metabolites including amino acids, biogenic amines, lipids, fatty acids, hexose and metabolites associated with energy pathways. Multivariate statistical analyses were performed on the resulting metabolomics data to identify metabolites whose concentration levels increase or decrease between specific sites on each platform. Approximately 85% of the 222 metabolites could be detected in samples for each platform. Samples collected from Platform A showed significant distance-dependent differences in mussels collected at 0.5m below the surface but this was not the case for those collected at 12m below the surface suggesting that, for this platform, differences are weaker at larger depths. Fewer differences were seen for mussels collected from Platform 2 though a small number of lipids were identified as differing between the pillars at both collection depths. Analysis of mussels collected from Platform 3 showed metabolite differences that were both distance and depth specific. In all cases, the metabolites with statistically significantly concentration changes are being associated with functional biological information which allow us to identify associated pathways and potential biological impacts. This study illustrates the power of metabolomics as a strategy in environmental toxicology and serves as a template for future analyses.
Copper oxide (CuO) nanoparticles (NPs) and microparticles (MPs) are widely used in various industrial and consumer products and potentially pose risks to environmental organisms. Both particles' toxicity mode on organisms has mostly been attributed to oxidative stress and membrane perturbation in the literature. To further examine this toxicity mode, we employed a global metabolomics approach to investigate the changes of both polar and nonpolar metabolites in microalgae Chlorella vulgaris after exposure to CuO NPs and MPs (1 and 10 mg/l) and copper ions (0.08 and 0.8 mg/l). After 5-day exposure, a total of 75 differentiated metabolites were identified. The metabolic alterations caused by CuO NPs exposure were similar to those of CuO MPs and Cu ions, including accumulation of chlorophyll intermediates, membrane lipids remodelling (decrease of phosphatidylethanolamines and phosphatidylincholines, as well as increase of phosphatidic acids, phosphatidylglycerols, monoacylglycerols, diacylglycerols, digalactosylmonoacylglycerols, diacylglycerols, lysophospholipids, and fatty acids), perturbation of glutathione metabolism, and accumulation of osmoregulants. The only difference between metabolic responses to particles and ions was the accumulation of fatty acids peroxidation products at 1 mg/l CuO NPs and MPs. These results confirm the predominant role of dissolved Cu ions on the toxicity of CuO NPs and MPs, and reveal novel insights on how environmental photosynthetic organisms reprogram their metabolism to cope with oxidative stress and membrane damage induced by Cu ions, CuO NPs and MPs exposure.

The Fathead Minnow Reference Genome Assembly and Annotation: Overview and Utility for Sequencing-Based Technologies

WP047 Characterizing molecular toxicity pathways associated with 17β-Trenbolone exposure in adult fathead minnows to predict adverse apical outcomes

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17β-trenbolone is a biologically active metabolite of trenbolone acetate, an anabolic steroid used as a growth promoter in the beef cattle industry. 17β-trenbolone is found to be stable in cattle excreta and has been an anabolic steroid used as a growth promoter in the beef cattle industry. 17β-trenbolone is a strong androgen receptor agonist and has been shown to cause masculinization of female fish where females, morphologically and chemically, exhibit male characteristics (i.e. dorsal pad and dorsal nuptial tubercle formation, as well as decreased vitellogenin and estrogen). While many studies have reported morphological and biochemical effects of 17β-trenbolone in fish, there are fewer studies focused on the underlying molecular pathways that contribute to these apical outcomes. To this end, this exposure was conducted to look at molecular response patterns in fathead minnows (Pimephales promelas) exposed to 17β-trenbolone and use these to characterize the toxicity pathways associated with exposure. Sexually mature fathead minnows were exposed to 17β-trenbolone for 21 d. After 4 d fish were subsampled for omics endpoints (i.e. transcriptomics, proteomics, and metabolomics). After 21 d the remaining fish were sampled for apical endpoints (i.e. histopathology, plasma steroid concentrations, as well as dorsal pad and dorsal nuptial tubercle formation in females). Fecondity was monitored throughout the exposure. Toxicity pathways will be characterized by analyzing the 4-d omics data and linking those to the 21 d apical endpoints. It is anticipated that this research will help identify molecular toxicity pathways for 17β-trenbolone in adult fathead minnows that could be used to predict adverse apical outcomes of exposure. This study is part of the EcoFoxChip project (www.ecotoxchip.ca).

WP048 Comparing microarrays to RNA-seq for transcriptomic analysis of whole Fathead Minnow larvae

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RNA-seq is displacing microarrays for mRNA expression analysis, due to the declining costs of sequencing, and published studies reporting better performance for RNA-seq. However, most empirical comparisons lack a gold standard, and those experiments that do have a gold standard often evaluate synthetic samples whose representativeness of real-world experiments is unclear. Furthermore, RNA-seq performance is expected to be a function of sample complexity and sequencing depth. For complex samples, deeper sequencing depth is expected to be required to quantitate expression of rare transcripts. We are interested in using mRNA measurements in whole Fathead Minnow (FHM; Pimephales promelas) larvae for detecting aquatic toxicant exposures. Whole larvae represent a wide variety of cell types, some of which constitute a very small percentage of the total sample. The applicability of other RNA-seq performance studies to this system are unclear. To compare RNA-seq to microarrays, we exposed 2d post-hatch FHM larvae to bifenthrin or negative control water for 48h, split the RNA from each larva, evaluating one sample half using a microarray and the other half using RNA-seq with a targeted sequencing depth of 30 million 100 base pair (bp) reads per sample. About 35 larvae were exposed to each condition. Reads were resampled at depths ranging from 2-30M reads per sample and lengths ranging from 25 bp to 100 bp. Larvae were resampled at depths ranging from 10 larvae per condition to 30 larvae per condition. Resampled reads were mapped to FHM gene models. Sets of normalized read counts per gene and microarray spot intensities were reduced to the most informative features using a linear model, and the reduced feature set was used to develop classifiers using randomForest. Ten-fold cross-validation was used to estimate performance (Brier scores). Our results showed excellent results for microarrays and RNA-seq across a range of read lengths, read depths, feature selection stringency, all of which had much smaller effects on performance than the number of samples per treatment. Near optimal RNA-seq results, comparable to microarray performance were achieved with 8 million mapped 35-mer reads per sample. Quality trimming of reads and read-mapping software had only minor effects. Our results suggest the primary advantage of RNA-seq stems from cost per sample, rather than from the quality of the measurement data.

WP049 Development of Exposure Classifiers using the Fathead minnow, including Evaluation of an Alternative Lower Cost, RNA-seq Library Preparation Method

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Transcriptome-wide screening of organisms exposed to different stressors has become common in the ecotoxicology literature, with RNA-seq becoming the preferred tool for mRNA expression analysis. Though costs continue to decrease such studies remain fairly expensive, resulting in underpowered experiments with limited numbers of conditions examined. Traditional short-read RNA-seq sequences across entire transcripts. Resulting sequences are mapped to a set of reference genes and the number reads mapping to genes is counted. Most researchers are concerned with comparing counts of reads mapping to a gene in one condition relative to another to determine whether the gene is being up or down regulated. This only requires that there is enough sequencing depth
so reads can be mapped/counted accurately so counts-per-gene can be compared. Sequencing the entire transcript results in wasted resources as accurate mapping can be achieved by mapping to a relatively small region of a given gene. This directly effects cost since the level of multiplexing is reduced to reach sufficient depth to get stable count values. PolyA-seq targets a limited region of the transcript, theoretically reducing the number of sequences required to achieve adequate per-gene sequencing depth. As costs are directly dependent on the level of multiplexing, polyA-seq should provide cost reductions by increasing the level of multiplexing possible. The aim of this work was to compare the performance of poly-A seq to traditional RNA-seq.Fathead minnows (FHM) were exposed for 48 h to copper (n=11), bifenthrin (n=11), or not exposed (n=10). Sequencing libraries were then prepared using traditional RNA-seq and polyA-seq kits. All other technical factors were kept identical. Following sequencing, reads were resampled at various depths (ranging from 2–20M reads per sample) and reads were mapped to FHM genes. Respective gene lists were compared at different per-sample sequencing depths to determine where they diverged. A functional comparison was also conducted by calculating the performance of gene-expression-based classifiers developed using randomForests in a ten-fold cross-validation at different sequencing depths. This presentation will highlight the utility of the FHM gene models in an RNA-seq expression study and present data comparing the performance of polyA-seq at different levels of multiplexing with results obtained using traditional RNA-seq and discuss these in terms of per-sample cost.

WP050 Differential Expression of Coding and Non-coding RNAs in Propranolol-exposed Fathead Minnow Larvae

G. Toth, D.C. Bencic, D.L. Lattier, W. Huang, M. Kostich, A. Biales, US Environmental Protection Agency / ORD/NERL/EMMD

Propranolol, a beta-blocker used for high blood pressure, is one of several pharmaceuticals which have been found in freshwater aquatic resources. 48 h post-hatch FHM larvae were exposed to propranolol (@ 100 µg/l - 5 mg/l) for 48 h. Lexogen Small RNA-Seq Library preparations were done, followed by Hi-Seq RNA-seq analysis. miRNA analyses were done using the mirDeep* program while piRNA analyses were conducted using the Pano and piRNN programs. Differential expression of the smRNAs was analyzed using edgeR. These results will be presented in the overall context of developing and characterizing exposure and effects biomarkers for propranolol.

WP051 Phylogenetic analysis of the Fathead Minnow genome


Phylogenetic analysis is an important component of the Fathead Minnow (FHM; Pimephales promelas) genome annotation process. It can be used to identify evolutionary relationships between FHM genes and genes from other species. Furthermore, genome-wide phylogenetic analysis allows more accurate reconstruction of species trees and estimation of divergence times between taxa than can be done with single gene analysis. Model species gene annotations often include consistently and accurately assigned descriptive gene names. These names can be used to infer functions and categorize genes into gene sets, which are valuable for interpreting changes in gene activity and sequence polymorphisms observed in functional studies. Resolving relationships between FHM and model species genes can be used to transfer model species gene annotations to genes predicted in FHM. FHM genes can be related to similar genes in other species as either analogs (convergent evolution), orthologs (direct one-to-one descent) or paralogs (descent with intermediate within species gene duplications). The nature of the relationships must be accounted for to accurately transfer gene names across species. Phylogenetic analysis of FHM genes together with genes from 17 model species allowed us to put descriptive gene names on over 20,000 of our approximately 26,000 FHM gene models. Analysis of FHM together with 19 fish and fish-like species identified over 1200 groups of one-to-one orthologs across all these species. Protein sequences for these genes were concatenated into one ‘super-gene’ for each species, which were then aligned with one another. Ambiguous parts of the alignment removed, and the remainder was used to construct maximum-likelihood phylograms. The phylograms were calibrated with fossil-based divergence time estimates, resulting in chronograms describing the evolutionary history of these species.
Fate and Effects of Chemicals from Stormwater Runoff

WP053 A Novel Pulsed Study Approach to Storm and Receiving Water Monitoring at the Scripps Institution of Oceanography in San Diego, CA

K. Buckley, C. Stransky, Wood Environment & Infrastructure Solutions, Inc. / Aquatic Sciences and Toxicology; M. Colvin, Naval Information Warfare Center, Pacific / Energy and Environmental Sustainability; G.H. Rosen, SPAWAR Systems Center, San Diego / Energy and Environmental Sustainability; R. Schottle, Wood Environment & Infrastructure Solutions / Aquatic Sciences; K. O’Connell, University of California, San Diego / Environmental Affairs; J. VanVoorhis, Wood Environment Infrastructure Solutions, Inc. / Toxicology

Current monitoring requirements for many ocean-front facilities under National Pollution Discharge Elimination System (NPDES) permits include standardized toxicity tests that use whole effluent guidelines. However, these protocols were originally developed for continuous point-source discharges and not episodic storm events. The University of California Scripps Institution of Oceanography (SIO) has monitored storm water discharges under an NPDES permit since 2005. Long-term monitoring at this site has demonstrated limited to no toxicity in receiving water samples in the laboratory or in situ during wet weather. To better understand impacts in the adjacent receiving waters, a pulsed study method to more realistically assess toxicological impacts related to storm water runoff into receiving waters. This novel method consists of a series of bioassays that alter the duration and concentration of storm water exposed to the test organisms. Whereas conventional laboratory tests expose purple urchin (Strongylocentrotus purpuratus) embryos to storm water continuously for a 72 to 96-hour period, a pulsed study performed during wet weather in 2018 included 6 and 26-hour exposure durations to undiluted stormwater after which embryos were transferred to clean filtered seawater. These time frames were chosen based on the 50th and 95th percentiles for storm events in San Diego. Results from the study indicated that duration of exposure did affect the outcome, with shorter exposures to storm water demonstrating less of an effect. To ensure protection and validate laboratory results, in situ tests are routinely performed concurrent to all compliance monitoring events providing a more representative measure of effects in this dynamic environment. These studies will assist with guidance to enhance prioritization of best management practices and future regulatory decisions that are both protective and appropriate for these unique episodic discharges.


K.C. Schieff, M. Beck, Southern California Coastal Water Research Project

Billions of dollars ($ US) will be spent in California on stormwater best management practices (BMPs) over the next 10-20 years attempting to treat wet weather runoff prior to discharge. Despite hundreds of structural BMP installations, no standardized effectiveness (e.g., influent-effluent) monitoring occurs to assess how well these treatment structures perform. The goal of this project was to compile the ad hoc BMP monitoring throughout California to assess effectiveness for concentration reductions. Four methods were evaluated for assessing effectiveness including percent reduction, effluent probability, linear regression, and quantile regression. Water quality data from 81 BMPs and 1,700 site-events (storm BMP combinations) were compiled spanning the period 1998-2018 for seven different flow-through BMPs such as bioretention, permeable pavement, or constructed wetlands. Of these, vegetated swales and media filters performed the best, having the largest concentration reductions for total and dissolved copper (50%), lead (71%), and zinc (78%). BMP removal for nitrate (14%) and phosphorus (36%) removal were less effective for these flow-thru BMPs. At times, some BMPs actually exported nutrients, typically because of leaching from bioretention media (i.e., mulch) or exported plant materials from vegetated swales. Quantile regression was the best performing statistical method for assessing effectiveness due to the fewest assumptions, least bias, and moderate precision compared to the other statistical methods. Based on quantile regression, the uncertainty associated with BMP effectiveness was quite large, with the 5th and 95th probabilities of achieving specified effluent concentrations ranging up to an order of magnitude. Based on the compile date the uncertainty was not due to differences in precipitation, but may be due to geography (underlying geology) and age of BMP (maintenance practices).

WP055 Bioretention soil media efficiency in reducing tire dust leachate toxicity to aquatic life

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Road runoff contributes to the total pollutant budget of receiving waters. Besides combustion engine emissions, brake and tire wear are major contributors to traffic-related particulate matter. Tire particulates released into the environment per capita is estimated at 0.81 kg/year. Tire dust has a complex chemical composition and some of its components are water soluble. During rain events chemicals from tire dust can be leached into stormwater runoff. Coho salmon (Oncorhynchus kisutch) are acutely sensitive to chemicals that leach from tires. Previous assays showed that coho salmon are approximately 10-fold more sensitive to tire dust leachate than the crustacean Ceriodaphnia dubia (LC50 estimated at 0.1 g/L for coho salmon vs. 1.05 g/L for C. dubia). A laboratory study was conducted to assess whether bioretention soil media (BSM) could reduce or eliminate toxicity of tire dust leachate to juvenile coho salmon and to C. dubia. A tire dust mixture was created by grinding tread from nine different tires (new and used) from light duty vehicles. A 2 g/L tire dust leachate was produced using a closed recirculating system, allowing water to run through the tire dust mix for 24 h. The tire dust leachate was treated via infiltration through a BSM composed of 60% sand and 40% compost and was tested on juvenile coho salmon (24-h exposure) and on C. dubia (2-day and 8-day exposure).

WP056 Evolution of a NPDES Permit- Novel Implementation Strategies for Storm Water Compliance Monitoring at the Scripps Institution of Oceanography in San Diego, CA

C. Stransky, Wood Environment & Infrastructure Solutions, Inc. / Aquatic Sciences and Toxicology; R. Schottle. Wood Environment & Infrastructure Solutions / Aquatic Sciences; K. O’Connell, University of California, San Diego / Environmental Affairs

The University of California’s Scripps Institution of Oceanography (SIO) campus is situated adjacent to an Area of Special Biological Significance (ASBS) in southern California. In 2005, the University was issued a National Pollutant Discharge Elimination System (NPDES) permit, one of the early Ocean Plan exceptions granted to allow discharges to an ASBS, The Scripps ASBS is one of the 34 designated ASBS’ throughout the State of California. Seawater from SIO research facilities and a public aquarium, as well as storm water during wet weather, enters the ocean therefore requiring an NPDES permit to monitor discharges from the facility during both dry and wet weather. As the first marine institution in the State to receive an exception, the University has become a vanguard for development and implementation of innovative and more representative monitoring strategies under their permit. This presentation will highlight the key special studies conducted by the University to more accurately characterize possible impacts to the receiving waters of the ASBS. Results from these novel studies have helped to inform regulators to develop a definition of natural water quality for ASBS’ statewide. The key special studies and advisory committee findings to date include; Defining natural water quality; A site specific dilution model; Species sensitivity evaluations and implementation of the EPA Test of Significant Toxicity to establish compliance; Toxicity identification evaluation (TIE) studies for stormwater and the receiving water; Ongoing special studies including in situ “SEA-Ring” toxicity monitoring of receiving waters and pulsed studies to further examine storm water impacts under more representative exposure scenarios.
WP057 Longevity of bioretention depths for preventing acute toxicity from urban stormwater runoff

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The migration of coho salmon every fall from the ocean to freshwater streams coincides with increasing rainfall in the Pacific Northwest. Much of this rainfall runs off of asphalt and other impervious surfaces found in urban areas, such as the Puget Sound Basin, and into the very streams where salmon spawn. Exposure to urban stormwater runoff, which contains a complex mixture of contaminants, can be acutely toxic to coho salmon. Previous studies have demonstrated the effectiveness of bioretention treatment systems in treating urban runoff and preventing acutely lethal and sublethal effects to aquatic organisms. Municipalities are especially motivated to incorporate bioretention treatment systems into existing infrastructure in order to comply with National Pollutant Discharge Elimination System (NPDES) permit requirements. NPDES permits are administered by the Washington Department of Ecology (Ecology) and require local governments to manage polluted stormwater in order to mitigate the effects of pollution and contamination on downstream waters. The current study aims to determine the effectiveness and longevity of bioretention soil media over time at various infiltration depths, including those shallower than 18 inches, the depth currently required by Ecology. Stormwater runoff is being collected from a busy, urban road site and applied to experimental columns, containing five different depths of bioretention soil media. Runoff is applied at an accelerated rate in order to simulate 10 water years over two calendar years. The chemical and biological effectiveness of the columns in treating urban stormwater runoff will be assessed using analytical chemistry and the health of two fish species: juvenile coho salmon and zebrasfish embryos. The study outcomes are expected to help inform stormwater managers, National Pollutant Discharge Elimination System (NPDES) permit coordinators, and others involved in stormwater management.

WP058 Low exposures of urban stormwater runoff are lethal to coho salmon

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Urban stormwater runoff contains a complex mixture of toxicants that is acutely lethal to coho salmon (Onchorhynchus kisutch). Although it is unknown what chemicals in the mixture are responsible for the toxicity, the land use most strongly related to rates of mortality in the field is roads -- particularly busy arterials. Juvenile and adult coho salmon experimentally exposed to 100% collected road runoff die within a few hours of exposure. In field studies, dead coho spawners are observed following rain events, but it is unknown how dilute are the chemicals causing the mortality, nor how quickly these mortalities occur after exposure to runoff. To better understand the lethality of road runoff to coho salmon, we experimentally exposed juvenile coho salmon to dilutions of road runoff collected from a busy arterial in Seattle, Washington, USA, varying the concentration and exposure duration. Two pilot tests indicated that concentrations above 25% caused 100% mortality within 24 h and that no mortalities occurred at any concentration beyond 24 h. Using runoff collected from a subsequent three storm events, the 24-h median lethal concentration (LC50) for each event was remarkably similar at 6-10% (95% C.I. = 5-12%). The NOEC (estimated from dose-response curves) ranged from 0.3-1.2%. Runoff from an additional storm event (24-h LC50 = 4%; 95% C.I. = 3-6%) was used to determine minimum exposure durations to cause mortality. Factorial exposures of 1, 2, 4, and 8 h were conducted for runoff concentrations of 5%, 11.2%, and 25% and survival monitored up to 24 h. Nearly all mortality occurred after fish were transferred to clean water. Mortality (24-h) occurred for exposures as brief as 1 h at 25%, 2 h at 11.2%, and 8 h at 5%. No mortality occurred following 1-h exposure to 11.2% and following 1, 2, and 4-h exposures to 5%. All other combinations of exposure time and concentration caused mortality for at least some individuals. Median lethal exposure times were approximately 22 h for 5% runoff, 5.5 h for 11.2% runoff, and 1.8 h for 25% runoff. By linking these results to observed rates of mortality in urban creeks, we can begin to estimate the amount of treatment required for runoff entering streams where coho salmon spawn.

WP059 Mapping Particle Deposition Patterns with GPS Drifting Particle Simulators in Pearl Harbor Hawaii

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Source assessment and control is a critical challenge for investments in sediment cleanup as well as in the prevention of future contaminated sediment liabilities. Stormwater sources are at the nexus of this challenge, spanning virtually every harbor, coastal and riverine site. Stormwater discharge assessment is connected to every aspect of regulatory compliance, including National Pollutant Discharge Elimination System (NPDES) permitting, Total Maximum Daily Load (TMDL) actions, Environmental Installation Restoration (E/IR) programs, and associated source control strategies. The ubiquitous and non-point source nature of these sources makes them difficult to characterize and control effectively. Regulatory pressure to reduce and cleanup adjacent water bodies is increasing. This poster presentation will demonstrate two tracking and monitoring technologies specifically modified by the US Navy, Naval Information Warfare Center (NIWC) Pacific, to assess the trajectories and deposition patterns of particles associated with stormwater and other discharges that impact sediment quality. The Drifting Particle Simulator (DPS) is a GPS drifter with position data telemetry, programmable depth control, and bottom detection, for measuring depositional footprints and sampling of source related particles. The DPS tracks water currents at depths of 1-30 meters, and accommodates a range of additional sensors. The Sediment Deposition (SeDep) Sensor is an adaptation of a standard USGS Load-Cell Scour Sensor modified to incorporate a highly sensitive differential pressure sensor. The SeDep senses small changes in sediment load and measures both scour and depositional variations such as infilling of gravel and cobbles with fine grained sediments. These technologies were deployed in Hawaii at the Pearl Harbor Naval Complex (PHNC). The demonstration focused on determining the depositional footprint of particles associated with a storm drain. The results showed that particles released could potentially deposit over a 1-1.5 km wide area to the north and south of the outfall under the influence of tidal currents and silt sized particle settling rates. Depositional rates suggest that movement and deposition into the footprint correlate to runoff events and ship driven scour and resuspension.

WP060 Specification of copper in bioretention soils receiving runoff from a copper roof

E. L. McGovern, D. R. Ownby, R. E. Casey, Towson University / Chemistry

Roofing materials can be a substantial source of copper (Cu) released into the environment. Previous studies have demonstrated that bioretention planter boxes can attenuate >90% of Cu in stormwater from sheet Cu roofing materials. Less is known about the fate of retained Cu in bioretention media that have received stormwater inputs over a long duration. This study evaluated the speciation of Cu retained in bioretention planter boxes that received runoff for 4.3 years. Nine soil cores were obtained from each of two replicate planter boxes. Cores ranged from 21-34.5 cm in depth and were divided into top, middle, and bottom soil sections and sieved (< 2 mm) prior to analysis. Nitric acid (7 M) extractable Cu was determined for each sample and selected samples were subjected to a modified Tessier sequential extraction analysis. Total Cu in the core sections ranged from 11-1043 mg Cu kg⁻¹ of dry soil. Copper concentrations were generally...
highest at the top of the planter box with Cu concentrations decreasing with depth. Cu concentrations were highest in closest proximity to the downspout (at the center of the box) and generally declined toward the periphery of the planter boxes. The total load of Cu retained in the media was 7 to 10 times greater in the top layer compared to the bottom layer. Sequential extraction analysis yielded similar results to the total extractable Cu values when all fractions were summed. Summed fractions represented approximately 70-110% of Cu recovered in the 7 M nitric acid extractions. Overall the highest Cu concentrations were in the organic fraction and the lowest were in the exchangeable fraction. Because copper found in the organic fraction is generally less bioavailable and less subject to leaching, these results suggest that Cu in aged bioretention material may be relatively stable. Because the majority of the Cu was found in the potentially less bioavailable fractions and the lower layers of the planter box had much lower Cu concentrations than the surface, these results suggest that the bioretention media in these planter boxes had substantial capacity for continued copper retention beyond the 4.3 year period that was evaluated.

**WP061 Acute toxicity of copper and zinc pulse exposure to Ceriodaphnia dubia**

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The continuous traditional exposure method to assess the toxicity of pollutants to aquatic organisms is not always relevant, especially for pollutants coming from stormwater discharges and runoff. The present study characterized the acute toxicity of copper (Cu) and zinc (Zn) to Ceriodaphnia dubia using pulse exposure method. Less than 24 h old C. dubia were exposed to a Cu or Zn pulse of 6h, 12h, 26h, or 96h under standard laboratory conditions. These pulse durations were chosen based on analysis of frequency of rain in the U.S. over the past 20 years, and therefore would be relevant to runoff and stormwater exposure. Except for the 96h exposure, surviving organisms at the end of the shorter pulses were transferred to clean water and monitored for mortality to 96h post initiation of the exposure. Lethal median concentrations (LC50s) were determined based on mortality of the organisms both at the end of the pulse and the full 96 h test. In general, acute toxicity increased with increasing pulse duration in the short term. For example, the LC50 for the 6h pulse mortality decreased, following a power function, from 44.8 µg Cu/L to 23.5 µg Cu/L for 12h pulse and 96h pulse and 752 µg Zn/L to 158 µg Zn/L for 12h pulse and 96h pulse, respectively. Interestingly, the mortality continued to increase post metal exposure, after the organisms were transferred to clean water. The LC50s for the end pulse were approximately 1.5-2 times higher than those for the end of the 96 h test. These results indicate a latent effect of Cu and Zn to Ceriodaphnia dubia. Surviving Ceriodaphnia dubia from metal exposed treatments were visually smaller than those in the control. Reproduction was also lower in Cu and Zn treatments compared to the control. This study reveals that continuous exposure without post exposure assessment might underestimate the toxicity of pollutants. More research should be conducted to understand latent effects of pollutants to aquatic organisms.

**WP062 Daphnia magna Demonstrate Severe Toxicity to Stormwater Runoff**

L. Wedel, University of Cincinnati; L.M. Jackson, University of Cincinnati / Biology

First season rain events and snowmelt carry high levels of pollutants, where they are deposited directly from surrounding storm water sewer systems to nearby receiving waterways (Karlsson et al., 2010). Seasonal first flushes of storm water demonstrate high levels of pollutants such as heavy metals, organic compounds, and snow-melting agents. Standard acute toxicity tests were run on populations of the invertebrate, Daphnia magna, to demonstrate the toxicity of storm water runoff from major highways, creeks and rivers in Cincinnati, Ohio. First flush seasonal rainfall was collected in March 2019 from the uttermost downstream of the Mill Creek watershed; the Ohio river, where Mill Creek empties into it and diluted to 25%, 18%, 9%, and 3%. Mortality was 20% in Mill Creek site 25 and 15% in the Ohio River at 9% dilution. In dilutions as small as 3%, the water remained lethal to the D. magna between 25-30%. D. magna and other primary consumers support the entire ecological food chain of aquatic ecosystems. The health and vitality of all levels of the food chain are dependent on the survival of the D. magna and other invertebrates, and toxic storm water runoff is becoming malignant to the higher level consumers of the food chain.

**Fate and Effects of Metals: Mechanistic Knowledge of Metal Interactions With Aquatic Biota**

**WP063 Development of QICAR models to address the lack of toxicological data for technology-critical metals**

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Over the last twenty years, industrial advances in diverse areas (e.g., computers, catalytic converters, wind turbines) have led to the increasing use of a wide range of ‘new’ elements, including metals that were previously poorly exploited. The potential impacts of many of these technology-critical metals (TCM) on aquatic biota remain to be elucidated. Quantitative structure-activity relationships (QSAR) have been developed for many years to fill a similar gap for new organic compounds. Here, a similar approach was used to develop Quantitative Ion Character Activity Relationships (QICARs) to relate intrinsic metal properties to their toxicity towards aquatic organisms. In total, 23 metal properties (e.g. molecular weight, density...) were tested as predictors of acute EC50 values for 12 data-rich metals (Ag, Cd, Cu...) for algae, daphnids and fish. Metal characteristics were examined for missing values as well as redundancy using principal components analysis. Simple and multiple linear regressions were developed using the toxicological data expressed as a function of the total metal concentrations and the free ion activities. In that latter case, linear free energy relationships were additionally used to estimate the binding constants of the TCM with HO-, CO32-, EDTA4- and Cl-. These values were lacking. Finally, the QICARs were tested by comparing the predicted EC50 values for the TCM with the few measured values that are available. Twelve out of the 15 ‘best’ QICAR models (adjusted r² > 0.6) used Xm2r as the predictor. Xm represents the metal electronegativity and r is the ionic metal radius; for a given metal ion, the composite Xm2r parameter, also known as the covalent index, is a measure of the importance of covalent interactions relative to ionic interactions. The effects of the TCM was well predicted using the total metal concentrations. However, the models based on the free ion activities systematically underestimated their EC50 values. This unexpected result might be due to the formation of neutral polyhydroxo-complexes in the exposure media leading to extremely low free TCM activities (< 10^{-15} M), a speculation that differs markedly from that of the data-rich metals used to construct the models. QICARs show potential as a screening tool to review toxicity data and flag ‘outliers’, which might need further scrutiny. The TCM fall into this latter category and require further testing to elucidate the role of polyhydroxo-complexes in metal toxicity.
WP066 Bioaccumulation and Subcellular Measurements of Trace Metals in Amphipods collected from the Yellowknife Area
J. Labrie, University of Quebec in Montreal / Biology; A. Rolland, Université du Québec à Montréal / Biological Sciences; M. Palmer, Gov. Northwest Territories / Cumulative Impact Monitoring Program; J. Chetelat, National Wildlife Research Centre Environment Canada; M. Amyot, University of Montreal / Biological Sciences; M. Rosabal, University of Quebec, Montreal / Département des Sciences Biologiques

Mining activities in the Yellowknife area have increased concentrations of various trace elements (mainly arsenic) in nearby aquatic ecosystems. As a consequence, these contaminants accumulated in aquatic organisms can provoke harmful effects for their survival. However, little attention has been paid to examine the toxicity potential of these metals for aquatic organisms, in particular, for invertebrates. We aim to evaluate the potential for toxicity of trace elements in amphipods considering bioaccumulation and subcellular measurements of these contaminants. Knowledge of subcellular metal partitioning, which reveals the subcellular targets (sensitive compartments) responsible for adverse effects including mitochondria, heat-denaturable proteins and microsomes is necessary to understand and predict metal toxicity. Furthermore, these measurements allow researchers to determine the metal-handling strategies used by aquatic organisms to cope with high metal concentrations. To perform these measurements, amphipods were collected from three lakes and five sites in Yellowknife Bay in 2015 and in 2017. To better estimate bioaccumulation measurements, depuration experiments (to remove gut contents), adsorption essays (to remove metals on the surface) and dissections (to estimate metals from the exoskeleton and the soft tissue) were conducted in parallel, and metal concentrations were determined by ICP-MS/MS for a suite of metals (arsenic, antimony, lead, cadmium, zinc, copper, selenium, lanthanide, cerium, yttrium). Our results showed significant spatial differences for As, Sh, Cd, and Pb (but not for Ce and La), which reflect the impact of mining activities on aquatic ecosystems sampled. For some elements studied, internalized metal burden was consistently higher (more than 40%) than that measured as adsorbed. Our results also showed that a 48-hour depuration step is needed for mostly all the trace elements analyzed. With regards to subcellular analysis, a customized protocol has been validated using enzymes specific to subcellular fractions. Next steps will be focused on the application of the subcellular metal partitioning approach, which allows us to discriminate between metals accumulated in the metal-sensitive compartment and in the detoxified-metal compartment. Such information should help the development of improved models for predicting metal toxicity, based on the biologically active pools that contribute to toxic responses and not on the total accumulated metal concentrations.

WP067 Developing whole sediment toxicity assays with early life stages of medaka fish for assessing heavy metal contaminated sediment
P. Chen, C. Lee, W. Li, G. Chen, National Taiwan University / Department of Agricultural Chemistry

The aquatic sediment is considered as a sink and source of heavy metals due to their non-biodegradable and high accumulative properties. These toxic metals can be released to the water column from sediment, thus enhancing exposure risk to the aquatic life. However, the method with...
WP068 Mitochondrial responses for exploring heterogeneous resolutions of contaminant bioavailability using cell-based in vitro assays

Z. Wang, Jiangxi University of Science and Technology

With the intensive developments induced by rapid industrialization and extensive urbanization, increasing amounts of anthropogenic contaminants have been discharged into aquatic environments. While using traditional methods based on the chemical analysis alone of extracted samples from environmental and biological matrices, it is difficult to accurately determine the bioavailability of contaminants and then reflect their cell-based effects as well as subsequent toxicity risks. Therefore, understanding the degrees of contamination and pollution characteristics regarding of entirely environmental matrix and biological samples in the selected study sites and successfully culturing the primary cells from critical tissues in aquatic organisms of ecological niche, the field exposure were performed to analyze the subcellular distributions and adverse effects of contaminants combined with cell-based in vitro assays and in situ tests. Further, the dynamic exchanges, translocation and mobilization of contaminants such as metals were then clarified among the “various particles, pore water and cells in exposed organisms” interfaces of matrix through measuring relevant dynamic parameters and resultant induced fluxes during experimental procedures. Moreover, coupled with chemical analysis to quantify the mitochondrial components (mitochondrial proteins, lipids, and nucleic acids, modulating mitochondrial membrane potential and ATP production et al.) within culture wells of primary cells and molecular approaches to assess the expression of responsive genes in field exposure, the mechanisms of associated toxicity were elaborated and the interactive relationships were then obtained between chemical bioavailability and in situ stress. Simultaneously, the assays of cell-based evaluation and monitoring were established considering the consistency of framework as protocols among cell culture, field tests and exposure effects. Overall, the adverse outcomes acquired in this study support full-scale considerations of environmental prevention and retrieval and thus provide robust tool to scientifically extrapolate the environmental quality guidelines, further improving accuracy and ecological relevance towards future pollution monitoring as powerful tools and more comprehensive risk assessments in complex scenarios. (The author acknowledge financial support by Grant No. 21777156/B070403 from National Nature Science Foundation of China.)

WP069 The effects of waterborne chromate (Cr6+) on protein abundance patterns in Lake trout (Salvelinus namaycush) and White sucker (Catostomus commersonii)

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In anticipation of the development of the Ring of Fire in Northern Ontario for the mining of Chromium, we assessed the effects of Cr6+ on the plasma proteome of Lake trout and White sucker - two species’ which are native to that region. Juvenile Lake trout were exposed in the laboratory to waterborne Cr6+ (0, 0.2 ppb and 3 ppm). Exposures lasted for 21-days in flow-through conditions, with the exception of the highest (3 ppm) treatment because we had observed mortalities after 7-days in our pilot study. Plasma proteins were analyzed using a reverse phase liquid-chromatography tandem quadrupole time-of-flight mass spectrometry system with data-dependent full scan acquisition, and peptide spectral files were subsequently sequenced and matched to proteins using bioinformatics software. Results from liver transcriptome analyses from these same fish indicate there was significant differential gene expression in both the 0.2 ppb and 3 ppm treatments. There were also significant changes in the concentration of some plasma metabolites. Plasma protein abundance will be compared to these results to detect where there is an agreement between the datasets and we will discuss how changes in gene expression caused by exposure to Cr6+ could result in higher level biological effects, and be used for monitoring fish health in Ring of Fire mining activities.

WP070 Copper binding to a rainbow trout gill cell line: determination of biotic ligand model parameters

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Copper is a potentially toxic element in aquatic environments that is also an essential nutrient, aiding in the growth and development of all aerobic organisms. In small quantities, copper acts as a micronutrient, playing a large role in many enzymatic reactions but at increased concentrations, copper is a potential aquatic pollutant causing metal toxicity. The biotic ligand model (BLM) is a tool that is used for metals risk assessment and helps to establish protective water criteria, guidelines and risk assessment. Previously, the BLM has been used to model metal complexation directly at the biotic ligand (e.g., gill) for both whole organisms and primary gill cells but has not yet been used to model metal complexation directly for gill cells from a continuous cell culture. For this study, the cupric ion selective electrode was used to directly characterize copper binding to a rainbow trout gill cell line, RTgill-W1. Prior to titration cell viability curves and EC50 values were generated using the RTgill-W1 cell line to determine what concentrations of copper (II) sulfate induces cell toxicity using two fluorescence indicator dyes, Alamar Blue and CFDA-AM. These tests confirmed the titratable range for the cells in order to maintain viability. For titration, RTgill-W1 cells were seeded into cell culture inserts and copper titrations performed at non-toxic concentrations. Preliminary results suggest that the interaction of copper with cell derived from a continuous cell line is much weaker than interactions with cells from primary culture. These results will determine the potential use of RTgill-W1 as an alternative to whole organism and primary cell testing; thus, potentially providing an alternative to animal testing. Additionally, this study will provide insights into cupric ion transport in a rainbow trout gill continuous cell line.
Fate, Effects, Mitigation and Monitoring of Oil and Oilfield Wastewater Spills in Freshwater Ecosystems

WP071 Inland oil spill planning: Baseline fish health for pallid sturgeon in the Upper Missouri River Basin and bull trout in the Flathead River, Montana


Enhanced oil and gas production in North America have led to large volumes of product transport in pipelines, railcars, and tanker trucks. Formations such as Three Forks and Bakken within the Williston Basin of Montana and North Dakota have produced more than 1 million barrels of oil per day. Along with the enhanced transport comes greater risks of spills within transportation corridors which often follow riverine habitat for fish species important for recreation, commerce, and conservation. Risk characterization identified potential threats from oil spills to populations of two threatened or endangered species, pallid sturgeon (Scaphirhinchys albus) in the Upper Missouri River Basin and bull trout (Salvelinus confluentus) in Montana. The objective of this study was to develop baseline fish health information on these species or appropriate surrogate species in critical habitats with elevated risks of oil spills. Shovelnose sturgeon (Scaphirhinchys platyrynchus) were collected in three locations near the confluence of the Missouri and Yellowstone Rivers and cutthroat trout (Oncorhynchus clarki lewisi) and mountain whitefish (Prosopium williamsonii) were collected from critical bull trout habitat along the Middle Fork of the Flathead River. Fish health metrics evaluated included gene expression/enzyme induction in various tissues, differential changes in white blood cells, polycyclic aromatic hydrocarbon bile metabolites, histological changes in gills, metabolic oxidative stress, immune dysfunction, and disruption of endocrine signaling pathways. Baseline values are presented as well as comparisons of these metrics in fish from oil spill investigations. These data are critical to accurate evaluation of injury to fish populations in post-spill monitoring and assessments.

WP072 Zooplankton metabarcoding to assess the ecological impact of remediation efforts after diluted bitumen spills: A mesocosm study

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The Freshwater Oil Spill Remediation Study (FOReSt) is a collaborative project to determine the efficacy of minimally invasive methods for removing diluted bitumen (dilbit) from freshwater shorelines. In 2019, pre-weathered dilbit was applied to shoreline enclosures (5 x 15m) deployed in two areas with physically different underlying substrate types (organic/peat and rock/cobble). Dilbit was applied at a dosing level of 1:10000 (oil:water) and, after 72h, was removed using sorbent pads and low pressure shoreline rinsing. Two secondary remediation techniques were then employed: nutrient addition for enhanced Natural Recovery (eMNR), or COREXIT EC9580A(TM) shoreline cleaner. Adult fathead minnows (Pimephales promelas) were deployed into each enclosure (n = 12) for an exposure period of 80 days. Dermal mucus was sampled from every individual prior to deployment, and upon recapture at the end of the exposure period. F$_2$-isoprostanes were quantified in the mucus using high performance liquid chromatography tandem mass spectrometry (HPLC-MS/MS) to compare levels of lipid peroxidation related to oxidative in exposed FHM relative to those in control enclosures. Levels of F$_2$-isoprostanes were also compared to biomarkers of polycyclic aromatic hydrocarbon (PAH) exposure, namely...
Potential environmental impacts of oil spills are a concern for the Canadian public and the oil industry. Optimizing methods to treat residual oil that remains after an oil spill cleanup and to assess the potential impacts of residual oil in impacted freshwater systems are both high priorities. In 2018, the International Institute for Sustainable Development-Experimental Lakes Area (IISD-ELA) began a collaborative program to examine the efficacy of minimally invasive remediation methods for residual bitumen and conventional heavy crude oil in the freshwater shoreline environments. In 2018, model oil spills in contained shoreline environments (15X2.5m) were used to examine the efficiency of immediate oil recovery and then to compare degradation of residual oil via Monitored Natural Recovery (MNR). Results from the 2018 pilot study were used to design a larger study being performed in 2019 that focuses on comparing the efficacy of oil removal using nutrient additions, a shoreline cleaner and engineered floating wetlands relative to MNR. As part of these studies the effects of residual diluted bitumen on juvenile fathead minnow development and deformity rates were evaluated. Because exposure to UV radiation can potentiate the toxicity of certain compounds in residual oil by up to 100-fold, we conducted a paired test exposing juvenile fathead minnows to water from enclosures treated with model spills of diluted bitumen with and without UV radiation.

WP076 Assessing the efficacy of minimally invasive remediation techniques for oil spills on freshwater shorelines using bile metabolites in fish

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The boreal shield is Canada’s largest terrestrial ecozone covering more than 1.8 million km² and containing more than 22% of the country’s freshwater resources. While numerous crude oil pipelines and rail transportation routes cross the boreal zone, additional information is required to establish the most effective remediation methods for oil spills in lakes within this region. The Freshwater Oil Spill Remediation Study (FOReSt), conducted at the IISD-Experimental Lakes Area in Northwestern Ontario, Canada is using controlled model spills of diluted bitumen in mesocosms deployed in physically different shoreline environments of a boreal lake. Enhanced monitored natural recovery (eMNR) and a shoreline cleaner were applied as remediation techniques to residual oil remaining after traditional cleanup was performed. In terms of chronic toxicity, polycyclic aromatic compounds (PACs) represent the most toxicologically relevant compounds in crude oil. Biliary PAC metabolite concentrations are well established as a biomarker of short-term exposure to PACs. In this study, biliary metabolites were quantified in fathead minnows (Pimephales promelas) living within the mesocosms and used as a metric to evaluate the efficacy of the different remediation techniques studied. Concentrations were determined using liquid chromatography-mass spectrometry. Results from this study will inform spill responders regarding the best remedial methods to use on shorelines affected by oil spills in the future.

WP077 Tracking the fate and biodegradation of oil-derived carbon in simulated oil spills in lake limnocorals

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Commercialization of land-locked crude oil reserves, such as the Athabasca Oil Sands, involves terrestrial transportation of the extracted crude, increasing the potential for a spill in freshwater systems. While many coastal and marine systems are known to host active microbial communities able to degrade oil-derived hydrocarbons, there is limited research into the potential for microbial communities in freshwater systems to make use of these carbon sources and contribute to natural attenuation after a spill. The BOREAL project set out to assess the fate and effects of diluted bitumen spilled into a boreal lake via a large-scale, in-lake study where nine 10-m diameter limnocorals were treated with varying amounts of diluted bitumen. Within the greater BOREAL project, this study aimed to track the movement of oil-derived carbon through the experimental systems and determine the carbon sources used by the active microbial communities. Because of its geological age, bitumen contains no detectable radiocarbon (Δ14C = -1000‰), whereas the 14C content of recently fixed organic matter reflects that of modern atmospheric CO2. As a result, radiocarbon can be used to track incorporation of petrogenic carbon in the environment. Water samples were collected from the high (~1,600 oil:water, v:v), medium (1/5,700), and low (1/6,600) treatment limnocorals, as well as the control, on day -4 before oil application and 8 times up to day 70 post application. Radiocarbon isotopes (Δ14C) were determined in the dissolved and particulate organic carbon as well as dissolved inorganic carbon fractions. Δ14C values averaged ~410% in the DOC and POC fractions of the highest oil/water treatment on day 70 indicated significant oil contribution to the carbon in these pools. Petrogenic contributions were less apparent in the DIC (Δ14C ~ -10‰). Radiocarbon contents of the total organic fraction were also measured in surface sediment samples collected on days -4 and 78. Phospholipid fatty acids (PLFAs) in the same surface sediments were also extracted and quantified. No treatment-dependent differences in PLFA composition, a surrogate for the active microbial community composition, were observed. Compound-specific Δ14C values were determined on six individual or grouped PLFA fractions and were used to assess the degree to which oil-derived carbon was being used and incorporated by different elements of the active microbial community in the surface sediments of the limnocorals.

WP078 Wild-sourced fathead minnow embryos exposed to Cold Lake Blend diluted bitumen spilled at the IISD-Experimental Lakes Area

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The physical effects of oil in marine environments have been well studied, but there is a critical lack of information regarding the impacts of oil spilled undergoing natural weathering in freshwater lakes. The
specific aim of this project was to study the potential effects of Cold Lake Blend (CLB) diluted bitumen spilled into a Northwestern Ontario boreal shield lake in wild living fish embryos. For this, three subsequent experiments were conducted in one of the IISD-ELAs (Lake 260) in early, mid, and end of July 2018. Fertilized embryos of wild fathead minnow (Pimephales promelas) were exposed to water drawn from 9 large limnocorals, which encompassed 2 controls and 7 CLB dilbit concentrations. Each FHM exposures lasted 7 days. At exposure completion, mortality rate, malformation occurrence, and/or hatch time were recorded. Preliminary data suggest that at the tested concentrations, the spilled dilbit does not alter fish embryo survivorship, but is likely inducing malformations for the exposed animals. Chemical analysis is ongoing. Future work include 1) a recovery exposure to be performed in summer 2019 to assess fish embryonic recovery and 2) a throughput transcriptional investigation of all time-points, including targeted real-time RT-PCR analysis of a series of genes related to xenobiotic detoxification and oxidative stress (e.g., cyp1a, ahr, gst, gsr, and p53). This research is part of the large NSERC-SPG research effort where the results will help to understand the direct and indirect repercussions of a dilbit spill in freshwater ecosystems.

WP079 Limnocorral study to examine impacts of diluted bitumen on wild small-bodied freshwater fish at IISD-Experimental Lakes Area, northwestern Ontario
L. Timlick, University of Manitoba / Department of Environment and Geography; J. Séguin, J.M. Blais, University of Ottawa / Biology; M.L. Hanson, University of Manitoba / Department of Environment and Geography; B.P. Hollebone, Environment and Climate Change Canada / Emergencies Science & Technology; V.S. Langlois, Institut National de la Recherche Scientifique / Centre Eau Terre Environnement; D.M. Orihel, Queen’s University / Department of Biology/School of Environmental Studies; J.L. Rodriguez-Gil, University of Ottawa / Department of Biology; V. Palace, IISD-Experimental Lakes Area

The Boreal lake Oil Release Experiment by Additions to Limnocorals (BOREAL) project began in 2018 at the IISD-Experimental Lakes Area (Ontario, Canada) to study the fate, behaviour, and potential toxicological impacts of diluted bitumen (dilbit) in fresh water. Model spills were contained within seven 10 m diameter, littoral limnocorals (~2 m deep) and dilutions ranged from 1:100,000 to 1:1,000 dilbit:water. These values were chosen to represent a regression of real-world spills equivalent to the 50th and 99th centiles in North America over the last two decades. Two additional limnocorals untreated with dilbit and fish caught from the open lake serve as references. Adult male and female finescale dace (Phoxinus neogaeus) were released in the limnocorals 21 days after oil addition, while incidental juvenile fathead minnows (Pimephales promelas) were present in the enclosure from oil addition onwards. Here we report the effects of chronic exposure (~21 days) on reproductive health of adult fish, development of juveniles, and physiological and molecular responses in both stages. Assessed metrics of reproductive health and metabolism include calculation of male and female gonadal somatic indices, egg diameter, histological development of gonads in both sexes, and condition factor. Gills were scored for deformities and hepatocyte volume indexes were examined as well as mRNA upregulation of Cyp1a. Results indicate that in the lower exposures (~1:10000) there are no significant effects on the health of adult or juvenile small-bodied fish, but in the higher exposures (~3:10000) there is a significant increase in mortality.

WP080 Use of Petroleum “Biomarkers” to Isolate Chemical Behaviours of Diluted Bitumen in a Freshwater Boreal Lake
B. Hollebone, Z. Yang, K. Shah, R. Faragher, Environment and Climate Change Canada; M.L. Hanson, University of Manitoba / Environment and Geography; D.M. Orihel, Queen’s University / Department of Biology / School of Environmental Studies; V. Palace, IISD-Experimental Lakes Area; J.M. Blais, University of Ottawa / Biology

Recent reports from the Royal Society of Canada (RSC) and the United States National Academy of Sciences (NAS) have highlighted the difficulties in modelling the behaviour of heavy oils, including dilutted bitumen. Of particular concern are the behaviours and mass balances for evaporation, dissolution, photolytic degradation and degradation. However, experimentally, it is challenging to find chemical markers in crude oils that are affected primarily by single types of behaviour, to estimate the rate of these behaviours and so determine mass balances for the oil spilled. The recalcitrant hydrocarbon fossils found in abundance in bitumen may offer unique solutions. The C14 to C16 diesel-range alkylated adamantanes are good candidates for following evaporation; they will not readily photodegrade, are not significantly water soluble, and are not favoured as food-sources by oil degrading organisms. Similarly, the aromatic steranes are insoluble in water, too massive to readily evaporate, and not biodegraded, however their aromatic chromophores can be chemically degraded by photolysis. Using a dataset from oils exposed for 80 days in a boreal lake at the International Institute for Sustainable Development-Experimental Lakes Area, we examine the hypotheses that these petroleum “biomarkers” are suitable for the task of quantifying evaporative and photodegradation changes in diluted bitumen, in response to the data gaps identified by the RSC and the NAS.

WP081 Petroleum hydrocarbons in the water column and sediments following experimental additions of diluted bitumen to freshwater limnocorals
S.S. Stoyanovich, J.L. Rodriguez-Gil, University of Ottawa / Department of Biology; M.L. Hanson, University of Manitoba / Environment and Geography; B.P. Hollebone, Environment and Climate Change Canada; D.M. Orihel, Queen’s University / Department of Biology / School of Environmental Studies; V. Palace, IISD-Experimental Lakes Area; K. Shah, Z. Yang, Environment and Climate Change Canada; J.M. Blais, University of Ottawa / Biology

The BOREAL (Boreal-lake Oil Release Experiment by Additions to Limnocorals) project involved adding diluted bitumen (dilbit) to a series of nine limnocorals installed in a freshwater lake to examine the fate, behaviour and effects of hydrocarbons in a boreal lake. A regression design was utilized, comprised of 2 controls (one near field and one far field) and 7 treatments that received dilbit volumes ranging from 1.5 to 179.8 L of dilbit, resulting in oil/water ratios ranging between 1:1000 to 1:10000. This presentation will focus on assessing the partitioning behaviour of dilbit’s chemical constituents; including n-Alkanes, mono/poly cyclic aromatic hydrocarbons (BTEX and PACs) and petroleum biomarkers, between the dilbit slick, water column and sediments. Briefly, total BTEX concentrations measured in the water over the first four days of the study showed rapid increases in water column concentrations, reaching maximum concentrations by day 1, ranging from 1.83 to 107 mg/L across all treatment levels. Total PAC (TPAC) concentrations in the water column reached their maximum (ranging from 729 to 2466 ng/L) across all treatments by day 15. Following this increase, concentrations in the water column then began to deplete, coinciding with a subsequent increase in sediment TPAC concentrations. At the end of the experiment, sediment TPAC concentrations ranged from 49 to 188 ng/g dry weight, while sediments in direct contact with sunken dilbit had TPAC concentrations ranging from 1800 to 5600 ng/g dry weight. Petroleum hydrocarbon contamination of both the water column and the sediments followed a dose-dependent relationship, with higher levels of contamination observed in the higher dilbit treatments. These results are important for our understanding of dilbit’s behaviour in the environment across a wide range of possible spill sizes and the potential impacts it can have on important environmental media such as the water column, the sediments and the surrounding biota. It is our hope that our findings will help inform evidence-based management strategies for the transport of dilbit in Canada.
WP082 Toxicokinetics of Polycyclic Aromatic Compounds and Metals in Giant Floater Mussels (Pyganodon grandis) Exposed to a Simulated Diluted Bitumen Spill

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Canadian bitumen is mainly transported via pipeline, train, and trucks, all posing a risk as they can lead to the accidental release of diluted bitumen (dilbit) into the aquatic environment. In the summer of 2018, a collaborative large-scale field experiment was conducted at the IISD - Experimental Lakes Area to assess the impacts of a dilbit spill in a freshwater ecosystem. The research objectives of the Boreal lake Oil Release Experiment by Additions to Limnocorals (BOREAL) project are to understand the fate, behaviour, and potential toxic effects of dilbit in a Boreal lake ecosystem to inform evidence-based management strategies for the transport of dilbit in Canada. A range of controlled dilbit spills were conducted in seven 10 m diameter limnocorals (~100,000 L of water) resulting in environmentally realistic dilbit:water dilutions ranging from 1:66,071 to 1:588, representative of the upper half of the distribution of oil spill sizes occurred in North America in the last decade. Additionally, two limnocorals, not treated with dilbit, were studied as controls. Here we identify the bioaccumulating compounds associated with naturally weathered dilbit in giant floater mussels (Pyganodon grandis), and determine the rates at which they are accumulated and excreted. More specifically, the bioaccumulation and toxicokinetic parameters of polycyclic aromatic compounds (PACs) and various metals were evaluated. When environmental [Na\(^+\), K\(^+\), Ca\(^{2+}\), Cl\(^-\), and HCO\(_3^-\)] in freshwater systems are critical for physiological functions. However, elevated concentrations of chloride ions from road salts eventually make their way into waterways. Previously, Daphnia have been used as test organisms to generalize the toxicity of Cl\(^-\) from road salt to zooplankton species, and these experiments have played a crucial role in our understanding of the environmental effects of increased salinity. Although Daphnia are vital to the functioning of freshwater ecosystems, many lakes with elevated Cl\(^-\) concentrations are shallow and therefore are not ideally suited to these pelagic species. Consequently, two dominant littoral Cladocera species (Eubosmina longispina and Chydorus Brevilabris) were selected as test organisms for this study because results from sediment core analysis suggest that they are particularly Cl\(^-\) sensitive (E. longispina) and Cl\(^-\) tolerant (C. brevilabris). 21-day renewal bioassay experiments were conducted with eight different Cl\(^-\) treatments, ranging from 0.4 mg/L to 1200 mg/L using a softwater medium. This softwater medium more closely reflects actual conditions in Precambrian shield lakes in the region. Our results add to the growing body of work examining whether the current Canadian Water Quality Guideline (CWQG) for chloride concentrations in lakes is sufficient for the protection of aquatic life in low-nutrient sites typical of the Precambrian Shield.

WP084 Assessing the impact of chloride from road salt on the survival and reproduction of two littoral Cladocera species (E. longispina and C. brevilabris)

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Road salt is commonly used as a deicing agent for winter road maintenance. Of the several compounds that can be used for this purpose, sodium chloride (NaCl) is the most commonly used in Canada. NaCl is highly water-soluble and, because of their conservative nature, almost all chloride ions from road salts eventually make their way into waterways. Previously, Daphnia have been used as test organisms to generalize the toxicity of Cl\(^-\) from road salt to zooplankton species, and these experiments have played a crucial role in our understanding of the environmental effects of increased salinity. Although Daphnia are vital to the functioning of freshwater ecosystems, many lakes with elevated Cl\(^-\) concentrations are shallow and therefore are not ideally suited to these pelagic species. Consequently, two dominant littoral Cladocera species (Eubosmina longispina and Chydorus Brevilabris) were selected as test organisms for this study because results from sediment core analysis suggest that they are particularly Cl\(^-\) sensitive (E. longispina) and Cl\(^-\) tolerant (C. brevilabris). 21-day renewal bioassay experiments were conducted with eight different Cl\(^-\) treatments, ranging from 0.4 mg/L to 1200 mg/L using a softwater medium. This softwater medium more closely reflects actual conditions in Precambrian shield lakes in the region. Our results add to the growing body of work examining whether the current Canadian Water Quality Guideline (CWQG) for chloride concentrations in lakes is sufficient for the protection of aquatic life in low-nutrient sites typical of the Precambrian Shield.

WP085 Major Ion Toxicity Studies in Daphnia magna: Hemolymph Ion Concentration and Transepithelial Potential Endpoints

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Cladocera are powerful osmoregulators and thrive in a wide range of aquatic ecosystems. Fluorocarbon concentrations within these environments cause disturbance to the hydromineral homeostasis of freshwater species. Major ions (Na\(^+\), K\(^+\), Ca\(^{2+}\), Cl\(^-\) and HCO\(_3^-\)) in freshwater systems are critical for physiological functions. However, elevated concentrations of these ions cause osmoregulatory stress in freshwater animals that live in hypo-osmotic habitats. Many anthropogenic activities (e.g. mining, de-icing with road salt, irrigation) have been identified as sources of major ion runoff into freshwater habitats. Daphnia magna, a cladoceran toxicology model, is adapted for active ion uptake and reduction of passive ion loss in freshwater to maintain its osmotic balance. Using ion-selective microelectrode techniques, hemolymph ion concentrations were evaluated. When environmental [Na\(^+\)] or [K\(^+\)] are gradually elevated, the animals exhibit a sustained elevation in the hemolymph levels of the same ion. This corresponds with previously published LC50 values, indicating that hemolymph ion levels may be used to help predict toxicity. Interestingly, the rise in hemolymph [K\(^+\)] was mitigated by exposure to ambient Na\(^+\). Conversely, the rise in hemolymph [Na\(^+\)] was mitigated by exposure to ambient Ca\(^{2+}\). Lastly, transepithelial potential (TEP) (another measurable parameter that could be used to predict toxicity) baseline was characterized. Alterations in TEP took place following exposure to elevated ambient levels of major ions. These data advance our understanding of whether hemolymph ions and TEP could be used to build a model to predict major ion toxicity in environmental context.

WP083 Acute toxicity of NaCl based road salts to aquatic macroinvertebrates

H.R. Wilson, Alma College / Environmental Studies; A.D. Harwood, Alma College / Environmental Studies / Biology

In Michigan alone, salt application on state highways ranges from 343,000-760,000 metric tons per year. About half of these salts enter freshwater ecosystem. The research objectives of the Working Towards Solutions – Experimental Lakes Area to assess the impacts of a dilbit spill in a freshwater ecosystem. Normalization for chloride ion had no effect on these relationships; therefore, the toxicity of road salts used in this study can be predicted based on chloride ion concentrations. Although LC50 values found in this study were greater than environmental concentrations reported by existing literature, more research is needed to evaluate chronic or sublethal effects of road salts on freshwater macroinvertebrates.

FWater Freshwater Salinization: Causes, Effects and Working Towards Solutions

WP083 Acute toxicity of NaCl based road salts to aquatic macroinvertebrates

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WP086 The Relative Toxicity of Road Salt Alternatives to Early Life Stage Freshwater Mussels

L.H. Nguyen, C. Zhang, University of Houston, Clear Lake / Environmental Science

With the increasing use of glyphosate- and glufosinate-based herbicides in agricultural and non-agricultural sectors, the need for routine monitoring is warranted to protect environmental and public health exposures. Currently, the consensus on whether or not glyphosate is cancerous is contentious and controversial, and there is no effective method, such as direct injection ion chromatography coupled with a single quadrupole mass spectrometry (IC-MS), that can be used for the routine analysis of glyphosate, glufosinate, aminomethyl phosphonic acid (AMPA), and 3-methyl phosphonyl propionic acid (MPPA) concentrations in water. A novel direct injection IC-MS method with pre-concentration was developed to analyze these compounds in surface/drinking water and wastewater samples. The pre-concentration (anion exchange column) technique allowed for lower detection limits without the labor-intensive and time-consuming step of derivatization. The calculated method detection limit (MDL) for glyphosate, AMPA, glufosinate, and MPPA were 0.352, 0.174, 0.509, and 0.324 µg/L, respectively. The method shows an excellent linear range (0 - 50 µg/L) and good recoveries (41% - 125%) except for MPPA. Representative water samples across the U.S. were collected for determination of all four compounds (n = 14, 4, and 6 for drinking water, surface water, and wastewater, respectively). Glyphosate, AMPA, glufosinate, and MPPA were found to have a detection frequency of 7, 13, 100, and 100%, respectively. The range of concentration for glyphosate, AMPA, glufosinate, and MPPA were MDL - 20.9, MDL - 40.6, 14.8 - 176.6 and 2.3 - 26.11 µg/L. The IC-MS method coupled with an online pre-concentration SPE column can serve as a better and cost-effective alternative over existing methods to accurately analyze glyphosate, glufosinate, AMPA, and MPPA at their environmentally relevant concentrations. Although the sensitivity of this online SPE IC-MS method still needs to be refined in reference to LC-MS/MS at the sub-ng/L or ng/L level, we were able to demonstrate that glyphosate, glufosinate and their degradation products can be frequently detected in the environmental water at their ug/L level. Our results implied negligible adverse human health effects based on the existing maximum contaminant level (MCL) in drinking water (700 µg/L) and reference dose (2 mg/kg-d) for glyphosate, but the health risks of the other three compounds remain unknown because of the lack of current regulatory thresholds.

WP088 Glyphosate: General researches and toxicology - a scientometric review

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Glyphosate (GLY) is a broad-spectrum organophosphate herbicide. It is currently the most used herbicide globally. The International Agency for Research on Cancer (IARC) has recently (2016) classified GLY as a Group 2A, i.e., ‘probably carcinogenic to humans’. With the enormous input of scientific information daily, it is difficult to follow and analyze all the global publications. In this sense, the scientometrics analysis is a super new tendency that help to evaluate quantitatively the scientific and technological activity in diverse fields. For this reason, the aim of this research was to perform a scientometric review with all the publications about GLY, specially focusing in the researches categorized as ‘toxicology’. The data were retrieved from the Web of Science database (WoS) (http://apps.webofknowledge.com). The searched keyword was TS (Topic Search) = Glyphosate. It was found 10,509 results, among 1975 and 2019. After the refinement we selected 10,069 records. The data were analyzed using WoS tools and CiteSpace, to evaluate and visualize co-citation networks. With all the refined records about GLY, the H-index was 124, with an average of 16.62 citation per item. It means that this dataset had 124 papers with at least 124 citations each. The leader country was USA, with the highest citation count (3621) and centrality (c=0.34). The 2nd ranked was Brazil with 970 citations, but 9th in centrality (c=0.08), followed by Canada (740) and China (620). Germany was the 2nd in centrality (0.22), followed by Australia (c=0.12), and Poland (c=0.1). China, France and Germany were set in Cluster #0, whilst USA, Australia and Argentina were in Cluster #1; and Brazil, Canada and Spain were in #2. About the WoS categories, the top ranked item was AGRICULTURE, with 4426 citation counts, followed by AGRONOMY, with 3191. The 3rd was PLANT SCIENCES (3177), followed by ENVIRONMENTAL SCIENCES & ECOLOGY (1694), ENVIRONMENTAL SCIENCES (1458), CHEMISTRY (1173) and TOXICOLOGY (789). On other hand, the top ranked item by centrality was TOXICOLOGY, with centrality of 0.30, followed by ENGINEERING (0.28), CHEMISTRY (0.23), BIOCHEMISTRY & MOLECULAR BIOLOGY (0.21), and AGRICULTURE (0.18). The centrality reflects the influence of an area or countries whilst the frequency main the visibility. Thus, we can see that not always the category with greater visibility has greater scientific influence. In this sense, by this metric, TOXICOLOGY is the important research area in GLY researches.
WP089 Preliminary assessment of the potential impacts of neonicotinoids on wild fish health in Ontario streams

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Pesticides are designed to be toxic and can cause detrimental effects not only to the species that they are intended to control but also to non-target organisms. Previous studies have documented the occurrence and distribution of neonicotinoid insecticides in surface waters in over 90% of Ontario streams sampled. There is concern about their potential to cause changes in higher levels of biological organization such as fish health. This study investigates fish health and fish populations and community structure in two small watersheds in southern Ontario (Canada): Sturgeon Creek, which is in close proximity to agricultural activity and where neonicotinoids have been routinely measured, and Cedar Creek, which is removed from agricultural activity. The ability of Pumpkinseed sunfish (Lepomis gibbosus) to respond to contaminants (e.g. oxidative stress, acetylcholinesterase [AChE]) and whole organism endpoints (e.g. weights, lengths, organ weights, visual anomalies) were analyzed and compared between collection sites. At the time of fish collections, surface water grab samples from Sturgeon Creek had measurable levels of imidacloprid and acetamiprid. Fish in Sturgeon Creek were larger and had greater hepatosomatic indices than those collected at the reference site. Analysis of AChE and oxidative stress indicators are on-going. The results generated from this research will be provided to Health Canada’s Pesticide Management Regulatory Agency (PMRA) for consideration when conducting risk assessments, special reviews, and re-evaluations, and when developing water quality guidelines for these compounds.

WP090 Assessing Daphnia magna population-level response to the differential toxicity of chlorpyrifos and chlorpyrifos-oxon at the watershed scale

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Pacific Northwest freshwater resources are key elements in the life history and ecology of Pacific salmon and steelhead (Onchorhynchus sp.). In addition to overfishing, critical habitat degradation and loss has been identified as contributing to population decline, resulting in 28 evolutionary significant units listed as threatened or endangered under the Endangered Species Act. Characterizing risks to Pacific salmonids and their food web related to pesticide exposure requires complex spatial and temporal information on life history and ecology, as well as pesticide use patterns and environmental fate. Probabilistic methods can be used to characterize realistic pesticide use practices while ecotoxicological models can simulate pesticide transport from the application sites to freshwater resources utilized by Pacific salmonids and their food web allowing for spatial and temporal estimation of exposure of aquatic receptors. Daphnia magna was chosen as a sensitive indicator of receptor response to freshwater toxicant exposure, allowing modeling results to be cautiously extrapolated to other populations of aquatic receptors higher on the species sensitivity distribution. For this study, a probabilistic approach was used to characterize use practices of the organophosphate insecticide chlorpyrifos in the Zollner Creek watershed, Willamette Valley, Oregon between 2010 and 2011. The Soil and Water Assessment Tool (SWAT) was used to simulate the fate and transport of chlorpyrifos and chlorpyrifos-oxon, a degradation product of toxicological concern, and estimate daily aqueous exposure concentrations. In aquatic life, chlorpyrifos is metabolized to chlorpyrifos-oxon, which is thought to be the primary neurotoxic agent. To investigate the impact of chlorpyrifos use practices on aquatic resources in the Zollner Creek watershed, we utilized daily model estimates of chlorpyrifos and chlorpyrifos-oxon concentrations and a Tier 1 population model, parameterized with acute and chronic bioassay data, to evaluate the combined effect of chlorpyrifos and chlorpyrifos-oxon on D. magna population dynamics over a 2-year period.

WP091 Potential aquatic toxicity of pesticide mixtures in Canadian Prairie wetlands

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WP092 Current-Use Pesticides in New Zealand Streams: Comparing Results from Grab Samples and Three Types of Passive Samplers

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New Zealand uses more than a ton of pesticides each year; many of these are mobile, relatively persistent, and can make their way into waterways. While considerable effort goes into monitoring nutrients in agricultural streams and programs exist to monitor pesticides in groundwater, very little is known about pesticide detection frequencies, concentrations, or their potential impacts in New Zealand streams. We used the Polar Organic Chemical Integrative Sampler (POCIS) approach and grab sampling to survey pesticide concentrations in 36 agricultural streams in Waikato, Canterbury, Otago and Southland during a period of stable stream flows in austral summer 2017/18. We explored a new approach for utilizing site-specific POCIS sampling rates. We also tested two novel passive samplers designed to reduce the effects of hydrodynamic conditions on sampling rates: the Organic-Diffusive Gradients in Thin Films (o-DGT) aquatic passive sampler and micro-porous polyethylene (MPT) tubes filled with Strata-X sorbent. Multiple pesticides were found at most sites; two or more were detected at 78% of sites, three or more at 69% of sites, and four or more at 39% of sites. Chlorpyrifos concentrations were generally the highest, with a maximum concentration of 180 ng/L being measured. Concentrations of the other pesticides were generally below 20 ng/L. Mean concentrations of individual pesticides were uncorrelated with in-stream nutrient concentrations. Most pesticides were frequently detected in POCIS due to its higher sampling rate and the relatively low concentrations of most pesticides. In contrast, chlorpyrifos was most frequently detected in grab samples. Chlorpyrifos concentrations at two sites were above the 21-day chronic No Observable Effect Concentration (NOEC) values for fish and another two sites had concentrations greater than 50% of the NOEC. Otherwise, concentrations were well-below NOEC values, but close the New Zealand Environmental Exposure Limits in several cases.
WP093 Ecological Risk Assessment of pesticides from freshwater ecosystems in Pampas region of Argentina: Legacy and current use compounds contribution

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Agricultural production in Pampas region is one of the most important economic activities in Argentina. However, the possible environmental effects related to the growth of this activity in the last years have not been studied enough. Particularly, the effects of pesticides mixtures are a topic of great concern both for society and regulatory authorities worldwide, given the possible additive and synergistic relationships between these chemicals and their possible effects on aquatic biota. Based on a concentration addition model, this study developed an Ecological Risk Assessment (ERA) of pesticides from freshwater ecosystems in Pampas region. For this purpose, reported pesticides concentrations available in public bibliography and a Risk Quotients (RQs) approach were used. A cumulative risk map was established to display RQs for current use pesticides (CUPs) and legacy chemicals. The ΣRQs were calculated for 66 sites, using available reported measured environmental concentrations (MECs) and predicted no effect concentrations (PNECs) of pesticides. While RQ for only CUPs resulted in a high and very high risk (ΣRQ>1) for 29 % of the sites, when legacy pesticides were incorporated this percentage reached the 41 % of the sites, increasing significantly the absolute values of ΣRQ. Herbicides like glyphosate and atrazine contributed considerably to the ΣRQCUPs while organochlorines were the major contributors for ΣRQs when legacy pesticides were incorporated. Moreover, some active ingredients (acetochlor, carbendazim and fenitrothion) which are approved for their use in Argentina but banned in EU showed high contribution to ΣRQCUPs. The present study is the first attempt to develop an ERA in surface water of the Pampas regions of Argentina and it provides a starting point for a more comprehensive pesticides monitoring and a further risk assessment program.

WP094 California’s Stream Pollution Trends (SPoT) Program: Ten years of monitoring sediment toxicity and contaminants

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California’s Stream Pollution Trends (SPoT) Program assesses long-term trends of contaminant concentrations and toxicity in watersheds throughout the state. As part of the State Water Resources Control Board’s Surface Water Ambient Monitoring Program, sites at the base of 90 watersheds have been monitored annually for sediment toxicity and a suite of current-use and legacy pesticides, industrial organic chemicals, and trace metals since 2008. Toxicity is assessed with the amphipod Hyalella azteca, and more recently with the midge Chironomus dutilus as well. Monitoring results are related to land use within each watershed. Toxicity and contaminant concentrations, particularly pesticides, tend to increase with increasing urban land use. The addition of C. dutilus testing at urban sites has identified toxicity at sites that were not toxic to H. azteca, indicating the importance of testing with multiple species of varying sensitivity. SPoT’s network of sites is used to support California’s integrated report and support other agencies, and data from SPoT sites support a number of collaborations from urban stormwater programs to specific trend monitoring. In addition to regulatory uses, SPoT data are used to investigate the efficacy of the Department of Pesticide Regulation’s 2012 pyrethroid pesticide label changes, and the effectiveness of recent brake pad regulations. SPoT is the first statewide program to evaluate trends of the current-use pesticide fipronil and the algal toxin microcystin in sediments, both of which were detected in many regions. As part of California’s Open Data Initiative, an interactive data portal was developed to allow broad public access to SPoT data. Data from all aspects of SPoT will be presented to summarize the first decade of this statewide monitoring program.

WP095 Monitoring and Risk Assessment of Chlorfenapyr Residue

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This study was conducted to monitor the residue of Chlorfenapyr in Korean melon and to assess its risk for human health. This study was carried out on three different field trials and the pesticide was uniformly sprayed two times with intervals of 7 days onto the crop using a powder sprayer at ratio of approximately 2.0 L/10 m² (a.i. 5%). After last application, the crops were harvested at 0, 1, 3, 5, 7 and 14 days. The samples collected from the field trials were divided into two specimens of peel and pulp, and then each sample was analyzed using GC-MS/MS after a QuEChERS pretreatment method. Analytical method was validated prior to analysis of samples, showing method limit of quantitation (MLOQ) was 0.008 mg/kg and the recovery’s results with three spiking levels (MLOQ, 10 times of MLOQ, 50 times of MLOQ) ranged from about 70.0 to 115.0% and relative standard deviation (RSD) was less than 11.7% for all samples. Most residue of chlorfenapyr remained in peel part during the test period and about 10 to 20% of total residues were detected in pulp part. Based on the residue results of chlorfenapyr, a risk assessment was calculated using a percentage ADI depending on an ED1 value, resulting in less than 0.09 % and considered to be safe for human health.

WP096 Temporal Patterns of Pesticide Residues in Four Major River Basins in Korea

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To evaluate residues of environmental concerned pesticides which mainly include pesticides used for rice cultivation, total ninety four sampling sites were selected through main streams and branch streams of four major river basins. And the water samples at these sites were collected four times per year, April, May-June, July-August, and September-October or November-December in 2012 and 2014. Besides, the water samples at sites of Keum, Mangyang and Dongjin rivers belong to the Keum river basin were regularly collected with a month interval, especially biweekly from May to August in 2013. Of the pesticides monitored, fenoxanil, hexaconazole, isoprothiolane, iprobenfos and thiофenate-methyl fungicides were mainly detected in rice season. While other fungicides including diniconazole, procymidone, fenarimol, muriarim and boscalid, were detected with low frequencies and their average residue levels in positive samples were also fairly low. Of the insecticides monitored, some organophosphorus, cadusafos, diazinon, fenithiofan, fenitrothion, phenthoate and prophos, two carbamates, carbofuran and fenobucarb, and endosulfan were detected with low frequencies and low residue levels. Of the herbicides monitored, nine pesticides which include alachlor, butachlor, dimethametryn, dithiopyr, ethalfluralin, metolachlor, oxadiazon, simetryn and thiobencarb were detected with frequencies of 1-48% and in their residue level of 0.01-1.9 μg/L. Detection frequencies and residue levels of insecticides and herbicides were the highest in waters sampled in May and June. Almost pesticides detected were for the rice plants and their residue levels were very low to compare with standard values.

WP097 Estimating Regulatory Surface Water Pesticide Thresholds from Effect Databases

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Regulatory threshold levels (RTL) represent robust benchmarks for assessing aquatic risks of pesticides in surface waters. However, RTL
are currently only available for a few substances as a result of extensive literature searches reviewing regulatory documents. Thus, we developed a model that estimates large numbers of RTL using publicly available ecotoxicological effect databases. The model applies validity criteria used in USEPA review guidelines and is validated against manually retrieved RTL. Estimated RTL (N=779) are made publicly available and kept up-to-date via continuous synchronization of effect databases. The provided dataset enables large-scale risk characterizations and can be used for informed decision making for various stakeholders. Especially regions without established pesticide regulation may benefit from this dataset by using it as a baseline information for pesticide risk assessment and for the identification of priority substances.

WP098 Persistent pesticides: Effects of Endosulfan on gene expression and enzymatic activity of the aquatic invertebrate Chironomus riparius

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Endosulfan is an organochlorine pesticide widely used against pests and mites for the last five decades around the world. Commercialized as a mixture of α and β isomers (7:3), α has a longer half-life about 157 days. It has been banned in many countries, but due to their chemical properties, such as semi-volatility and relative persistence, it is a ubiquitous contaminant present in air, soils and water reservoirs. It was the most used pesticide in the United States for a wide number of crop types, including cotton, cereals, fruit trees. Besides, it is an extremely toxic and harmful compound to beneficial non-target invertebrates, aquatic life, and even humans by the consumption, because it biomagnifies in the food chain. Chironomus riparius, as a basal organism in the food chain, is ideal to evaluate the effects of endosulfan in water bodies. In this work we have exposed fourth instar larvae at 0.1, 1 and µg/L, environmentally relevant concentrations, for 24 hours, looking for a deeper analysis of the effects of these acaricide at sub lethal concentrations for C. riparius. The aim was to understand the changes on the organism at gene expression level by Real time PCR using an array designed with 42 genes related to endocrine system, detoxification response, immune system, DNA repair, apoptosis and stress response as well as the enzymatic activity of Glutathion-S-transferase (GST), Phenoloxidase (PO) and Acetylcholinesterase (AChE). All evaluated routes have been altered by endosulfan exposure, significant differences were found on Met, EcR, InR, E93, Dis, Cyp9f2, GSTδ3, GST β, MRPl, Proph, Def, ATM, PARP, hsp70, hsp40, and hsp24 mRNA levels, showing a strong effect despite the low concentrations used. According to the enzymes at the concentrations tested, no differences were observed, showing less neurotoxic effect (AChE) on Chironomus comparing to the previous results in other invertebrates and for PO and GST activity activation, a longer exposure may be necessary. These results reflect the damage suffered in organisms despite the absence of lethality, showing the importance of this exposure over the next generations. The new risk assessment strategies should contemplate a combination between physiological parameters and damages at the molecular level in order to obtain a comprehensive evaluation of the toxicants in the environment. Funded by: Ministerio Economía y Competitividad CICYT (SPAIN), CMT RTI2018-094598-B-I00

WP099 Occurrence of organochlorine pesticides and current use pesticides in the atmosphere and fecal from primates in protected areas

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The prevalence and environmental adverse effects of organochlorine pesticides (OCPs) and current use pesticides (CUPs) are a well-known problem. Since environmental threats occur across boundaries, protected areas are vulnerable despite their conservation status. Sharing a close evolutionary history with humans, nonhuman primates meet crucial criteria for serving as informative sentinels. While biomonitoring can be a challenge in wildlife, fecal sampling can provide information regarding internal exposure with minimal disturbance to threatened populations. Therefore, we examined the occurrence of OCPs and CUPs in the atmosphere and in fecal samples from primates in Costa Rica and Uganda. Our goal was to identify how regional differences and protected status influenced potential exposure to organic pollutants in protected areas. Air samples were collected using passive air samplers (PAS) with polyurethane foam (PUF) disks. PAS were deployed for ~3 months in Kibale, Uganda, and two biological field stations in Costa Rica, La Selva (LS) Biological Station and Las Cruces (LC) Biological Station. Fecal samples from primates were also collected in Kibale and Costa Rica. Samples were analyzed for OCPs and CUPs using gas and liquid chromatography mass spectrometry. In air, the most abundant OCPs were alpha-endosulfan and alpha-chlordane in Costa Rica and hexachlorobenzene (HCB) in Uganda, and the most abundant CUP was chlorpyrifos for both countries. Significantly higher concentrations for CUPs were observed around LS, while LC had a higher concentration of OCPs. Land use analysis indicated that LS had a higher fraction of agriculture than LC (33% vs. 14%), suggesting higher CUPs concentration at LS was related to pesticide intensive crops, while higher OCPs concentration at LC may be attributed to the area’s long agricultural history characterized by small-scale subsistence farming or long-range transport. In fecal samples, the most abundant OCPs were alpha-HCH, beta-HCH, and HCB in both Uganda and Costa Rica and the most abundant CUP was chlorpyrifos. This is the first to report the occurrence of OCPs and CUPs in feces of primates. The levels of target chemicals measured in primate’s feces together with negative health effects associated with some of these chemicals are a concern for primates living in these areas.

WP100 Organochlorine Pesticide Residues in Locally Cultivated Allium fistulosum, Spinacia oleracea, Lactuca sativa L. in Lagos, Nigeria

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Concerns are mounting over the health risks associated with the use of pesticides, especially organochlorines, to control crop pests in developing countries. In this study, some vegetables (Allium fistulosum, Spinacia oleracea and Lactuca sativa L.) and soil samples from three farms (Idi-Araba, Tejuosho and Alapere) in Lagos, Nigeria, were evaluated for organochlorine pesticide residues, using gas chromatography-mass spectrometry (GC-MS). The hazard index of consuming these vegetables was also calculated. Eighteen organochlorines were detected in the vegetable and soil samples at varying concentrations. In Idi-Araba farm, α-BHC occurred in highest concentration of 0.06±0.07 mg/kg in the shoot of L. sativa, Endosulfan I occurred in highest concentration of 0.29±0.26 mg/kg in A. fistulosum, while both P, P-DDE and L-Cyathrin occurred in highest concentrations of 0.08±0.03 mg/kg and 0.08±0.08 mg/kg respectively in the shoot of S. olerace. In Tejuosho farm, L-Cyathyrin, PF-38, and Chlorothalonil occurred in highest concentrations of 0.50±0.71 mg/kg, 0.13±0.07 mg/kg, and 0.03±0.01 mg/kg in the shoots of L. sativa, A. fistulosum, and S. olerace respectively. In Alapere farm, Endosulfan I occurred in highest concentration of 0.33±0.02 mg/kg in the shoot of L. sativa. Aldrin occurred in highest concentration of 0.02±0.01 mg/kg in the shoot of A. fistulosum, while L-Cyathyrin occurred in highest concentration of 0.04±0.05 mg/kg in the shoot of S. olerace. The concentrations of these organochlorine residues were higher than the Maximum Residual Limit (MRL) prescribed by the European Union (EU) Commission. Furthermore, Hepatoclar, Aldrin, and Endosulfan I was highly bioaccumulated and translolated by all the sampled vegetables. The Hazard Index (HI) calculated for A. fistulosum and S. olerace from Idi-Araba farm, and L. sativa from Tejuosho farm exceeded 1 (HI>1). This implies that the consumption of these vegetables exposes the consumers.
to potential health risk. Therefore, governmental protection agencies at all levels in Nigeria are advised to embark on awareness campaign, and institute monitoring programmes aimed at discouraging farmers from using organochlorine pesticides.

**WP101 Assessment of organochlorine pesticide residues in water and some selected fish species of Oli River, Nigeria**  
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The risk of Organochlorine pesticides in the protected areas is increasing due to the various agricultural activities ongoing around some national parks. The aim of this study was to determine the concentration of the spectrum of Organochlorine Pesticide in water samples from Oli River passing through Kainji Lake National Park and discharging into River Niger to assess the potential toxicity within the ecosystem. The physicochemical parameters of water sample were measured and analyzed by gas chromatography. Six fish species were sampled twice including Tigerfish (Hydrocyrus forskalii), Tilapia (Tilapia zilli), catfish mormyrid (Mormyrus delicious), Silver catfish (Chrysichthys nigrodigitatus), Nile perch (Lates niloticus). Homogenised samples were extracted by Soxhlet extraction and cleaned-up with florisil adsorbent and characterized for organochlorine content using Gas Chromatography (GC) equipped with Electron Detector (ECD). Substances such as α-BHC, δ-BHC, Heptachlor, aChlordane, Endosulphan I, Endosulphan sulphate, pp-DDT, and methoxychlor show higher concentration between 0.0356-0.113 ppm while the others of the OCP spectrum detected show lower concentration between 0.0152-0.0286 ppm. However, Endrin showed the lowest concentration with 0.09%. The highest concentration with 15.72% (α-BHC) followed by Endosulphan II (6.77%) and pp-DDT (6.44%) was found in Oli River. In all the cases, the levels of OCPs were a little high when compared to the FEPA limit of < 0.01 ppm. The mean concentrations of OCPs were higher than European Community allowable limit of 0.1ug/L for individual OCP. Ten OCPs were detected from the samples analyzed which include, α-BHC, β-BHC, Lindane, chlorothalonil, d-BHC Heptachlor, Aldrin, Heptachlor-epoxide (B), Dieldrin Endrin, Endosulphan 11, P”P”-DDT, Endosulphan Sulfate, P”P”-DDT, Lambda-Cyhalothrin, permethrin. α – BHC has the highest concentration in the fish species with a concentration of 3.853 mg/kg in fish Heterbranchus bidrosalis and the lowest organochlorine contaminant was P”P”-DDT which ranges from 0.056-0.0212 mg/kg in Mormyrus delicious. The Organochlorine concentration value of all the fish species was above the limit of Maximum Residue Limit (MRLs) and Dietary Intake (ADI) and these levels could harm the wildlife in the river. There is a need for enforcement of legislation on the use of insecticides by the farmers especially in surrounding of protected areas.

**WP102 Effects of Organophosphate Aquaculture Pesticide Azamethiphos on American Lobster (Homarus americanus) Larvae (Stage I, II, III)**  
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Both the American Lobster fishery and salmon aquaculture are important to the economy of Atlantic Canada. Where these industries operate in close proximity, research is needed to better understand any interactions and their possible effects. Lobster larvae, like other crustaceans, are known to be more susceptible to contaminants than adults. Laboratory exposures have revealed various pesticide effects on lobster larval survival, behaviour, development, and immunity. Salmoan(R) WP50 is a fully registered pesticide formulation used as a bath treatment to control sea lice (Lepeophtheirus salmonis or Caligus elongatus) in farmed Atlantic salmon (Salmo salar) in Atlantic Canada. The Salmoan(R) WP50 formulation is a wettable powder having 49.8% by weight of the organophosphate azamethiphos. This study explored the effects of Salmoan(R) WP50 on the survival and development of planktonic early life stages of American lobsters, Homarus americanus. Individual lobsters of Stages I, II, and III, were exposed for 3 hours to a water-borne concentration of Salmoan(R) WP50 at six nominal target concentrations; 0, 0.5, 1.6, 5, 16, and 50 µg azamethiphos/L (n = 30 individuals per treatment), which are reflective of concentrations observed following application and dispersion. Treatment-related effects were observed, with higher concentrations causing increased mortality and decreased moulting success. Significant effects on immobilization were observed after 3 hours of exposure to concentrations as low as 2.8 µg L⁻¹ azamethiphos. Acetylcholinesterase (AChE) response proved consistent across stages in terms of acting as a biomarker for exposure. Decreasing AChE activity was significantly correlated with increased immobilization and mortality, and activities below 1.1 (2.4, standard error), 1.2 (7.3, standard error), and 22.9 (7.4, standard error) nmol/min mg for Stage I, II, and III respectively, may indicate significant immobilization and predict future mortality of those stages. The temporal and geographical overlap of larval lobster life stages and the use of Salmoan(R) WP50 is important to consider when assessing potential risk.

**WP103 Effects of pesticides on aquatic and soil non-target organisms on different levels of biological organization - a project introduction**  
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During the last years a vast decline in species diversity has been observed not only in Germany but worldwide. This decrease is often linked to the usage of pesticides. A lack of biodiversity can have adverse effects not only on food chains and whole ecosystems but indirectly also ecosystem services. As pesticides eventually reach various environmental compartments, they present a problem for both soil and aquatic ecosystems. The current regulations only include standardized toxicity testing of the active substances, so important data is missing on the different modes of action and possibly varying toxicity of commercial formulations. To assess the possible impacts on the environment it is therefore helpful to extend the available data for pesticides already in use. To this end, it is also necessary to improve existing and develop new methods for assessing the effects of these substances on different levels of biological organization. Methods for the investigation of effects and toxicity mechanisms however often require high numbers of laboratory animals. A thorough investigation of pesticide effects using improved methods should therefore try to keep the number of used laboratory animals as low as possible. The application of early warning signals (biomarkers) can be of an advantage. However, they do not always conclude possible effects on whole populations. Consequently, a comprehensive test battery should investigate different levels of biological organization. This project will try to further develop a multi-species and multi-biomarker strategy to investigate the effects of the herbicides dimethenamid-P and prosulfocarb as well as the insecticides thiacloprid and esfenvalerate. Besides conventional enzymatic endpoints novel non-invasive, fluorescence-based assays will be applied. Both soil (Eisenia fetida) and aquatic model organisms (Daphnia magna) will be used for the experiments in this study, including study of behavioral changes as a sensitive, low-dose effect. This project is funded by the Deutsche Bundesstiftung Umwelt DBU (German Federal Environmental Foundation).

**WP104 The effect of Triphenyltin on zebrafish larvae as a non-target organism model**  
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Triphenyltin (TPhT [(C₆H₅)₃Sn-X]) has been widely used in many countries as an agricultural fungicide for the control of fungus diseases and
bliet on several crops. Also, this compound has also been worldwide used as molluscicides to control snails in rice crops. Unfortunately, this procedure on a large scale is dangerous considering its environmental effects such as the toxicity to non-target organisms. The toxic effects of this compound to aquatic life have been reported; however, when fish are considered, those results were obtained based on toxicity tests conducted with more resistant stages like juveniles or adults. Based on that, acute lethal fish toxicity tests were carried out using Danio rerioembryos and larvae as the test-organisms. Embryos were exposed from 90 minutes post-fertilization to 96 hours post-fertilization. Acute toxicity test using the larval stage was conducted for 48h using zebrafish between 6 and 14 days old. The commercial product Mertin 400, a suspension containing 400 g/L 1 TPhT hydroxide was used and experiments are still being carried out in order to achieve a statistic robust analysis. The present study highlights the necessity of using the most sensitive developmental stage when considering standard methods to evaluate the effects of substances representing non-target species.

WP105 Assessing interspecific variation in earthworm pesticide toxicokinetics

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Widespread interspecific variation is seen in the sensitivity of soil invertebrates to chemical pollutants (e.g. pesticides). Since chemical risk assessments are performed on the basis of tests in a small number of reference species there is a danger of significantly underestimating the effect a toxicant may have in the environment. Differences in toxicity may be caused either by toxicokinetic (TK) or toxicodynamic (TD) factors. By combining TK and TD parameters a robust predictive tool may be developed to identify chemicals or organisms that pose particular risks. In this study we assess the sensitivity of 5 earthworm species to different organic toxicants of increasingly complex modes of action. Sensitivity was measured using toxicity tests carried out over 4 weeks at 7 concentrations of fluoranthene, chlorpyrifos, cypermethrin and imidacloprid, measuring both survival and reproduction (cocoon production rate). For chemicals showing the greatest inter-species variation in sensitivity, the TK parameters (uptake rate K₁ and elimination rate K₂) were calculated by exposing individuals to 14C labelled chemicals and analysed using a liquid scintillation counter. Tissue specific concentrations differed significantly between species, even when overall body levels were similar. Differences in TD parameters were addressed by assessing target receptor diversity and expression levels for key tissues. Important differences in tissue specific expression and ligand specificity were observed which may drive variation in sensitivity. In particular, non-target binding effects were found to greatly influence susceptibility to insecticides. Overall, greater ranges in sensitivity were found for chemicals that have a specific biological target than for toxicants that have a non-specific mode of action, such as non-polar narcosis. This suggests significant potential for variation between species when the nature of the mechanism of action is complex, with the majority of effects being driven by differences in TD parameters rather than TK.

WP106 Effects of Cyprosulfamide, Mefenpyr diethyl and their Primary Herbicides on Survival, Growth and Reproduction of Daphnia Magna

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Safeners are becoming an important class of chemicals because they prevent or reduce injury caused by herbicides used to selectively remove weeds from crops. These safeners can find their way into aquatic environments, where they may cause adverse effects on aquatic species. This work examined the effects of cyprosulfamide and mefenpyr diethyl on the freshwater invertebrate Daphnia Magna, in both acute and chronic studies. The acute studies were designed using seven concentrations ranging from 0.01-100 mg/L. The results from the acute exposure (48 hrs) using cyprosulfamide and mefenpyr diethyl (separate exposures) showed no lethal effects at concentrations up to 100 mg/L, suggesting that these chemicals are unlikely to elicit acute effects in aquatic invertebrates at environmentally relevant concentrations. Chronic exposures for both chemicals at 1, 10 and 50mg/L over 21 days were conducted to assess growth and reproduction endpoints. Additional experiments are ongoing to test the mixture toxicity of cyprosulfamide and mefenpyr diethyl in combination with their primary herbicides (Isoxaflutole and fenoxaprop-p-ethyl respectively). This work represents an important preliminary assessment of the toxicity of herbicide safeners.

WP107 Fate, Mobility, and Behaviour of Five Herbicide Safeners in Aquatic, Sediment, and Soil Environments

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Herbicide safeners work against the injurious effects of many herbicides to protect the crop plant. Safeners are applied in large volumes in commercial formulations, however, their fate and behaviour in soil and aquatic environments are poorly understood. In this work, the direct and indirect photolytic behaviour of five safeners (cyprosulfamide, mefenpyr diethyl, dichlormid, benoxacor, furilazole) will be investigated under natural sunlight. Photolysis rate constants and quantum yields were determined and photodegradation products were identified using Orbitrap ultra-high-resolution mass spectrometry. Soil sorption experiments were conducted to estimate the distribution coefficient (Kd) and organic carbon normalized distribution coefficient (Koc). The data were fitted to Freundlich and Langmuir sorption isotherms. Several different soil properties were assessed including organic carbon content, cation exchange capacity, pH, and clay content. This work provides important physio-chemical properties of these safener chemicals that will be important to understand their fate and behaviour in the environment and facilitate appropriate exposure and risk assessment of these poorly understood chemicals.

WP108 Application of nanotechnology towards improving efficiency in application of fungicides

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Copper is one of the most widely used antifungal agents in organic farming worldwide. In cocoa farming in Ghana, copper-based fungicides are the predominant chemicals approved for the control of black pod disease, a devastating fungal disease caused by Phytophthora palmivora and Phytophthora megakarya. However, the excessive usage coupled with the non-biodegradable nature of copper is a major cause for environmental concern. This study explored the use of a simple, cost effective and green approach in synthesising and applying nano-copper as an improved alternative to conventional copper fungicides. The nanoparticles take advantage of their smaller sizes, increased surface area, and higher surface-to-volume ratio thereby improving activity, efficiency and toxicity to target pest. Copper nanoparticles were synthesized using extracts of diverse local plant materials with known fungal activity, to explore possible synergies. Synthesized nanoparticles were characterised using UV-Visiblespectroscopy, x-ray diffraction spectroscopy and scanning electron microscopy. Microbial studies showed a clear correlation between size and morphology on the one hand and antifungal activity under laboratory conditions. The findings show huge promise in the use of these materials towards improving the efficiency of fungicide application.
WP109 Modeling Vapor Drift Potential of Dicamba Herbicide
S. Das, University of Otago / Chemistry; K.J. Hageman, Utah State University / Chemistry & Biochemistry

Dicamba, (3, 6-dichloro-2-methoxybenzoic acid) is a synthetic systemic herbicide, widely used around the world because of its versatility in noxious and invasive weed control. It is considered only mildly to moderately toxic to mammals, pollinators, wildlife, and aquatic organisms; however, due to its tendency to volatilize, it can undergo vapor drift and deposit on non-target fields. This can cause injury to nearby sensitive plants, ultimately resulting in crop damage and yield loss. For instance, dicamba alone has damaged about 3.6 million acres of off-target crops in the United States in 2017 cropping season. While only a handful of field studies were conducted to chemically measure dicamba volatility, no quantitative prediction is available in the form of modeling to identify the factors that trigger the volatilization of dicamba. To better understand dicamba volatilization and vapor drift potential under field conditions, we have used a visual screening tool, developed by our research group to predict the volatilization and vapor drift potential of dicamba herbicide from an agricultural field. The screening tool uses the environmentally relevant partition coefficients and the mass-balance distribution of pesticides between soil, plant, air, and water to calculate 24-h cumulative volatilization losses. Different environmentally relevant conditions were analyzed to identify the conditions under which the greatest dicamba volatilization occurs. We have found that, at least ~20% of applied dicamba will volatilize within 24 hours of spraying if the ambient air temperature remains at 30 °C and more importantly, current recommended wind speed (1.3 - 4.5 m/s) for dicamba application can cause more than 10% cumulative dicamba loss within 24 hours of application, which suggest more careful investigation of wind speed effects to control dicamba volatilization and off-target injury. However, minor/no visible effect was observed with changing soil physicochemical properties. Measured losses of dicamba under field conditions were also compared with the modeled predictions. This modeling approach could be used to aid future decision-making regarding dicamba herbicide regulation and use in the agriculture sector.

What’s Next? Future Contamination Challenges for Water Resources and Identifying Novel Tools to Solve Them
WP111 The Future is Now: How Current Research on Contaminants of Emerging Concern Can Inform Management of Water Resources

Population growth, aquifer depletion, infrastructure failure, saltwater intrusion, floods, and drought: these are just a few of the environmental drivers which currently affect the quantity and quality of water available for human and ecosystem use. Such effects are projected to exacerbate future water crises. It is unlikely that the amount of potable water will be more than we currently have. What can we, as scientists and stewards of the future, do now to mitigate the impacts of these environmental conditions? This presentation is designed to be the introduction to the Wave session “What’s Next? Future Contamination Challenges for Water Resources and Identifying Novel Tools to Solve Them.” The goal of the session is to encourage a high-level interdisciplinary discussion. This presentation is an outgrowth of a paper commissioned by the American Geophysical Union for its Centennial collection on Grand Challenges in the Earth and Space Sciences. It will be tailored, based on the other submissions to the session, to set the groundwork for the discussion within the session.

WP112 Drugs of Abuse and Illicit Drugs: An Environmental Analytical Method for Detection and Quantitation

A critical North American public health issue is the opioid epidemic. Beyond the direct human impact, there is concern that widespread use of opioids, drugs of abuse, and other illicit drugs could adversely impact ecosystem health and increase secondary human exposure. These drugs and their metabolites can pass through wastewater treatment plants and enter surface waters. The psychoactive properties for some drugs are a concern for ecosystem health, with oxycodone and cocaine recently detected in mussels and shrimp, respectively. There is a need for analytical methods to understand and characterize the occurrence, distribution, and fate of these drugs in the environment. To this end, an ultra-high performance liquid chromatography mass spectrometry (UHPLC-MS) method was developed for pain management drugs, depressants, stimulants, and hallucinogens (including amphetamines, barbiturates, benzodiazepines, cannabinoids, and opioids) as well as some common metabolites of these drugs. The method was validated in surface water, wastewater effluent, and bed-sediment. This low part-per-billion to part-per-trillion detection method will provide further understanding about the variety, concentration, and potential exposure pathways of these drugs, and represents a valuable tool to assess risk to water quality, ecosystem health, and human exposure. In the future this method will be expanded to analyze for these drugs in biosolids and aquatic insects.
WP114 Development of a direct injection LC-MS/MS method for the detection of glyphosate and aminomethylphosphonic acid (AMPA) in Sri Lankan well water

J. Ulrich, Duke University / Civil and Environmental Engineering; N. Jayasundara, University of Maine / School of Marine Sciences; L. Ferguson, Duke University / Civil and Environmental Engineering

The global burden of disease due to unsafe drinking water is large and disproportionately impacts the developing world. In recent years, persistent water-borne diseases in these countries, potentially intensified by the presence of emerging contaminants, have become an increasing issue. Within Sri Lanka, rural areas have recently been experiencing an epidemic of chronic kidney disease of unknown etiology (CKDu) that appears to be linked to drinking wells with considerably hard water. It has been hypothesized that the pesticide glyphosate is a driver in kidney toxicity within this region due to the long half-life of glyphosate in hard water (~7-22 years) and its ability to form metal complexes with nephrotoxic metals in the environment. Due to the zwitterionic characteristic of the pesticide, typical analytical methods for the detection of pesticides are incompatible. Here we present a novel LC-MS/MS direct injection method for the detection of glyphosate and its main degradation product AMPA within groundwater and surface water. The method uses reversed-phase and weak anion-exchange mixed mode column chromatography to analyze both glyphosate and AMPA. Mixed-mode chromatography is successful in retaining glyphosate (and other negatively charged polar compounds) for enhanced identification and quantification using mass spectrometry, which overcomes the challenges of the zwitterionic characteristics of both glyphosate and AMPA. Detection is performed using a high-performance, ion-funnel equipped triple quadrupole mass spectrometer. Due to the high-performance of the mass spectrometer, we estimate our detection limits for glyphosate and AMPA to be between 1-3 ppb and our limits of quantitation to be between 5-10 ppb. This work is one of the first studies to utilize a direct injection LC-MS/MS method to analyze glyphosate and AMPA in water. In addition, the application of the method to analyze these important pesticides in drinking water sources within the developing world is novel. Our results will help to further understand the persistence and origins of CKDu in Sri Lanka while advancing toxicology research in this region of the developing world.

WP115 Risks Assessment of Typical Emerging Contaminants and their Byproducts during the Photochemical Transformation in Water

Y. Gao, Institute Environmental Health & Pollution Control; G. Li, Guangdong University of Technology / School of Environmental Science and Engineering; T-Au, Guangdong University of Technology / Institute of Environmental Health and Pollution Control

Emerging contaminants such as fragrance synthetic musks and bactericides have attracted attention worldwide recently, due to the widespread occurrence and potential toxicities. Given their extensive use, emerging contaminants have caused a widespread contamination in water environment. Especially they may photo-chemically transform into other products. Accordingly, the aquatic ecosystems and human health are exposed to an unknown cocktail of these pollutants as well as their degradation products. Therefore, it is of great concern to unmask the transformation mechanisms, kinetics, as well as the potential toxicity of these photochemical products. This study will focus on the two different categories of typical emerging contaminants, synthetic musks including poly cyclic musk (tonalide) and nitro musk (musk xylene) and bactericide parabens. The direct and indirect photo-chemical transformation processes were modeled using both experimental and high-accuracy molecular orbital theory calculations. Results show that the OH-indicated indirect photochemical transformation of musk xylene occur mainly via H-abstraction pathways from its methyl group, while tonalide and parabens mainly via both +OH-addition and H-abstraction pathways. Furthermore, in assessing eco-toxicity and human health of these products, several products were found to be more bioaccumulative and harmful to organisms. The obtained results will provide the helpful information for environmental protection and will help design further experimental studies.

WP116 USEPA CompTox Chemicals Dashboard as a web-based data resource to help identify contaminants in water

A.J. Williams, US Environmental Protection Agency / National Center for Computational Toxicology; J.R. Sobus, E.M. Ulrich, US Environmental Protection Agency / Office of Research and Development National Exposure Research Laboratory

Non-targeted screening, targeted screening and suspect screening, as well as “Known Unknowns” and “Unknown Unknowns” are now common terms in the field of water analysis. While mass spectrometry data processing can be highly automated, the identification of chemicals from the resulting extracted masses, formulae or fragmentation patterns utilizes reference spectral libraries or ranking of tentative candidate lists from large structure libraries. The USEPA CompTox Chemicals Dashboard provides access to data for ~875,000 substances, searchable by mass and formula and then ranked using associated meta-data. Cheminformatics approaches are also utilized to provide mapped relationships between individual substances and their “MS-Ready” (desalted, non-stereospecific) forms. This presentation will review how the freely available Dashboard application can be utilized to support structure identification using mass spectrometry and our efforts to enhance the application using computational spectral fragmentation and access to predicted data such as relative retention time index values and computed collision cross section values to support ion mobility spectrometry. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

WP117 Impact of extreme weather events on organic pollutant occurrence in surface waters: Hurricane Florence in North Carolina

L. Ferguson, A. Joyce, G.J. Getzinger, Duke University / Civil and Environmental Engineering

Hurricane Florence made landfall in North Carolina on September 14, 2018 and moved across the state until September 17, drenching the eastern half of NC with rain and causing massive flooding in the Cape Fear and Neuse river basins. Because of unprecedented inundation of agricultural, residential, and industrial areas with floodwaters and widespread failure of storm and sanitary sewer systems during the storm, it was deemed likely that the storm could lead to large-scale releases of organic pollutants into rivers and their associated floodwaters. We have addressed this concern by conducting water sampling along longitudinal transects in the Neuse, Trent, and Cape Fear rivers within Eastern NC during the height of flooding (9/19/18) and after subsidence of floodwaters (10/10/19) for analysis of a broad suite of organic pollutants. Water samples were analyzed using UHPLC with ultra-high resolution tandem mass spectrometry (Orbitrap Fusion Lumos, ThermoFisher Scientific) and non-targeted compound identification was conducted using a harmonized data processing workflow including mass spectral feature consolidation, aggregated spectral library searching, computational mass spectrometry-based structure annotation, occurrence/use metadata integration, and probability-based annotation validation. Results show evidence for point-sources of untreated wastewater in river samples collected downstream of several wastewater treatment plants that experienced failure or overflow conditions during the storm, as evidenced by elevated signals for sucralose and polyethoxylated surfactants. Signals for several polyfluorinated alkyl substances (PFAS) were elevated in the Cape Fear and Neuse rivers during storm conditions, suggesting the presence of specific sources for these compounds associated with storm flooding. Most conventional stormwater tracers and agrochemicals were observed at lower signal intensity in floodwater-impacted samples than samples from normal flow conditions in the rivers studied here, indicating significant dilution due to the large volumes of water associated with the Hurricane impacts. Overall, our
results show that floodwaters associated with extreme storm events have unique organic pollutant signatures, consistent with point- and diffuse sources of contaminants due to inundation.

**WP118 Unleash the Data: Integrating high resolution MS and bioassays to better identify the causes of toxicity to human and environmental health**


A theme of current environmental research is to develop tools that correlate and identify responses to toxicants in water resources, to the identity the causes, individually or in mixtures, of that observed toxicity. One important constraint is the limited number of chemicals that can be identified and quantified in environmental samples due to limitations in analytical techniques and unavailability of authentic standards needed to verify identities and concentrations of any toxicants. For organic contaminants, recent advances in high-resolution mass spectrometry have permitted identification of thousands of unique molecular entities in environmental samples, each of which may contribute to any toxicity measured for that sample. These nontarget screening or analysis (NTA) approaches have become singularly important techniques in environmental analytical chemistry. Data analysis tools that systematically and iteratively sort these molecular entities to standardized levels-of-confidence result in prioritized sets of known, suspect, or unknown contaminants that may contribute to observed toxicity. Parallel developments of in vitro and low complexity in vivo effects-based assays (bioassays), provide a similar non-targeted screening approach for organic contaminants in water samples. Bioassays measure cumulative toxicity responses from environmental mixture exposures. For both NTA and bioassays, interpretative sophistication is required to understand the effects of multiple contaminants or multiple toxic responses present in environmental samples. Integrating these two data-rich streams of chemical and biological information to extract meaningful knowledge (with tools such as iceber modeling, mass balance) is an area of focused research effort with the potential to yield significant advances in our understanding of the sources of aquatic toxicity that could have adverse effects upon human and ecosystem health. This presentation examines recent developments in NTA analysis and toxicity screening and the potential for integration of these data streams to advance our understanding of the sources of toxicity and to characterize that toxicity. We discuss the challenges to comprehensively assess the sources and mechanisms of toxicity in water, soil, tissue, and sediment and the implications these challenges pose for improving human and ecosystem health.

**The Impacts of High Resolution Mass Spectrometry on Analytical Chemistry**

**WP119 Accurate PAH Analysis using Gas Chromatography coupled to High Resolution Quadrupole Time-of-flight Mass Spectrometry (GC-QTOF-MS)**

_C. Yang, Environment and Climate Change Canada; C. Brown, Environment and Climate Change Canada / Pacific and Yukon Laboratory for Environmental Testing_

Polycyclic aromatic hydrocarbons (PAHs) and their alkyl-substituted homologues (APAHs) generally occur in crude oil and are widely found in environment. Their accurate identification and quantitation are critical to reliable toxicity assessment and damage evaluation of oil pollution to the environment. At present, identification and characterization of these petroleum compounds mainly rely on gas chromatography coupled to a single quadrupole mass spectrometer (GC-MS) in selected ion monitoring mode. Analyses using low resolution mass spectrometry (LRMS) can be severely interfered with by other co-eluted material even though with proper sample preparation and chromatographic separation, potentially resulting in misidentification and overestimation of target analytes. This is especially true when PAHs occur only in trace amounts or in chemically complex environmental samples, where their chemical fingerprints which are usually relied upon for the identification of target compounds have been significantly altered. Capillary gas chromatography coupled to a quadrupole time-of-flight mass spectrometer (GC-QTOF-MS) delivers faster full spectrum, acquiring higher resolution, and a more accurate mass measurement than a single quadrupole MS. QTOF-MS increases the detection selectivity by using exact monoisotopic mass, eliminating or reducing interferences both internally from petroleum content and sample matrix, and externally from the added quality control materials; thereby improving the confidence of identification and quantitation accuracy of analytes. This study compared GC-MS and GC-QTOF analyses of PAHs and their C1- to C4- alkylated homologues in a number of crude oils, refined products and petroleum-impacted environmental samples. Quantitation disparities were found for various PAHs analyzed by LRMS (unit mass +/- 0.5 u) and HRMS (exact monoisotopic mass +/- 10 ppm). Results of PAHs with high abundance in samples, particularly naphthalene and phenanthrene series, are generally very comparable by using the two different instruments, while significant difference was obtained for the analyses of pyrenes and polycyclic aromatic sulfur heterocycles (PASHs). For instance, the concentration of dibenzothiophene and benzo-naphthothiophenes determined in 20 samples by GC-QTOF are averagely 87.1 +/- 1.8% and 92.9 +/- 1.5 % of those by GC-MS, respectively.

**WP120 Analysis of Short Chain Chlorinated Paraffins (SCCPs) using negative chemical ionization (CI) and low energy EI by high-resolution GC/MS**


Short Chain Chlorinated Paraffins (SCCPs) are bioaccumulative and persistent in the environment and are commonly used as flame retardants in plastics and other materials, as well as in few other applications such as metal processing. Analysis of these compounds represents substantial challenge due to their self-interference as well as an interference with other components of complex industrial matrices. Thus, the analytical technique not only have to be sensitive but also very selective, this is where high-resolution MS can be very attractive, especially when combined with negative CI and low energy EI. Here, we demonstrate the performance of high-resolution GC/Q-TOF for SCCP analysis in complex SCCP mixtures. The pure congener standards as well as standard SCCP mixtures were analyzed using a high-resolution GC/Q-TOF system. The data were acquired in both negative CI (using methane as a reagent gas) as well as low energy EI. NCI fragmentation patterns of SCCPs were evaluated for comparison with established methods using pure congeners standards. When methane was used as a reagent gas, NCI spectra of SCCPs exhibited minor fragmentation. In most cases M- and (M-HCl)- were predominant ions with some contribution of (M-H)- and (M-CI)-. No significant fragmentation of the carbon backbone was observed. Low energy EI data indicated higher degree of fragmentation of the SCCPs as compared to negative CI. However, using this technique allowed to detect the SCCP species with low CI content (such as C10C4).

**WP121 Approaches to the Interrogation of Non-targeted Sample Data Acquired by High Resolution Accurate Mass (HRAM) mass spectrometry**

_A. Vien, J. E. Doig, University of Saskatchewan / Toxicology Centre; J. Giesy, University of Saskatchewan / Department of Veterinary and Biomedical Sciences; P. D. Jones, University of Saskatchewan / School of Environment and Sustainability and Toxicology Centre_

Increasingly, High Resolution Accurate Mass (HRAM-MS) mass spectrometry is being used in the analysis of complex chemical mixtures. The ability of HRAM-MS to potentially resolve all compound masses even in the most complex mixtures suggests the possibility of using untargeted approaches to collect all chemical information from a sample and
then apply post hoc chemometric techniques to scrutinize samples for compounds of interest. This paper addresses the challenges in the development of chemometric approaches to perform data analysis on non-target mass spectra of water and sediment samples. Water samples and sediment TOC samples were diluted to 30% MeOH and 0.1% formic acid and were then analyzed by direct infusion into the ESI source of an Orbitrap mass spectrometer running at a nominal resolution of 240,000 at 200 m/z. Spectra were acquired at approximately 2 Hz and around 1000 spectra were averaged to provide a single mass spectrum for each sample. In water and sediment samples approximately 5,000-1,0000 individual ‘features’ can be identified in the mass range 80 - 1200 m/z with fewer than 5% of these peaks represented by overlapping peaks as determined from expected peak widths. We have investigated both ‘top down’ methods to identify all features and targeted interrogation of the mass spectra for various algal pigments and metabolites. Pigments such as aphanizophyll, zeaxanthin and echinenone were commonly detected in sediment core sections from a small lake while secondary metabolites such as microcystins and saxitoxin were comparatively rare. Together these approaches suggest the feasibility of collecting and screening water and sediment DOC samples for ‘chemical features’ and then archiving those data in silico for subsequent interrogation.

WP122 Are there any other non-classic PFASs binding to FABP?

D. Yang, University of Toronto / School of the Environment; J. Sun, H. Peng, University of Toronto / Department of Chemistry

Per- and polyfluoroalkyl substances (PFASs) are great concern due to their persistence, bioaccumulation and toxicities. Fatty acid bind protein (FABP) has been reported as one of the major factors to determine toxicokinetics of PFASs. But the potential role of FABP has been only characterized for several classic perfluorinated acids such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), while there are hundreds of PFASs and their precursor compounds reported in the environment by non-targeted analysis. In this study, we aim to determine the potential PFASs binding to FABP in a global level, by integrating biochemistry and non-targeted analysis methods. Firstly, human liver FABP protein was expressed and purified from E. coli, the binding affinities of 74 structural diverse PFASs with FABP was determined by competitive fluorescence method. A quantitative structure-activity relationship (QSAR) was established by integrating molecule descriptors and functional groups. Secondly, the potential PFASs binding to FABP from technical products containing hundreds of uncharacterized PFASs was investigated. The technical products were incubated with recombinant FABP protein, and then the PFASs bound to FABP were identified by Affinity Pull-down combined with untargeted analysis. The bound ligands were dissociated by methanol and analyzed by Q-Exactive High Resolution Mass Spectrometer. The global interaction spectrum between PFASs and FABP will provide an important basis to understand the bioaccumulation and toxicities of non-classic PFASs.

WP123 Are We Doing Non-Targeted Analysis Right? A Progress Report from the Benchmarking and Publications for Non-Targeted Analysis Working Group

E.M. Ulrich, US Environmental Protection Agency / Office of Research and Development / National Exposure Research Laboratory; B. Place, National Institute of Standards and Technology / Chemical Sciences Division

The broad availability of high-resolution mass spectrometers has made their use more common for environmental and other applications, particularly for suspect screening and non-targeted analysis (NTA). While fields like metabolomics have developed mature methodologies and quality control practices, NTA of the exposome is still experiencing a steep learning curve and growing pains. The current state of NTA has been described as “the wild west,” where each research group approaches the technique in their own way, with little overlap, consistency, or harmonization. The EPA’s Non-Targeted Analysis Collaborative Trial (ENTACT) used ten mixtures of 1,269 unique and known substances to look at the state of the science, provide insight into the chemical space coverage, and identify potential benchmark methods and approaches for NTA. Approximately 30 laboratories participated in ENTACT and each used their own methods and approaches not only to analyze the samples, but to interpret the results and their performance. Many ENTACT participants described their experience with the mixture samples at an EPA-hosted workshop in 2018, which included discussions amongst the attendees. One of those discussions resulted in the formation of a working group called “Benchmarks and Publications for Non-Targeted Analysis” or BP4NTA. The group has the ultimate goal of publishing a white paper describing terms, definitions, recommendations, and best practices surrounding NTA studies. Topics of particular importance and relevance within this white paper will include recommendations on how to characterize an NTA method’s performance and minimum reporting information should be published for transparency and reproducibility. This presentation will provide an update on the progress of the BP4NTA group, as well as some of the “sticking” points surrounding these issues. The use of NTA data for regulatory purposes requires that practitioners use sound, defensible, and commonly accepted techniques for data collection, analysis, and reporting. Therefore, BP4NTA and other groups like it in related fields are critical for coming to a scientific-community consensus to make an impact on environmental and health policies.

WP124 Bioaccumulation and biotransformation products of pharmaceuticals in Oryzias latipes

H. Cha, Changwon National University / Department of Eco-friendly Offshore Plant FEED Engineering; J. Jeon, Changwon National University

So far, studies on pharmaceuticals in the aquatic environment have focused on their occurrences in water system. These substances are threatening to aquatic organisms because of the continuous existence in water. Under this circumstance, the bioaccumulation of pharmaceuticals and the identification of metabolites in organisms can be evidence for the exposure to those substances. This study was aimed to identify metabolites of the four selected pharmaceuticals, atenolol (ATN), carbamazepine (CMZ), metoprolol (MTP) and venlafaxine (VFX) in Japanese medaka (Oryzias latipes). The in vivo exposure test was performed during 4 days to allow the formation of metabolites following bioaccumulation process. We collected exposure media samples and whole body tissue of fish at the beginning and every 48 hours until the end of the experiment. Each samples were pretreated and analyzed using LC-ESI-Orbitrap (Q Exactive plus) by target/suspect screening methods. As a result, four test compounds were quantitatively detected via target screening. The estimated bioaccumulation factor (BAF) was 0.2 for ATN, 3.6 for CMZ, 0.5 for MTP and 0.2 for VFX. Meanwhile nine metabolites were tentatively identified by suspect screening as follows: atenolol acid from ATN, carbamazepine 10,11-epoxide and iminostilbene from CMZ, α-hydroxymetoprolol, metoprolol acid and O-demethylmetoprolol from MTP, O-desmethylvenlafaxine, VLF280 and VLF 294 from venlafaxine. Among them, four metabolites (atenolol acid, carbamazepine 10,11-epoxide, metoprolol acid and O-demethylvenlafaxine) were confirmed with reference standards, while the others (iminostilbene, α-hydroxymetoprolol, O-desmethylmetoprolol, VLF280 and VLF294) were tentatively identified with MS2 library matching with mzCloud and MetFrag. The findings on formed metabolites provide information on bioaccumulation and major metabolic pathways for emerging pharmaceuticals which are often occurring in domestic river waters.

WP125 Comparison of Targeted and Non-targeted Analysis of Surface Waters from a Nationwide Survey of the United States

D. Tush, M. Meyer, R. Lane, US Geological Survey / Organic Geochemistry Research Laboratory

Surface waters are complex mixtures that contain innumerable chemical compounds from natural sources, anthropogenic sources, and degradation/transformation products from biotic and abiotic processes. Determining specific compounds or groups of compounds which produce
deleterious effects on water quality and environmental health is problematic. Even large-scale studies using a wide variety of targeted methods only measure a small fraction of the compounds in a sample. High-resolution mass spectrometry is a platform for non-targeted analysis in an effort to characterize complex mixtures but transforming the resulting data into useful information is a challenge. Samples were obtained from a range of urban and agriculturally impacted sites across the U.S. A method which included solid phase extraction, ultra-high-performance liquid chromatography, and time-of-flight mass spectrometry was used to generate positive and negative ion data. This data, analyzed with a hierarchical processing scheme, was compared to an existing suite of targeted analysis data (719 organic analytes). The comparison of data from non-targeted analysis to the existing data from targeted analysis demonstrates that although targeted analysis does not capture as much of the complexity of the samples as the non-targeted analysis does there are correlations between the two types of data.

WP126 Measurement of retinoids in freshwater fish by liquid chromatography – mass spectrometry (LC-MS)
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Retinoids (vitamin A) are essential for numerous physiological processes including vision and reproduction. They are stored as biologically inactive retinyl esters that are metabolized to transcriptionally-active retinoid acids (RAs) according to physiological and nutritional requirements. Disruptions to the retinoid system have been observed in several species of fish upon exposure to various contaminant sources, including pulp mill effluent and mine tailings. Assessments of retinoid status typically only consider retinol and its esters, which are easily analyzed by ultraviolet (UV) spectrophotometry as it provides acceptable detection limits. UV detection lacks the specificity that mass analyzers can provide and thus requires expensive or unavailable standards for qualitative work. Additionally, RAs are thought to be present at the sub-pmol level in fish and require high sensitivity instrumentation to attempt quantitation. A streamlined extraction and analysis workflow was developed to measure multiple retinoids in fish to facilitate further research into retinoid biology. Retinoids were extracted from liver using solid phase extraction (SPE) to generate an acidic fraction containing RAs and a neutral fraction containing retinol and retinyl esters. Liquid chromatography coupled to triple-quadrupole and high-resolution quadrupole time-of-flight instrumentation were used to analyze the two fractions. This method was applied to samples from two Great Lakes Areas of Concern (AOCs) to evaluate efficacy for detecting differences in retinoid status between populations of fish. Significant differences in retinoid abundance and distribution were measured, with achieved limits of detection < 1 ng/mL. Commercially unavailable retinoids were also tentatively identified by their high-resolution mass spectra. These investigations advance retinoid biology by allowing for a greater range of compounds which can be analyzed without authentic standards, providing qualitative and quantitative data in a single high-throughput workflow.

WP127 Mercury Speciation by Automated Derivatization and Headspace Solid-Phase Microextraction Followed by Gas Chromatography Orbitrap Mass Spectrometry
B. Tendler, University of Saskatchewan / Toxicology Centre; J. Giesy, University of Saskatchewan / Department of Veterinary and Biomedical Sciences; P.D. Jones, University of Saskatchewan / School of Environment and Sustainability and Toxicology Centre

Mercury (Hg) concentrations in fish can be of significant concern for human consumers, with exposure to methylmercury causing the greatest concern. Mercury speciation has been well studied with methods utilizing varying preparation techniques and analytical instrumentation, though the use of modern ultra high-resolution mass spectrometers (MS) has not been studied as thoroughly. This research assesses the advantages of mercury analysis by modern ultra high-resolution MS with robotic derivatization, Solid-phase Microextraction (SPME) and injection into the Gas Chromatography and Orbitrap Mass Spectrometry (GC-Orbitrap MS) system. The method is based on previous derivatization with sodium tetratetraethylborate, Headspace SPME, and GCMS methods. The use of the GC Orbitrap MS allows for the scanning of a wide range of mass/charge (m/z) in each scan with ultra-high resolution (>200,000). This scan range and resolution allow quantification of the different Hg species, and for the complete Hg isotope profile in the derivatized methylmercury (MeHg) and inorganic Hg species, as well as the Hg isotopes in the fragments created by fragmentation in the ion source of the mass spectrometer. These isotopes and their patterns can be used to identify and confirm analytes of interest. The observed mercury isotope patterns from these analyses had near perfect alignment with the theoretical isotope patterns based on the known natural abundance of Hg isotopes. Muscle samples of fish collected from the Slave and Athabasca rivers were analyzed using this technique. The mean MeHg percentage was found to be 82.4% of Hg in goldeye, 90.2% in northern pike, 87.2% in walleye, 92.3% in whitefish, and 87.5% in burbot.

WP128 Non-Targeted Analysis of Chemicals in Indoor Consumer Products
S. Kutarna, University of Toronto; H. Peng, University of Toronto / Department of Chemistry

Humans spend 90% of their time indoors, and every day are exposed to a wide variety of compounds. For example, flame retardants have been detected in furniture, chlorinated paraffins in paint and wire coverings, and perfluoroalkyl substances in non-stick coatings. Building a knowledge base is made more difficult by the fact that companies are not required to report their reagents. This means that the vast majority of compounds in consumer products are unknown to the public and limited information is available for the sources of pollutant emissions to the indoor environment. The aim of this research is the non-targeted identification of chemicals in different indoor products to determine their potential pathways in indoor environments, with a focus on halogenated organic compounds (HOCs) such as brominated azo dyes and chlorinated paraffins. The categories of consumer products include children’s toys, electronics, clothing, and furniture, all of which have been shown to contain HOCs. A one-step automatic non-targeted analysis workflow was established from raw mass spectrometry files to final compound identifications. With this method, >1,500 chemicals in ~100 samples were identified in under 2 days. In particular, many previously undetected chlorinated compounds were identified in the indoor environment for the first time. The chemical database of indoor products we construct from this research will provide an important basis for future indoor chemical management.

WP129 Suspect and nontarget screening for polar organic pollutants in drinking water source using HILIC-LC-HRMS
P. Naree, Changwon National University / Environmental Engineering; J. Jeon, Changwon National University

River water, used as a drinking water source in Korea, has been contaminated with numerous organic substances mainly discharged from waste water treatment plants. Among them, highly hydrophobic substances are of concerns because of the low elimination rate in water purification processes. The poor elimination may result in the high concentration of pollutants in drinking tap water. The present study was aimed to identify major hydrophobic substances present in drinking water source and to monitor their fates in purified water. Water samples were pretreated with SPE materials specified for hydrophobic and ionized substances. The extracted substances were then separated with hydrophilic interaction liquid chromatography (HILIC) before injection to HRMS(QExact) for suspect and non-target screening. Suspect list was filled with hydrophilic contaminants (log Kow < 3.5) which have been frequently reported as 134 aqueous pollutants in Korean surface waters, top waters and effluents. Among 27 suspected compounds were tentatively identified with MS/
MS library. After purchasing reference standards, 9 pollutants were confirmed (atenolol, atenolol acid, benzotriazole, caffeine, carbendazim, flucnazole, metformin, sulphride and tramadol). The nontarget screening enabled tentative identification without reference standards for unexpected compounds like surfactants (e.g., C12-LAS, dodocyl benzene sulfonic acid and xylene sulfonate), amine-based industrial chemicals (e.g., trisopropylamine and triethanolamine) and PFBS. Moreover, 5-methylbenzotriazole, melamine and telmisartan were confirmed for with reference standards. In view of these results, the suspect/nontarget strategies based on HILIC-LC-HRMS applied provide additional evidence for identifying unexpected compounds, which may affect drinking water. In future studies, since some tentatively identified pollutants were left unconfirmed, this compound should be updated additional confirmations. In future studies, since some tentatively identified pollutants were left unconfirmed, this compound should be updated additional confirmations.

**WP130 The Impact of Ultra-high Resolution Mass Spectrometry on Environmental Chemistry**

P.D. Jones, University of Saskatchewan / School of Environment and Sustainability and Toxicology Centre; J. Giesy, University of Saskatchewan / Department of Veterinary and Biomedical Sciences

The recent development of new mass spectrometry technologies and instrumentation has increased the amount and quality of analytical information that can be obtained from samples. In particular, dramatic increases in mass resolution have made possible unequivocal identification of contaminants even in complex mixtures and matrices. The development of Ultra-High Resolution Mass Spectrometry (UHRMS) has made available previously unprecedented levels of mass resolution and mass accuracy in timeframes compatible with typical chromatography systems. In addition to high mass resolution and accuracy 'image current' detection systems provide full mass spectral data for each scan. When coupled to liquid chromatography systems we have used these capabilities to investigate the occurrence of various halogenated disinfection by-products (DBPs) as well as naturally occurring organohalogen compounds. The recent release of a GC/UHRMS systems brings levels of mass resolution not previously available for the analysis of environmental contaminants by GC chromatography. Here we report the use of GC-UHRMS for identification and quantification of PCDD/Fs and PCBs. The methods developed are based on standard USEPA methods (Methods 1613 and 1668) but are enhanced by use of the new capabilities provided by image current detection and high mass resolution (> 100,000 FWHM). Together these studies demonstrate the unprecedented depth of data now available from UHRMS systems. The ability of some systems to collect UHRMS and MS/MS data simultaneously demonstrates capabilities far beyond those of 'classical' analytical systems. Furthermore, these UHRMS systems are available in robust and stable systems capable of 'routine' analysis suggesting that in years to come UHRMS instruments may replace current instrumental systems used for these analyses. The availability of this additional data raises questions about the relevance of current QA/QC criteria developed on earlier MS systems and suggests that the time is right to evaluate what, if any, additional criteria we might develop to support current analytical determinations.

**Plastic Pollution Research and Solutions**

**WP131 Twitter Reveals Global Conversation Around Plastic Pollution**

H.R. Hapich, W. Cowger, A.B. Gray, University of California, Riverside / Environmental Science

Plastic pollution is taking an increasingly large toll on our natural environment. There is currently speculation about how people perceive the problem of plastic pollution, but little quantitative evidence. In this study, we used English and Spanish data extracted from Twitter over a 3 month period to investigate the public discussion about plastic pollution. As a hub for scientific conversations as well as one of the most widely used social media platforms, Twitter provides an abundance of data from a wide variety of user demographics. We first ask the question, does discussion of plastic pollution by individuals and stakeholders coincide with global hotspots of plastic pollution? Our results provide some of the first evidence for where discourse on plastic pollution is happening and which social groups are most involved (academics, government, non-profit). Within these groups we investigated plastic pollution messaging in terms of sentiment, sources of evidence used to support claims, and stated motives (e.g. awareness raising, discussing prevention, networking). We also investigated the common associations individuals make with plastic pollution by analyzing unique and linked words in Tweets. Our results provide a clearer picture of global concern surrounding plastic pollution and eliminate some of the ambiguity surrounding this discussion.

**WP133 Macroplastics in the environment**

K.J. Kulaeksi, Exponent / Ecological and Biological Sciences; S.B. Kane Driscoll, Exponent / EcoSciences; M.W. Kierski, Exponent / Ecological and Biological Services Practice; J.P. Sanders, Exponent / Ecological and Biological Sciences; W.L. Goodfellow, Exponent / Ecological and Biological Services Practice

Long thought desirable features, the durability and longevity of plastics are now often seen as problematic, as reports of plastics found impacting organisms in increasingly remote environments continue to emerge. Macroplastic debris can not only serve as a source for microplastics, as large items break down into smaller and smaller pieces, but can also be transported across environmental boundaries and interact with biotic and abiotic components of the environment as large items. We performed a state-of-the-science review on the sources, characterization, fate and transport, and effects of macroplastics in the environment. This presentation provides an overview of types of macroplastics, field and laboratory methods for their qualitative and quantitative analyses, relevant environmental transformation processes, ecological and human health exposures and effects, and research gaps. By understanding the range of environmental issues associated with macroplastic waste, we can develop better solutions targeted to each phase of its complete life cycle.

**WP134 Urban rivers as transporters and transformers of plastic pollution - Te wairere o te paratiki**

J.B. Gadd, NIWA / Department of Chemistry; A. Valois, L. Rauhina-August, NIWA; O. Pantos, ESR; S. Gaw, University of Canterbury / Chemistry

Plastics are significant pollutants in the NZ environment, as is increasingly observed around the world. We are studying plastic sources and transport in an urban-affected river, the Kaiwharawhara Stream, which discharges to Wellington Harbour, New Zealand. From the headwaters in a forested ecosanctuary, the stream becomes piped through an old landfill, then winds its way through residential suburbs to a commercial and industrial area near the mouth, receiving stormwater (largely untreated) throughout its journey. With the assistance of community groups, we are surveying the sources and types of macroplastics entering the stream via stormwater and direct littering through a mixture of catchpit inserts, end-of-pipe nets and stream surveys. We are quantifying microplastics discharged via stormwater and found at multiple locations in the stream and at the mouth. The goal is to quantify the discharge of plastic pollution from an urban stream into the harbour and ultimately the wider marine environment. A workflow led by and conducted by mana whenua (indigenous Maori people) is using cultural monitoring methods to assess both the level and impact of plastic pollution in the awa (river). The research will identify the most common sources and routes of plastic to urban streams and in subsequent steps, assess the transformation of macroplastics to microplastics within the stream network. The potential outcomes of the research include improving waste management infrastructure, reducing plastic use, and reducing littering. Our partnerships with mana whenua, community and industry will increase awareness of plastic pollution and ensure the uptake of methods to reduce it.
WP135 Identifying polymers of plastic marine debris to monitor the effectiveness of Maui’s expanded polystyrene foam food service containers ordinance

S. Weller, A. Moua, K. Teague, J. Marchiani, M. Jung, Hawaii Pacific University / Center for Marine Debris Research; C. King, Sharkastics; J.M. Lynch, National Institute of Standards and Technology / Chemical Sciences Division

Some of the largest documented quantities of marine debris occur in Hawaii. Municipal bans on single-use plastic items are becoming more common, but the effectiveness of these policies on marine debris have rarely been studied. Maui County in Hawaii enacted a ban on expanded polystyrene (EPS) foam food service containers, which went into effect on Dec. 31, 2018. The ban includes cups, plates, bowls, clamshells, and serving trays, with goals to protect wildlife, reduce plastic waste and combat climate change. The objective of the current study was to use polymer identification methods to determine whether the ban has an effect on the plastic marine debris composition on two Maui beaches: Kaehu on the northern windward side and Kealia on the southern leeward side. Three sections along the high tide drift line were surveyed monthly at both beaches from seven months pre-ban and continue. Plastic debris items >1 cm in length along the drift line were collected from the beach surface until 50 items were collected. Survey length was then measured. Plastic items were categorized by type - specifically noting if they were from an EPS foam food container, color, length, mass, weathering, and then analyzed for polymer composition via attenuated total reflectance Fourier transform infrared spectroscopy (FTIR). Preliminary results on 1511 pre-ban debris pieces show that debris amounts, types and polymers differ substantially between the two beaches. Plastic debris abundance was an order of magnitude greater on Kaehu (9 g/m) compared to Kealia (1 g/m), which is typical of windward vs. leeward beaches. The proportion of PS (regardless of expanded or extruded) on Kaehu (≈25 %) was larger than Kealia Beach (≈10 %), and the proportions did not change substantially throughout the pre-ban months. The percentage of all debris items that were visually identified as EPS food service containers was greater on Kaehu (12 %) compared to Kealia (3 %) in pre-ban months. The percentage did not change four months post-ban on Kaehu but significantly decreased on Kealia (0.3%). Additional analyses of post-ban samples will reveal how quickly and where the new policy improves the plastic pollution on Maui beaches. Since a large percentage of debris washing ashore on Hawaiian windward beaches is from distant sources, local legislation concerning particular single-use items are expected to make a small, but important, noticeable improvement in the marine debris issue on Hawaiian coastlines.

WP136 Comparing the sorption of hydrophobic organic contaminants to bio-based and petrochemical-based plastics

K. Uhlig, R.C. Hale, College of William & Mary / Aquatic Health Sciences; D.R. Luellen, Virginia Institute of Marine Science / Aquatic Health Sciences

Microplastic contamination of aquatic environments has only recently caught the attention of scientists, regulators and the public. Microplastics are typically more recalcitrant than naturally occurring polymers and so have the potential to cause a range of issues, including increased exposure of aquatic life to chemical contaminants sorbed to or leached from microplastics. Bio-based, bio-degradable polymers have begun to gain market share as an alternative to traditional petrochemical-based plastics, but not much is known about their impacts in marine environments. The objective of this work was to improve our understanding of how bio-based microplastics compare to petrochemical-based plastics with respect to the sorption of organic pollutants. This study investigated the potential of four types of microplastics, polyethylene (PE), polyvinyl chloride (PVC) and two bio-based polymers, poly-3-hydroxybutyrate (PHB) and polyactic acid (PLA), to sorb hydrophobic organic contaminants (HOCs; pyrene, PCB-153, and BDE-47) from the surrounding water column. 0.5 g of plastic production pellets (< 5mm) were added to 500ml of salt water spiked with HOC concentrations ranging from 1.0 - 4.0 μg/L and mixed at 100 rpm on an orbital platform shaker. At the end of an equilibrium period, plastics were separated from the aqueous phase, and aqueous phases were extracted using dichloromethane and analyzed by gas chromatography/mass spectrometry. The concentration of HOCs sorbed on the plastic pellets was calculated by difference. Sorption isotherms were drawn by plotting the concentration of the HOC in the water versus that on the plastic beads, and the partitioning coefficients calculated from these isotherms. The bio-based polymers used in this work exhibited a lower partitioning coefficient for the organic contaminants investigated compared to the more widely used, petrochemical-derived microplastics. This may be due to several factors including hydrophobicity of the plastic surfaces and the chemical structure of each plastic. This information could be used to evaluate the overall environmental impact of bio-based plastics as replacements for petrochemical-based plastics.

WP137 Phthalate esters in the environment: Sources and quantification

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Consequent upon their widespread use as plasticizers and high volume of production, phthalates constant diffuse release into the various environmental compartments (air, water, soil) has become noticeable. In this study, levels and presence of phthalate esters were analyzed in newly purchased plastic toys and in Polyethylene Terephthalate bottled drinking water samples. Phthalates in the samples were liquid-liquid extracted, preconcentrated and analyzed for detection and quantification using HPLC. From the data obtained, the levels of DMP, DEP and DBP in the PET drinking water samples did not exceed the stipulated threshold levels while the level of DEHP was dominant and exceeded the safe limit. PEs were detected in all the 10 plastic toys samples analyzed including mouthable ones (teethers) used by children, imported into the country from China, Taiwan etc. The values obtained revealed that the concentrations of PEs in the plastic toys ranged between 0.96 - 532 (ug/l). Also the percentage (w/w) values obtained were significantly higher than the European Union (EU) recommended limits for all phthalate esters in toys, this portends risk to children who innocently put these toys in their mouth or chew them, as the toxic chemicals could leach into their blood stream. These results can be used as reference levels for future monitoring programs for pollution studies.

WP138 To Drink or Not to Drink? Estrogenic Activity of PET Bottled Water Under Various Storage Conditions

L. Markley, C.T. Driscoll, Syracuse University / Civil and Environmental Engineering

Water bottled in polyethylene terephthalate (PET) plastic is a source of human exposure to endocrine disruptors. Current data on this exposure focuses heavily on a subset of endocrine disrupting chemicals, such as BPA or antimony. However, targeted chemical analyses neglect the combined biological effect, like estrogenic activity (EA), of endocrine disruptors present in a sample. The migration of compounds exhibiting EA from PET water bottles present a potential health risk to humans and the environment. Though previous studies have found positive EA in water samples taken from PET bottles, data on how EA varies with storage conditions is lacking. This study compares EA from multiple brands of PET bottled water using the E-Screen. Bottles were exposed to consumer-relevant storage conditions, including high temperature, UV light, and UV light with increased temperature. This analysis will further inform the human health risk associated with consumption of bottled water.
Utilizing Biodegradability Data to Effect Meaningful Interpretations

WP139 Challenges and opportunities in the application of the biodegradation deroga for microplastics under ECHA Annex XV


The European Chemicals Agency (ECHA) Annex XV Restriction Report for Microplastics aims to eliminate the use of intentionally added persistent microplastics in consumer, professional, agricultural, and industrial products marketed in Europe. ECHA has clearly outlined their intention to move industry away from persistent microplastics to biodegradable alternatives. In order to achieve this goal ECHA has defined a biodegradation deroga for microplastics. This deroga outlines a series of tests and pass criteria which move from conservative screening assessments through high tier simulation tests. While it is considered critical that biodegradation be considered a deroga strategy, the reality is that little experience exists in Industry or Academia using biodegradation test methods to assess microplastics. This talk will discuss the proposed biodegradation testing strategy as well as discuss key differences in testing microplastics and soluble chemicals (for which most of the test methods were developed). We will share experiences gained using the OECD 301B Ready Biodegradation Test to evaluate microparticle biodegradation. We will specifically address challenges in test material, dosing, intra-test replication, and the need for extended test duration. Particle size plays a large role in the surface area : volume ratio of the material. Larger particles have smaller surface areas, compared to the total volume, susceptible to microbial attack. This produces a slower measured rate of biodegradation compared to particles made of the same material but smaller in volume and higher in surface area. Test material hydrophobicity and low density can also impede microbial interaction with the test material in aqueous test systems. Finally, the low inocula concentrations prescribed in the 301B limit the number of degraders available to interact with the particles. Of particular focus will be recent work to evaluate the impact of starting particle size (63 um through 2 mm) on biodegradation rate and time to complete mineralization.

WP140 Biodegradability of Polymers and Plastics - Applicability and Limitations of Five Existing ISO Guidelines

N. Timmer, Charles River Laboratories / Environmental Sciences; M. Desmares, S. Buitenweg, M. Migchielsen, W. Westerink, Charles River Laboratories; M. Tobor-Kaplon, Charles River / GET

Synthetic polymers (i.e. ‘plastics’) are widely used around the globe. Over 300 million tons are produced annually, of which a significant percentage ends up in landfills or the environment. There is worldwide growing societal concern about the environmental and economic implications of the fate of these often poorly degradable polymers. Shifting to more easily degradable or even readily biodegradable polymers could be an important part of the solution. In order to more accurately assess the environmental impact, the guidelines used to test biodegradability of such newly developed polymers should be practical and relevant. In addition, regulatory authorities might need to provide better guidance on how to interpret experimental results. We have tested biodegradability of 20 different biodegradable polymers and one non-biodegradable polymer using the ISO 11398 protocol under standard conditions (sea sediment, activated sludge, soil). We tested several commercially available reference polymers (cellulose, polyactide, polybutylene succinate) and two proprietary polymers. Ultimate biodegradation was assessed by measuring CO2 evolution and/or manometric determination of O2 consumption. To further broaden the scope of this study, we included two types of standardized LUFAs, two types of vegetable material (coarse and silty), and activated sludge pre-conditioned overnight and up to seven days. The combined findings of these experiments will provide valuable and relevant insights in the biodegradability of the compounds tested in different environmental compartments, while simultaneously providing information on the applicability and limitations of existing guidelines. Our findings can be used to optimize biodegradability testing of polymers using ISO guidelines, and might also provide valuable insights for specific guidance by regulatory authorities.

WP141 Improving Relevance and Applicability of Ready Biodegradation Studies by Environmentally Relevant Modifications

N. Timmer, Charles River Laboratories / Environmental Sciences; M. Desmares, S. Buitenweg, M. Migchielsen, W. Westerink, Charles River Laboratories; M. Tobor-Kaplon, Charles River / GET

Standard ready biodegradation study guidelines accepted by regulatory authorities might not have been updated for the last 20 to 30 years. However, increased awareness of environmental impact of chemicals discharged in large volumes in combination with regulations such as REACH have led to biodegradability testing of increasingly complex chemicals and chemical mixtures. Such substrates might only degrade to the maximum extent if the right inoculum is present, or if steps are taken to ensure the substrate remains biodegradable during the study. To address these challenges, we have experimented with several additions to improve environmental relevance and reliability of biodegradation studies. Results show how difficult to degrade substrates respond to the use of mixed-source inoculum (soil and activated sludge), and how addition of silicon dioxide to increase bioavailability impacts biodegradability. We have applied these modifications in an attempt to test biodegradability of moderately volatile chemicals in an open, aerated test setup. The use of silicon dioxide and other sorbents was also applied to cetylpyridinium chloride, a biocide that is known to poorly degrade under standard conditions. Our main conclusion is that the proposed modifications and additions, some of which are not clearly permissible in existing guidelines, can impact biodegradability classification. As biodegradability should be an inherent property, we propose that use of mixed-source inoculum, addition of inert sorbents, and other modifications that can be justified as being based on environmental relevance should be permissible.

WP142 Environmentally relevant biotransformation testing of multiple substances using spiked incubation and non-target screening

Z. Li, Stockholm University / ACES; M. McLachlan, Stockholm University / Environmental Science and Analytical Chemistry (ACES)

Biotransformation in surface waters is often (e.g., in the OECD 309 standard method) studied by spiking a single substance into surface water, incubating the bottle in the laboratory, measuring the dissipation of the spiked substance over time, and comparing its dissipation rate to that in a sterile control. We recently showed that the dissipation rate differs between spiked tests and unspiked tests in which the dissipation of chemical already present in the surface water is measured. Since spiking modified the biotransformation properties of the water, we concluded that an unspiked test would deliver a more environmentally relevant biotransformation rate. An unspiked test also opens the possibility to study the biotransformation of many substances simultaneously. This study aims to test and evaluate the possibility of combining a non-target screening approach and an unspiked bottle incubation test to obtain biotransformation kinetics of chemicals that are already present in natural systems. An unspiked bottle incubation test based on the OECD 309 protocol was conducted using water from Norra Bergundasjon, a Swedish lake with a high WWTP effluent load. The water samples collected during the incubation were filtered and analyzed with UHPLC-Orbitrap-MS/ MS using large volume direct injection. The HRMS data were processed using CompoundDiscoverer 3.0 with compound online-searching using the database mzCloud. A spiked bottle test was conducted in parallel in which 12 chemicals were spiked into the same lake water. The ability of the non-target screening procedure to identify and quantify the dissipation kinetics of the spiked analytes was first evaluated. Then the ability of the procedure to quantify the dissipation kinetics of unspecified chemicals was assessed and the diversity of dissipation kinetics was examined. Finally, the dissipation kinetics of unspecified chemicals in the spiked bottles was
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WP143 Comparing chemical persistence assessed using the unspiked OECD 309 test to field measurement

Z. Li, Stockholm University / ACES; M. McLachlan, Stockholm University / Environmental Science and Analytical Chemistry (ACES)

Biodegradation is an important removal pathway for many organic contaminants in natural systems. The OECD 309 protocol is a standard method to generate kinetic biodegradation data in surface waters for use in persistence and risk assessments. In this protocol, aerobic natural waters are spiked with test chemicals and incubated in the laboratory. However, our prior work comparing spiked and unspiked OECD 309 tests has shown that spiking surface water with test chemicals can strongly influence biodegradation kinetics, most likely due to adaption of the microbial community. This study was designed to test the environmental relevance of unspiked OECD 309 tests by comparing chemical biodegradation half-lives assessed in the laboratory against their persistence measured directly in the field using a benchmarking approach. To this end, Lake Norra Bergundasjon in southern Sweden was selected. It is a recipient for wastewater treatment plant (WWTP) effluent with a fresh-water dilution factor of ~4. For measuring chemical persistence in the field, the WWTP effluent discharged to the lake, as well as water of the lake inlet and outlet were collected over a period of 3 months in 2017 and analyzed. The data were used to assemble contaminant mass balances and calculate biodegradation half-lives. The unspiked laboratory test was carried out using a mixture of fresh lake water and WWTP effluent collected at the end of the field sampling period under conditions recommended by the standard OECD 309 protocol, lasting for a period of 60 days at 20 °C in the dark. The field study yielded a half-life < 120 d for 28 chemicals. Of these, 12 were observed to degrade in the lab test following first-order degradation kinetics, while the half-life could not be determined for the remaining 16 chemicals due to non-significant dissipation or absence of first-order kinetics. There was good agreement between the half-lives determined in the field and in the laboratory test for 5 of the 12 chemicals, while the half-lives were markedly longer (up to two orders of magnitude) in the field for 6 of the 12 chemicals. This shows that biodegradation in the lake could not be reliably measured using an unspiked bottle test based on a mixture of lake water and effluent from the dominant contaminant source.

WP144 Inoculum criteria for OECD ready biodegradability tests

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A primary objective of biodegradation testing of chemicals is to screen for commercial substances that are persistent. Persistent chemicals may accumulate in the environment and could result in hazardous effects, irreversible contamination, and increased possibility for long range transport. The OECD has published guidelines for biodegradation testing, such as the OECD 301 ready biodegradability tests (RBTs), in which the test substance is exposed to a microbial population (seawater, sludge), and the transformation or mineralization of the test substance is measured. While these RBTs have been heavily criticized for their conservative nature and lack of relevance to environmental systems, they provide a standardized, quick and easy screen for most substances. Unfortunately, RBTs often show variable results for a single substance, as (bio)degradation of a substance is controlled partly by the substance’s intrinsic properties but also by the environmental system used in testing, i.e., the microbial community, temperature, organic load, etc. The “Revised introduction to the OECD guidelines for testing of chemicals, section 3,” which covers biodegradation testing as well as other fate processes, names several factors that affect the performance, accuracy and replicability of biodegradation testing such as the inoculum quality. Inoculum quality can be described as the level of microbial activity, the concentration of microbes in the inoculum, and the microbial diversity in that environmental sample. Unfortunately, these factors are poorly controlled in RBTs. Microbial activity is often assessed by inclusion of a positive control, such as sodium benzoate or aniline, but this control does not guarantee the required diversity of the inoculum. Microbial load is typically assumed through use of a prescribed volume of activated sludge or can optionally be measured using plate counts or other method. However, there is large variation in the concentration of microbes from even the same environmental medium. Microbial diversity is often assumed based on the inoculum, normally being environmental samples or activated sludge. Capturing the diversity present in natural systems is key for an accurate reflection of biodegradability of a substance. In this work, we discuss criteria that could be used to qualify a microbial inoculum for use during a RBT to improve consistency and confidence in testing outcome.

WP145 Application of ready biodegradation tests for chemical mixtures


The OECD standardized ready biodegradability tests are designed to provide an estimate of a potential for a substance to degrade in the environment. These are intended to evaluate the rate of breakdown for single substances and are not indicated specifically for use in analyzing complex compositions containing different types of constituents. However, useable information can be gained by testing a mixture, such as providing insights into synergisms that may increase or decrease rates of degradation within the testing system. Various authorities require biodegradability data on complex substances, such as UVCDs, to meet policy needs, hence the necessity for mixture testing. There is, however, no specific regulatory instruction on how to appropriately address the biodegradability of complex mixtures. Furthermore, as chemicals exist solely as complex mixtures in wastewater, there is a high degree of value in understanding their behavior. To address this need, our work will propose a process for evaluating ready biodegradability testing of complex mixtures, considering 1) the minimum level of unique substance(s) that are present in a mixture that will be introduced to the test system, 2) structure similarity of the substances, 3) uncertainties associated with mixture testing results, and 4) how to mitigate those uncertainties. The process can provide valuable information regarding the biodegradability of the mixture, guidance on how to make selections of relevant mixtures for biodegradability testing and an ability to interpret the outcome of the mixture test.

WP146 Evaluation of Organic Chemical Biodegradation in Environmental Media

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Organic chemicals that are resistant to biodegradation, hydrolysis, and photolysis processes are classified as persistent and are considered potential environmental pollutants. Due to the wide variability in the methodology and parameters reported in biodegradation studies, classification of an organic chemical as persistent is a challenge. Key parameters needed to determine biodegradation rates of an organic chemical include the number and identities of viable microorganisms present, the environmental conditions, and the identity of the chemical. Light, water, oxygen availability, temperature, chemical concentration, the density of the microbial population, the concentration of nutrients and other carbon sources present in the environmental media all play roles in evaluating organic chemical biodegradation studies. The best experimental indicators of biodegradation are: 1) screening tests, 2) biological treatment simulations, 3) grab sample tests, and 4) field studies. Field and grab sample studies give an indication of biodegradation in the natural environment; however, the conditions represented in these studies vary more than standardized screening tests and give more variable results. Screening studies simulate either the environment or biological treatment;
therefore, results from each give insights into biodegradation under these conditions. Data from standardized, guideline screening tests such as MITI or OECD, and multiple, consistent biodegradation results reinforce reliability; and results from these tests are used to develop biodegradation models (i.e., EPI SuiteBIOWIN 5 and 6 based on MITI test data). When experimental data are unavailable, classification based on chemical structure and comparison to analogs with experimental data can be performed. Functional groups and chemical classes that have extensive experimental data include simple aromatic hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), chlorinated aliphatics, phenols, ketones and phthalates. Finally, if there are no suitable structural analogs, persistence evaluation is based on estimation programs. Herein, we propose a decision process to evaluate organic chemical biodegradation studies and give a case study to demonstrate the utility of this method.

Chemistry and Exposure in the Indoor Environment

WP147 Non-targeted and suspect screening analysis of indoor environmental chemicals using SCIEX X500R QTOF system and SCIEX OS software

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Exposomics and human bio-monitoring (HBM) are rapidly advancing disciplines addressing risk assessment in environmental and occupational health and contributing to the development of policies and programs to protect human health. One of the tools available to the disciplines and utilized with growing popularity is non-targeted and suspect screening using high resolution mass spectrometry (HRMS). Non-targeted screening workflows enable simultaneous detection, characterization, identification (if reference was reported previously) as well as relative quantitation of multiple environmental chemicals, metabolites and other small molecules. Non-targeted screening with HRMS helps overcome challenges of characterization of thousands of compounds present in samples of interest (e.g. environmental exposure samples as well as human samples). The workflow allows scanning extensive mass ranges to determine molecular weight, elemental composition, and molecular structure information. In the study presented here, we report on the analysis of non-targeted screening of household laundry drier lint. Lint samples were selected as a representative source of human exposure to environmental contaminants, including polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organophosphate flame retardants, plasticizers, pesticides etc. Lint samples were collected from two households in Ontario, Canada. Initial extraction and clean-up procedures were performed using methanol and acetonitrile. Solid-phase extraction procedure was conducted using Strata GSB cartridges from Phenomenex. HPLC separation of analytes was performed both on a reverse phase and HILIC analytical columns in gradient regimes. Mass spectrometry analysis was performed with a SCIEX X500R QTOF System. SCIEX OS 1.5 software was utilized for data processing in non-targeted workflow. Our results demonstrate the advantages of the non-targeted and suspect screening analyses of for comprehensive characterization of multiple chemicals present in indoor environment. Specifically, high confidence identification was achieved for suspect compounds from the expected environmental chemical classes as well as true unknown features.

WP148 Effect of particle-bound polycyclic aromatic hydrocarbon on dermal absorption: Barbecue as a case study

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Up to now, there is still a big knowledge gap between particle-bound polycyclic aromatic hydrocarbon (PAHs) and dermal absorption. As high molecular weight PAHs are on basis of existing in fine particles, especially in ultrafine particles which have higher deposition velocity and could be much more easily absorbed by skin. Thus, it is necessary to figure out the effect of particle-bound PAHs on dermal absorption and then fill the knowledge gap. To address this issue, we conducted an indoor barbecue in Guangzhou, China. Particle and gaseous samples of background and barbecue fumes, and forearms-wipe samples of 12 participants were included to be analyzed. Particle and gaseous concentrations of PAHs increased from 4.2 and 37 ng m^-3 to 612 ± 17 and 949 ± 79 ng m^-3, respectively. For lower molecular weight PAHs, coarse particles played a greater role on their dry deposition flux, while those of high molecular weight PAHs were greatly controlled by fine particles. The logarithms of gas-particle partitioning were well correlated to logarithms of octanol-air partition coefficients (r^2=0.9504) and the subcooled liquid-vapor pressure (r^2=0.9393), indicated that both adsorption and absorption were contributed to the transport and fate of PAHs derived from barbecue fumes. There are considerable amounts of PAHs were detected on forearms-wipe samples, which were in good linear correlation with dry deposition flux of coarse particles (r^2=0.9915, p < 0.01), but not with fine particles (r^2=0.1389, p > 0.05). It definitely gave an good insight to minimize the effect of particle-bound PAHs.

WP149 Heterogeneous Ozonolysis of Cigarette Smoke and Nicotine Deposited onto Indoor Surfaces

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Indoor air pollution can lead to significant exposures to toxic compounds (e.g., harmful gases and particulate matter), especially for populations who spend a majority of their time indoors. Despite the importance of indoor air, chemical transformations indoors are relatively understudied compared to those that occur outdoors. One defining feature of the indoor environment is the large amount of surface area available (typically orders of magnitude higher than the outdoors) for semivolatile compounds to deposit onto and the variety of surface materials. Compounds deposited onto surfaces can continue to react through heterogeneous reactions with atmospheric oxidants over long timescales (days to weeks) since they are less subject to removal by building air exchange. In this work we focus on the heterogeneous ozonolysis of tobacco smoke and individual components of cigarette smoke (e.g., nicotine) in a set of laboratory flow tube experiments. Gas-phase products produced from the heterogeneous ozonolysis of cigarette smoke are measured by depositing smoke onto a variety of indoor surfaces and monitoring gas-phase composition with an acetate ion time-of-flight chemical ionization mass spectrometer (CIMS) during ozone exposure. Over a wide range of environmental conditions, isocyanic acid (HNCO) is detected as a major product, showing the capability of surface reactions to be an additional source of exposure to toxic compounds indoors. Condensed phase products such as nicotine 1'-oxide, cotinine, and N-formylnornicotine, are identified by high-performance liquid chromatography with electrospray ionization tandem mass spectrometry (HPLC ESI-MS/MS). Additionally, the surface behavior of nicotine on glass and cotton surfaces is monitored to determine whether oxidation by ozone can compete as a loss process with volatilization for this relatively volatile component of cigarette smoke.

WP150 Indoor Chemistry of Ammonia and Amines: A Need for Quantitative Non-invasive Passive Sampling

L. Salehpoor, T. Vandenhoor, York University / Department of Chemistry

Analytical techniques to quantify amines are newly emergent outdoors and will play a pivotal role in assessment of the chemistry and exposure of indoor atmospheres. Ammonia and amines may form inhalable particles which can lead to respiratory effects such as occupational asthma. They may also present toxic and carcinogenic effects on human health by conversion to nitrosamines in the presence of nitrogen oxides and nitrite. The study of ammonia and amines as atmospheric pollutants is therefore critical in the indoor atmosphere. This is because people spend ~ 90% of their time indoor where sources of amines can be emitted from tobacco smoke, pets’ excrement, cooking meat, cleaners, and consumer products. The purpose of this work is to collect aliphatic amines quantitatively by passive samplers. To do this, a measure of the passive sampling rate of aliphatic amines with respect to relevant indoor parameters of temperature
and relative humidity must be captured. The chemistry controlling the rate and stability of amine reaction product formation will be explored through environmental chamber studies. These new analytical developments will allow us to quantify the concentration of ammonia and amines in new and existing homes, which is not possible with existing technology. Passive sampling used to collect amines both indoors and outdoors also has advantages over active sampling for measuring ultra-trace analytes because it is simple, safe, cost-effective, and non-intrusive to the activities of indoor occupants. We have built a custom permeation oven to generate up to four independent controlled gaseous concentrations of parts-per-billion-by-volume (ppbv) of the most abundant atmospheric alicyclic amines (C1-C6). Calibration concentrations of a gaseous amine (or mixture) can then be introduced to a Teflon environmental chamber to determine amines passive sampler rates and product stability against common oxidants such as O3 and OH. All the analytes were measured quantitatively by ion-chromatography coupled with a conductivity detector. Alicyclic amines collected and quantified by passive samplers and annular denuder devices in both indoor and outdoor environments will be used to validate the accuracy and robustness of passive sampler measurement. The performance and concentration of ammonia and amines quantified by this passive technique in homes will be discussed.

WP151 Developing a Robust, Reliable, and Reproducible Nitrous Acid (HONO) Calibration Source for Indoor Chemistry

M. Lao, T. Vandenboer, York University / Department of Chemistry

The ranges of outdoor nitrous acid (HONO) under sunlit conditions varies from a few pptv in less polluted areas, up to 15 ppbv in polluted areas and 10 ppbv in fire plumes. Indoor air quality is affected by HONO because it is a pollutant which photolyses to release oxidizing hydroxyl (OH) radicals. Inhalation HONO is linked to respiratory damage, can react to form carcinogenic nitrosamines, and initiate oxidation of volatile organic compounds. Photolysis of HONO has been shown to occur under indoor light conditions (λ=≤405 nm). Recent publications have observed peak HONO accumulation of 100 ppbv indoors from gas stoves – greatly exceeding maximum outdoor concentrations. The potential chemistry of HONO indoor is therefore of concern due to humans spending 90% of their lives indoors. To support future research on understanding exposure, making accurate measurements, and indoor modelling of HONO, an in situ HONO calibration source was developed to provide high reproducibility, selectivity and accuracy. Previous HONO calibration sources required a bed of powdered sodium nitrite (NaNO2), with a limited lifetime and experiences of unstable emission rates. The desorption of HONO at high concentrations results in dissociation and low conversion efficiency, producing gaseous interferences such as NO and NO2. Our new HONO source is designed to produce a large order of magnitude calibration range across all environmentally relevant concentrations. The use of an NaNO2 coated device requires lower salt quantities, resulting in less waste and stable conversion efficiency. The source is a fully thermostated system and uses a new configuration of the acid displacement reaction between gaseous hydrochloric acid and NaNO2 at ~50% relative humidity. The resulting high purity HONO is released into ultra-pure zero air for calibration of gaseous sampling devices. The stable HONO output was measured across all experiments by a gas-phase chemiluminescence detector. The HONO source was confirmed to be of high purity through a series of negative control experiments. The robustness of the system was determined by simulating field transport of the calibration system before initiating the experiments. Under these testing conditions, the HONO calibration system has a precision of +/- 30% on start-up, with one-minute precision within a calibration period near 10% when generating 0.2 to 2 ppbv calibration quantities.

WP152 Atmospheric Pollutants in Vehicle Cabins

C. Kroptavich, S. Zhou, S. Koval, Syracuse University / Chemistry; T. Kahan, University of Saskatchewan / Chemistry

North Americans spend approximately 90% of their time indoors, and close to 7% of that is spent in vehicles. Air quality in vehicle cabins may therefore have an impact on human health. We measured time-resolved concentrations of the common gaseous pollutants ozone (O3), nitric oxide (NO), nitrogen dioxide (NO2), nitrous acid (HONO), and carbon dioxide (CO2) in a parked vehicle under different conditions (e.g., engine on and off, various fan settings, occupant present and absent). Spectral irradiance was measured inside the vehicle, and photochemical hydroxyl radical (OH) formation rates were determined. Pollutant concentrations in the vehicle were generally influenced by, but different than, outdoor levels. In contrast with several chamber experiments that report greatly reduced ozone levels indoors in the presence of people (due to reactive uptake of ozone to skin oils), O3 concentrations in the vehicle were not affected by the presence of an occupant. Under sunlit conditions, HONO photolysis could be an important hydroxyl radical (OH) source.

WP153 Developing Novel Instrumentation to Measure Total Chlorine in an Indoor Environment

T. Furlani, York University / Chemistry; T. Kahan, University of Saskatchewan / Chemistry; T. Vandenboer, C. Young, York University / Department of Chemistry

The typical modern person spends approximately 90% of their life indoors, and therefore understanding the air quality impacts in these environments is crucial to understanding overall human health. Reactive chlorine (Cly = Sum of all chlorinated species that yield Cl after common atmospheric transformations) plays an important role in outdoor air quality and may be important indoors as well. Consumer cleaning products are known to have a variety of chlorine containing compounds due to their strongly oxidizing properties. The chemistry at these surfaces is not well understood but has been shown to yield common reactive chlorine species such as HCl, HOCl, and Cl2. Currently, reactive chlorine evolved from normal residential or workplace activities has an unknown impact on indoor air quality. Due to the complexity of the indoor air matrix and the need for an unobtrusive measurement that can be deployed in occupied indoor environments, a simple and robust technique to measure the total chlorine in indoor air is needed to explore the extent of total chlorine, present a novel instrument design to be used in tandem with an acidic gas scrubbing technique or in situ HCl instrument. Complete combustion of reactive chlorine is achieved through a heated platinum catalyst. The chlorine atom released from this process abstracts hydrogen from a hydrogen source producing 1 HCl molecule per 1 Cl present. The objective of this project is to demonstrate complete combustion of the carbon chloride bond, and to produce a stable HCl signal for quantifying a total chlorine mixing ratio in an indoor environment.

WP154 Measurements and reaction pathways of reactive chlorine in a college athletic facility


Chlorine chemistry in indoor environments is poorly studied, while there is evidence that it could play a significant role in indoor air chemistry. Due to the overall low abundance of the hydroxyl radical indoors, the chlorine atom may be an important contributor to indoor oxidation. Since chlorine containing compounds are used in cleaning products, they can be released in significant quantities in the indoor environment. Yet it is largely unknown to which extent they impact indoor air oxidation. The processes of chlorine chemistry were studied in a workout room facility of the University of Colorado Dal Ward Athletics Center. Measurements were performed over a period of two weeks, while the workout room was being used by University athletes. The facility was equipped with a HVAC system that delivered air into the workout room; cleaning of equipment was carried out on a regular basis. Measurements of both the room and supply air were rapidly alternated to determine the enhancement indoors relative to outdoor air, and the origin of emissions. Since hydrogen chloride (HCl) is a tracer for chlorine chemistry in the atmosphere, HCl measurements were performed using a high time resolution...
cavity ring-down spectroscopy analyzer. Baseline HCl mixing ratios were typically below 20 pptv, while during cleaning events distinct peaks of HCl reaching up to 1.3 ppbv were observed. The increases of HCl were accompanied by elevated mixing ratios of other reactive chlorine compounds, which were measured by time-of-flight chemical ionization mass spectrometry utilizing iodide reagent ion. A wide suite of supporting gas and particulate measurements were also collected. In our presentation we will discuss the formation and removal mechanisms of HCl and other chlorine-containing compounds and how they are affected by cleaning and ventilation of the indoor environment.

WP155 Acetylcholinesterase activity evaluation as a biomarker for determination of occupational exposure to hexavalent chromium

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Increasing need for industrial development in recent decades, cause unwanted health risk among employees. In this regards, monitoring and engineering control should be applied in the workplaces, which highly depend on air contaminant concentrations. Hexavalent chromium as approved carcinogen mainly used in electroplating. In this study, chromium air levels were determined by the application of NIOSH 7600 method (0.014 - 0.051 mg m⁻³). Also, the acetylcholinesterase (AChE) activity as a biomarker of chromium toxicity was measured by Elman method in taken blood of exposed group (35.88±10.44 years old) and control group (35.80±7.58 years old). Results showed that there was a significant relationship between AChE activity suppression and concentration of hexavalent chromium in the workshops. The AChE activity in exposed and control subject was determined 33.82±26.5 and 44.98±2.56, respectively, which was statistically significant (P=0.008). In comparing with control group AChE is a suitable biomarker for occupational exposure even in the presence of another root of exposure such as environmental and food intakes.

WP156 Passive sampling across environmental compartments: A glimpse on the bioaccumulation of organic pollutants and its relation with trophic level

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Passive Sampling Devices based on polymers such as silicone, operated in equilibrium mode, offer a superior approach to assess bioaccumulation to traditional exhaustive extraction, since they avoid the need for normalization of the total concentrations of hydrophobic organic compounds to the main sorptive phase, e.g. lipids or organic carbon. Recently, a new approach for passive equilibrium sampling (PES) in lean tissue has been proposed, allowing to reach equilibrium in biota tissue with low to medium lipid content, and thus to compare bioaccumulation across trophic levels. In this study, a well characterized closed ecosystem has been selected, a small Swedish lake (Angen), and five different biota species were studied: crayfish, perch, roach, bream and eel. For crayfish and eel, the selected tissue was the muscle. For perch, roach and bream, the entire fish were analyzed. The samples were homogenized, and the lipid content was determined. In order to calculate the trophic level, δ15N was also determined. The homogenized tissues were sampled using silicone with three different thicknesses: 125, 250 and 350 um to confirm equilibrium partitioning between the samples and the silicone, relocating the samplers six times per day over five days. The silicone was extracted, and the extracts were cleaned-up using EMR-Lipid cartridges (Agilent Technologies). Six sediments from the study area were sampled using coated glass jars, a well established method for PES in this matrix. The analysis and quantification of a wide range of compounds, including PAHs, PCBs, PBDEs, pesticides, musk compounds, sunscreens and antioxidants, were achieved with a gas chromatograph coupled to a high-resolution mass spectrometer (GC-HRMS Orbitrap Q-Exactive, Thermo Fisher). The present work accomplished the study of 160 compounds using PES in biota, from lean tissue to lipid-rich tissue. The equilibrium was confirmed for the compounds quantified in the different tissues, using silicone of different thicknesses. The results of this study showed that PES allows to compare concentrations of contaminants in biota from different trophic levels directly and, thus, assess biomagnification. This so-called “chemometer” technique, using silicone as common reference phase for direct comparison across media, also allows to compare these concentrations with those found in abiotic compartments (e.g. sediment).

WP157 Butyltins in surface water using polydimethylsiloxane

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Tributyltin (TBT) was used in antifouling paints for more than four decades and, due to its intensive use and high toxicity, it was banned by the International Maritime Organization (IMO) on January 1, 2008. However, recent studies have been detecting TBT and its degradation products in different environmental matrices (i.e. sediment and biota) from Latin America. On the other hand, water column studies assessing current use of TBT, its freely dissolved concentrations and measuring time-weighted average concentrations are rare. Thus, polydimethylsiloxane (PDMS) sheets (with individual total surface area of 100 cm²) were used as passive samplers to measure levels of TBT, dibutyltin (DBT) and monobutyltin (MBT) in the water column of Pato Lagoon estuary (southern Brazil), the world largest cooked lagoon. Five 8 weeks-long samples were taken during 2018. Prior to exposure, the PDMS were spiked with Performance Reference Compounds covering a wide range of partition coefficients, which are used to calculate the analytes exchange rates between sampler and water. An analytical method was developed and validated for the determination of butyltins. PDMS were extracted by Soxhlet (acetonitrile with 2% (v/v) acetic acid), derivatized using sodium tetraethyl borate, cleaned-up with silica and analyzed by GC-MS. Surrogate (tetrabutyltin) recoveries varied between 58 and 105%. Analytes were quantified at all samples, with amounts ranging between 15.9 and 68, 8 and 251, and 5.8 and 363 pg Sn sampler⁻¹ day⁻¹ for TBT, DBT and MBT, respectively. Results indicate that fresh inputs of TBT are still taking place in the study area. Since passive sampling can mimic bioconcentration in organisms, the freely dissolved concentrations of butyltins found in the water phase during all the monitoring period pointed out their bioavailability and possible exposure risks to the local biota.

WP158 Exposure assessment of indoor and outdoor air quality within the informal settlement neighbourhoods

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Poor indoor and outdoor air quality is a major challenge facing developing countries. Half of the human population based in the developing countries experienced in developing countries. The main goal of this study is to assess and compare seasonal exposure of indoor and outdoor air quality within the informal settlement neighbourhoods. Weekly indoor and outdoor air quality exposure assessments of PM2.5, O3, CO and NO2 were conducted in the households of four informal settlement neighbourhoods for one month each in summer and winter. PM2.5 measurements
WP159 Active passive sampling for pesticides to include recording of sampled water volumes

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Water quality monitoring is an essential part of decision making within health and environmental issues. Contamination levels of dissolved organic pollutants can be determined with chemicals analysis and/or biological response assays. Traditional grab sampling of water may not accurately represent spatiotemporal trends of the contaminant levels if emission fluxes are variable. Grab sampling also requires complex transport and storage logistics. Passive sampling with various polymeric sorbent materials could provide for time-weighted average concentrations. Clean solvent extracts can be used both in chemical analysis and bioassays. However, the uptake kinetics of chemicals in commonly deployed samplers such as POCS/chemcatcher/speedisk are not constant, and depend largely on the water flow. The volume of water that has passed such samplers in situ needs to be identified by the depletion curves of series of pre-loaded performance reference compounds (PRC) that cover a representative chemical domain, which requires additional chemical analysis, undesirable chemicals in extracts for the bioassays, while still rendering rather uncertain sampling volumes. The PRC approach can be circumvented if water is continuously pumped through a sorbent filter and the passing water volume is tracked. The rechargeable Continuous Low-level Aquatic Monitoring (CLAM) sampler provides these options, with a pumping rate of ~1.5L/h in clear water and HLB packed filters. We aimed to use the active passive CLAM sampler to assess the levels of dissolved pesticides in various Dutch agricultural regions. To evaluate the efficacy of the CLAM sorbent filters, we first evaluated the potential pre-filter losses, breakthrough volumes, and comparison to parallel aqueous samples of 100 spiked common pesticides in the first 10L passing the CLAM. Secondly, we analyzed 24h CLAM extracts from various field locations using LC-MS/MS and bioassays primarily with water flea Daphnia magna, potentially extended with other assays, to identify whether contamination levels in these locations pose a potential risk. The glass pre-filter retained <5% of the HLB accumulated amount for all tested pesticides. Many acidic herbicides demonstrated >60% breakthrough if more than 10L water passed, while neutral pesticides with a logKow>2 had <10% breakthrough even after 10L water passed. Field samples will be assessed during the summer period of 2019.

WP160 PCB levels in the surface water, sediment porewater, and benthic organisms in Back River watershed

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Polychlorinated biphenyls (PCBs) are major contaminants of concern in Back River, resulting in fish consumption advisories in Maryland. In collaboration with the Baltimore County and the Maryland Department of Environment (MDE) we are performing a pilot assessment of ongoing contribution of PCBs from several streams in Back River watershed. Direct measurement of sparingly soluble chemicals like PCBs in the water phase is challenging due to the ultra-low aqueous concentrations and interference with colloidal particles. However, the freely dissolved concentrations are indicative of biological uptake, toxicity, and flux of pollutants between sediments and water column. In addition, the freely dissolved concentrations provide an indication of potential sources or hot-spots of PCB release in a watershed. Passive sampling has emerged as an alternative technique to assess freely dissolved concentrations of hydrophobic chemicals without interference from colloidal particles. In the present project we deployed polyethylene (PE) passive samplers at 4 tributaries and in the main stem of Back River to measure the freely-dissolved concentration of PCBs and to understand potential sources of the pollutants. PCB concentrations ranged from 0.027 - 2.6 ng/L during the deployment period from June 2018 to August 2018, with Bread and Cheese Creek tributary showing the highest dissolved PCB concentrations among the sampling sites. PCB levels at two locations in Back River itself were 0.99 and 0.56 ng/L. Concentrations at five out of nine sampling locations exceeded the USEPA Water Quality Criteria of 0.64 ng/L, associated with a carcinogenicity risk of 10 in a million. These monitoring results will be used to investigate potential legacy sources of contaminants in upland areas that may be impacting water quality. Benthic organisms were collected from sediments in the Back River and are being analyzed for PCB concentrations to assess accumulation at the base of the aquatic food chain. Ongoing analysis of PCBs in sediment porewaters will be used to obtain greater insight into exchange of PCBs between surface water and porewater and also allow quantification of bioavailability of PCBs to benthic organisms.

WP162 Characterization of the Variation in Dissolved Organic Matter and Agrochemicals in an Agricultural Stream Using Passive Sampling

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Dissolved organic matter (DOM) is a heterogeneous mixture of various organic biopolymers derived from the degradation of terrestrial and aquatic biomass. DOM plays a crucial role in the environment as a mediator of several key ecosystem functions, including carbon cycling, nutrient cycling, and the fate of many environmental pollutants. This poster describes the use of DEAE anion-exchange resins as a passive sampler tool to monitor the spatial and temporal variation in the composition of DOM in an agricultural stream. The composition of DOM is analyzed using NMR spectroscopy and is compared to the presence of agrochemicals in the stream to explore the role that variation of DOM composition due to different land-use practices plays in the behaviour and occurrence of agrochemicals in an agricultural impacted stream.

WP163 Characterizing freely dissolved polychlorinated biphenyls and organochlorine pesticides in San Diego Bay (CA, USA) using polyethylene passive samplers


Determination of the freely dissolved concentration (C_free) improves our ability to assess and predict bioaccumulation of hydrophobic organic contaminants (HOCs) in aquatic environments. San Diego Bay is an urbanized embayment listed as impaired due to the presence of HOCs such as polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). To characterize the contribution of contaminated sediments to HOCs present in the water column, C_free for PCBs and OCPs were dedicated at 10 stations throughout San Diego Bay using polyethylene (PE) passive samplers. PE samplers preloaded with performance reference compounds (PRCs) were deployed at mid-water depth and in bed sediment at each station for 1 month during the wet and dry seasons in 2018. The PE samplers in sediment were deployed using a device that allowed for estimation of C_free both above and below the sediment-water interface.
Seawater and sediment grab samples were also collected and analyzed for comparison to $C_{\text{free}}$. Forty-two PCB congeners and 12 OCPs (5 chlordane insecticides, dieldrin and 6 DDT and its degradates) were determined by GC/MS. Water-column $C_{\text{free}}$ for the sum of 42 PCBs ranged between 58 ± 3.9 to 1250 ± 130 pg/L, whereas the $C_{\text{free}}$ for the sum of 12 OCPs were 7 to 23 times lower. The sum of 42 PCBs in the sediments ranged between 0.84 to 690 ng/g dry weight, but the sum of 12 OCPs were 4 to 162 times lower. The highest levels for the sum of 42 PCBs were found at stations 1, 3, and 5 for water-column $C_{\text{free}}$ and bulk sediment concentration ($R^2=0.88$ and 0.82 for wet and dry season events, respectively, $n=10, p<0.05$). Water-column $C_{\text{free}}$ for the sum of 42 PCBs in the dry season were 1.7 to 4.9 times higher than in the wet season. Mass flux of PCBs across sediment-water interface indicated transport out of sediment into the water column. Results from this study will used to quantify the contribution of sediment HOCs to bioaccumulation by resident fish in San Diego Bay.

WP164 Using integrative passive sampling devices to obtain more meaningful and cost-effective data on metal-associated impacts from stormwater runoff

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In many cases, stormwater compliance monitoring is labor intensive, expensive, and largely unsuccessful in providing the data needed to support informed stormwater management goals. To help address these issues, time weighted averaging (TWA)/integrative metal passive samplers, Diffusive Gradients in Thin-film (DGTs), are being used to monitor stormwater runoff for copper (Cu) and other stormwater relevant metals in various monitoring approaches, primarily focused on stormwater management. In current studies, DGTs were co-located with traditional autosamplers, within the stormwater conveyance systems at Naval Base San Diego (NBSD) and a hybrid-Low Impact Development (LID) Best Management Practice (BMP) objective at Naval Base Point Loma (NBPL), to provide a direct comparison DGT-labile TWAs and composite sampling of the operationally defined dissolved fraction. In a more controlled fashion, DGTs were exposed in the laboratory to composite samples from NBSD stormwater conveyance systems. These controlled experiments showed increasing uptake over time (range = 1.5 to 24 h) for Cu, with statistically significant positive, linear correlations ($r^2=0.9890$) between time exposed and metal mass accumulated. Under laboratory testing, corresponding calculations of the DGT-labile fraction relative to the dissolved fraction fluctuated with exposure duration; giving an indication of necessary equilibration/minimum deployment windows. In general, trends observed for DGT-labile measurements from the field were consistent with trends in the lab DGT exposures and traditional dissolved metal measurements from composite samples. TWA Cu concentrations from DGTs deployed for the first and second half of a storm event were within 30% of measurements from DGTs that were deployed for the entire storm event in the same stormwater vault at NBSD. Finally, comparisons between flow-weighted composite samples collected before and after the LID BMP at NBPL showed convincing agreement with the DGTs deployed in the influent and effluent sampling locations. Cumulatively, these results show promise for continuous monitoring with DGTs as an approach that produces concentrations more representative of those in the receiving environment during episodic events than those concentrations measured from traditional grab or composite chemistry sampling, as well as a cost-effective method to measure BMP efficacy.

WP165 Non-Targeted Fingerprinting of Contaminated Waters Using Passive Samplers Analyzed Using Benchtop NMR Spectroscopy

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Nuclear magnetic resonance (NMR) spectroscopy offers unique advantages for the non-targeted characterization of contaminated waters. Adding to these advantages is the practicality and reduced expense of benchtop NMR spectrometers. Nevertheless, benchtop NMR spectrometers lack the sensitivity necessary to effectively characterize dilute environmental samples. Passive sampling is a highly practical solution to this issue which allows for the preconcentration of contaminants improving the sensitivity of the NMR method. Through the implementation of passive sampling, the concentration of coal-tar and PFAS contaminated samples were increased allowing for 2-dimensional NMR experiments to be performed using benchtop NMR instrumentation. The use of passive sampling coupled to benchtop NMR shows the potential to be highly valuable to the fields of environmental monitoring and remediation, as a practical and affordable tool for the characterization of contaminated sites.

WP166 Development and Testing of a Novel Passive Sampler for Methylmercury in Sediment and Soil Porewaters

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Aquatic mercury can pose a significant risk to ecological and human health if it is converted to the more toxic and bioaccumulative methylmercury (MeHg) by anaerobic microorganisms near the sediment-water interface. As such, quantitative measurements of the bioavailability of MeHg to benthos are critical for risk assessment of contaminated sites. Existing technologies designed to function in a kinetic mode (e.g., DGT) have not achieved wide acceptance for generating such measurements. We are developing a novel passive sampling technology to emulate the steady-state (pseudo-equilibrium) mode of benthic bioaccumulation. A target range for sampler-water partitioning (log K) was set at 3.0-4.5 in view of analytical detection limits, the logistics of sampler deployment in the field, and typical sediment-water partitioning coefficients. Custom polymers containing reduced sulfur functional groups or embedded activated carbon (AC) particles were prepared and evaluated in a series of increasingly environmentally realistic experiments, culminating in a sediment exposure alongside a benthic test organism. In mildly saline water isotherms, many of the polymers showed strong, log-linear partitioning of MeHgOH across an environmentally relevant range of concentrations. Partitioning of MeHg complexed with dissolved organic matter was somewhat lower (log K = 2.83 to 3.31) but still in or near our target range. In slurries of contaminated soil, polymer-predicted porewater concentrations ($C_{pw}$) were within factors of one to five of directly measured (centrifuged) water samples. In beaker soil microcosms, accumulation of MeHg by our AC-based polymer reflected temporal variations in $C_{pw}$ as well as reductions due to amendment of soil with AC. Polymer-derived and directly measured $C_{pw}$ agreed equally well at 8, 14, 21, and 28 d of exposure, indicating an approach to steady state on the order of one week. In sediment microcosms, polymer uptake of MeHg was correlated with bioaccumulation by the test amphipod L. plumulosus at 21 d. Mechanistic studies showed that MeHg uptake by AC polymers is relatively rapid, characterized by internal diffusion rather than surface adsorption, and at least partially reversible. These findings indicate the potential for dynamic equilibrium sampling. Compared to existing alternatives, this novel passive sampler could permit more reliable predictions of benthic MeHg bioavailability and improved risk assessment and management for mercury-impacted systems.
WP167 Relevance and limits of passive samplers for monitoring priority micropollutants in surface waters: Results of a French national scale study

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The implementation of the Water Framework Directive (WFD) requires the monitoring of micropollutants in the aquatic environments to prevent any damages to both human health and ecosystems. In this context, a number of 105 organic and inorganic compounds have been selected as priority pollutants and their measurement is necessary to ensure that water-quality standards are maintained (EC, 2008; EC, 2013; EC, 2015). For two decades, passive sampling methods have been developed for the monitoring of organic and inorganic compounds. Passive samplers allow measuring these compounds at trace levels by accumulation and concentration over long-term exposure. Moreover, the use of integrative passive samplers allows a better representativeness of measurements because it takes into account the episodic pollution. Such passive sampling techniques have been recommended in the European Commission Guidance Document on surface water chemical monitoring, as complementary methods to improve the level of confidence in water monitoring data in comparison with conventional spot sampling. In this context, French government relied on the expertise of AQUAREF consortium to set up a national scale study in order to demonstrate the relevance and limits of passive sampling for the regulatory monitoring of contaminants in fresh and marine surface waters. To achieve this objective, (i) a total of 427 POCIS and 276 DGT were deployed during one year, every 2 weeks on 3 different sampling stations (temporal approach) and (ii) a total of 342 POCIS, 106 DGT and 229 SR were deployed during 2 weeks on 20 sites spread throughout France (spatial approach). For these 2 approaches, spot samples were systematically retrieved during deployment and recovery of IPS. Mean concentrations obtained by the IPS and grab water samples were compared in order to assess the limits and the relevance of these two methods in the frame of regulatory monitoring. The results of this national scale study aim at proposing guidelines for the monitoring of micropollutants by the IPS. Especially by concluding on the relevance of using replicates, the use of field blanks, the determination of exposure times and to propose recommendation such as the necessary number of campaigns in the year. The results also showed that IPS are relevant to obtain a spatial ranking of micropollutant contamination by a unique deployment on several sites.

WP168 Alternative passive samplers for non-invasive assessment of human pollutant exposure

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Persistent and bioaccumulative organic pollutants remain a risk factor for human health around the globe. Monitoring the human exposure to these pollutants, however, relies heavily on invasive sampling methods. Shifting towards non-invasive sampling methods can therefore increase the accessibility of samples for environmental and human health research. Recently, silicone wristbands have been established as passive samplers to describe human exposure to hydrophobic chemicals. A shortcoming of this approach is the lack of information on the origin of sampled compounds, as the wristbands are exposed to both external (e.g. dust-associated or airborne) and dermally excreted compounds, making the assessment of external vs. internal exposure difficult. To address this problem, our project aims at the development of a non-invasive sampling method that focuses on exposure measurement via skin contact and thus more accurately represents internal contaminant burdens. For this purpose, silicone sheets are directly attached to the skin and shielded from the surrounding environment with an isolation layer. Two protective layers are tested for their contaminant-blocking capability: fabric layers, creating a passive, physical barrier, and activated carbon-impregnated fibers that can trap compounds before they reach the silicone sampler. The tests are initially carried out as “sandwich” experiments, in which the test materials are positioned between a donor medium spiked with model contaminants, and the silicone passive sampler sheet as a receptor. In a second step, the isolated silicone sheets are tested in comparison to non-shielded silicone sheets and simultaneously worn wristbands on volunteers. The function of the isolation layer will be verified with an additionally worn silicone sheet isolated towards the skin. Unlike the established sampler, these controls are expected not to accumulate tracer compounds that are excreted from human skin, but not present in the environment (e.g. soy flavonoids). Altogether, the newly developed samplers have the potential to reduce random effects on data variation in non-invasive human exposure assessment. In addition to the potential of focusing on internal exposure, the silicone sheets permit a larger sampling area and a more reproducible skin contact than wristband samplers. In larger-scale applications, this setup can help to increase the potential for identifying exposure risks to the general public.

WP169 Silicone Wristbands as Personal Passive Samplers: Evaluating Exposure to Organophosphate Flame Retardants Based on Electronics Use

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Organophosphate flame retardants (OPFRs) are used as additives in a variety of industrial and commercial products, such as furniture and electronics, to meet fire resistance standards. However, OPFRs have been associated with health effects, including neurotoxicity, hormonal changes, and cancer; therefore, insight into levels of exposure is necessary for health and risk assessments. An individual’s exposure to OPFRs can be measured using silicone wristbands as passive samplers, which utilizes equilibrium partitioning of a chemical between the solid phase (the sampler) and air to measure personal exposure to contaminants over time. Because OPFRs are frequently used in electronics, this study aimed to examine correlations between electronic use and personal exposure to OPFRs. Silicone wristbands were cleaned to remove surface contaminants and deployed to participants to wear for one week. Following deployment, the wristbands were extracted and 8 OPFRs were quantified using gas chromatography-mass spectrometry. While deployed, participants filled out a questionnaire indicating their weekly electronic use, which was used to draw correlations between electronics and exposure to OPFRs. Preliminary experiments with wristbands worn for three days found a variety of OPFRs including triphenyl phosphate, tris(2-chloroethyl) phosphate, and ethylhexyldiphenyl phosphate. The average concentration of OPFRs found on the wristbands was 356 ng/g with an average exposure rate of 118 ng/day. This project will be one of the first in Canada to use silicone wristbands as personal samplers to address exposure to OPFRs in relation to electronic use, and thus will prove useful in risk assessment due to the increasing use of electronics in society.

WP170 Using Contaminant to Polymer Mass Regression Relationships to Confirm PRC-inferred Equilibrium Concentrations in Passive Sampling

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For passive sampling-based measurements of the freely dissolved concentration (C_{free}) of nonpolar organic contaminants to be accurate, equilibrium conditions between the sampler and the surrounding environment must be established. Currently, methods for validating equilibrium for passive samplers include temporal sampling and polymer mass comparisons. While performance reference compounds (PRCs) are used to correct for equilibrium conditions. Both temporal sampling and polymer mass comparisons involve extra samples and deployments which have adverse logistical and financial costs. Using PRCs is the most logistically and financially sound method to infer equilibrium concentrations.
However, few investigations have independently validated if the PRC modelled estimates of $C_{\text{free}}$ are accurate. In this study, PRC-based estimates of polymer concentrations (used to estimate $C_{\text{free}}$) were validated using polymer mass comparisons to confirm the equilibrium status of target contaminants. At equilibrium, a strong linear relationship exists between target contaminant mass and polymer mass resulting a high coefficient of correlation ($r^2$) and low $r^2$ when equilibrium does not occur. Four thicknesses (i.e., masses) of low-density polyethylene (LDPE) were deployed in the water column of a PCB contaminated Superfund site. After 30 days with several $^{13}$C-labelled PCB PRCs, 27 target PCBs were quantified. Raw concentration data was analyzed using three commonly-applied PRC mass transfer models: first order (FO), non-linear least squared (NLS) and diffusion (DIF). When simply assuming equilibrium (no PRC modelling), lower molecular weight congeners had $r^2$ values from 0.65 to 0.97, confirming the assumption was viable. For all congeners above PCB52, the $r^2$ values were low (e.g., 0.00 to 0.58) indicating a linear relationship did not exist for 81% of the congeners. High $r^2$ values were highly inaccurate. For higher molecular weight congeners and assuming equilibriums above PCB8 to PCB126 (i.e., 0.79 to 0.96), for PCB8 to PCB126 and above, $r^2$ values ranged from 0.59 to 0.53 and representing 35% of congeners. These results validate the NLS and DIF models will generate $C_{\text{free}}$ values reflecting equilibrium conditions and correctly estimate exposures in aquatic environments while the FO model was unreliable for higher molecular weight congeners and assuming equilibrium was highly inaccurate.

**WP171 Developing a Polar Chemical Integrative Sampler for Neonicotinoid Pesticides with New Sorbent**

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Polar Organic Chemical Integrative Samplers (POCIS) have been used as a passive sampler to measure time-weighted average concentrations of various chemicals. However, efficient trapping of neonicotinoid pesticides with aquatic passive samplers such as POCIS can be challenging due to their hydrophilic nature. In a previous study, ENVI-Carb (EC), a non-porous graphitized carbon sorbent, was proposed as a possible receiving phase that has high affinity for neonicotinoids on the basis of the results of batch sorption experiments. In this work, sampling rates ($R_s$) for neonicotinoids by POCIS with EC were obtained and compared with those by POCIS with Oasis HLB (HLB). The POCIS used in this study was comprised of a receiving phase (220 mg of HLB or EC) sandwiched by PES membrane filters. To estimate $R_s$ of POCIS with EC and HLB, static renewal calibration experiments were conducted. The experiments were carried out in glass beakers containing 1 L sample solution with a stirring speed of 400 or 1500 rpm, placed in a thermostat at 20°C under a dark condition. The sample solution was prepared by tap water contained 200 ng/mL each of seven neonicotinoids, which were acetamiprid, clothianidin, dinofeturan, imidacloprid, nitenpyram, thiamethoxam, and thiacloprid. POCISs including EC or HLB as sorbent were placed in the glass beakers covered by aluminum foil. These samples were sacrificed for 1, 3, 7, 14, 21 and 28 days in triplicate. The sample solution was replaced every day with fresh sample solution to avoid effects of possible contamination and degradation of neonicotinoids on the experimental results. The flow velocities in the 1 L glass beaker under 400 and 1500 rpm calculated by alabaster mass losses were 1.0 and 18 cm/s, respectively. The higher velocity condition (1500 rpm) was considered to be similar to aquatic environmental conditions. The $R_s$ of neonicotinoids, except for nitenpyram, obtained by the calibration experiments of POCIS with EC and HLB were 0.039 ± 0.031 to 0.070 ± 0.024 and 0.077 ± 0.013 to 0.12 ± 0.048 L/day, respectively, under the low velocity condition, and 0.10 ± 0.011 to 0.18 ± 0.068 and 0.11 ± 0.16 to 0.26 ± 0.11 L/day under the high velocity condition, respectively. $R_s$ tended to be higher in the higher flow velocity. The notable result was that the time periods of the linear phase obtained using EC were longer than those obtained with HLB. The periods of linear phases were 7 to 28 days for EC and 3 to 14 days for HLB under the high velocity condition.

**WP172 New Methods and Applications of PUF Disk Samplers for Investigating Particles and Associated Chemicals in Air**

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Polyurethane foam (PUF) disk passive air samplers - including the conventional PUF-PAS sampler for ambient air as well as the dry deposition sampler (PAS-DD) - are simple to use, cost-effective and their electricity-free operation allows them to be deployed anywhere. The passive sampling approach trades-off temporally resolved data, possible with high volume active air samplers, for spatially resolved data that is relatively easily to obtain. In many instances, the spatially resolved data is a more relevant and pragmatic approach for investigating abundances in air, long-range transport behaviours, effectiveness of chemicals management measures (temporal trends), and for validating models. Very recently, the use of the PUF-disk samplers has been extended to investigations of particulate matter, including trace metals, black carbon, and microfibers. Particle deposition on PUF-PAS and PAS-DD samplers has been characterized through field calibrations, through particle deposition mapping studies using microscopic methods and by using computerized fluid dynamic models. Methods are also being developed to link contaminant burdens with indicators of toxicity for the mixture of chemicals in air (e.g. mutagenicity, cytotoxicity, oxidative potential) by using in vitro and chemical assays. These developments greatly extend the application scope of PUF disk samplers.

**WP173 Monitoring Emerging Contaminants in Wastewater-Impacted Vernal Pools Using Passive and Grab Sampling Techniques**

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Some of the active ingredients in pharmaceuticals and personal care products (PPCPs) can persist through wastewater treatment plants and be released into the environment. With recent advancements in analytical techniques, PPCPs are increasingly detected in wastewater effluent. However, PPCPs remain largely unregulated in the environment due to a lack of monitoring and understanding of the toxicological impacts they pose on the environment and human health. While research has focused on the presence of PPCPs in lotic waters (rivers and streams), this study aims to evaluate the temporal variability of PPCPs in lentic waters (specifically vernal pools) impacted by treated wastewater, using integrative and grab sampling techniques. In this study, the use of Polar Organic Chemical Integrative Sampling (POCIS) membranes will be compared to grab sampling techniques to monitor the presence and persistence of 40 selected PPCPs in 3 vernal pools receiving treated wastewater from spring through fall 2018 and 3 non-irrigated control sites. Overall, 35 of the selected compounds were detected at the study sites. In general, we note that POCIS tend to detect more compounds compared to grab water sampling. As POCIS can act like amphibian skin, we anticipate that POCIS may be used to interpret toxicological impacts of PPCPs on the declining amphibian population. In this way, we hope that future studies may be able to better inform researchers and policy makers on how PPCPs should be monitored in lentic systems and how vernal pools are evaluated as critical habitats for amphibians.
Micro- and Nano-Plastic Methods Research: Harmonizing Methods and Addressing Challenges

WP174 Identification and Classification of Microplastic Particles Using Machine Learning Algorithms

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The widespread distribution of microplastics has attracted increasingly more attention due to their potential effects on human and ecosystem health. One fundamental step in microplastic studies consists of the identification and classification of microplastic particles in a given sample. Currently, this process relies heavily on manual labor, including picking the possible microplastic particles under a microscope and confirming their nature using infrared or Raman spectroscopy. This process is time-consuming, prone to human error, and requires expensive spectroscopic techniques and expertise to interpret data. The goal of this research is to propose an alternative method based on machine learning algorithms to predict the microplastic composition of a given sample. For that, we are using data that can be readily measured, for example, the total mass of particles in a given size range. A model relating microplastic counts to simple descriptors such as mass will be developed. Training data from our laboratory and nearby research groups will then be collected and a variety of methods will be applied to the model, including linear regression, logistic regression, and kernel method. The hypothesis is that with the tuned model, more than 90% of the microplastic particles in a given sample can be identified without undertaking complex experimental procedures. If successful, this method can save a large amount of time and effort for people who need a preliminary report on microplastic count in a given sample, in particular in underdeveloped areas where advanced laboratory equipment is unavailable.

WP175 Comparison of microplastic isolation and extraction methods for marine sediment

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Microplastics are a growing concern in our environment. Methods for the isolation and extraction of these small particles (1-1000nm) from environmental media vary widely and prevent meaningful comparison among reported environmental concentrations. As microplastics become biofouled and aggregate in the water column, sediments become their ultimate sink. We quantified recovery among five commonly used extraction/isolation methods for sediments that were chosen to represent a wide range of approaches in the literature. We tested each of the five methods with five polymers: polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC), polyethylene terephthalate fiber (PET) and polypropylene (PP) rope in a variety of shapes and sizes including flakes, fibers and spheres ranging from 40-700 mm. All combinations of methods and plastics were tested in two marine sediment types (i.e., sandy and silty). In addition to the five tested methods, we used Nile Red staining post extraction on all methods to determine if the stain increased recovery of spiked plastics. Mean recoveries of microplastics ranged from 0-87%, depending on method, polymer and sediment type. No one method recovered all plastics with the same efficacy, and all methods had mean recoveries <70% per plastic type. As expected, denser plastics were not recovered by lower density salt solutions. Organic matter present in silty sediments increased the complexity of recovery and probably reduced method success. The Nile Red stain increased the fluorescence background in complex, organically rich samples further confounding recovery. Lessons from this investigation provide valuable information for developing a hybridized method for the isolation and extraction of MPs from marine sediments (see Cashman et al. 2019 poster). In addition, we recommend using a standardized mixture of weathered microplastics to quantify method performance.

WP176 Microplastics in the St. Lawrence river: Methodological development for extraction and identification in biota

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Microplastics are increasingly considered as priority substances because of their ubiquity and their potential toxic effects on the environment. These particles are extremely diverse in size, shape, composition, chemical additives, associated contaminants, and fate in the environment. It is essential to develop methods of analysis, monitoring and toxicity evaluation to accurately identify the sources of microplastics and to assess their impact for the aquatic environment. Currently, very limited data are available for the St. Lawrence River, Canada. This study aims to: 1) develop methods of extraction and analysis of microplastics in water and aquatic organisms representative of the St Lawrence River ecosystem 2) To evaluate the bioavailability of model particles under controlled exposure and 3) To identify sources of microplastics in the river through caging experiments in urban effluent-impacted sites and agricultural-impacted sites. In a preliminary work, two protocols of extraction were compared for several types of freshwater bivalve tissues (Elliptio complanata and Dreissena bugensis). The effect of digestion techniques on microplastic analysis by fluorescence microscopy and infrared spectroscopy was assessed. In a second step, zebra mussels were exposed in laboratory to two types of polymers (PA6 and PMMA) in order to characterize the kinetic uptake and tissue distribution of these particles. To identify potential sources of microplastics in the St. Lawrence River, Elliptio complanata, an indigenous and ecologically important freshwater mussel collected from a pristine site, was caged in several effluent-impacted sites and agricultural-impacted basins. Digestive gland and gills were dissected to quantify and characterize microplastics caged organisms. Our findings validate a method for extracting microplastics in freshwater bivalves, without compromising the characterization of polymers and provide information on the ingestion mechanisms of model microplastics. This is also the first assessment of microplastics in freshwater mussels in the St. Lawrence River.

WP177 When ‘natural’ microfibers are not natural: A method for identifying anthropogenic cellulose-based microfibers in different environmental media

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Microfibers in the environment can be categorized as synthetic, semi-synthetic or natural based on the material of origin. Microfibers classified as ‘natural’ fiber are often assumed to be an environmentally friendly material compared to synthetics, however cellulose textiles can often contain additives and dyes which may influence its persistence and toxicity in the environment. In addition, cellulose fibers have been found in higher concentrations in the environment than synthetics where reported. Characterization of microfibers through spectral analysis, via Raman or FT-IR spectroscopy, can help differentiate between material types. However, different cellulose materials, such as cotton, linen or hemp, all contain varying proportions of cellulose, and spectral analysis techniques lack the ability to differentiate between specific types of cellulose fibers, resulting in a non-specific cellulosic spectral signature. Here we propose a decision-tree method for identifying different cellulose-based fibers using a combination of their spectral signature and morphology. Further, we propose categorization of cotton fibers as ‘anthropogenic’ or ‘unknown origin’ based on the presence of man-made dyes or additives. This method
was tested for cotton by comparing cellulosic-based fibers found in various environmental compartments to cotton fibers released when washing 98-100% cotton textiles. Moreover, the method was successful in identifying cellulosic microfibers across various environmental compartments, including sediment and biota, despite varying extraction techniques. Use of the method has indicated that cotton made up ~85% of cellulosic fibers found across environmental samples, with ~75% of these fibers being of anthropogenic origin. In order to accurately identify sources, evaluate persistence, and assess solutions to the widespread contamination of cellulose fibers, there is a need to be able to accurately identify cellulosic-based microfibers.

**WP178 Development of a non-invasive technique for estimating microplastic ingestion in a large carnivore: Polar bear**

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Polar bears (Ursus maritimus) are known to bioaccumulate some of the highest concentrations of contaminants of all Arctic species, yet little is known about ingestion and excretion of microplastics in these large carnivores. A newly published review of polar bear ecotoxicology emphasizes how little knowledge exists on this, but suggests that polar bears are unlikely to ingest considerable amounts of plastics through their prey because they mainly feed on seal blubber. However, as sea ice extent shrinks as the Arctic warms, the polar bear diet could be changing and exposing them to more plastics through ingestion. Considering the ubiquity of plastics in the Arctic, coupled with the possibility of climate-induced shifts in polar bear diet, it is prudent that exposure of polar bears to plastics in the Canadian Arctic be assessed. To our knowledge, there are no peer-reviewed publications that have empirically assessed microplastic exposure in polar bears, nor are there standardized techniques used to assess microplastics in large carnivores using non-invasive sampling. With a fast-changing northern landscape, conducting an assessment of polar bear scat, specifically focused on plastics, would assist in better defining the extent of this issue. In this pilot project, we use hunter-collected scat from Nunavut as a means of evaluating exposure of polar bears to plastics, and generate the first spatially resolved data set on contemporary levels of plastics in polar bear scat in the Canadian Arctic. This project is part of a larger effort called ‘BearWatch’ (http://bearwatch.ca/) that seeks to develop non-invasive, scat-based tools to assess numerous aspects of polar bear health.

**Engineering, Remediation and Restoration**

**WP179 The challenge of measuring activated carbon dose in sediments**

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Activated carbon (AC) is used as an amendment for in situ remediation of persistent organic pollutants (POPs) in contaminated sediments. In situ application of AC at a dose of 1-5% by weight has been demonstrated to significantly reduce bio-uptake into aquatic food webs. The most important factors in the success of the technology are the application of the correct dose of AC, uniformity of the dose in the treated area, and persistence of the applied AC dose over time. However, there is no standard method to measure the amount of AC in sediment, and researchers have used a variety of techniques including measures of total organic carbon, loss on ignition, traditional black carbon determination, and a specialized method for AC. In this work, two different carbon treatments (AC and Biochar) were measured for the amount of black carbon after several years of implementation in multiple field pilot studies. Three analytical methods (loss on ignition, total organic carbon, and specialized AC measurement) were compared for the efficacy of measuring the amount of black carbon present in the sediments for several different sites. A comparison of the accuracy and precision of each method and recommendation for adoption is presented in this study. Accurate measurement of AC in sediments as demonstrated in this study is necessary to build confidence in the adoption of in situ remediation of sediments.

**WP180 Naphthalene Desorption Kinetics and Degradation Rates in Activated Carbon**

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Sequestration of hydrophobic organic contaminants (HOCs) in sediments by activated carbon represents an efficient and well-established practice to reduce mobility in the environment, control bioavailability, and minimize biomagnification. Desorption can diminish the effectiveness of the sequestration, impacting risk assessment and design feasibility. The presence of HOCs facilitates the in situ development of indigenous microbial communities able to biodegrade such toxic compounds. Biological degradation coupled to desorption improves the performance of activated carbon placements, as desorbed toxic compounds are transformed into benign products by the growing microorganisms. The objectives of this study are to elucidate desorption and biodegradation kinetics of HOCs sorbed onto activated carbon, and model biodegradation rates in a system mimicking in situ capping or treatment. Batch experiments were prepared using activated carbon, artificial water, and cultures enriched from lake sediments heavily contaminated by HOCs. Sand and sterile microcosms were used as controls. Naphthalene was used as model contaminant because of its high mobility within solid and aqueous phase. Aerobic and anaerobic microcosms were monitored for naphthalene concentrations, and microbial community composition was examined to follow the impact of desorption rate on the indigenous microbial community. Substantial increases in naphthalene mineralization is observed in activated carbon amended systems, even under anaerobic conditions. No significant degradation enhancement was observed in sterile or sand microcosms. Desorption from activated carbon facilitates sustained biodegradation rates, while batch systems containing inert materials such as sand cannot support degradation.

**WP181 Adsorption of Malachite Green from Aqueous Solution of Binary Dye Mixture using Carbonized Weeds (Gliricidia sepium and Chromolaena odorata)**

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Rising industrial activities and human population has brought about the introduction of different pollutants into the environment. Water pollution mostly comes from wastewaters containing different types of contaminants, including dyes. The discharge of highly coloured effluents into natural water bodies is aesthetically displeasing, and reduces light penetration thereby affecting biological processes in the aquatic environment. Some dyes are also toxic to humans, and can be resistant to natural biological degradation. Hence, their removal from effluents is of great importance to human and environmental health. Adsorption has been recognized as an efficient wastewater remediation technique. However, the high cost of commercial activated carbon is a concern. As a contribution to the efforts towards getting low-cost but adsorbents, this study investigated the potential of carbons prepared from two weeds, Gliricidia sepium and Chromolaena odorata, for removing dyes from aqueous solutions by adsorption. Leaves of the two weeds collected from and around Ladoke Akintola University of Technology, Ogbomoso, Nigeria were washed with distilled water, dried, ground and carbonized in SX-4-10 England Labsciences Furnace at 300 °C for 20 minutes to obtain the adsorbents. The two adsorbents were characterized using SEM and FTIR; and batch adsorption experiments were conducted to study the influence of different parameters on the adsorption of Malachite green dye from
single and binary systems. The experimental data subjected to different isotherm and kinetic models were better fitted to Freundlich isotherm and Pseudo-second order kinetics models. The adsorption processes were thermodynamically spontaneous (except for the binary system at low temperatures) and increased with increasing temperature (-0.585 to -9.81 kJ/mol); they were endothermic and with increased entropy. The presence of crystal violet had synergistic effect on the adsorption of Malachite green.

**WP182 Selective sorbents for the in situ immobilization of iodine-129 and technetium-99 at the Four-Mile Branch Seepline**

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Long-lived isotopes like iodine-129 (129I) and technetium-99 (99Tc) are the primary risk drivers at the Savannah River Site (SRS) and other Department of Energy (DOE) facilities. As high yield fission products, both isotopes are generally found together in nuclear waste materials, and both display very limited adsorption to common soil minerals. On the SRS, facilities in F Area discharged hazardous waste from 1955 through 1988 to a series of unlined seepage basins located up-gradient from Fourmile Branch Stream. Recent studies have demonstrated the difficulty in developing a single remediation strategy that targets multiple contaminants with disparate chemical properties, more specifically 129I and 99Tc. In an effort to address this complex problem, a series of criteria were identified to aid in choosing an appropriate in situ remediation strategy to specifically address 129I and 99Tc based on their disparate chemical properties. Additionally, the remediation strategy must be cost effective, compatible with ongoing remediation efforts and acceptable to stake holders. The primary objective of this study was to evaluate selective sorbents for the in situ immobilization of 129I and 99Tc. Sorbents tested include Porous Iron Composite (PIC) materials (with some that incorporate copper (Cu) and silver (Ag) into the materials), granular activated carbon sorbents impregnated with various metals (i.e., Cu, Ag, Fe), reagent grade Zerovalent Iron (ZVI), and a commercial Fe-oxide based sorbent. A limited set of batch sorption tests were conducted using both 129I and 99Tc and non-radioactive analogues to evaluate the sorption capacity for each of the tests sorbents. Iodine-129 and 99Tc concentrations were chosen to reflect current conditions at the seepline. The samples were repeatedly spiked until the retention capacity was exhausted. After each contaminant exposure period, pH and ORP of each sample was measured, and a small aliquot of the batch solution was analyzed by low-energy gamma analysis or liquid scintillation counting (LSC). Samples were analyzed to evaluate the fate of various nitrogen species that occur within the plume. Trends with respect to batch pH, ORP and nitrogen speciation were used to test whether the non-rad batch tests were directly comparable to those using 129I and 99Tc.

**WP183 Biosorption of cadmium from aqueous solution using Cunninghamamella bertholletiae isolated from soil**

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Heavy metals discharge from industrial effluent of different industries has become a serious environmental problem. Cadmium (Cd) is one of the most deleterious trace heavy metals to plants and animals. The objective of this study was to evaluate the utilization low-cost biomass of Cunninghamamella bertholletiae in the removal of Cd2+ from wastewater. In this investigation, the performance of C. bertholletiae biomass was checked at different biosorbent doses, pH, temperature, contact time and agitation speed were checked. Four isotherm models were selected to fit the experimental data, namely Langmuir, Freundlich, Sips and Redlich–Peterson isotherm models. Using the expression \( \Delta G = RT \ln k \), the spontaneity of the process was evaluated. The Cd2+ removal was optimal (absorptive capacity (Qe) of the biosorbent was found to be 91.3) at pH 4.2, temperature =350C, biosorbent dose=0.35g, contact time=20 min, and agitation speed=140rpm. The biosorption of Cd2+ was estimated using Freundlich isotherm (n=1.8; KF=3.27; R2 = 0.911) and was thermodynamically feasible (\( \Delta G_0 = -45.2 \text{mol}^{-1} \)). Thus the reaction was spontaneous and the biosorption process followed pseudo-second order kinetic pattern. The outcome of the current study showed that the dried biomass of C. bertholletiae has potential for removal of Cd2+ from wastewater.

**WP184 Response surface methodology approach for the optimization of removal of Pb2+ from aqueous solution by immobilized cells of Sporobolomyces sp**

*K.O. Chukwu, C.O. Onwosi, University of Nigeria, Nsukka / Department of Microbiology*

Owing to the progressive development in technological and industrial activities, heavy metals are unavoidably introduced into the environment. Since a significant amount of these heavy metals are toxic, it is crucial to find an appropriate solution for their disposal. Microorganisms are reliable option for removing heavy metals from a contaminated environment. The objectives of this study are to assess the effectiveness fungi isolated from waste battery dumpsite in removal of lead from aqueous solution and to optimize the biosorption process using relevant models. The strain, identified as Sporobolomyces sp. immobilized on Careca papaya fibrous network was applied in bioremediation of Pb2+ in aqueous medium. The central composite design (CCD) was used to optimize the biosorption process, with three factors: pH, initial metal concentration, concentration of the biosorbent. The ability of the isolates to remove heavy metals from aqueous solution was evaluated using isotherm (Langmuir and Freundlich), kinetics (Pseudo-first and -second order) and the thermodynamics (AGo). The CCD revealed that the absorptive capacity (Qe = 81.9) can be achieved using the combination of the following factors: pH = 4.5; initial cadmium concentration= 141.9mg/L and bioborbent dose = 0.2g. The biosorption of Pb2+ was estimated using Langmuir isotherm (qmax = 144.24; KL = 0.04; R2 = 0.962) and was thermodynamically feasible at high temperature (AGo = +79.69 Jmol-1). The biosorption followed pseudo-second order kinetics. In conclusion, the isolate from waste battery dumpsite has potential for heavy metal removal from wastewater.

**WP185 Bioremediation of petroleum-polluted soil using rhamnolipid biosurfactant produced by Pseudomonas nitroreducens**

*C.O. Onwosi, University of Nigeria / Department of Microbiology*

Oil pollution has caused untold hardships to the oil-producing nations such as Nigeria. Efforts have been made to find suitable means of controlling this pollution. One of such ways is the use of microbial-derived surfactants. The objective of this study was to produce rhamnolipid biosurfactant using Pseudomonas nitroreducens isolated from petroleum-polluted soil and to compare the produced biosurfactant with chemical surfactants in the remediation of oil pollution. The production of rhamnolipid in laboratory batch shake flask using P. nitroreducens isolated from petroleum contaminated soil was investigated in the present study. The emulsification properties of the rhamnolipid were monitored. The effects of pH, temperature and salt concentration on the emulsification properties of the biosurfactant were monitored. The maximum activity of the rhamnolipid was recorded at pH 5. Increase in salt concentration (2 - 10%) enhanced emulsification activity while variation in temperature from 30-70°C had a slight effect on the emulsification properties of the rhamnolipid. pH and temperature also had effects on the ability of the rhamnolipid biosurfactant to stabilize olive oil and kerosene. The maximum stabilities of - 4.9d-1 and - 5.89 d-1 were recorded at temperature of 60°C and pH 8 respectively for olive oil. And for kerosene, the maximum stabilities of - 4.578 d-1 and - 4.622 d-1 were recorded at pH 5 and temperature 100°C. Also the activity of the rhamnolipid was compared with other chemical findings show that the rhamnolipid can be utilized in both petroleum and industrial (oil mill) wastewater remediation.
WP186 Identification of genes involved in per- and poly-fluoroalkyl substance metabolism in the soil bacterium, Gordonia sp. NB4-1Y

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To date, perfluoroalkyl and polyfluoroalkyl substance (PFAS) biodegradation pathways have been inferred by studying mass loads in sewage treatment plants, or determined experimentally with in vitro studies examining PFAS biotransformations using mixed sewage inocula, sediment in microcosms, or in mammalian cell cultures, and extracts. While these studies are valuable, developing a deep understanding of the biochemical machinery driving biological PFAS biotransformations in the environment demands detailed examination of the specific genes and proteins involved. Building on pathways elucidated for fluoroelotolomer sulfonamidooalkyl betaine (6:2 FTAB) and 6:2 fluorotelomer sulfonate (6:2 FTSA) metabolism by the soil bacterium, Gordonia sp. NB4-1Y, the present study compared gene expression profiles of NB4-1Y exploiting either 6:2 FTAB, 6:2 FTSA, octane sulfonate and magnesium sulfate as the primary source of sulfur for growth. High-throughput sequencing of mRNA from exponentially growing NB4-1Y allowed for the identification of 2 nitrotolriacetate monoxygenase genes (ntaA) as being differentially expressed on exposure to 6:2 FTSA, enzymes which are hypothesized to catalyze 6:2 FTSA desulfonation, a novel activity for this enzyme class. Other genes that were observed to be differentially expressed include: 4 genes putatively involved in C-N bond cleavage in 6:2 FTAB; 4 genes putatively involved in dehalogenation and acetyl-CoA addition to the fluorinated alkane backbones of 6:2 FTAB and FTSA; 17 stress response genes; and 8 genes related to sulfur starvation. Of 14 genes annotated as taurine dioxygenase (tauD), alkane sulfonate monoxygenase (ssuD) or nitrotolriacetate monoxygenase (ntaA), 4 were upregulated on 6:2 FTSA, 6:2 FTAB and octane sulfonate, 6 were upregulated on 6:2 FTSA and 6:2 FTAB, 1 was upregulated on 6:2 FTSA, and 3 were not expressed under any condition. In combination with proteomic analyses, genes of interest are being cloned and expressed to allow for identification of structural features that allow the enzymes to interact with PFAS breakdown products. This work is improving understanding of the molecular mechanisms of PFAS metabolism and will allow for the development of site assessment tools to inform remediation practitioners of the biological potential for PFAS removal, thus guiding treatment decision making processes.

WP187 Biochar reduces the toxic effects of imidacloprid to Eisenia fetida

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The effects were assessed by introducing E. fetida biochar amendment on the toxicity of imidacloprid to life cycle parameters and biomarker responses of an oligochaete species, Eisenia fetida. The effects were assessed by introducing E. fetida in non-amended soil and soil amended with 10% biochar, spiked with 0, 1, 3, 3.5, 4, 6 and 4 mg imidacloprid/kg for 28 days. The LC50 value of 5.4 mg/kg was only computed in the non-amended soil yet not for biochar amended soil because of insignificant mortality. Moreover, EC50 of 1.83 mg/kg for no-amended and 1.96 mg/kg for amended soil was obtained. Significant weight loss was observed at two highest treatments for non-amended soil and only at the highest treatment for amended soil. CAT activity decreased significantly at two highest concentrations of non-amended soil yet in the amended soil a significant increase was observed at two highest concentrations. In all non-amended treatments, there was a significant AChE inhibition while lower inhibition percentages were observed in biochar amended soil. Nevertheless, more studies would be needed to optimize the easing effects of biochar on the toxicity of these chemicals.

WP188 Upgrading biochar via co-disposal of agricultural biomass and polyethylene terephthalate wastes

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Spent polyethylene terephthalate (PETE) bottles were collected and co-pyrolyzed with rice straw (RS) to examine the characteristics and performance of biochar as a sorbent for various types of USEPA priority pollutants, including 2,4-dinitrotoluene (DNT), 2,4-dichlorophenol (DCP), Pb, chrome (CrO42-), and selenium (SeO42-). During sorption of contaminants to PETE/RS-derived biochar, PETE residues from pyrolysis, pH, and pyrolysis temperature greatly affect the sorption of contaminants. Depending on the types of contaminants and experimental conditions, co-pyrolysis of PETE and RS may enhance the sorption of contaminants through different sorption mechanisms, including hydrophobicity, electrostatic force, ion exchange, surface complexation, and surface precipitation. Unlike other contaminants, selenium was reductively transformed by delocalized electrons from graphic structure in biochar. Our results strongly suggest that co-pyrolysis of PETE and agricultural wastes may be favorable to enhance the properties of biochar. In addition to syn-gas and bio-oil from the co-pyrolysis, biochar may be a valuable by-product for commercial use.

WP189 Enhanced phytoremediation of industrial waste

J.O. Anyansi, University of South Africa / Environmental Sciences

The study entails an isolation of Bacterial endophyte from plant growing around a crude oil sludge dam. Based on morphological characterisation, gram reactions and 16S rDNA sequence analysis, the isolate was identified as Bacillus safensis strain CS4. Following the tests on the abiotic effects as well as the initial concentration of perylene on growth and degradation efficiency of the strain, a total degradation percentage of 87 % was observed from the initial concentration of 30 mg/l for one week. Analysis of the degradation products of perylene using GC-MS/MS, indicated a shift from the previously degradation product of other bacterial endophytes showing that the strain provided a new pathway for PAH degradation. In order to evaluate the influence of a polycyclic hydrocarbon transforming ability of the bacterial strain on the phytoremediation of petroleum aromatic hydrocarbon (PAH), B safensis CS4 was inoculated into Chromolaena odorata plants. The plants were grown for 16 weeks with or without pyrene, chrysene, and perylene (500 mg/kg soil in each 1L pot) in non-sterile peat medium. Plants inoculated with the strain CS4 were much tolerant towards the phytotoxic effects of PAHs, in terms of biomass index, leaves and stem dry weight. Although the presence of plants acted as the main effective treatment for PAH dissipation (72-89%), the inoculum with the strain lead to the highest PAH removal (up to 91%). Uninoculated plant control planted in the contaminated soil was susceptible to the phytotoxicity of the contaminants in the parameters tested. The study therefore presented the strain as a suitable plant endophyte for enhanced phytoremediation of industrial waste.

WP190 Phytoextraction Efficiency and Effects of Ascorbic Acid on the Tolerance Mechanism of Water Hyacinth (Eichhornia crassipes) in a Non-Hypotonic Medium

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The mean concentration of Cd and Mn in the root of E. crassipes were significantly (p < 0.05) higher than in the shoot across all the treatments. The bioconcentration factors for Cd and Mn were higher than 1000 with ascorbic acid treated groups having the highest values. The translocation factor values for Cd and Mn were lower than 1 across all treatment which shows that the metals were not mobile. Antioxidant enzyme activities in the Cd treated plants were enhance while a little reduction was observed for
manganese treated plants. The plants were collected from Oranyin River, Okitipupa Local Government Area of Ondo State, thoroughly rinsed under running bore-hole water (to remove dirt, sludge, and other debris) and acclimatized in plastic container of 7 L capacity with bore-hole water containing heavy metal concentrations at 0, 5.0, 10.0, 20.0, 30.0 and 40.0 mg/L for CdCl2 and 0, 5.0, 10.0, 15.0, 20.0 and 25.0 mg/L for MnCl2, for two weeks. The experiment was of two types: with and without optimization with ascorbic acid in triplicate which gives a total of 72 replications. Cadmium and Manganese concentrations in the root and shoot were measured using Buck Scientific Atomic Absorption Spectrophotometer.

Bio-concentration, Bio-translocation factors and the residual activities of selected antioxidant enzymes were determined. A major water pollutant of utmost concern is heavy metal and the phytoextraction potential of some macrophytes in heavy metals-polluted environment is based not only on their ability to uptake, translocate and accumulate metals but also on ability to mitigate toxicity. Most phyto remediation studies on aquatic plants have been carried out in a hypotonic solution. The phytoremediation potential and effects of ascorbic acid on antioxidant enzyme induction in Water hyacinth plant (Eichhornia crassipes) cultivated in a non-hypotonic medium, was investigated in this study.

WP191 Does gypsum enhance the pesticide mitigation ability of three aquatic plant species?

M. Moore, USDA-ARS / Water Quality and Ecology; M.A. Locke, USDA-ARS National Sedimentation Laboratory / Water Quality and Ecology Research Unit

Agriculture is heavily scrutinized because of potential pesticide runoff following irrigation or storm events. These potential contaminants can have deleterious effects on aquatic systems receiving agricultural drainage. While no “silver bullet” management practice exists to functionally remediate all agricultural-derived contaminants, combinations of practices are likely the industry’s best option to reduce agriculture’s contribution to global water contamination. To this end, twelve, 379 L mesocosms (1.32 m x 0.70 m x 0.66 m) were constructed by layering 16 cm of Lexington silt loam atop a base of 22 cm of washed sand. Three mesocosms (each) were planted with monocultures of either Leersia oryzoides L., Typha latifolia L., or Spartanium americanum Nutt. (n=9), while three mesocosms were left unvegetated to serve as controls. Gypsum (167 g) was added to each individual mesocosm to simulate a recommended field application (reduced for scale). Water amended with the herbicides diuron and glyphosate, as well as the insecticide diazinon (targeted exposures of 60 µg/L, 10 µg/L, and 1 mg/L, respectively) was pumped through each mesocosm using a metered piston pump to deliver an 8 h retention time for each system. After the 8 h exposure, pesticide-amended water ceased, and the system was allowed to sit for 40 h. Approximately 48 h following the original pesticide amendment initiation, the system was flushed with unamended water for another 8 h retention time to simulate effects of system flushing. No significant differences existed between the three plant species and unvegetated control when examining overall retention capacity of the systems for each of the three pesticides. For diuron, overall mitigation ranged from 56-65%, while diazinon mitigation was slightly higher (65-71%). Glyphosate overall mitigation was lowest, ranging from 45-56%. Control mesocosms lost significantly more glyphosate mass during the flush period than vegetated mesocosms. Based on the current results, gypsum amendments do not appear to enhance plants’ abilities to mitigate diverse pesticides in runoff water.

WP192 Short and long term efficacy of bioretention at sequestering PCBs in stormwater

R.A. Jack, King County / Department of Natural Resources and Parks

Stormwater has been identified as a significant ongoing source of PCBs to numerous Washington State waterbodies including Lake Washington, the Duwamish River, and the Spokane River. These loads have lead to 14 fish advisories; many recommending no consumption at all. Western Washington Municipal Stormwater Permits require the use of Low Impact Development (LID) where feasible and bioretention is a commonly utilized LID best management practice (BMP) in Western Washington. Bioretention is considered very effective at PCBs removal, but little is known about the longer-term retention rates of PCBs captured by this BMP. For Washington State stormwater design purposes, the default bioretention soil mixture (BSM) is 60% sand, 40% compost. This study used 208 L barrel mesocosms with both BSM alone and BSM plus plant treatments, each replicated three times. Mesocosms were dosed with high-traffic highway runoff for two years. The ultimate objective was to better understand how well default BSM captures and retains PCBs across seasons over a two-year period. The project addressed the following questions: 1. What is the PCB removal (capture) rate for BSM by storm, and does it vary by congener? a. Does newly installed default BSM perform differently than older BSM? 2. What is the wet season PCB sequestration (retention over multiple storm events) in the default BSM, and does this vary by congener? a. Compare sequestered mass of PCBs with estimated stormwater loads. 3. What is the PCB retention in default BSM during the dry season, and does it vary by congener? Because the chemical properties of PCBs vary by congener, PCB losses from the mesocosms were evaluated on both an individual congener basis, as well as total PCBs (sum of detected congeners). The congener-specific mass balance provides a conceptual model of PCB congener behavior in mesocosm bioretention cells, with and without plants. Combined, the conceptual model and mass balance describe the potential effectiveness of Western Washington bioretention cells over time to reduce PCB loadings to receiving water bodies. Given current large investments in stormwater infrastructure, it is important to ensure bioretention BMPs effectively sequester PCBs to reduce their circulation in the environment.

WP193 Biochemical analyses and microbial community dynamics in model constructed wetlands

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Previous research has demonstrated that constructed wetlands can enhance remediation of metals toxicity through a combination of biochemical mechanisms. Organic matter derived from plant root exudates and detritus function to make divalent metals biologically unavailable by forming complexes with metals to produce molecules too large to cross cell membranes. Furthermore, sulfide, produced by sulfate-reducing bacteria (SRB) during the oxidation of organic molecules, will also complex with divalent metal ions, which are precipitated and sequestered in the sediment layer. The objective of this project was to use model constructed wetlands to compare vegetation species for their ability to produce dissolved organic material and support SRB. This model used three species of hydrophytes, Canva x generalis, Pontederia cordata, and Carex stricta, arranged in a 12-tank model system. The system was designed with three replicates of each plant type, and three non-vegetated controls. Porewater extracted from tanks was routinely monitored for sulfate/sulfide, total organic carbon, and nutrients. Microbial DNA was extracted from the anoxic sediment layer using a MioBio Powersoil kit. The abundance of the SRB, Desulfovibrio vulgaris, was determined by qPCR using primers for the dsrA (dissimilatory sulfite reductase) gene. The abundance of Desulfovibrio desulfuricans, a SRB known for its ability to methylate mercury in wetland environments was determined using qPCR. The composition of microbial communities was evaluated using both phospholipid fatty acid analysis (PLFA) and 16S rRNA sequencing. The qPCR results indicated distinct differences between vegetated treatments versus controls, as well as differences between vegetation types. This was reflected by the amount of sulfide produced and the abundance of D. vulgaris. The microbial communities were equally diverse; however, differences in community structure were detected.
WP194 Influence of a Restored Urban Wetland on Nutrient Retention and Cycling: Preliminary Trends After Three Years of Enhanced Monitoring

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The 6.7-acre McDonogh Road wetland restoration on Scotts Level Branch in Randallstown, Maryland was completed in 2014, with ongoing post-construction mitigation monitoring since that time. In 2016, enhanced monitoring was initiated in addition to mitigation monitoring. The objectives of the enhanced monitoring were to 1) provide supplemental data on the functionality of the site for wildlife and wildlife habitat; 2) to determine if nutrient cycling in the restored wetland was increasing toward levels found in mature wetlands; and 3) to assess the site functioning in nutrient capture and retention. The three-year study included nutrient concentration sampling in sediment and plant tissue. Sediment and tissue samples were collected from the McDonogh Road site and upstream and downstream reference sites in mature forested wetlands. Samples were collected twice per year in May and August. Tissue and sediment data were analyzed using multifactor analysis of variance (ANOVA) and multiple comparisons to assess trends in nutrient development at the McDonogh Road restoration site in comparison with both upstream and downstream reference sites. Data were also assessed to determine trends across years and due to seasonality. Initial trends in nutrient concentrations in sediment and tissue show that the McDonogh Road restoration site is similar to reference sites for several key nutrients, including total organic carbon, bulk density, and phosphorus. Total Kjeldahl nitrogen concentrations in sediment appear to be increasing at the restoration site, but levels were lower than at the reference sites. Many parameters of wetland nutrient cycling can take years to develop to concentrations found in natural wetlands, but initial monitoring suggests that the site is performing several wetland functions and developing nutrient cycling. Continued monitoring of wildlife, plant tissue, and sediments with more replicates at less frequent time intervals is recommended to provide more statistically powerful data that still continues to provide valuable information on nutrient cycling development and increased nutrient capture.

WP195 In situ evaluation of using clean dredged material as an alternative to clean sand for enhanced monitored natural recovery

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Thin layer clean sand placement has shown merit towards Enhanced Monitored Natural Recovery (EMNR) as an alternative to dredging at low to moderately contaminated sediment sites. The use of uncontaminated natural sediment including clean dredged material, referred to here as sediment EMNR (sEMNR), allows uncontaminated sediment with a natural level of binding capacity (primarily associated with organic carbon and fines) to sequester contaminants, and further enhance recovery when compared with traditional EMNR. This study explored the use of locally available clean dredged material at a remote site as thin cover, in comparison with other increasingly common sediment remedies, at a mesocosm scale using field-deployed Remedy and Recontamination Assessment (RARA) arrays (SERDP ER-2537). The arrays provided a site-specific, direct measurement of performance of a range of remedies (activated carbon, two sources of clean dredged material, clean sand, control) while providing increased realism compared to laboratory treatability studies and reduced costs and complexity compared to pilot studies. The arrays were placed at a site in Pearl Harbor that is moderately contaminated with PCBs and metals and may be subject to EMNR following thin layer capping. Lines of evidence included bulk sediment chemistry, passive sampler/mowerate and invertebrate bioaccumulation assessment, benthic community recolonization, and potential recontamination from upstream sources based on sediment trap characterization, and other tools. All sediment remedies evaluated exhibited significant reduction of contaminants of concern relative to the native sediment for nearly all lines of evidence, with reductions generally a factor of 2-5 or more, while also meeting preliminary remediation goals. Statistically significant reductions with respect to bioavailability measures were reliably observed at 2- and 10-month monitoring periods for all treatments, with dredged material performing nearly as well as activated carbon in the short-term. Sediment trap material and 10-month surface sediment chemistry showed lower PCB and metal concentrations, suggesting that recontamination risk was low. These results suggest that clean dredged material is a viable, and potentially better, alternative to clean sand for EMNR applications, especially at sites where clean sand is not economically feasible, and where long-term storage of clean dredged material presents site-specific challenges.

WP196 Incorporating Unique Remedial Design Features to Facilitate Community and Stakeholder Acceptance of Bank Remediation along the South River (Virginia)

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Historically released mercury (Hg) from a textile manufacturing facility (Site) has accumulated on and adjacent to some bank areas of the South River, Virginia. Introduction of legacy Hg impacted soils to the South River through bank erosion is the most significant source of Hg loading to the system. Phase 1 Interim Measures are being conducted through a phased adaptive management approach with the objective of reducing or eliminating this source of loading to the river. The strategy is to progress from upstream to downstream, addressing areas of highest loadings in the first two river miles downstream of the Site; lessons-learned from each successive project are incorporated into the next project as appropriate. This phase of the program includes stabilization of approximately 6,000 linear feet of eroding riverbanks across several bank management areas (BMAs) with both public and private land ownership. The Shiloh Baptist Church BMA is the fourth Interim Measure project to be implemented in Phase 1. Due to its location and stakeholder preferences, several unique design features are being incorporated into the design to achieve remedial action objectives and gain community acceptance. Open communication with multiple stakeholder groups during the remedial design process identified several factors that were considered and accommodated in the final design. Additionally, lessons learned from previous Phase 1 Interim Measures were incorporated into the design and construction of this BMA to expedite construction, thereby reducing disruption to local stakeholders. This presentation will focus on progression of the unique design features for the Phase 1 IMs at Shiloh Baptist Church BMA, and discuss how these features facilitated acceptance by key stakeholders.

WP197 PCB degradation rates in soil: Results from a semi-field rhizoremediation experiment

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In the last two decades there has been a growing interest in bioremediation technologies which use plants and microorganisms to degrade organic chemicals such as PCB in contaminated soils (rhizoremediation). Different studies have been conducted to investigate the potential of
WP198 PCDD/Fs degradation rates in soil: Results from a semi-field rhizoremediation experiment

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In the last two decades there has been a growing interest in bioremediation technologies which use plants and microorganisms to degrade organic chemicals such as Polychlorinated Biphenyls (PCBs) and Dioxins and Furans (PCDD/Fs) in contaminated sites. These techniques represent a good alternative to traditional remediation technologies, being cheaper, not disruptive and more suitable for large contaminated areas. Different studies have been conducted to investigate the potential of plant-microbe interactions in the remediation of organic chemical contaminated soils with respect to natural attenuation, providing useful data such as chemical degradation rates (Kd) or half lives (HL). Such a type of data can be used to predict soil concentration temporal trend, as well as the time needed to achieve natural attenuation considering three different areas characterized by a high spatial variability of PCB and PCDD/Fs concentrations. Geostatistical techniques were used to build up remediation time maps for the three different areas. The aims were to: 1) couple a rhizoremediation half-live dataset to spatially variable concentration data, 2) evaluate the effectiveness of rhizoremediation when a complex contamination gradient is present, 3) compare the influence of natural attenuation vs. plant/microbe interactions on remediation time. Moreover, it showed that when a complex contamination gradient (spatial variability of concentrations, contaminant mixture, etc.) is present, rhizoremediation must be accurately implemented and fine-tuned (in terms of species to be selected, their density, etc) to account for effective remediation.

WP200 Sudbury, Ontario, Canada: 40+ Years of Healing a Smelter-Impacted Landscape through Creating Novel Functional Ecosystems

P. Beckett, Laurentian University / Biology; G. Spiers, Laurentian University / School of the Environment

Sudbury houses major nickel mining and smelter complexes. The impacts of sulphur gases from roast yards before 1928 through to the more modern smelter operations emitting sulphur gases and metal particulates created a barren landscape of ca 17000 ha and an additional 64000 ha of stunted forest. The accumulation of bioavailable and potentially toxic metal levels in the acid surface soils, accompanied by soil erosion, lack of organic matter and soil nutrient depletion, impeded natural vegetation recovery. The requirement for reduction of emissions (now 95%) from the largest smelter complex led to the construction of the 381 m Superstack employing gas and particle-capture technologies.

The stage was set for an assisted landscape recovery program. Over the past forty plus years the Sudbury Regreening Story, based on effective interaction between community, government, academia and industry, describes the regional transformational program now recognized globally as a model to emulate. The Sudbury Protocol for technogenic barren landscape restoration has evolved from regreening activities that involved application of dolomitic limestone, fertilizer, seeding of agricultural grasses, legumes and planting of tree seedling to a more complete biodiverse restoration strategy.using over 80 species. By 2018, 3478 ha had received soil amelioration and ca 10 million trees and shrubs had been planted for approximately $32.7 million while employing over 4775 individuals. The outcome of the Regreening Program is a new image for the city and environs which has helped to attract new...
Activated persulfate is a strong oxidant with the potential to degrade recalcitrant petroleum hydrocarbons (PHCs). Thermally activated persulfate (TAP) is gaining popularity as it does not require additional reagents and is most efficient as compared to other activation methods. Since PHCs can be highly sorbed to soil and desorption is a slow process, bioremediation following TAP treatment may be suitable to degrade residual PHCs that did not react with persulfate. Sulfate, generated after TAP oxidation of organics, can serve as a terminal electron acceptor and promote biodegradation under sulfate reducing conditions. However, the impact of TAP on the microbial community and activity has not been intensively studied. The partial oxidation products of PHCs after TAP treatment are not well understood. In this study, we conduct a combined treatment of TAP and biodegradation to remove PHCs. We use naphthalene (Nap) and phenanthrene (Phe) as the model compounds, as they are frequently present at high concentrations at PHC-contaminated sites, relatively recalcitrant to remediation, and catalogued as potential carcinogens. In our tests, persulfate concentrations are measured by a spectrophotometric method, and the concentrations of Nap and Phe are quantified by a headspace solid-phase microextraction method using a gas chromatography equipped with a flame ionization detector. In the first phase with solely TAP in batch assays, we determine the dosages of persulfate at various temperatures that lead to incomplete oxidation of Nap and Phe for later combined treatment, and assess the partial oxidation products of Phe and Nap by a gas chromatography-mass spectrometry. In the second phase, we include aqueous cultures in batch assays with known capability to degrade benzene or Nap under sulfate reducing conditions. We evaluate the overall removals of Nap and Phe, the bio-elimination of the products from partial oxidation by TAP, and the influence of TAP on organisms by running quantitatively polymerase chain reactions targeting the universal 16S rRNA genes and specific genes. In the last stage, we introduce synthetic soil to include the sorption phase in batch assays and columns to study the impact of TAP on microorganisms and the overall removals of Nap and Phe. Our study will improve the understandings of the effects of TAP on indigenous organisms and will provide design guidelines for application of TAP for remediation of PHC-contaminated sites.

Fate, Toxicology or Risk Assessment of Materials of Interest to the Military

WP201 Evaluating the Combined Treatment of Thermally Activated Persulfate and Bioremediation to Remove Petroleum Hydrocarbons

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We determined toxicity benchmarks for insensitive munition (IM) compounds 2,4-dinitroanisole (DNAN) and 3-nitro-1,2,4-triazol-5-one (NTO), developed to replace present munitions that contain highly sensitive explosives for future weapons systems. We adapted the earthworm toxicity test with Eisenia andrei (ISO 16387:2004) to determine DNAN and NTO toxicity in Sassafras sandy loam (SSL), a natural soil that has a “very high” qualitative relative bioavailability score for organic chemicals. Studies included exposures to DNAN or NTO individually freshly amended (F-A) or weathered and aged (W-A) in soil for 10 days in a greenhouse. Exposure data were analyzed using best fit regression models to determine IM concentrations producing 20% (EC20) or 50% (EC50) reduction of measurement endpoints compared with controls. Exposure to DNAN in F-A soil yielded EC20 concentrations (mg/kg) of 99, 102, and 112, and EC50 values of 128, 256, and 281 for cocoon production, juvenile production, and adult survival, respectively. The EC20 and EC50 concentrations for NTO in F-A soil were 429 and 596, respectively for cocoon production. Adult survival was not affected up to 2360 mg/kg NTO in SSL soil. Juvenile production was insufficient to determine ECx. Exposure to DNAN and NTO in W-A in SSL soil significantly increased reproduction toxicity. Exposure to DNAN in W-A soil yielded EC20 concentrations (mg/kg) of 55 and 91, and EC50 values of 91 and 67, for cocoon production, juvenile production, respectively. The EC20 and EC50 concentrations for NTO in W-A soil were 145 and 242 mg/kg, respectively for cocoon production. Adult survival was not affected up to 785 mg/kg NTO in SSL soil. Juvenile production was insufficient to determine ECx. Increased toxicity with W-A IM may be attributable to transformation products. Concentrations of the transformation products of DNAN (2-A-4-NAN and 4-A-2-NAN) increased during the test in proportion to soil concentrations of the parent material. Reproduction toxicity benchmarks determined in these studies will be used to develop individual Draft Ecological Soil Screening Levels for DNAN and NTO to fill existing data gaps.

WP202 Reproduction Toxicity of Insensitive Munitions Compounds for Soil Invertebrates

R.G. Kuperman, US Army CCDC Chemical Biological Center / Molecular Toxicology Branch; M. Simini, US Army CCDC Chem Bio Center / Research and Development Center; C. Thoennes, US Army CCDC Chemical Biological Center / Molecular Toxicology Branch; G.R. Lotufo, US Army Corps of Engineers / Environmental Laboratory

We determined reproduction toxicity benchmarks for insensitive munitions (IM) compounds 2,4-dinitroanisole (DNAN) and 3-nitro-1,2,4-triazol-5-one (NTO), developed for future weapons systems to replace present munitions that contain highly sensitive explosives. We designed our studies to meet regulatory requirements for developing Ecological Soil Screening Levels (Eco-SSL) for use in screening-level ecological risk assessment by adapting standardized toxicity test for the soil invertebrates earthworm Eisenia andrei (ISO 11268-2:1998), potworm Enchytraeus crypticus (ISO/16387:2005), and collembolan Folsomia candida (ISO 11267:1998) using exposures in Sassafras sandy loam (SSL). This soil has a “very high” qualitative relative bioavailability score for organic chemicals in natural soils. Studies included exposures to DNAN or NTO individually weathered and aged in soil (alternating wetting-and-drying cycles for 10 days in a greenhouse). Reproduction data were analyzed using best fit regression models to determine IM concentrations producing a specified percent effect (e.g., 20%) on the measurement endpoints. Reproduction of all species tested was affected by exposures to IM compounds in soil with EC20 concentrations (mg/kg) of 55 (cocoon production) and 42 (juvenile production) for earthworms, 16 (juvenile production) for potworms, and 27 (juvenile production) for collembolans. The EC20 concentrations for NTO were 145 (cocoon production) for earthworms, 16 (juvenile production) for potworms, and 63 (juvenile production) for collembolans. Reproduction toxicity benchmarks determined in these studies will be used to develop individual draft Eco-SSLs for DNAN and NTO and to fill the existing data gaps in current knowledge of the potential ecological risks of release of IM compounds into soil.

WP203 Toxicity of Insensitive Munitions Compounds to Earthworms

M. Simini, US Army CCDC Chem Bio Center / Research and Development Center; G.R. Kuperman, C. Thoennes, US Army CCDC Chemical Biological Center / Molecular Toxicology Branch; G.R. Lotufo, US Army Corps of Engineers / Environmental Laboratory

We determined toxicity benchmarks for insensitive munition (IM) compounds 2,4-dinitroanisole (DNAN) and 3-nitro-1,2,4-triazol-5-one (NTO), developed to replace present munitions that contain highly sensitive explosives for future weapons systems. We adapted the earthworm toxicity test with Eisenia andrei (ISO 16387:2004) to determine DNAN and NTO toxicity in Sassafras sandy loam (SSL), a natural soil that has a “very high” qualitative relative bioavailability score for organic chemicals. Studies included exposures to DNAN or NTO individually freshly amended (F-A) or weathered and aged (W-A) in soil for 10 days in a greenhouse. Adult survival and reproduction data were analyzed using best fit regression models to determine IM concentrations producing 20% (EC20) or 50% (EC50) reduction of measurement endpoints compared with controls. Exposure to DNAN in F-A soil yielded EC20 concentrations (mg/kg) of 99, 102, and 112, and EC50 values of 128, 256, and 281 for cocoon production, juvenile production, and adult survival, respectively. The EC20 and EC50 concentrations for NTO in F-A soil were 429 and 596, respectively for cocoon production. Adult survival was not affected up to 2360 mg/kg NTO in SSL soil. Juvenile production was insufficient to determine ECx. Exposure to DNAN and NTO in W-A in SSL soil significantly increased reproduction toxicity. Exposure to DNAN in W-A soil yielded EC20 concentrations (mg/kg) of 55 and 91, and EC50 values of 91 and 67, for cocoon production, juvenile production, respectively. The EC20 and EC50 concentrations for NTO in W-A soil were 145 and 242 mg/kg, respectively for cocoon production. Adult survival was not affected up to 785 mg/kg NTO in SSL soil. Juvenile production was insufficient to determine ECx. Increased toxicity with W-A IM may be attributable to transformation products. Concentrations of the transformation products of DNAN (2-A-4-NAN and 4-A-2-NAN) increased during the test in proportion to soil concentrations of the parent material. Reproduction toxicity benchmarks determined in these studies will be used to develop individual Draft Ecological Soil Screening Levels for DNAN and NTO to fill existing data gaps.
WP204 Bioaccumulation of Insensitive Munitions in Soil and Aquatic Organisms

G. R. Lotufo, US Army Corps of Engineers / Environmental Laboratory; R. E. Boyd, US Army Engineer Research and Development Center / Environmental Laboratory; A. Harmon, US Army Engineer Research and Development Center; M. Simini, US Army CCDC Chem Bio Center / Research and Development Center; R. G. Kuperman, US Army CCDC Chemical Biological Center / Molecular Toxicology Branch

We investigated the bioaccumulation potential of the insensitive munitions (IMs) 2,4-dinitroanisole (DNAN), 3-nitro-1,2,4-triazol-5-one (NTO) and methyl-nitroguanidine (MeNQ), developed for future weapons systems to replace present munitions that contain sensitive explosives. We exposed the earthworm Eisenia andrei to Sassafras sandy loam (SSL) soil freshly spiked with sublethal concentrations of DNAN or NTO. This soil has a “very high” qualitative relative bioavailability score for organic chemicals in natural soils. Formation of 2- and 4-amino-nitroanisole (2A-4NAN and 4A-2NAN) occurred in spiked soils, but never at concentrations higher than that of DNAN. SumDNAN (sum of 2A-4NAN, 2A-4NAN, and 4A-2NAN) in soil decreased during the exposure period (14 d), more so in the presence of earthworms, likely driven primarily by irreversible binding. SumDNAN body residue in earthworms increased up to day 3 and decreased thereafter. Between days 3 and 14, the decrease in bioaccumulation (73%) was greater than the decrease in the soil concentration (23%) suggesting that irreversible binding may occur in the tissues. At day 14, DNAN accounted for only 45% of SumDNAN, with 2A-4NAN, and 4A-2NAN accounting for 55%. The highest bioaccumulation factor (BAFs: ratio of the tissue to soil concentration), 6.2 kg/kg (dry wt.) was measured at day 3 and the rate of uptake was 2.0 kg/kg/d. The rate of elimination of DNAN in clean soil was fast, 1.49 d-1. The concentration of NTO in spiked soil (initially 800 mg/kg) decrease by 57% during 14 d, likely because of formation of unknown transformation products. NTO accumulated at negligible levels in earthworms (BAF = 0.018 kg/kg dry wt.). Using spiked aqueous medium, low bioconcentration factor (BCF; 0.13 L/kg dry wt.) and extremely fast rate of elimination (2.76 h-1) were determined for NTO in earthworms, as expected considering its low hydrophobicity. MeNQ showed higher potential to bioconcentrate in earthworms and fathead minnows (BCF = 3.9 and 1.1 L/kg dry wt., respectively) and slower rate of elimination (0.40 and 0.34 h-1) compared to NTO, despite having similar low hydrophobicity. DNAN showed relatively low bioaccumulation potential in aquatic invertebrates (BCF = 0.75, 3.0, and 2.9 and 0.75 L/kg for Rana pipens tadpoles, fathead minnows and Hyalella azteca, respectively). As shown previously for conventional munition compounds, IMs have low potential to bioaccumulate in biota from soil or water.

WP205 Multi-species aquatic toxicity of insensitive munitions 1-methyl-3-nitro-1-nitroguanidine

M. Ballentine, US Army Corps of Engineers / ERDC; G. R. Lotufo, US Army Corps of Engineers / Environmental Laboratory; L. May, K. A. Gust, US Army Engineer Research and Development Center / Environmental Laboratory

Due to the unintended detonation of munitions and munition stockpiles that have caused loss of human life, infrastructure, and material, the US Department of Defense (DOD) has a stated goal of replacing traditional munitions with insensitive munitions (IM) that are chemically stable enough to withstand mechanical damage, fire, and impact of projectiles during combat operations. Munitions constituents in soil may undergo weathering, dissolution, and transport with the potential of eventually contaminating surface and groundwater. In addition, aquatic ecosystems may receive environmental inputs of munitions via wastewater from manufacturing plants. To our knowledge, the present study is the first to investigate the toxicity of 1-methyl-3-nitroguanidine (MeNQ) to aquatic vertebrates and invertebrates. Larval Pimephales promelas, Rana pipiens, Chironomus dilutes, Lumbriculus variegatus, Hydra littoralis, Hyalella Azteca, and Daphnia pulex were exposed to MeNQ in a series of acute, subchronic, and chronic bioassays. Mean control survival was 89% or higher for all bioassays, except for the R. pipens 28-d (79%). Overall, survival was high and not different from the control across all treatments, including the highest concentration tested, which ranged from 2,286 to 5,285 mg/L MeNQ. No-observed-effect concentrations (NOECs) and lowest-observable-effect concentrations (LOECs) were experimentally calculated. Sufficient mortality for the calculation of an LC50 of 1,368 mg/L was only achieved in the C. dilutes 10-d bioassay. Sublethal effects on growth were observed for C. dilutes (LOEC = 903 mg/L), H. azteca 10-d (LOEC = 1,098 mg/L) and H. azteca 35-d (LOEC = 1,446 mg/L). Significant sublethal effects on reproduction were also observed for H. azteca 35-d (LOEC = 2,775 mg/L) and D. pulex (LOEC = 174 mg/L). The toxicity of MeNQ observed and reported in this study when compared to nitroguanidine (NQ), a related munitions constituent, and other IM was lower for all species tested. Based on generic hazard categories of the US Fish and Wildlife Service, MeNQ is classified as “relatively harmless.”

WP206 Developmental pathologies associated with persistent organic pollutant exposure in arctic fish living near a formerly used defense site

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Point-source contamination from formerly used defense (FUD) sites across the Arctic are of increasing concern for environmental health. St. Lawrence Island is located off the west coast of mainland Alaska in the Bering Sea and is home to ~1,600 Siberian Yupik residents. During the Cold War, the US military installed two defense sites on the island, including a radar surveillance station on the Northeast Cape. Previous research reports that significant levels of polychlorinated biphenyls (PCBs) remain downstream of the Northeast Cape FUD site. PCBs pose considerable threats to wildlife and human health because of their toxicity coupled with their ability to persist in local environments and within biological systems. This project examined the effects of PCB and other pollutant exposure on developmental pathologies in ninespine stickleback (Pungitius pungitius) living downstream of the Northeast Cape FUD site. Fish were collected from 11 contaminated and three reference sites. Liver, gonad, and thyroid tissue samples were paraffin-embedded, cryosectioned and stained with hematoxylin and eosin. All slides were imaged and analyzed using a Leica DM4500B microscope and LAX software. Histomorphological biomarkers for each tissue were compared between fish from contaminated and reference sites in order to examine differences due to FUD site contamination. Gonadal tissue analysis compared structural development of each sex, including developmental maturity. Thyroid analysis compared follicle morphologies, including shape, size, and number of follicles, as well as colloid depletion and thyrocyte dimensional. The environmental risks can be managed through the implementation of appropriate mitigation or remediation procedures.
which are unfortunately extremely expensive and lengthy. Obtaining precise, unbiased and accurate MR concentrations with soil matrices is therefore critical to adequately assess the environmental impact at stake and properly address the issue, if any. Guidelines for the soil sampling, processing and EM analysis are provided in SW-846 Method 8330b from the U.S. Environmental Protection Agency (EPA). The goal of this project was to better understand the way those guidelines were applied in commercial laboratories. To achieve this goal, samples of known concentrations were prepared by adding EM particles to general purpose sand typical of Canadian RTAs, which was then extracted and analyzed as prescribed by SW-846 EPA method 8330b. To mimic as closely as possible an actual RTA soil, EM were grinded and sieved to particles smaller than 2 mm prior to their dispersion in soil. Significant discrepancies were observed between results and spiked concentrations, due to the ineffective homogenization of solid matrices by the laboratories. The validation of the analytical method was also thought to be faulty, because commercially reference materials available for validation purpose had much lower EM concentrations than actual soil samples. However, validating a method using a reference material having much lower analyte concentrations than actual soil concentration is not suitable, because it may hide the fact that some of the EM present in the soil have reached their concentration limit and are not dissolved during sample processing. The current communications will present an overview of the challenges encountered for the analysis of MR by commercial laboratories as well as the improvements that were made to the analytical method in order to get precise and accurate MR concentrations.

WP208 Development of mitigation methods for minimizing the detonation footprint of munitions

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The use of munitions in training leads to the deposition of energetic materials, either during firing or disposal. Some energetic molecules, such as 1,3,5-trinitro-1,3,5-triazinane (RDX), 2,4-dinitrotoluene and ammonium perchlorate (AP) are potentially harmful to the environment and can be dispersed surrounding areas. Those molecules are mobile enough through the soil profile to migrate to groundwater and represent a potential threat to sensitive receptors. This risk is accentuated by new insensitive molecules, designed to resist external stimuli and therefore leaving more residues when disposed of. To better assess this risk, their detonation efficiency has been measured, using a protocol that was developed in order to have replicable results by detonating munitions on pristine snow. The goal was to determine which munitions were the least contaminating. This protocol was applied to representative munitions from the Canadian Armed Forces (CAF) inventory, from 40 mm grenades to 155 mm artillery shells. Results show that various quantities of energetics were dispersed, some of which reaching disturbing levels for insensitive munitions. Some energetic molecules, designed to resist external stimuli and therefore leaving more residues when disposed of. To better assess this risk, their detonation efficiency has been measured, using a protocol that was developed in order to have replicable results by detonating munitions on pristine snow. The goal was to determine which munitions were the least contaminating. This protocol was applied to representative munitions from the Canadian Armed Forces (CAF) inventory, from 40 mm grenades to 155 mm artillery shells. Results show that various quantities of energetics were dispersed, some of which reaching disturbing levels for insensitive munitions. Therefore, mitigation methods were proposed to manage the risk posed by training with munitions, by developing remediation techniques aiming to decrease the environmental impact of training. New explosive ordnance disposal techniques were thus developed and tested on explosives; results show that demilitarization of an explosive using shaped charge greatly minimize their environmental impacts. The goal of this work is to provide the CAF with better tools and methods to decrease their footprint when training, and ultimately to maintain sustainable life-fire training.

WP209 Effect of Munitions on Tadpole Health, Skin Microbiome, and Susceptibility to fungal pathogen, Batrachochytrium dendrobatidis

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This study describes the effects of chemical exposures on both an amphibian host, the leopard frog tadpole (Rana pipiens), and its skin microbiome to gain insights into tadpole health, skin microbiome composition, and susceptibility to the pandemic, extinction-inducing fungal pathogen Batrachochytrium dendrobatidis (Bd). Multiple amphibian species present on US military ranges require active management for range sustainment, thus our study investigated exposures in the larvae (tadpoles), the most sensitive stage of amphibian development, with dose-series exposures to one legacy munition, 2,4,6-trinitrotoluene (TNT), and three new insensitive munitions (IMs): nitroguanidine (NQ), methyl-nitroguanidine (MeNQ), and the IM formulation, IMX-101. The NQ and MeNQ exposures had low toxicity in acute (4d) and chronic (28d) exposures where no mortality was observed for either chemical, even at the highest chronic exposure concentrations of 2,509 and 3,447 mg/L, respectively. IMX-101 elicited mortality with LC50s of 68.1 and 12.5 mg/L in the acute and chronic exposures while the legacy munition, TNT, was by far the most toxic eliciting LC50s of 3.0 and 0.013 mg/L, respectively. None of the chemicals significantly affected tadpole development or developmental rate. Although NQ and MeNQ did not cause mortality, both decreased the alpha-diversity of the tadpole skin microbiome relative to controls, even in the acute exposures where NQ caused significant deviations from controls at 965 mg/L and MeNQ at 5,285 mg/L. IMX-101 significantly decreased alpha-diversity for all acute exposure concentrations (>=10.5 mg/L), as did the TNT exposures (>=1.0 mg/L). RNAseq assays have been completed for all acute chemical exposures in tadpoles with chronic exposures in queue. Differential transcript expression and functional enrichment analyses have begun with the purpose of providing mechanistic insights into metabolic and cell-signaling effects of each chemical exposure. Further, mutual information and frequent item set analyses will be conducted to identify correlations among tadpole and skin microbiome responses to identify potential interactions among host and symbionts. Finally, combinatorial exposures of the munitions and Bd exposures in factorial treatment arrangements have recently been completed to determine if munitions ultimately affect Bd infection rates and will be presented at the SETAC North American Meeting.

WP210 Comparing Site-specific to Literature-based Lead and Polycyclic Aromatic Hydrocarbons Terrestrial Plant Uptake Factors for a Former Firing Range

J. Hedgecock, H. Loso, AECOM / Remediation; S. McKnight, AECOM Environment

Collection of plant tissue from a former skeet range from a variety of silage plants in an agricultural field as well as ruderal vegetation coupled with 3-point composite co-located soil data have allowed for the estimation of site-specific plant uptake factors (PUFs) for selected metals and polycyclic aromatic hydrocarbons (PAHs). Due to a limited dataset, an evaluation of the representativeness of these site-specific PUFs relative to readily available literature-based PUFs was made. In addition, soil properties potentially affecting lead uptake in plants, including pH, cation-exchange capacity, organic carbon, phosphate fertilizer usage on the soils, the presence of other heavy metals, and various other factors that affect microbial activity, could be different at this site from the PUF literature studies. This evaluation also considers any noted differences in estimated PUFs derived from the variety of plants growing on or adjacent to soils impacted by lead pellets and skeet targets associated with a former skeet firing range. The plant data were compared to other research that has suggested that forage grasses do not tend to be hyperaccumulators of lead. Lastly, the lead and PAH PUFs based on plant data at firing ranges will be compared to PUFs developed for sites with different sources of these contaminants in other environmental settings that lack lead pellets and clay targets to assess whether plant PUFs are influenced by the source of lead and PAHs. It is anticipated that the findings will be useful in identifying appropriate lead and PAH PUFs for human and ecological risk assessments where site-specific plant tissue data are not collected.
WP211 Derivation and Assessment of Site-Specific Plant Uptake Factors for Lead and PAHs in Agricultural Plants at a Former Firing Range
H. Losa, J. Hedgecock, AECOM / Remediation; C. Wong, AECOM / Modelling/Statistics Dept.; K. Schwach, AECOM / Environmental Remediation

The presence of lead shot and skeet in soils of a former firing range surrounded by agricultural land prompted the need to collect plant tissue and co-located soil samples to assess the potential for chemical uptake into plant tissue. Samples were collected from a variety of silage plants in an agricultural field with the goal of estimating site-specific plant uptake factors (PUFs) for selected metals and polycyclic aromatic hydrocarbons (PAHs). Depending on the distribution of the plant and co-located soil samples, three different approaches to calculating PUFs were explored: simple linear regression analysis, averaging across co-located sample pairs, and calculating the average and high-end uptake factors from a range of sample pairs. Soil properties potentially affecting uptake of lead and PAHs in plants, including pH, cation-exchange capacity, organic carbon and phosphate fertilizers (particularly for lead) were incorporated into the PUF development process. The presentation will include plots of chemical concentrations in plants and soil to test for a significant functional relationship (e.g., lead concentrations in plants could also be plotted against pH and/or phosphate levels), as appropriate. This type of multivariate statistical approach will be considered if the data are amenable. In order to establish cost-savings, plant samples were not collected within each study area, and the rationale to extrapolate these PUFs to other study areas where only incremental soil sampling data are available will also be presented. Characteristics of each study area considered in this extrapolation process will include lead pellet density and depth, and soil properties such as pH and organic carbon to assess the potential for pellet oxidation. In addition to presenting PUFs for lead and PAHs that may be considered to assess risk at former firing ranges, the outcome of this evaluation may also support the addition of soil amendments as a potential in situ remedial strategy.

Pharmaceuticals in the Environment - Science Innovation and Current Regulatory Developments

WP212 Analytical Method Development for the Quantification of Selected Pharmaceuticals using Liquid Chromatograph-Mass Spectrometer
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Recent advancement in medical sciences has brought about improved human health. However, this has been accompanied by adverse effects resulting from exposure to continuous discharge of pharmaceuticals from different point sources including households, pharmaceutical industries, clinics/hospitals, agricultural/livestock industries run-offs into the aquatic environment. The detection and quantitation of pharmaceutical compounds in different environmental matrices is still a challenge, due to their extremely low (ng-ug) concentrations and the lack of rapid and sensitive analytical techniques. A number of techniques such as enzyme-linked immunosorbent assay (ELISA), chromatographic, electrophoretic, and electrochemical methods have been explored. These instrumental techniques are limited with respect to their sensitivity (limit of detection). In this study, a liquid chromatograph coupled to mass spectrometer (LC-MS) method was developed and validated for the detection and quantification of seven active pharmaceutical ingredients. The sensitivity achieved for the method allowed for LODs (ng/ul): lamivudine, 0.0459; acetyaminophen, 0.0375; vancomycin, 0.0304; ciprofloxacin, 0.0347; sulphamethoxazole, 0.0240; diclofenac, 0.0949; ivermectin, 0.0343 ng/ul and LOQs (ng/ul) of 0.1531; 0.1249; 0.1013; 0.1157; 0.0799; 0.13162; 0.1142 respectively at a linear range of 0.01 to 1.00 ng/ul. Other ICH validation parameters are also discussed.

WP213 Environmental risk assessment for gene and cell therapy products: Critical issues for clinical trial and market authorisation applications
U. Jenal, Jenal and Partners; J.G. Tell, Merck & Co., Inc. / Global Safety and the Environment

The environmental risk assessment (ERA) forms a significant part of clinical trial and market authorization applications for therapies with drug substances containing or consisting of genetically modified organisms (GMO). An ERA is required regardless of the type of therapy, i.e. in vivo or ex vivo gene therapy, oncotherapy or immune therapy. This presentation addresses the most frequent and tricky questions related to an ERA, drawing from actual experiences with clinical trial and market authorization application processes. In order to prepare a comprehensive and compelling risk assessment document, an ERA should cover all characteristics of the GMO having a potential adverse effect in case of exposure of people other than the treated patients or the environment. Most importantly, a rational has to be given on a) how exposure is avoided due to safe application of the drug substance or b) how negative consequences from exposure are prevented due to safety features of the GMO or through post administration measures. To this end, information will have to be derived from specific data gained from research and development, from manufacturing processes as well as from pre-clinical or clinical trial studies.

WP214 Estimating Critical Environmental Concentrations of Pharmaceuticals: Using Human Therapeutic Concentrations or Mammalian Toxicology Endpoints
A.N. Perking, Eli Lilly and Company; N. Klüver, Helmholtz Centre for Environmental Research - UFZ / Department of Bioanalytical Ecotoxicology; S. Konradi, German Federal Environment Agency UBA

Active pharmaceutical ingredients (APIs) are data-rich molecules in terms of mammalian safety and human efficacy. However, many pharmaceuticals do not have a corresponding dataset regarding environmental risks. In the absence of ecotoxicology data, leveraging the available mammalian data is one way to prioritize the environmental risk potential of APIs. Human therapeutic plasma concentrations of APIs (HtPC) can be used to predict the critical environmental concentration (CEC) at which pharmacological effects may occur in fish. Used in a similar way, plasma concentrations associated with toxicological endpoints in preclinical mammalian toxicity studies (MtoxPC) may provide a better parameter to predict CEC causing toxicological effects in fish. We have developed a refined fish plasma model based on the parameters Dlipw or Dow in order to account for ionization state of APIs. In addition, we evaluated the accuracy of these models to predict plasma concentrations in fish exposed to APIs. Next, we use the plasma model to calculate critical environmental concentrations (CECs) for a suite of APIs with either HtPC or MtoxPC. We compare the predicted CEC values from these two datasets with the experimental ecotoxicity data (LOECs from chronic fish tests). Finally, we discuss its use with APIs of differing mechanisms of action and therapeutic classes and compare factors of the preclinical dataset including species, endpoint used (lowest adverse effect level, change in body weight, mortality), and study length.

WP215 Pharmaceutical Uptake Kinetics In Rainbow Trout From East Canyon Creek, An Effluent-Dominated Stream Influenced By Snowmelt In Park City, Utah, USA
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Whether seasonal instream flow dynamics influence uptake of select pharmaceuticals by fish is not well understood, specifically for urban lotic systems in semi-arid regions with flows influenced by snowmelt. We examined uptake of select pharmaceuticals in rainbow trout (Oncorhynchus mykiss) caged upstream and at incremental distances
downstream (0.15, 1.4, 13 miles) from a municipal effluent discharge to East Canyon Creek in Park City, Utah, USA during summer and fall of 2018. Fish were sampled over 7-d to define uptake kinetics. Water and fish tissues were analyzed via isotope dilution LC-MSMS. Several pharmaceuticals were consistently detected in water, fish tissue and plasma, including carbamazepine, diphenhydramine, diltiazem, and fluoxetine. Pharmaceutical levels in water ranged up to 151 ng/L for carbamazepine, whereas the effluent tracer sucralose was consistently observed at low ug/L levels. During both summer and fall experiments at each of three downstream locations from effluent discharge, rainbow trout rapidly accumulated these pharmaceuticals; tissue levels reached steady state conditions within 24 – 96 hrs. In addition, in situ bioaccumulation factors (BAFs) were calculated for diphenhydramine, diltiazem, and fluoxetine, and compared to model predictions. Such observations are consistent with our recent laboratory bioconcentration studies, which collectively indicate inhalational exposure from water governs rapid pharmaceutical accumulation by fish in inland surface waters.

Furthering Interdisciplinary Urban Groundwater Quality and Urban Sustainability Research

WP217 Anthropological Perspectives on Groundwater Policy in Southeast Michigan
C. Linn, Wayne State University / Anthropology

Drinking water contamination concerns is a growing issue across the country. In Ann Arbor, MI, dioxane plume contamination has been spreading from an industrial site for over 30 years. Recently, 1, 4-dioxane has been detected in the city’s surface water supply and finished drinking water. In addition to dioxane, PFAS contamination is also concerning the city and residents. This project takes a critical look at how citizens and cities are reacting to drinking water contamination concerns amid rampant findings that toxic chemicals exist in finished drinking water. This project is part of a larger research initiative that seeks to combine civil engineering modeling, toxicological testing, and anthropological inquiries into a cohesive project that can allow for holistic understanding of how groundwater contamination spreads, affects human populations, and how cities and citizens respond and manage contamination as it is spreading. Qualitative research methods were used to take a critical look at collective groundwater governance, from the city, state, and citizen-level mechanisms that grew as a response to drinking water contamination concerns and decision-making processes regarding water safety issues in a Southeastern Michigan community. Including anthropological research into broader scientific inquiries allows for a further understanding of how scientific findings are understood and reacted to by the larger community. These findings can aid in tailoring responses and communication efforts by the scientific community, and further illuminate the challenges cities and states face when responding to these problems.

WP218 Characterization of Shallow Groundwater in Detroit: Recovery Park
B. O’Leary, C.J. Miller, Wayne State University / Civil and Environmental Engineering

Groundwater plays a critical role in the vitality of the Great Lakes Basin, supplying drinking water, industrial water supply, cooling water for power generation, and irrigation water for farms in rural areas and landscape in urban areas. It also is interconnected with surface water features, including the lakes, streams, and reservoirs of the region. Therefore, the quality of the groundwater is crucial and has potential economic, health, and social implications for the region. The traditional focus of environmental and health concern, especially in urban areas, has been on surface water rather than groundwater, following the “out of sight, out of mind” mentality. The lack of data on groundwater (especially shallow, near-surface) flow, quality, and transport in urban centers is a threat to the health of the Great Lakes Basin. Urban groundwater movement along with a neighborhood scale urban water budget is currently being evaluated at Recovery Park in Detroit, Michigan. This project, centered at the Recovery Park, will serve as a model for evaluating the urban shallow groundwater movement in Detroit. This model will help develop and evaluate the potential risks posed to urban environments and human health.

WP219 Examining the Toxicity of Environmentally Relevant Concentrations of 1,4-dioxane Across the Lifespan in a Zebrafish Model

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Since the 1960s, a plume of 1,4-dioxane has been spreading through the groundwater underneath Ann Arbor, MI. Though not currently affecting the drinking water of most Ann Arbor residents, the plume is creeping closer to the Huron River, the source of the city’s drinking water. Though 1,4-dioxane is known to cause liver and kidney damage and is potentially carcinogenic, long-term or developmental exposure effects are not yet characterized, and it is unknown if there are transgenerational or reproductive effects. This study examines the effects of environmentally relevant concentrations of 1,4-dioxane using a zebrafish (Danio rerio) model. Zebrafish are an NIH-approved human model organism because of the genetic similarities between zebrafish and humans. Effects of developmental, acute, and long-term and transgenerational exposure will be analyzed through multiple -omic studies such as transcriptomics, as well as through morphologic, behavioral, and reproductive analysis. The results will help fill the gaps in knowledge of adverse health outcomes associated with 1,4-dioxane exposure. Additionally, the results may also give insight to potential effects on aquatic life in the event that the 1,4-dioxane plume reaches the Huron River.

WP220 Novel method for assessing biological effects of volatile organic compound exposure in zebrafish
T. Baker, J. Shields, Wayne State University / Institute of Environmental Health Sciences; Z. Siddiqua, Wayne State University / Pharmaceutical Sciences; S. McElmurry, Wayne State University / Civil & Environmental Engineering; D. Potts, Wayne State University / Pharmaceutical Sciences

Anthropogenic Volatile Organic Compounds (VOCs) have emerged as high priority environmental contaminants due to ubiquitous urban exposure and therefore play a pivotal role in several environmental and health related issues. Urban areas report increased levels of contamination due to industrial exhaust, fuel refineries, vehicle exhaust, and especially groundwater. Residents in urban areas are disproportionately exposed to potential VOC contamination as a result of indoor vapor intrusion, tap water, ingestion of contaminated fish, and ambient outdoor exposure. Inhalation, ingestion, and dermal adsorption of VOCs from indoor and outdoor sources are all routes for human exposure, and at-risk communities are often chronically exposed to complex mixtures of VOCs. A wide variety of adverse health risks have been associated with VOC exposure, which involve respiratory, cardiovascular, renal, hepatic, endocrine, immune, and nervous systems, and include cancer and abnormal birth outcomes. To date, the biggest challenge in characterizing VOC toxicity is the technological limitations that create unsafe and unreliable exposure conditions. In collaborative efforts, we have designed an innovative sealed exposure system for safely containing a VOC and analyzing behavioral changes in aquatic organisms. This novel exposure system utilizes the zebrafish animal model for exposing and evaluating VOC toxicity. Using this model, toxicant-induced behavioral changes, phenotypic abnormalities, and transcriptomic data can be compared to create profiles to not only screen VOCs, but also elucidate health concerns that could potentially translate to humans. Future studies will explore the synergistic effects of VOC mixtures and validate the translatability of these findings to humans.
WP221 Quality Assessment of Groundwater in Lagos State: A Case Study of Amuwo-Odofin/Festac Metropolitan Area
R. Alani, O. Akinrinade, University of Lagos / Department of Chemistry; O.B. Olaifa, University of Lagos; To. Waleola, University of Lagos, Akoka / Chemistry (Environmental Management Unit)

The increase in urbanization and extended industrialization has lead to a serious threat of surface water for drinking purpose in Africa with groundwater now serving as a reliable substitute. Amuwo-odofin/Festac Metropolitan Area (A/FMA) has a number of factors that could possibly affect the integrity of this groundwater sources. Such factors include the surrounding canals which accommodate tributaries and are potential sinks of pollutants that could leach into the aquifer. This study assessed 30 groundwater samples randomly collected from boreholes and hand dug wells in Amuwo-odofin/Festac Metropolitan Area. Physico-chemical parameters comprising pH, conductivity, turbidity, TDS (total dissolved solid), TS (total solid), temperature, total acidity, total alkalinity, Chloride, Hardness, COD (Chemical Oxygen Demand) and DO (Dissolved Oxygen); as well as 7 heavy metals [Iron(Fe), Chromium(Cr), Cadmium(Cd), Zinc(Zn), Manganese(Mn), Copper(Cu) and Lead(Pb)] were determined in each sample. The dominant metals were found in the order: Fe > Cd > Pb. 76.7 % and 60.0 % of the water samples indicated lead and cadmium respectively above the World Health Organization(WHO) regulatory standards - 0.01 mg/L and 0.003 mg/L. Cr, Cu and Mn were all determined very low relative to the health-based guidelines. Zn was not found in any of the samples. The groundwater of Amuwo-odofin/Festac Metropolitan Area (A/FMA) have physico-chemical parameters suitable for drinking purpose. The high level of Pb and Cd mean adequate treatments would be necessary to meet drinking requirement. There is a need for further investigation of the groundwater supply to further understand the pollution sources and trends.

Incorporating New Approach Methodologies to Improve Ecological Risk Assessment

WP222 Semantic Characterization of Adverse Outcome Pathways
R. Wang, US Environmental Protection Agency / Exposure Methods and Measurements Division

An ontology can be viewed as a graph. The semantic similarities among its classes depend on their relative positions in this graph. When the key events (KEs) from adverse outcome pathways (AOPs) are annotated as computable ontology classes, KEs and AOPs can be related to one another semantically. Based on a common integrated ontology encompassing multiple species and a wide range of knowledge domains, this ontology-based semantic mapping (OS-Mapping) approach not only effectively bridges the gap between molecular phenotypes and those at higher levels of biological organization, but also allows an independent assessment of AOPs. OS-Mapping is made possible by a wide variety of ontologies available, abundant phenotypic data from ongoing public phenomics efforts, and years of toxicity studies. To study the applications of OS-Mapping in evaluating existing AOPs and aiding their future development, over 1100 KEs belonging to more than 200 AOPs were annotated into ontology classes. Also included in the study were toxicity responses previously annotated from more than 700 exposure studies of ten chemicals in six vertebrate species. Together, they were assembled into over 200 phenotypic profiles as queries, and compared semantically to themselves, and to more than 37 thousand phenotypic profiles organized by genes, diseases, and biological pathways of human, mouse, and zebrafish by using a Java application developed in-house. Many AOPs appeared to be quite robust, as indicated by the underlying KEs having mutual similarities significantly above background. However, most of the adjacent KE pairs (i.e., KE X biologically upstream leads to KE Y downstream) had similarities of less than 0.2 (range 0-1). Some of the KEs from different AOPs were highly similar to one another, leading to their respective AOPs to become substantially related too. Many AOPs were also mapped to various genes, pathways, and diseases. These findings should help to delineate the biology underlying AOPs and provide some independent evidence for their robustness. Furthermore, semantic characterization of KEs and AOPs will also provide an approach to construct AOP networks complementary to the current reliance on the manually defined KE relationships, and aid the development of additional AOPs in the future.

WP223 Use of co-expression analysis to identify life stage-specific subnetworks in toxicogenomics data from Japanese quail
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Early-life stage (ELS) exposures are an attractive alternative toxicity testing strategy for avian species because of time, cost and ethical advantages compared to adult exposures. Differences in responses to contaminant exposure across life stages may be partially due to changes in the way genes are regulated and how they interact with each other as an organism develops. Thus, understanding the structure of gene interaction networks in ELS and adults may help explain and predict differences in biochemical responses to contaminant exposure between organisms of different life stages. The objective of this study was to compare the topological structure of gene-gene interaction networks across multiple life stages in Japanese quail. The rationale is that understanding which biological pathway networks are more or less conserved across life stages will improve our ability to design effective molecular assays for ELS exposures. First, RNA sequencing data derived from liver tissue of ELS and adult Japanese quail exposed to a medium and high dose of 8 environmental contaminants (n = 100 samples for ELS; n = 96 samples for adult) were generated. Second, co-expression network analysis was used to “discover” the underlying interactions between genes by constructing a correlation-based network for each life stage. This involved computing the pairwise Pearson’s correlation between genes and using hierarchical clustering to find subnetworks of densely connected genes with the “weighted gene co-expression network analysis” (WGCNA) R package. The subnetworks were then annotated with KEGG pathways and GO terms using gene set overrepresentation analysis to investigate their functional relevance. Finally, subnetworks were compared across life stages using three metrics: number of overlapping genes, Jaccard index, and the WGCNA subnetwork conservation score. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

WP224 Toxicity Translation: An emerging theme for modeling to understand adverse effects of chemical exposures on wildlife populations
N. Pollesch, M. Etterson, K. Flynn, US Environmental Protection Agency / ORD NHEERL / Mid-Continent Ecology Division; S. Kadlec, NRC Research Associateship Programs

To understand the potential for adverse effects of chemical exposure on wildlife, researchers and risk assessors must synthesize chemical exposure potential, the resulting acute and chronic effects to individuals, and what those individual-level effects mean for population-level impacts. Toxicity translators are tools developed to address the challenges that arise in this process of understanding the effects of chemical exposures to wildlife populations. This poster describes the toxicity translation process, creates a vision for the conceptual development of toxicity translators, and discusses existing approach to toxicity translation as case studies. This research seeks to define the field of toxicity translation by highlighting the common challenges and approaches used in the toxicity translation process. A benefit of establishing toxicity translation as a well-defined research area will be to determine synergies among efforts and to identify tools and techniques useful to those involved in toxicity translation. Here we start the conversation by providing insight into what
is involved in the toxicity translation process and by introducing the suite of toxicity translators developed and currently under development at the EPA and elsewhere. Special emphasis will be placed on how toxicity translators leverage existing datasets, models, and theoretical approaches. We will also discuss the potential for development of a computational environment for toxicity translation that could support computational linkages between available data sources, exposure models, effect models, and population/community models.

WP225 An Alternative Approach to Fish Acute Toxicity Test
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In ecotoxicity testing, acute fish toxicity is mandatory for data requirement. For acute fish toxicity test, mortality is the primary endpoint and it is often hypothesized that fish suffer distress and perhaps pain. Due to this reason acute fish toxicity test is not compatible with most current animal welfare legislation. Fish embryo toxicity test (FET) is one of the most promising alternative approaches to acute fish toxicity test. FET is mandatory test for whole effluent testing in Germany since 2005. It has been also standardized and adopted at the international level but it is yet to be implemented in India. Discussion of its application in environmental assessments on a global level was needed. In order to analyze an alternative to fish acute toxicity test, a comparative study on both fish and fish embryo toxicity was carried out for a total of 9 different industrial effluents, and results were compared to evaluate the correlation between the two data sets. Among the samples collected from three different sites of May, September and January, samples of site 2 and 3 of January were observed very toxic. Toxicity gradient among the sites of three different months were observed as site 2 of January > site 2 of September > site 2 of May > site 3 of January > site 2 of September > site 2 of May > site 1 of January > site 1 of September. Our results indicated that effluents collected from three different site in three different months were very toxic to zebrafish and its embryos at very higher dilutions. The result of acute fish toxicity test and fish embryo toxicity test are more comparable with each other. It can help to prevent the use of adult zebrafish and gives strong evidence for the use of embryos. In this study, it is proved that embryos are more sensitive as compared to adult zebrafish and FET can be used as an alternate to the acute fish toxicity test.

WP226 Investigating the applicability of the Fish Embryo Test (FET) to inform read-across for ecological hazard assessment
A.M. Strobel, Environment and Climate Change Canada / Environmental Assessment Division; J.S. Prindiville, Environment and Climate Change Canada / Ecological Assessment Division; T. Burns, Environment and Climate Change Canada; J.C. Achenbach, M.G. Morash, L.D. Ellis, National Research Council of Canada / Aquatic and Crop Resource Development

The global initiative to improve testing throughput and efficiency has led to the development and validation of new approach methodologies as alternatives to the commonly used regulatory tests for chemical risk assessment. The zebrafish fish embryo toxicity test (FET) and the general and behavioural toxicity test (GBT) are promising methods that have the potential to be used to provide chronic ecological toxicity data for risk assessment. The present study investigates the applicability of the FET and GBT assays to inform read-across for chronic ecological hazard potential between phthalates and structurally similar cyclo-hexane-based plasticizers as a case study. For the FET assay, zebrafish embryos/larvae were exposed to individual chemicals from 6-120 hours post fertilization (hpf) and from 72 - 120 hpf for the GBT assay (n=12 larvae x 3 replicates/concentration). Concentration-response profiles were generated as the definitive test for each substance. As phthalates have hard to test properties and potential stability issues, the exposure concentrations in both the external media and larval tissue were measured by liquid chromatography-high resolution mass spectrometry. Results on lethality, developmental and behavioural effects, as well as the uptake analysis, will be presented in this poster. This study seeks to identify non-traditional lines of evidence to inform read-across approaches in regulatory risk assessment.

WP227 Maternal transfer and toxicity pathways of hexabromocyclododecane (HBCD) in fathead minnow (Pimephales promelas)
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Hexabromocyclododecane (HBCD) is a flame retardant that is banned but is still detected in the aquatic environment and can bioaccumulate in aquatic organisms through the food web. HBCD can be maternally transferred and has been hypothesized to hinder development by way of reactive oxygen species production and apoptosis. However, little is known to date regarding the specific molecular mechanisms that drive the toxicity of HBCD. The purpose of this study is to (1) characterize the dynamics of maternal transfer of HBCD to embryos of fathead minnows (Pimephales promelas) over the course of 49 days, (2) further our current understanding of the specific toxicity pathways of HBCD by identifying key molecular response patterns that may be altered with early-life stage exposure, and (3) link these toxicity pathways with apical outcomes of regulatory relevance. In this study, adult male and female fathead minnows were exposed to HBCD for 49 days via the diet under static renewal conditions, and the resulting eggs were collected on days 0, 7, 14, 21, 28, 35, 42 for HBCD analysis. Eggs collected between 25-49 days were reared-up and the larvae were sampled at 7 and 14 days post-fertilization, and will be subjected to ‘omics (transcriptomics, proteomics, metabolomics) and apical outcomes (meristic parameters, growth, hatching success, histology) analysis, respectively. We predict this research will identify critical biological endpoints and toxicity pathways for HBCD in early-life stages of fathead minnows, which could be utilized to develop a gene expression-based toxicity model to predict apical outcomes. Which can also be applied across different species and chemicals acting through a similar mechanism of action. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

WP228 Quantification of an AOP network for UV radiation by exploratory data analysis and probabilistic modelling
J. Mog, K. Tøllesøen, L. Xie, Y. Song, Norwegian Institute for Water Research (NIVA) / Section for Ecotoxicology and Risk Assessment

In this study, we use a Bayesian network (BN) approach to evaluate, refine and quantify a conceptual AOP (Adverse Outcome Pathway) model, which describes the adverse effect of UV-B radiation. This tentative AOP, which is the first AOP for a non-chemical stressor, is a complex network linking a molecular initiating event (MIE: cellular ROS formation) to an adverse outcome (AO: reduced survival of a crustacean), through seven potential key events (KE). A tentative AOP structure has been developed based on literature studies, and will be evaluated with experimental data. In the experiment, Daphnia individuals were exposed to UV radiation in 6 different dose-rates in the range 0 - 0.4 w/m2. All variables (the MIE, KEs and AO) were measured with minimum three repeated measurements for each dose-rate. The resulting proposed AOP network consists of four potential pathways from the stressor to the adverse outcome. The structure of this AOP network has been assessed by exploratory data analysis (regression trees and generalized additive models). It will be further developed and quantified by BN modelling in three main steps: (1) Evaluation and refinement of the proposed AOP structure: using the structure learning capabilities of BN software to suggest the most important key event relationships (i.e. their causal directions and strengths) based
on correlations in the dataset and refining the AOP model accordingly. (2) Quantification of the refined AOP model; quantifying each selected KER as a conditional probability table based on statistical modelling of the experimental data (e.g., regression analysis of dose-response curves). (3) Sensitivity analysis; ranking the pathways of the AOP network according to the strength of their influence on the adverse outcomes. The approach demonstrated here - combination of expert knowledge, experimental data, exploratory data analysis and probabilistic modelling - is a promising strategy for data-oriented selection of key AOPs and for the identification of knowledge gaps associated with these AOPs. Further development of the AOP can also include extension to population-level adverse outcomes (e.g. abundance) by population modelling.

WP229 Optimizing data requirements for calibration of simplified TK-TD fish survival models to predict effects of pulsed exposure to pesticides
S. Kadlec, NRC Research Associateship Programs; K. Flynn, N. Pollesch, M. Etterson, US Environmental Protection Agency / ORD/NHEERL/ Mid-Continent Ecology Division

The effects of pulsed and time-variable exposures to pesticides may be under- or over-estimated with risk assessment approaches based on standard, constant-exposure toxicity tests. However, calibrating models to robustly predict the effects of fluctuating concentrations may require experimental data that are resource-intensive to gather and are not routinely provided for the EPA's pesticide registration process. Development of simplified toxicokinetic-toxicodynamic (TK-TD) fish survival models for pulsed, time variable exposure to pesticides shows promise for improving environmental realism of risk assessment endpoints, even when only standard toxicity test data are available. Our team has completed a metaanalysis of survival models calibrated with a range of input datasets with varying levels of information-richness. Our goal is to quantify the increase in goodness of fit and prediction precision that results from additional survival information, such as additional exposure durations and survival observation time points. The present work uses the effects of carbachy and diazinon on fathead minnow survival as an example, but this approach may be generalized to other compounds which are present in the environment in fluctuating concentrations. We observed systematic variation in model parameters, model fit, and predictive power that depended on the test design (e.g. exposure concentrations and durations) as well as timing and frequency of census. We discuss our results in terms of the toxicity test designs that may maximize predictive precision while minimizing laboratory resources. This work has potential applications for modeling effects of pesticides on fish populations and to support risk assessment.

WP230 Evaluating the Population-level Impacts of Contaminants of Emerging Concern on Sturgeon
M. Vaugeois, University of Minnesota, Twin Cities / Ecology, Evolution, and Behavior; P. Venturelli, Ball State University / Department of Biology; S.E. Hummel, US Fish and Wildlife Service; V. Forbes, University of Minnesota / Ecology, Evolution & Behavior

Chemical pollution threatens Great Lakes' ecosystems and the wild-life that they support. Among all of the species supported by the Great Lakes ecosystems, varieties of fish species face both chemical pollution and a variety of non-chemical stressors. The lake sturgeon (Acipenser fulvescens) is one of the largest and most unique freshwater fish in North America, and was once common in most inland rivers and lakes. Ironically, many of the characteristics that make the lake sturgeon unique (e.g., late maturation, longevity, and migrations) also make them vulnerable to anthropogenic impacts including overfishing, habitat fragmentation, and degradation. Consequently, lake sturgeon populations across North America have declined or have recovered slowly in the last 100 years. Increasing knowledge about these impacts must be part of any recovery plan. Although impacts of stressors are often measured on individual fish, conservation efforts are often intended to protect populations. This is because population-level effects are difficult to observe directly, particularly given the long life cycle and complex ecology of this species. We present a research project that focuses on population-level effects of exposure to Contaminants of Emerging Concern (hereafter, CECs) on lake sturgeon. The main goals of the project are to provide a better understanding of how CECs affect sturgeon populations and to inform best management practices. For this purpose, we developed a generic, lake sturgeon population model to identify which individual-level impacts of exposure to CECs (e.g., growth, survival, reproduction) are the most impactful at the population scale. The population model is an Individual-Based model in which the energetics of individuals are described by Dynamic Energy Budget theory. Using these methodologies allows us to infer impacts at the population-level from observations at the individual-level. We present results of simulations in which individuals were impacted by a generic, non-lethal stressor affecting either the cost of reproduction, maintenance costs, the ability to feed, or the cost of growth. We will use our population model to investigate more specific research questions linked to existing research projects at USFWS (e.g., population-level consequences of CEC impacts on imprinting, larval growth and/or survival rates). This project will provide guidance on sturgeon population-level effects of CECs, and help ongoing restoration programs by informing better management guidance and practices.

WP231 In situ assessment tools diagnose which stressors matter
G.A Burton, E.C. Cervi, University of Michigan / School for Environment and Sustainability

Over the past 27 years, we have developed and used a range of in situ assessment tools to evaluate chemical exposures, bioavailability, and multi-trophic level effects. These have been used in a weight-of-evidence (WoE) based approach, whereby in situ tools supplemented the use of traditional tools of chemical criteria, literature thresholds, laboratory mesocosms and benthic and habitat assessments. Here we review, these in situ-based tools successfully used and describe their applications, strengths and limitations, along with physical displays. The most recent tool, the in situ Toxicity Identification Evaluation (iTIE) technology has been renamed the in situ Toxicity Diagnostic System (iTDS) for improved clarity and is the subject of other poster and platform presentations. These tools are essential approaches that reduce uncertainty through increased exposure accuracy. Spatial and temporal fluxes and physicochemical interactions cannot be mimicked in the lab. These tools better link ambient exposures with effects and, when part of a strategic WoE approach, allow for improved science-based decision-making.

WP232 SYSTEMLINK - tracking the effects of stressors across ecosystem barriers

The impact of matter input from terrestrial sources on aquatic systems is well known. The reverse process, i.e. the transport from water (source) to land (sink) in aquatic-terrestrial meta-ecosystems, has received less attention. In SYSTEMLINK, we focus on the bottom-up and top-down mediated interactions in terrestrial ecosystems, which propagate from aquatic environments as a result of their exposure to anthropogenic stress. We consider micropollutants (fungicides and insecticides) and invasive species (riparian plants and invertebrates) as important manifestations of multiple stressors in disturbed aquatic ecosystems. We hypothesize that I) invasive invertebrates and insecticide exposure and 2) invasive riparian plants and fungicide exposure cause top-down and bottom-up mediated responses in terrestrial ecosystems, respectively. We test these general and several more specific hypotheses through collaborative experiments in replicated outdoor aquatic-terrestrial mesocosms (site-scale) amended by joint pot experiments (batch-scale), field studies (landscape-scale), and modelling. All experimental setups will be derived from the landscape scale representing a multi-stress environment. Several scales will regularly be combined to overcome scale-specific restrictions and to ensure both cause-effect quantification as well as environmental relevance of the
results. Ultimately, SYSTEMLINK thrives to increase our knowledge on effect translation across ecosystem boundaries. By integrating biogeochemical fluxes and biological subsidies we will be able to quantify their relative importance. Furthermore, we will closely combine the often-separated aquatic and terrestrial research areas.

WP233 Population modelling for environmental risk assessments - a case study investigating potential herbicide effects on common vole populations in Europe

Laboratory tests and field effect studies for environmental risk assessment (ERA) provide information on potential effects of active substances on exposed individuals under specific conditions. For practical and ethical reasons, however, such tests and studies cannot cover all the possible exposure scenarios, and therefore computational tools can be of much value to fill data gaps and make better use of results. Mechanistic effect models are ecological models that can predict the effects of one or more active substances on non-target wildlife at different levels of biological organization and under various environmental scenarios using information on the environmental setting, species ecology and toxicological sensitivity. This poster presents a case-study that used population modelling for an ERA in Europe. The study evaluated the likelihood of long-term repercussions on common vole (Microtus arvalis) populations due to 2,4-D herbicide uses in grasslands. The approach, its reasoning and its inclusion into the higher-tier data package for decision support was discussed with the evaluating member state authorities. The spatially-explicit individual-based population model, eVole 3.0, was used. It considers the processes of reproduction, mortality and spatial behavior which are relevant for common vole population dynamics. In the model, individuals lived in landscapes that represented grasslands in which herbicides were applied, resulting in foliar residues whose fate was simulated. Individuals were exposed via their diet i.e. the contaminated grass, within their dynamic daily home-ranges. Toxicological effects resulted from individual exposure based on dose-response relationships calibrated from standard multi-generation rat studies. The population-level responses emerged from the fates of vole individuals, which constituted the modelled populations. Increased application rates were simulated in addition to the intended rates to demonstrate a margin of safety and to provide positive controls. The impacts of annual applications on population density were assessed by comparing treatment to control simulations. Treatment-related population-level effects were evaluated and, where relevant, the time needed to achieve population recovery following the cessation of herbicide applications was determined. The results for the common vole are partly transferable to other Microtus species occurring in farmland in North America due to their comparable ecology.

WP235 Aquatic Site Characterization and Monitoring Using Passive Sampling Technology in Point Pelee National Park, Ontario, Canada
T. Bortoluzzi, Fisheries and Oceans Canada / Fisheries Program; M. Ryan, Fisheries and Oceans Canada / Fisheries Protection Program; B. O’rae, Parks Canada

Point Pelee National Park (PPNP) is located on the most southern tip of Ontario, a 15 km peninsula marsh and woodland habitat bordered by Lake Erie. The park provides habitat critical for hundreds of species of migrating birds and insects including over 53 Species at Risk, but is also a designated contaminated site listed on the Federal Contaminated Sites Inventory (FCSI). The contaminants of potential concern in PPNP are associated with pesticides (mainly DDT, dieldrin and lead arsenate) historically applied during the 1940s to 1970s. As of 2016, PPNP had minimal environmental contaminant data for the aquatic marsh areas of the park. With an objective to maintain the lowest disturbance to the park ecosystem, long term monitoring and assessment of DDT was assessed through the use of Passive Sampling Devices (PSDs). PSDs bind chemicals from environmental media and provide assessments of the biologically available contaminants. The use of PSDs for monitoring concentrations of contaminants in surface waters may offer a number of advantages over conventional point/grab sampling as they measure contaminants over extended periods providing time-integrated concentrations (smoother average of exposures), and measure contaminants in very low concentrations compared to typical small-volume sample analysis. PSDs can also act as biological surrogates, reducing the need for lethal sampling of living organisms, and determining the bioavailability of contaminants that may fluctuate over time, which is critical in accurately estimating exposure for risk assessments. This research aimed to assess the potential value of passive sampling approaches to provide high-quality contaminant data to effectively and efficiently assess and monitor ecologically sensitive contaminated sites. PSDs were suspended in the water column for 30 days at 10 sites across the marsh in October of 2016 and 2017 to collect surface water data on biopharmaceuticals, metals, and pesticides. Surface water and sediment grab samples, as well as fish were also collected for comparison to PSD data. Results indicate that the PSDs were more effective at detecting DDT concentrations in surface waters of the marsh compared to conventional surface water grab samples. DDT concentrations in whole fish samples were significantly correlated with DDT water concentrations as measured by PSDs. Conversely, DDT concentrations in sediments were not significantly correlated with DDT in whole fish samples. Aside from some disadvantages of PSD deployment, the PSDs are a reasonably viable, minimally invasive method for monitoring and assessing DDT in the aquatic environment at PPNP or other ecologically sensitive sites.

WP234 Geospatial, physico-chemical and microbiological water quality data can be used to prioritize impacts of land users and determine water quality
H.J. Potgieter, North - West University (NWU); C.C. Bezuidenhout, J.J. Bezuidenhout, North - West University / Unit for Environmental Sciences and Management

Increased urbanisation and anthropogenic disturbances have caused water quality of many freshwater systems to deteriorate over the years in South Africa. This is due to domestic, industrial, and agricultural waste being disposed of into surface waters and the surrounding environment. To meet growing water requirements a monitoring program needs to be applied nationally. Monitoring the Mooi River and Wonderfonteinspruit River were the focus point for this study. By combining data mining techniques and Geospatial information systems (GIS) the determination of water quality, both historically and current, becomes possible. In the present study such an approach was used. Microbiological, physico-chemical and GIS data (temporal and spatial) were combined to explore relationships between bacterial communities and physico-chemical changes and whether a correlation between industrial pollution, agriculture and urbanisation could be demonstrated and how this impacts on water quality. The results in the present study demonstrated that the Mooi River had water usable for all purposes although nitrate-nitrite (NO3-N02) were slightly elevated, which were contributed to the agricultural activities within the surrounding area. The Wonderfonteinspruit River on the other hand was highly polluted with phosphate (PO43-), sulphate (SO42-) and NO3-N02 which were contributed to mining and agricultural activities. The Wonderfonteinspruit River sites also showed high electrical conductivity (EC) values, that connects with the high SO42- levels within the Wonderfonteinspruit River. Bacterial community composition of the Mooi River and Wonderfonteinspruit seemed mostly similar. Bacteriodetes, Proteobacteria, Actinobacteria and Cyanobacteria are the four most dominant phyla identified spatially and temporally, but the Wonderfonteinspruit River had a higher abundance of Cyanobacteria which seemed to be driven by elevated PO43- and NO3-N02. The major land-use activities that influenced physico-chemical parameters and bacterial communities were identified as mining and agriculture, with erosion also playing a role.
WP236 Defining and refining concepts of avian exposure to pesticide-treated seeds

J.D. Maul, Syngenta Crop Protection, Inc. / Environmental Safety; E.M. Peterson, Texas Tech University / Department of Environmental Toxicology; P. Smith, The Institute of Environmental and Human Health, Department of Environmental Toxicology / Texas Tech University; L.W. Brewer, Compliance Services International / Department of Wildlife Toxicology

The objective of this project is to assimilate avian species-specific life-history traits, body size, nutritional information for cultivated and wild seeds, avian feeding behavior, and additional information that can be used to refine estimates of potential pesticide exposure to avian species associated with the consumption of pesticide-treated crop seeds. The review of this information will be used to address uncertainty associated with exposure assumptions that may impact risk estimates derived from current avian risk assessment methodologies. The primary objective is to use the compiled species-specific morphological characteristics (e.g., gape limitation), physiological (e.g., bioenergetics and nutritional requirements), behavioral (food selection behavior), and breeding phenology (i.e., temporal overlap) information to refine estimates of potential exposure for individual avian species. Because this approach has a species or size-specific focus, there is potential to apply components to refine risk to threatened or endangered species in the future. An in-depth literature review and information extraction has been conducted to generate these data, which will be presented in a format transferable to current regulatory models used to evaluate risk of pesticide seed treatments among avian species.

WP237 Using Spider web as possible indicator of heavy metal polluted environment?

O. Olawale, Federal University of Wukari

Although spider webs in residential buildings are considered a menace and a possible distortion in the aesthetics values of human environment, there are possibilities that its presence in most residential buildings may be of more benefits than being a pollutant. This study therefore aimed at evaluating the potentials of using cobwebs as possible indicators of heavy metal pollution in residential buildings. Spider web samples were collected from some residential buildings in order to determine the level of trapped heavy metals indoor. These samples were digested in hydrochloric acid and nitric acid before analysis using atomic absorption spectrophotometer (AAS). The result shows that cadmium and lead were present in the cobweb samples while As, Hg and chromium were not present. However, the mean concentration of lead and Cd were found to be significant (p < 0.05) when compared with the WHO set standard for residential buildings. Similarly, the concentration of Pb and Cd decreased as the sampling locations were distant away from major roads. The result of this research has shown that spider webs are useful bio-indicator and accumulator of heavy metals in environment.

WP238 Hard counting Made Easy by Automated device in cladoceran bioassays

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Ecotoxicology faces the challenge of assessing and predicting the effects of an increasing number of chemical stressors on ecosystems. The selection of species for laboratory tests has historically incorporated a thorough evaluation of ecological as well as methodological and economical/practical considerations. Following these considerations, Daphnia magna has been the invertebrate species most recommended for acute or chronic toxicity testing. However, in most cases this species fails the criteria of “being indigenous” and/or “being representative” of ecosystems that receive pollutants. The preference for this species is mostly because of the larger size of the neonates (easier to pick up and count) in comparison to other cladoceran species. In opposition, Daphnia longispina has been recognized as having high ecological relevance but the smaller size of their neonates difficult their counting. Accordingly, Ceriodaphnia dubia testing has also been considered attractive due to its short reproductive life-cycle; however, practical difficulties piking and counting their neonates has somehow refrained the worldwide spreading of bioassays using this species. An automated counting device would certainly simplify the application of bioassays using these species. Thus, facing the main difficulty of picking and counting neonates of such small species, we have been developing an automated device (D counter) for automatically counting of neonates of several cladoceran species. The D counter has been previously validated for counting of D. magna neonates and in this work we present the first results concerning their validation for counting neonates of D. longispina and C. dubia. The manual counting was performed by an experienced technician, whereas automatic counting was performed by the D counter, for both species. Results of the manual vs automatic counting presented a very good linear correlation for both species (y = 0.9921x, R² = 0.991, n = 41, and y = 0.9904x, R² = 0.990, n = 37, for D. longispina and C. dubia, respectively), highlighting the very good performance of the methodology, which will likely be a useful tool assisting ecotoxicology bioassays.

WP239 Microplastic Analysis with FTIR and Raman Spectroscopy


Microplastics are particulates, roughly 1 micron to 5 mm in size, originating from various man-made materials. Over the past several decades, these materials have begun to enter aquifers and been found entering the human food chain when consumed by filter feeders. This has led to a major effort in industry, government, and academia to better understand the proliferation and potential risks associated with microplastics. In this presentation we will review best practices in sample preparation, filter selection, and spectroscopic analysis of microplastics from environmental and industrial samples. FTIR and Raman microscopy are excellent for analyzing these materials non-destructively and without further sample preparation, through either point-by-point identification or through area mapping or imaging. Together, these two techniques offer researchers complementary analytical tools that are straightforward, providing particle sizes, counts, identities, and distributions.

WP240 Tiered Screening of Australian Hydraulic Fracturing Fluids for Risk Assessment Prioritization

T.M. Biksey, C. Peterson, EHS Support / Risk Assessment

A tiered screening was conducted on hydraulic fracturing chemicals used in tenure leases in the Northern Territory of Australia to identify potential human health and environmental hazards and prioritize chemicals for risk assessment. A conceptual exposure model identified potential complete exposure pathways and receptors during the life cycle of chemical usage including transportation, hydraulic fracturing, and treatment/beneficial reuse. Human and environmental exposure may occur due to accidental releases (transport/storage) and planned releases (beneficial reuse). The tiered hierarchy included Tier 1 – chemicals identified of low human health and ecological concern that do not require any additional chemical risk assessment in the tier assessment process; and Tier 2 – chemicals identified as a human health/ecological concern that require additional risk analysis to characterize potential risks. The tiered screening followed the methodology presented in the Northern Territory 2019 draft guidelines, DOE’s 2017 Chemical Risk Assessment Guidance Manual for CSG, and NICNAS IMAP framework. The challenges encountered in implementation of the tiered screening included the proprietary nature of the hydraulic fracturing chemicals and lack of robust experimental data. Critical to the tiered screening is the preparation of environmental and toxicological dossiers that compile existing information necessary to conduct the screening. The Tier 1 screening includes a PBT (persistence,
bioaccumulative, toxic) assessment and identification of potential chemicals of concern by Australian NICNAS. The potential for exposure includes estimation of concentrations of chemicals in downhole and flowback hydraulic fracturing activities as well as beneficial reuse activities. Tier 2 screening focused on chemical-specific exposure pathways and receptors identified in the Tier 1 screening. Selected Tier 2 screening will be presented including exposure to surface water resources from accidental ponded releases and infiltration/overland flow, and exposure of avian receptors drinking from open-top storage tanks. Using the tiered screening, multiple fluid systems may be accessed to identify sustainable fluid systems, or to identify chemicals within fluid systems that are a high concern and should be substituted.

**Strategies for Successful Collaboration and Communication of Human Health Risk Assessment**

**WP241 Risk Communication- Challenges, Opportunities when Emerging Contaminants are at Issue**

*J. Phillips, TRC Environmental Corp.*

**Background/Objectives.** Risk communication is an art and a science. Communications regarding emerging contaminants add several challenges to an already challenging practice. The goal of risk communication is to simply and clearly present information to interested parties regarding the potential for adverse risk and potential exposures, and also to listen. Recognition that all concerns and questions are valid assists in communications regardless if the concern is a potential risk or not. The objective of this presentation is to discuss the common challenges in communicating risk effectively and provide some suggestions which can create opportunity to build trust and set a path forward of cooperation. Approach/Activities. Through use of some key tools, risk communication and its acceptance by the public and stakeholders can be greatly improved. Key tools for discussion include: 1) determination of key messages and objectives to share early and often, particularly related to the emerging contaminant or issue 2) relationship building to earn and gain trust 3) credible technical expertise to discuss the contaminant thoroughly and responsibly, 4) do the work, understand the target audiences and their point of view and 5) be open about what you know and what you don’t know. With emerging contaminants the technical community often doesn’t have all the answers, be clear with how new information will be communicated. Results/Lessons Learned. Adding to the complexity of risk communication is the very real issue of emotional or perception of risk vs. scientific evidence and the tendency for the public not to know who to trust in impacted environmental situations. Recognition of this with the stakeholders may help in gaining credibility. Uncertainties associated with the risk and toxicity of emerging contaminants make preparation and thoughtful delivery of clear messages and responses even more critical. Sometimes saying less is more. In this presentation, the basic tools of risk communication will be presented, with the focus on adjustments necessary when discussing emerging contaminants.

**WP242 Multi-agency coordination and public education to update the fish consumption advisory in the Coeur d’Alene Basin, Idaho**

*M. Wilming, Idaho Department of Health and Welfare / Division of Public Health*

The Coeur d’Alene River Basin in Idaho has been impacted by historical mining activities and the Bunker Hill Superfund Site. Because of these historical exposure concerns, understanding human health risks from exposure to metals in fish is of particular importance for communities within the Basin. Fish were sampled across the Basin and tissue was analyzed for arsenic, cadmium, lead and mercury. Completion of this project required successful coordination among several agencies including the Idaho Department of Environmental Quality, Idaho Department of Fish and Game, Coeur d’Alene Tribe and U.S. Environmental Protection Agency. Species collected included bass, panfish, bullhead, northern pike, kokanee, and trout. As part of the Idaho Fish Consumption Advisory Program, the Idaho Department of Health and Welfare assessed tissue concentrations to determine potential human health risks due to consumption of fish and provide recommended meal limits. Stakeholder collaboration as well as public education and outreach strategies and challenges will be described.

**WP243 Health and Safety Messaging for Recreational Activities near Abandoned Mined Lands in Idaho**

*N.E. Paden, Idaho Department of Environmental Quality / Ecological Division*

Mining activity in Idaho has left a legacy of heavy metals in the environment. Some of the abandoned mined lands in Idaho are located in areas ideal for recreational activities such as camping, hiking, and off-road vehicle use. This close proximity makes recreationalists susceptible to exposures to heavy metals in the environment. This study will highlight success stories for three abandoned mined land areas in Idaho where risk investigations showed elevated levels of heavy metals in soils. As a result of collaboration with other agencies, targeted health and safety messaging and public outreach tools were created to reduce human health exposures. Messaging includes ways to reduce exposures during recreational activities and how to limit tracking of contaminants back home. These examples could be applied in similar mining sites in other parts of the country.

**WP244 A Spatially Explicit Probabilistic HHRA: Quantifying Risks to Subsistence Populations in the Vicinity of a Proposed Mining Development**

*M. Sanborn, M. Rankin, AECOM Canada, Ltd.; D. Lalonde, BBA; M. Trindade, TSMC*

Quantitative human health risk assessment is an important component of the environmental assessment and permitting requirements for proposed development projects in Canada. Risk assessment provides not only a means for quantifying potential risks, but can also provide a critical tool for the communication of potential impacts/effects to local populations and stakeholder groups. The following study presents the methodology and results of a spatially explicit probabilistic human health risk assessment conducted in support of a proposed iron mine near Schefferville, Quebec. Consultation with local First Nation’s and community stakeholder groups identified critical hunting and gathering locations within the regional project area which are visited by the Innu and Naskapi people of the region. Subsistence land users represent critical human receptors, as they are considered to be maximally exposed individuals who spend considerable time at locations in proximity to the proposed development and consume high proportions of country foods. The quantitative risk assessment was conducted in a phased approach with a deterministic assessment primarily conducted to assess risks to the general population in the local study area. Subsequently, a detailed probabilistic assessment of risks to human health was conducted for First Nation’s receptors engaged in hunting/gathering activities at 14 critical locations identified during First Nation’s consultation. Hourly predicted concentrations of fugitive dust were modelled using climatic data for a 5 year period. The resulting dataset consists of ~44,000 data points at each of the 14 critical receptor locations. Modelled results were used to create empirical probability distribution functions, which were used as inputs to assess the risk and variability of exposures at these locations using Monte Carlo simulation implemented in GoldSim. The approach allowed for direct discussion of risks and uncertainty at each critical location.

K.O. Omoyajowo, University of Lagos, Akoka / Cell Biology and Genetics / Environmental Biology; O.E. Odipe, Kwara State University, Malete / Department of Environmental Health Sciences / School of Health, Allied and Environmental Science; A.A. Adesuji, University of Lagos, Akoka / Department of Cell Biology and Genetics / Environmental Biology; K.A. Omoyajowo, Ekiti State University, Ado-Ekiti / Faculty of Law

This study in attempt to address the formidable and critically important issue on the increased pesticide poisoning scenarios in Nigeria (1958-2018) provided sustainable strategies and theoretical framework on how communities can reduce pesticide poisoning particularly the dietary exposure. Heath risk assessment studies viz-a-viz pesticide dietary exposure raised many questions. To what extent is our local foods contaminated with pesticides? What policies are needed to protect human health from pesticide contamination? What do we need as individual and as community to reduce pesticide-food poisoning and associated risks? How best can we respond to this incident as well as the consequences to decision making? This study explores answers to these questions and in doing so, illustrates how zero-pesticide foods can be sustainably produced through the insights provided by many perspectives for economic goals and community health benefits. Available data on bio-monitoring studies revealed that vast majority of local foods in Nigeria are contaminated with pesticides while the data on Pesticide Food Poisoning Scenarios in Nigeria (1958-2018) point to the fact that Government and relevant stakeholders need to sensitize the public on the dangers of injudicious use of pesticides as well as the implementation of an inclusive pesticide policy. The study reasoned that in order for food safety to be achieved in any state or nation, government and relevant stakeholders must sensitize the general public on the risk associated with poisoning by pesticide and the possible ways pesticide residues can be reduced in foods.

WP246 Knowledge of Risk Associated with Exposure to Per- and Polyfluoroalkyl Substances in Enugu State, Nigeria

C. Okudo, University of Nigeria, Nsukka / Pure & Industrial Chemistry

Per- and Polyfluoroalkyl Substances (PFAS) are a group of chemical compounds that contain mostly carbon and fluorine in their structure. They don’t occur freely in nature but are produced industrially. Recent Studies have shown that PFAS exposure to the environment are persistent, bio accumulative and toxic to both animals and humans. Also reports have indicated that some of these products are being phased-out in America and Europe but some of them still find their way to African markets and other parts of the world. The challenge is that a great number of people in Nigeria and Enugu State, the study area don’t know what PFAS is and the risk associated with the use of products that contain PFAS. Therefore the study is to ascertain the knowledge of PFAS in Enugu State and highlight the risk of PFAS exposure. A self designed questionnaire was used to obtain data using random sampling technique. A total of 400 questionnaires were distributed and only 365 were collected. The result revealed that 91% of the sampled population knew nothing about PFAS and its associated health risk while 9% have knowledge of PFAS and its associated health risk. This may point to the fact that PFAS exposure in Enugu State may not pose only localized risk but may progress to be a global risk. Therefore this paper recommends massive study and awareness programme on PFAS and also appeal for the support and collaboration of Industrialized nations towards programmes that will ensure sustainability.

WP247 Traditional Food Use by Indigenous Communities: Consideration of Nutritional and Cultural Benefits In Concert with Contaminant Risks

R. Haley, Hemmera, an Ausenco Company; D. Bright, Hemmera Envirochem, Inc.; T. Miller, M. Wilson, Hemmera, an Ausenco Company

In Canada, guidance provided by authoritative government health agencies on the conduct of HHRA may undermine the expressed interest of indigenous people to maintain and expand their use of traditional foods for nutritional, medicinal and cultural benefits. Federal and other guidelines for the conduct of human health risk assessments, whether for contaminated sites assessment and remediation or environmental effects assessments of proposed or existing projects and activities, generally discourage probabilistic assessments. Deterministic methods are favoured since they tend to be more transparent, easier to follow and review, and more amenable to less complex risk communication and risk management decisions. There is also a deep-rooted reluctance to initiate site- and community-specific epidemiological studies of environmental contamination issues, in spite of recent advances in methods for directly assessing the exposome and transcriptional/translational early health effect indicators. Thus, we are highly reliant on the conduct of deterministic health risk assessments per Health Canada’s and other agency guidance for the conduct health effects assessments. The prescribed HHRA methods, however, do not consider the broader determinants of health as would be considered in modern Health Impact Assessment (HIA). It is a HHRA best practice to use conservative assumptions for predicting individual exposures in the face of uncertainty. Typically, risk assessors will use maximum media concentrations, biotransfer factor estimates (e.g. measured gastrointestinal bioaccessibility), and dietary intake rates, or an upper estimate of the statistical distribution of values (90th %ile, 95th UCLM). This will generally result in exposure estimates that are at least an order of magnitude higher than the most probable estimates, or the actual exposure. However, overly conservative risk estimates can have unintended consequences on the realization of health benefits of shellfish, fish, plants, and game sourced from the natural environment. Detrimental effects associated with traditional foods reported or perceived to be contaminated can include increased stress and anxiety, and reduced nutrition due to the avoidance of traditional foods. Increased recognition of this issue by regulators and practitioners is required. This talk will also discuss current status of approaches for balancing risks and benefits for guiding decisions about the safety of aquatic and terrestrial food resources.

WP248 Metal and Particulate Exposures from an E-Waste Mobile Shredding Truck

M. Zhou, Harvard School of Public Health; R. Herrick, Harvard School of Public Health / Environmental Health; D. Ceballos, Boston University School of Public Health / Environmental Health

Due to increasing needs for secure data destruction of electronic devices, numerous electronics waste (e-waste) recycling facilities have introduced a novel business model of mobile shredding truck services. These trucks have the ability to shred electronics with data security concerns at remote location for a wide variety of clients. Shredding of e-waste has been documented as a source of high metal exposures, especially lead and cadmium. However, shredders in electronic recycling facilities usually operate inside large warehouses and no studies have been done to assess exposures on mobile shredding trucks. We conducted a cross-sectional exposure assessment at a mobile shredding truck (shredder operating, truck off) and two electronic recycling facilities (shredder not operating) in the Greater Boston area. The mobile shredder we evaluated did not have local exhaust ventilation and workers often carried shredding jobs hand-feeding electronics for 4-10hrs/day, 1-5 days. We performed area air and surface wipe sampling for metals in the three facilities. We also collected real-time measurements of particulates inside the mobile shredding truck. The highest metal concentration in area air (e.g., 3 mg lead/cm³) were found during mobile shredding, which was comparable to other shredding inside warehouses from previous studies. Metal surface contamination was highest around the shredder (up to 1,190mg/100cm²) and extended to other parts of the truck, similar levels to those found in the other 2 sampled facilities. During the mobile shredding job (truck back door open), the concentration of ultrafine particles was up to 250,000 particles/cm³ and did not return to background level (3,500 particles/cm³) until after 40 minutes of inactivity. The concentration of PM₂.₅ was up to 171 µg/m³. A diesel electric generator was used to power the shredder and could have contributed to some of the particulate emissions. E-waste mobile trucks are a source of metal and particulate emissions within confined spaces. Better controls, such as local exhaust ventilation, are needed to protect workers health.
Translating Environmental Science Into Improved Outcomes and Policy

WP249 Can the Unveiling of Scientists’ Values Embedded in the Controversy over Endocrine Disruptor Assessment Help to Overcome Political Impasse?
B. McIlroy-Young, University of British Columbia / Resources, Environment and Sustainability; A. Leopold, Calidris Environment BV; G. Oberg, University of British Columbia / IRES

Endocrine disrupting chemicals (EDC) alter the function of the endocrine system and, as a result, can cause negative effects in humans and wildlife. Some EDCs occur naturally, but they are also produced synthetically. There is concern that synthetic EDCs may pose a risk to human and environmental health. These chemicals are found in products used for agricultural and industrial purposes as well as in products that promote human and animal health. Scientists are divided over how to assess the risk posed by EDCs: some are in favour of a purely hazard-based approach, while others support a risk-assessment approach. This controversy has exacerbated difficulties encountered in developing EDC regulation in jurisdictions around the world. It is well documented that debates in policy-relevant science are impacted by value-judgements and therefore cannot be resolved merely by generating more data; however, there is little research about the role of value-judgements in risk assessment of chemicals involving both human and environmental health. This study investigates how differing value-judgements among scientists with expertise related to the assessment of EDC’s, may impact their scientific position. To explore this topic, we are conducting focus groups and deliberative dialogues with EDC scientists who have positioned themselves as hazard and risk proponents, respectively, as well as individuals who are in between. Our findings suggest that the groups’ value-judgements differ with regards to how the problem is framed, which evidence they find relevant, how much evidence they consider necessary and how different types of uncertainties should be handled. The goal of this study is not to produce consensus, but rather to unveil differences in underlying values between the two groups with the intention of bringing about a fruitful conversation about these differences, and finding out how the scientific community might move forward recognizing their existence. This research responds to calls for empirical studies that test theory about the role of values in policy-relevant science. It is anticipated that unveiling scientists’ values embedded in the EDC hazard-risk controversy will help overcome political impasse in order to move forward with informed EDC regulation in Europe and as well as other jurisdictions such as Canada.

Effective Science Communication in a Science Unfriendly World

WP250 Change the game for environmental research - communicate the science within
T. Seiler, RWTH Aachen University / Ecosystem Analysis; A. Leopold, Calidris Environment BV

Environmental research is aimed at the one idea: improving environmental quality. All environmental scientists certainly would agree that this goal is directly connected to every day lives. Environmental research matters to the people, to stakeholders, and to policy makers. However, since it is so close to the expectations, opinions, fears and desires of our target audiences, environmental research is difficult to communicate. These topics directly touch the sense of well-being of our audience, and are hence often taken on more emotionally than is actually necessary – or better say helpful. They have a tendency to go &lsquo;viral&rsquo; on social media platforms. Conversely, topics which may be seen as prosaic can often be under-reported and evade the popular consciousness; e.g., topics that strongly matter to mankind but are perceived as inconvenient or even superfluous, such as sustainability. As a consequence, findings from environmental research can be readily misunderstood, or simply ignored, when not communicated in a proper way. Unfortunately, science and risk communication is often neither an element of education when becoming an environmental scientist, nor part of many scientist&lsquo; job description; let alone that there is time left for this on a daily basis. Furthermore, scientific integrity is nowadays more and more under attack, especially in the social media realm. However, integrity and trustworthiness is at the heart of any communication attempt in science, as messages – especially negative ones – can only be believed if the source is considered credible. In this presentation I will review some of the basic concepts of science and risk communication that are often not known to scientists, and thus can lead from misconceptions to misunderstandings and eventually communication failures. I will dive into science and risk communication as a conflict situation, the role of cognitive dissonance and confirmation bias, the differences between a scientist’s and a non-scientist’s mind, the futile escape from the ivory tower, and my belief that we should communicate much more about our science rather than our research. The audience should leave being motivated to explore how their science and risk communication might be improved. They should have understood and be convinced that proper science and risk communication is at the heart of societal and political impact of environmental research.

WP251 How to engage with your community about scientific risk
L. Paulik, Maul Foster & Alongi, Inc. / Environmental and Molecular Toxicology

Effective science communication is becoming increasingly important in the modern age of technology and politicized science. Scientists are trained to talk about science with other scientists but are often now trained to talk about science with anyone else. This disparity creates a troubling communication gap between scientists and non-scientists. When scientists can’t, or don’t, communicate about their work and why it’s important, their work is taken less seriously by the public. When public opinion doesn’t prioritize science, there is less financial support for scientific research and scientific progress is hindered. Limiting the audience that learns about research advances also limits the impact those findings can have. During graduate school I participated in community-engaged research projects in which I talked directly with community members about the research and how its findings might impact their lives. Through these interactions I experienced first-hand some of the reasons that scientists don’t always communicate with the public about their work: it is challenging, there is minimal guidance, and outreach-specific financial support is often limited or nonexistent. I found the challenge of effectively communicating with community members about our research fascinating, so I began to seek every opportunity I could to gain more experience communicating science to non-scientists. I applied for a Science Communication Fellowship with my local science museum and volunteered to lead science outreach events for children in my community through my university. Since then I have also been working to increase SETAC’s public science outreach and to increase training opportunities for students in effective science communication. Volunteering with my local science museum has given me a platform for regularly interacting with members of my community about scientific topics. Engaging with SETAC science communication leaders from around the world has taught me about the theory and research findings about effective risk communication. If more environmental scientists prioritize seeking similar training opportunities in their communities and within SETAC, we will collectively be able to work to shift the narrative toward increased public trust of scientists and science.

WP252 Using Hands-On Exercises to Create Stakeholder Buy In: If you do it with them, they will come along
W.J. Berry, US Environmental Protection Agency / Atlantic Ecology Division / ORD/NHEERL; S. Agius, Environment Canada; J. Twichell, US Environmental Protection Agency

It is important that stakeholders have trust in the process used to make environmental management decisions and a sufficient level of understanding to be able to provide input to those decisions. This is especially
true in the current climate of distrust in both government and science. One way to increase stakeholder trust in the decision-making process is to walk them through it using hands-on exercises. The experience gained by interacting with the practical aspects of the decision-making process can also increase stakeholders’ understanding of the process, and build the confidence needed to provide input and see how it will help make better decisions. We will demonstrate the usefulness of hands-on exercises to increase the transparency of environmental management decision-making using three examples. The first is a two-hour-long game suitable for use alone or as part of a training course which illustrates the use of various sediment indicators in making sediment assessments. The game was based on the EcoChallenge game, which imposes a time and money budget, and forces the players to make choices as to what types and quantities of data they will “buy.” The second is a case study which was woven into a three-day training on the assessment and disposal of dredged material. The case study provided hands-on experience applying each of the units of the course, as it was being taught. Participants pretended to be regulatory decision makers, carrying out each step of the assessment process and comparing notes on their results. The third is a four-session participatory workshop for municipal stormwater decision makers to engage their communities in the development of stormwater management programs and funding solutions. Over the course of four months, participants learned and actively applied a practical skillset for undertaking a consensus-building approach in their communities. This built confidence in public processes and inspired continuing efforts by participants after the workshop. These three exercises vary greatly in complexity and time commitment, but all of them can increase stakeholders’ ability to influence the decision-making process, and their confidence in the ultimate decision.

Poster Only: Predictive and Statistical Toxicology

WP253 Meta-analysis of acute fish data I - Data approach and statistical analysis

H. Plugge, N. Das, Verisk 3E / Safer Chemical Analytics; J. Kostal, George Washington University

Regulatory assessments of acute fish toxicity assay data depend on numerous assumptions, only very few of which have been tested. We performed a meta-analysis of publicly available data for approximately 70,000 acute fish toxicity assays for 7400 chemicals. Preliminary data analyses very quickly demonstrated that even for chemicals with assays n>100, results were not normally distributed, but rather appeared to follow a log-normal distribution. We thus focused our high level analysis on log-normal statistics including geometric means with confidence intervals, rather than arithmetic means with standard deviations. Data analyses of the main database and data manipulation were performed in an adjacent poster. A curated database was derived and divided into more than 180 databases for chemicals with more than 50 assays (not individual assays but complete LC50 data). This accounted for approximately 30% of the total data. These databases lend themselves to a high level e.g. eliminate Klimisch scores of 3 and 4. Standardization of data normalizations and statistical analysis will be presented. The original database consisted of normalized data, from which duplicates (to avoid double counting) were eliminated. QA was performed at a high level e.g. eliminate Klimisch scores of 3 and 4. Standardization of duration (e.g. 24, 48, 72 and 96 hour) and taxonomy were also performed. The curated database was divided into nearly two hundred databases of chemicals with more than 50 assays (not individual assays but reported LC50 data). These databases accounted for approximately 30% of the total data. The results for the individual chemicals are presented in an adjacent poster. Metals were not only split out into the n>50 database but also combined in one giant sub-database for metals. Assignment of metals as metals was done mostly manually. Organometals were assigned as organics by default. Standard statistical analysis was also performed for this database in order to demonstrate the (perceived) differences between metals and all other chemicals. Species level information was also analysed, and organized by both absolute and relative toxicity. Absolute and relative toxicity assays required a minimum of three datapoints. Relative toxicity was indexed on 96 hour assays for pimenesa promalas aka fathead minnow. In addition to data for 24 and 96 hour duration, a 96/24 ratio was also calculated. An in silico uncertainty analysis was also derived and is presented elsewhere.

WP254 Meta-analysis of acute fish data II -- Chemical specific data

H. Plugge, N. Das, Verisk 3E / Safer Chemical Analytics; J. Kostal, George Washington University

Regulatory assessment of toxicity assay data depends on numerous assumptions, only very few of which have been tested. We performed a meta-analysis of 70,000 acute fish toxicity assays for approximately 7400 chemicals. Preliminary data analyses very quickly demonstrated that even for chemicals with assays n>100, results were not normally distributed, but rather appeared to follow a log-normal distribution. We thus focused our high level analysis on log-normal statistics including geometric means with confidence intervals, rather than arithmetic means with standard deviations. Data analyses of the main database and data manipulation were described in an adjacent poster. A curated database was derived and divided into more than 180 databases for chemicals with more than 50 assays (not individual assays but complete LC50 data). This accounted for approximately 30% of the total data. These databases lend themselves extremely well to detailed statistical analysis and interpretation - where else can one find 200 replicates of an LC50 assay i.e. derivation of an LC50 value. Influences of species and duration on sensitivity can “easily” be derived. Species level information was analysed, and organized by both absolute and relative toxicity. Absolute and relative toxicity assays required a minimum of three datapoints for further statistical representation. Relative toxicity was indexed on 96 hour assays for pimenesa promalas aka fathead minnow. In addition to data for 24,48, 72 and 96 hour duration, a 96/24 ratio was also calculated. For one of the major individual chemicals i.e. n> 100, an in silico uncertainty analysis was also derived and is presented elsewhere.

WP255 Variability in in vivo Toxicity Studies: Defining the upper limit of predictivity for models of systemic effect levels

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New approach methodologies (NAMs) to predict hazard are often evaluated via comparison to results from animal studies; however, variability in these in vivo reference data limits NAM accuracy. The USEPA Toxicity Reference Database (ToxRefDB) enables consideration of in vivo mammalian point-of-departure (POD) variability from subacute, subchronic, chronic, multi-generation reproductive, and developmental toxicity studies. The lowest dose at which an effect was observed in a study, termed the lowest effect level (LEL), and the lowest observable adverse effect level (LOAEL), for in-life observations and pathology, along with associated study descriptors, were used to understand variability across studies. The objective of this work was to quantify the variance within systemic LEL and LOAEL values, defined as potency values for effects in adult or parental animals only. Using the study descriptors and potency values from ToxRefDB, multiple linear regression (MLR) and augmented cell means (ACM) models were used to quantify the total variance, and the fraction of variance explained by the available study descriptors, for systemic LEL and LOAEL values. The MLR approach considered each study descriptor as an independent contributor to variance, whereas the ACM approach combined all categorical study descriptors, i.e. chemical, study type, species, sex, and administration method, into cells to more stringently define replicates. Using these approaches, total variance in systemic LEL and LOAEL values (in log10-mg/kg/day units) ranged from 0.74 to 0.92, and the unexplained variance, approximated by the residual mean square error (MSE), ranged from 0.20-0.39. Restricting the datasets to subchronic, chronic, or developmental study designs reduced the dataset size, but resulted in similar values. Based on the relationship between MSE and R-squared for goodness-of-fit, the maximal R-squared...
for a systemic POD model using these data may approach 73 to 78%.
The root mean square error (RMSE) ranged from 0.41 to 0.59 log10-mg/ 
kg/day, and suggests that a prediction interval for systemic PODs may 
have a width of 40 to 200-fold. These findings suggest an upper bound 
on predictive performance of NAMs based on these data and may have 
important implications for the evaluation criteria used for NAM predic-
tions of systemic POD values. This abstract does not necessarily reflect 
USEPA policy.

WP256 Prediction of soil adsorption coefficient of pesticides via 
experimental values

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The soil adsorption coefficient (Koc) plays an important role in the envi-
ronmental risk assessment of the pesticide registration. On the basis of the 
risk assessment, the applied and registered pesticides might be prohibited 
in EU. In order to obtain the Koc value of one pesticide, it requires nearly 
one year study and costs approximately 100,000 dollars. Therefore, it 
is necessary to estimate Koc value efficiently and conveniently in the 
early stages of research and development. In this study, experimental 
values of physico-chemical properties and molecular descriptors of the 
chemical structure were collected. The Quantitative Structure-Property 
Relationship (QSPR) models were developed using these values to evalu-
ate the prediction performance. We developed multiple linear regression 
(MLR) model, support vector machine (SVM) model, and random 
forest (RF) model respectively. With respect to the MLR model using 
experimental values from laboratory experiments, R2 of the test set 
corresponded to 0.717. Conversely, with respect to the MLR model using 
the molecular descriptor, R2 of the test set corresponded to 0.771. The 
experimental results suggest that a QSPR model with high performance 
could be developed only with the molecular descriptor calculated from the 
structural formula. Therefore, it is possible to carry out risk assessment 
without carrying out laboratory experiments which require long study 
period and large cost.

WP257 Developing an efficient pipeline for transcriptome assembly, 
annotation and pathway detection

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RNA-Seq is increasingly applied to identify perturbed biological 
pathways in environmental toxicology. For many non-model organisms, 
however, reference genomes are either not available or in poor quality. 
Transcriptome based analysis could be an alternative way to overcome 
these difficulties. However, most of transcriptome de novo assemblers 
are time-consuming, computationally intensive, and of low accuracy 
for transcript reconstruction. Moreover, gene annotation and pathway 
 mapping are extremely slow and require high-performance computing 
resources. To address this bottleneck, we performed a detailed investiga-
tion on currently available tools for transcriptome de novo assembly, gene 
annotation and pathway mapping. Two RNA-Seq (Illumina paired-end 
reads) datasets from zebrafish (~ 104 million) and chicken (~ 240 million) 
of different development stages were used and sub-sampled 50 million 
reads for each species only for transcriptome assembly. Transcriptome 
were assembled by SOAPdenovo-Trans (version 1.04) and Trinity (version 
2.6.6) on a machine with 64G RAM and 8 Cores. Salmon (version 0.13.1) 
was used for RNA-Seq quantification for both assembled transcriptomes 
and reference transcriptome. The raw count tables were submitted to 
our NetworkAnalyst for differentially expression analysis and pathways 
detection. Our preliminary results showed that SOAPdenovo-Trans 
finished both transcriptome de novo assembly within one hour. Moreover, 
SOAPdenovo-Trans detected 15 true, 5 false positive and 1 missing path-
way comparing with reference-based analysis for zebrafish dataset. For 
chicken dataset, SOAPdenovo-Trans recovered 11 true, 1 false positive 
and 5 missing pathways in comparison with reference-based analysis. 
We are currently assessing the performance of Trinity, SOAPdenovo-Trans, 
and gene annotation and pathway detection. Based on the findings, we 
aim to create a pipeline to enable efficient mapping of raw RNAseq data 
to biological pathways without requiring reference genome.

WP258 Equal genotoxic potential and different gene expression 
induced by organic extracts of total particulate matter from differ-
ent diesel blends

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The principal contaminant in the air of most cities is particulate matter 
(PM) from engines that use fossil fuels like diesel. The PM is causally 
correlated with morbi-mortality with different respiratory, cardiovascular, 
immunological and neurological diseases, among others. The offer of dif-
ferent mixtures of bioalcohols or with biodiesel with fossil diesel around 
the worldwide as alternatives to pure diesel, but the toxicity of PM emitted 
by these mixes are not taken into account. It is important to determine 
the mechanisms of toxicity of PM alternative fuel mixtures because it 
permits to predict the hazard to environmental and human health exposed 
to those emissions. The present research compares the toxicity of organic 
extracts of PM emitted by a pre-Euro I with pure diesel, blend diesel with 
10% sugar cane ethanol or blend diesel with 10% palm biodiesel, used 
commercially. The toxicity analyses are done in vitro taking into account 
the mutagenic potential in bacteria (Salmonella/microsome test), the 
genotoxic potential in the HepG2 cell line (Comet and chromosomic aber-
ration assay) and the differential global expressions of genes by means of 
the RNA sequence. The analyses showed no difference among the organic 
extracts of PM in diesel and the mixtures with 10% ethanol and 10% 
biodiesel in so far as mutagenic and genotoxic potential in the comet test. 
With respect to differential gene expression, the organic extract of PM in 
biodiesel regulated 343 genes, while 10% ethanol 177 and diesel 96, the 
majority overexpressed with respect to the control group. The principal 
functional routes impacted by the 10% biodiesel extract were principally 
related to cytokines and interleukins of the immune system and trans-
duction signals mediated by the receptor of factors in fibroblast growth 
(FGFR2). The 10% ethanol affected the extracellular matrix, in carbohy-
drate metabolism and transduction signals related to vascular epithelia, 
while diesel perturbed the routes related to embryogenesis, masculine 
reproduction, immune system and cellular aging. The results of evaluat-
ing toxic potential of particles, could integrate with the different health 
effects and be used to predict the environmental and human impact from 
exposure to PM in the short, medium and long term.

Poster Only: Systems Approaches

WP259 Subsurface dissolved and colloidal phosphorus flux in well-
drained forest soils

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Phosphorus (P) is an essential macronutrient for both plants and animals 
and changes in P concentrations and fluxes inevitably affect population 
growth and balance among dependent organisms in a shared watershed. 
It is therefore critical that P cycling is studied with a holistic approach 
that considers all possible pathways and parameters which influence P 
transport through soils and water. Ultrafine soil colloids (particles < 1 μm 
in diameter) are relatively mobile in surface water and in the subsur-
face. Inorganic and organic compounds can bind to mobile soil colloids. 
Colloid-facilitated transport is therefore a potential pathway for P move-
ment through soils. The following study aims to characterize subsurface 
transport of dissolved and colloidal P from the forest floor into ground-
water-fed lakes in well-drained forest soils. Our central hypothesis is 
that P flux in well-drained forest soils is strongly influenced by colloidal/ 
colloid-facilitated subsurface transport. We seek to test this hypothesis 
through measurement of the colloidal and total P content of groundwater,
forest litter, and litter leachate. We will also characterize P speciation and co-localization with other elements using synchrotron-based analysis X-ray absorption spectroscopy (XAS) and X-ray fluorescence (XRF) mapping. Using lysimeters and wells, litter leachate and groundwater samples were collected from soils of two long-leaf pine forests and one hardwood forest located in a primarily groundwater-fed watershed. Portions of these samples were filtered with 3 kDa filters and subsequently analyzed, along with unfiltered samples, to quantify dissolved and total P. The data on subsurface P fluxes and P cycling generated by this project will address key knowledge gaps related to forest ecosystem nutrient fluxes. Forest biomass and P demand is expected to increase in the future as a result of increased atmospheric nitrogen deposition and global temperatures; the data collected by this project will help inform future nutrient management decisions and improve our ability to predict future ecosystem change.

WP261 Using Multivariate Analysis to Characterize Toxic Pollutants Impairing Water Quality in the Willamette River Basin, Oregon

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Identifying and characterizing pollutant sources are critical for restoring water quality. However, conducting these assessments can be data- and time-intensive, delaying implementation of restoration activities. Here, we examine point and nonpoint sources of 48 toxic pollutants impairing 6,000 kilometers of Oregon’s Willamette River Basin (WRB) rivers. Our goal was to develop a strategy for developing total maximum daily loads (TMDLs) in the WRB based on a combination of pollutant geographic location and chemical characteristics. TMDLs are the primary mechanism for restoring water quality under the United States Clean Water Act. We compiled information describing sources (based on geographic location and source type) and key characteristics affecting environmental behavior (water solubility, vapor pressure, Henry’s Law Constant, octanol-water partition coefficient (K(W)), and organic-carbon-water distribution coefficient (KOC)) for metals, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), organochlorine insecticides, and organophosphorus insecticides for WRB water quality impairments. We used cluster analysis and non-metric multidimensional scaling (NMDS) to analyze pollutant characteristic similarities. Based on available data, permitted point sources in the WRB included 2,050 industrial storm/wastewater discharge facilities, 81 mines, and 522 road outfalls. Nonpoint sources included 937 toxic stock, flows, and emissions in 2000-2017; 2) projects future trends of the PFAS flows, stocks, and emissions under different scenarios until 2030. By incorporating the “stock” of carpet into the estimation, this study achieves a more accurate and systemic estimation of product-specific PFAS use and emissions to inform regional-level risk assessment and policy design.

WP263 Life cycle assessment of the impact of drilling fluid used by oil companies in Nigeria

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During oil drilling, cutting piles are discharged to the surrounding environment and they eventually end up in the sediment. This usually modifies the physical structure of the sediment, which invariably affects the benthic community and hence the primary food chain (productivity) in the aquatic environment. Life cycle assessment (LCA) is a good and very complex tool for determining the effects of a product on the environment, especially today when there is more and more awareness of environmentally friendly technologies, renewable energy and eco-efficiency. To successfully develop high quality data sources for LCA, all the inputs and outputs of different materials used including energy consumption and the amount of pollutants and emissions produced are required. However in this preliminary study we limited our data to toxicity in terms of the effect of the drilling fluid used with respect to some impact parameters in the aquatic environment studied. In generating our data, we considered some basic characteristics of Life cycle analysis reminiscent of forestry. Hence we developed a modelling approach that will enable the creation and collection of representative data for the LCA. The following impact categories were considered in our modelling approach: (i) oxygen depletion (total oxygen demand); (ii) rate of FeS2 production; (iii) biodegradation rate of drilling fluid; (iv) biodiversity (abundance and distribution of micro benthos), (v) chemical oxygen demand (COD) emissions to water and (vi) environmental loading (inert solid waste). It is hoped that this work will engender more research into LCA of the impact of several drilling fluids because according to Food and Agric. Organization (FAO), it is a useful tool for comparing the environmental aspects of specific products as it enables the ecological comparison of two or more products made of different raw materials but used for the same purpose.

Promoting Healthy Pollinator Communities Under Changing Landscape Conditions

WP264 Aluminum ingestion in honey bees: A subspecies perspective of exposure risk

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Poor mining practices and soil acidification increase bioavailability and uptake of aluminum by flora. Plant products such as pollen and nectar are then ingested by honey bees and stored in the hive where larval bioaccumulation can occur. This presentation discusses free-flight choice-making, captive survival, motility, and acetylcholinesterase activity experiments in honey bees exposed to aluminum. Using free-flight experiments such as artificial flower patches and floral nectary analogs, color preferences were determined to vary after exposure dependent on subspecies of honey bee (Apis mellifera mellifera, Apis mellifera carnica/caucasia and an Apis mellifera mellifera/scutellata hybrid). Additionally, captive experiments in Apis mellifera mellifera have shown that exposure makes circadian rhythmicity unstable, causes hyperactivity, and decreases lifespan. Behavioral and free-flight data have been corroborated by bee-head acetylcholinesterase enzyme activity and suggest a hormetic response in Apis mellifera mellifera while some tolerance is demonstrated in Apis mellifera ligustica. Additionally, we will be conducting Inductively
Coupled Mass Spectrometry and expect to observe minimal excretion of aluminum and dose-dependent head and body concentrations. The severity of the response to aluminum exposure is tied to subspecies but effects of aluminum exposure have occurred across Apis mellifera spp. We conclude that aluminum exposure from floral products is likely a limiting factor to pollinator health and may contribute to population decline; however, further understanding of subspecies tolerance to toxics is needed.

WP265 Comparative sensitivity of adult mosquitoes and butterflies to the mosquito control insecticides permethrin and naled


Permethrin and naled are both applied in ultra-low volume sprays in Florida for the control of adult mosquitoes. Application areas for both insecticides include or are adjacent to habitats in which imperiled butterfly species occur (Florida leafwing, Bartram's hairstreak, Miami blue, sawgrass skipper, and Shaus' swallowtail butterflies). The State of Florida and the U.S. Fish and Wildlife Service are concerned about the potential for adverse effects from these insecticides to existing populations of those butterflies and to management efforts focused on their conservation. Acute contact toxicity studies (24h LD50) are being conducted with adult mosquitoes and both adult and larval butterflies to increase our understanding of the relative sensitivity of the target and non-target organisms to the two insecticides. To date, toxicity studies have been completed for two mosquito species (Aedes aegypti and Culex quinquefasciatus) for permethrin. The 24h LD50s for A. aegypti and C. quinquefasciatus were 0.49 (SD = 0.178) and 0.98 µg/g (0.394), respectively. Both values approximate the 24h LD50 values reported for several adult (0.18 - 1.60) and larval (0.08 - 0.46 µg/g) butterfly species indicating mosquitoes and butterflies have a similar sensitivity. While preliminary, these data indicate a similar level of effect would occur to butterflies and mosquitoes in the field given identical exposures. Additional toxicity studies are ongoing with naled and permethrin to a third mosquito species (Anopheles quadrimacula) and to butterfly species whose sensitivity to these insecticides has not been reported.

WP266 Toxicology of two pyrethroid insecticides in the monarch butterfly (Danaus plexippus) and interactions with host plant defense chemicals

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Monarch butterfly (Danaus plexippus) population declines have caught the attention of the country and prompted nation-wide pollinator restoration activities. The USFWS has identified insecticide exposure and loss of milkweed (Asclepias) reproductive habitat as primary threats to the monarch. In the Corn Belt specifically, there may be a spatial and temporal overlap of insecticide usage and monarch larvae where milkweed is present near agriculture. Monarchs are not only exposed to insecticides in agriculture but also the insecticidal cardiac glycosides in milkweed, which target the Na⁺/K⁺-ATPase. In pharmacology, potassium has been shown to antagonize these compounds. Due to this mechanistic congruence, we are exploring interactions between cardenolides in the monarch larval diet, pyrethroid insecticides and potassium fertilizers on detoxification processes of monarch caterpillars. To understand these interactions, we are conducting laboratory experiments detailing the toxicology of bifenthrin, a Type 1 pyrethroid, and beta-cyfluthrin, a Type 2 pyrethroid, in 5th instar monarch caterpillars with and without coexposure of 1) a lipophilic cardenolide, ouabain, 2) a more hydrophilic cardenolide, digoxitin, and 3) a potassium fertilizer KCl. After identifying significant two-way interactions altering pyrethroid sensitivity, we will further explore the potential three-way interaction. Here we present the dose response curves, carboxylesterase activity, ATPase activity, and general physiological effect findings.

WP267 Bumble bee acute oral toxicity to four systemic insecticides and the diversity and abundance bumble bees within field crops in South-Central Ontario

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Bumble bees (Bombus sp.) are generalist pollinators supporting a wide array of flora within the Northern Hemisphere. These bees also contribute to agricultural production of many fruits, berries and vegetables. Bumble bees are facing a myriad of risks which vary in intensity of interaction across space and time, including habitat loss, disease, invasive species and pesticides. A specific category of pesticides, systemic insecticides, can be used as seed treatments, foliar sprays or soil drenches within greenhouses, blooming crops and field crops. All applications can result in non-target movement of insecticides into the soil, water, and plant materials. Although typically not considered as a route of exposure to bumble bees, field crops use systemic insecticides and can be surrounded by suitable nesting habitat and floral resources. Using in lab lethal toxicity testing, we assess the acute toxicity of the Common Eastern Bumble bee (Bombus impatiens) to four systemic insecticides (cytantraniliprole, flupyridafurione, sulfoxaflor, thiamethoxam) and use field work at paired farms and natural areas to assess the abundance and diversity of bumblebees present. We found that systemic insecticides differed in toxicity, with thiamethoxam, sulfoxaflor, flupyridafurione and cytrantraniliprole as the most to least acutely toxic. Further, field work found that bumblebee abundance was higher within natural areas, but diversity was highly similar between farms and natural areas. Our findings add to the growing body of literature around non-honeybee pollinator risk assessment and the differences in toxicity that may be found between species. Our work is also opening up a new channel of research into field crop exposure to native bumblebees that has been overlooked thus far as focus has been placed upon native bumblebees or commercially produced hives pollination services in flowering crops. Further analysis of foraging flowers and bumblebee collected pollen samples for pesticide residues is underway.

WP268 Field-exposure of neonicotinoids to wild bees in the Southern High Plains region (Texas, USA)

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In agricultural and urban systems, use of chemicals to control pest species can unintentionally result in exposure routes among non-target foraging insects. Across these systems, neonicotinoids are among the most widely used insecticides and are known to be highly toxic to bees, key pollinators in both wild and managed systems. The objective of this study was to quantify neonicotinoid concentrations across different bee genera and examine exposure in relation to taxon, habitat and body size. In May-June 2016, 282 wild bees were collected from 32 habitat patches (within dominate cropland, grassland or urban landscapes) and analyzed for occurrence and quantities of three neonicotinoid insecticides: thiamethoxam, clothianidin and imidacloprid. Twenty bees (7.45%) contained one or more of the neonicotinoid compounds above the limit of detection (i.e. 0.02 µg/bee), and neonicotinoids were detected in bees from 7 of 32 habitat patches across the area of interest. The most commonly detected neonicotinoid was imidacloprid, followed by thiamethoxam and clothianidin. Eight of fourteen bee taxa had at least one neonicotinoid above the limit of detection. Apis (honey bees) was the bee genus collected most frequently, also having the greatest number of occurrences of neonicotinoids above the limit of detection, followed by the long-horned bee Melissodes sp. with four individuals having neonicotinoids above the limit of detection. The small-bodied bees in the genera Perdita, Lasio glossum and Halictus were relatively abundant and had neonicotinoids above the limit of detection. Across bee genera, number of detections within a genus and the average body mass of genera showed a marginally significant trend
towards larger bees having a greater frequency of neonicotinoid detection (Pearson correlation: r = 0.45, P = 0.09). Cropland dominated landscapes were represented by four of the seven sites having bees with neonicotinoids above the limit of detection. Conservation practices focusing on ruderal habitats in agroecosystems and urban landscapes could assist in mitigating chemical exposure to foraging bees, while body size and other species traits could influence the frequency of exposure. Further studies are needed to address research questions aimed at documenting the spatial and temporal variability of chemical exposure to bees and other pollinators, and according to species traits and habitat resource use.

Plants in Environmental Risk Assessment: Assessing and Predicting the Effects of Chemicals on Plant Communities

WP269 Biochar and Other Amendments to Enhance Tree Seedling Growth for Mine Revegetation
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Biochar is the carbon-rich material remaining after pyrolysis (heating in a low oxygen atmosphere) of organic feedstocks. As a soil amendment, biochar has the potential to sequester heavy metals, improve soil water-holding capacity, and increase nutrient retention, thereby enhancing soil conditions to benefit plant growth. Thus, biochar can enhance the establishment and growth of plants for mine site revegetation. This was a preliminary greenhouse pot screening study with different amendments, to determine effects on soil and plants before initiating a full-scale on-site revegetation study. We evaluated the potential for biochar, along with agricultural lime and nutrient sources (biochars or mineral fertilizers), to enhance the survival and growth of Douglas fir [Pseudotsuga menziesii (Mirb.) Franco] seedlings in mine spoils from the Formosa mine Superfund site in southern Oregon. We made biochar by high temperature gasification of comifer softwoods, and applied it at 2.5% by weight to the spoil soil. The soil had an extremely low pH (~2.6). Addition of 0.5% or 1.0% lime (w/w) raised soil pH to 5.8 and 7.2, respectively. Increasing the soil pH was necessary for seedling survival and growth, and decreased concentrations of heavy metals (e.g., Al and Cu) in the soil leachate. However, a high level of added nutrients (2%, vs. 0.5% or 0.25% w/w of biochars or fertilizer) inhibited plant growth, especially at the higher pH. The addition of biochar enhanced biochar seedling survival, root growth, water usage, and new tissue potassium concentration, at least in part by reducing the detrimental effects of high nutrients. This study indicates that biochar, along with lime and nutrients, can enhance early seedling growth in mine affected soils by improving soil physical and chemical characteristics.

WP270 Improved Experimental Design for Non-Target Terrestrial Plant Studies
J.W. Green, JohnWGreen-ecostats.com / Data Science and Informatics
Regulatory guideline studies for Non-Target Terrestrial Plant (NTTP) are Seedling Emergence (OECD TG 208) and Vegetative Vigor (OECD TG 227). Both have growth responses (dry or wet weight and shoot height) and survival (TG 227) or emergence (TG 208). An extensive database was explored to find what experimental designs allowed adequate ability to estimate ECx, x= 10 to 50, and determine a NOAER. Design considerations were the number of application rates, replicate test vessels (pots) per application rate, plants per rep, and whether to have the same number of reps at all rates or to increase the number of control reps (e.g., using a square-root allocation rule). The decision criteria were the power of multiple comparison methods to establish a NOAER and the distribution of ECx estimates and their confidence bounds. The database determined the distribution of the within- and between-rep variances (VAREP and VAREEP, respectively) and the ratio VAREP/VARERR, as well as the range of rate-response shapes in such studies. A realistic simulation study was then developed to explore alternative designs. For emergence studies, a design with 6 application rates (including a zero-rate control), 8 reps/rate, 5 plants/rep, with equal allocation of reps to rates, provides NOAER determination and EC10 and EC25 of comparable power and quality to those possible from larger designs. For Vegetative Vigor studies, a design with 8 rates with 5 reps of 4 plants each, with equal allocation of reps to rates allows NOEC determination and EC10, EC25, and EC50 estimation with comparable power or quality to that possible under larger standard experiments. These conclusions must be qualified: Shallow rate-response curves occur frequently and vary across species and chemicals in mostly unpredictable ways. Both NOAER and ECx estimates suffer for such data. Quality of results depends on the statistical models and model selection criteria, and multiple comparison tests. Specific recommendations are provided.

WP271 Model Selection Criteria for Growth Responses in Non-Target Terrestrial Plant Studies
J.W. Green, JohnWGreen-ecostats.com / Data Science and Informatics
Growth responses in NTTP studies are dry or wet weight and shoot height. There is no apriori model for such data and for a single dataset, ERx estimates can vary substantially across different models that are plausible, at least in the abstract. It is thus necessary to define objective goodness-of-fit criteria and model selection criteria to select which, if any, model from an appropriate suite of models, provides reliable estimates of ERx and for what values of x. The suite of models explored are Bruce-Versteeg “probit type,” 3-parameter log-logistic, Brain-Cousens hermetic, and 2- and 3-parameter exponential models with and without an additional parameter defining a minimum level possible or “floor.” Including a floor is sometimes useful avoid estimating responses below any biologically plausible level (e.g., a plant will die before it shrinks to 1% of normal weight). Goodness-of-fit criteria include the following. ERx is estimated as a change from the model estimated control mean, so model agreement with the observed control mean is important. Somewhat less important is agreement of the model with observed treatment means, especially near the estimated ERx rate. If notable low dose stimulation is observed, the model should reflect it, since otherwise, the estimated control mean tends to be pushed towards the stimulated value. The width of the confidence intervals for ERx and the predicted response at ERx should not be overly wide. The model should not be sensitive to one or two observations and all model parameters should be significantly different from zero. Model selection criteria include Akaiki’s AICs or BIC and an assessment of how well models being compared meet the goodness-of-fit criteria. Results from a large NTTP database indicate the relative success of these models in fitting NTTP growth data using the stated criteria and the size effects that can be estimated from such studies under current test guidelines.

WP272 Rhizobacteria Mediate the Phytotoxicity of a Range of Biorefinery-relevant Compounds
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Advances in engineering biology have expanded the list of renewable compounds that can be produced at scale via biological routes from plant biomass. For sustainable chemical and fuel production, the industry needs to transition from fossil to renewable carbon sources, resulting in unprecedented expansion in the production and environmental distribution of chemicals used in biomanufacturing. In most cases, these chemical products have not been evaluated for effects on biological systems, defined here as bioactivity, that may be relevant to their manufacture. Further, while some relevant chemicals have been assessed for...
mammalian toxicity, environmental and agricultural hazards are largely unknown. Our study assessed six compounds that are representative of the emerging biofuel and bioproduct manufacturing process for their effect on plants (Arabidopsis thaliana, Sorghum bicolor). We describe the impact of the microbiome on bioactivity by testing the same chemicals against plants inoculated with individual bacterial species isolated from the roots of A. thaliana. We show that several of the test chemicals alter plant seedling physiology at sub-millimolar concentrations and that these responses change in the presence of two microbes. We additionally observe a pooled microbial community with different effects on root growth relative to its constituents individually. These findings indicate that screening industrial chemicals for bioactivity on model organisms in the presence of their microbiomes is important for biologically and ecologically relevant risk analyses.

WP273 Risk Assessments for pesticide effects on terrestrial plants
C. Habig, Compliance Services International
Terrestrial plants represent a vital component of terrestrial ecosystems, but are often overlooked in comparison to animal species found in those same ecosystems. However, due to their fundamental role in terrestrial ecosystems, adverse effects on terrestrial plants can result in indirect effects on both vertebrate and invertebrate species, including endangered species, that are present in those ecosystems. Currently, EPA evaluates potential exposure and risks to terrestrial plants from pesticides using a Tier I, screening level model, TerrPlant, which is focused on pesticide risks from agricultural uses. This model contains three distinct modules for estimating exposure and risks to terrestrial plants. One module evaluates potential effects from spray drift and runoff from a treated field to an adjacent, untreated field or area, the second module evaluates potential effects from spray drift and runoff from a larger treated area on a nearby wetland area, and the third module evaluates the potential effects of spray drift only on untreated adjacent areas. Since TerrPlant is a screening level model, there are limited inputs to the model, along with a number of hard-wired assumptions and modeling procedures. TerrPlant estimates potential effects on non-target monocots and dicots from a single pesticide application event. Key information used as model inputs are the pesticide application information, including the application rate and the formulation type (liquid spray or granular product), along with effects endpoints derived from standard guideline seedling emergence and vegetative vigor testing. The effects endpoints for estimating potential effects on endangered species are more stringent than those for estimating potential effects on non-endangered species. The model estimates spray drift as a set percentage of the application rate, while the percentage of applied product that runs off is estimated based on the water solubility of the pesticide. The model assumes that there is no buffer area between the treated area and the untreated area being evaluated for potential effects. Examples of TerrPlant modeling will be provided for both endangered and non-endangered species, along with a discussion of the underlying assumptions and limitations of the model. Currently, there are no set options (or tiers) for refining the risks to terrestrial plants if a product fails the TerrPlant screen. Options for refining both the estimated spray drift exposure and runoff exposure estimates will be discussed, including additional modeling options. These include using the AgDrift model to refine drift exposure estimates, and using EPA’s aquatic exposure model, PWC, to refine runoff estimates. Examples of these refinements using AgDrift and the PWC model, as well as additional options will be provided, including the effects of including buffer areas between the treated field and sensitive off-site areas.

WP274 Statistical Analysis of Survival/Mortality/Emergence Data
J.W. Green, JohnWG Green-ecostats.com / Data Science and Informatics
Survival data is a common type of response in many ecotoxicity studies. Estimation of EC50 or ECx for other choices of x is often done by probit analysis. Standard probit analysis ignores replicates and does not permit treatment of overdispersion. Background or control mortality must be taken into account to make a reasonable risk assessment. Abbott’s formula is a common way to deal with that, but it can create large errors in both ECx point estimates and confidence or credible intervals. Some software packages force use of this technique. Simple, practical easily implemented unbiased alternatives in SAS, R and other software exist to analyze survival data that uses the replicate structure, adjusts for background mortality in a direct and mathematically sound manner, and also accommodates overdispersion where present. These include probit or other generalized nonlinear models with binomial error structure and reps treated as a random factor (with an overdispersion parameter when needed), analysis of replicate proportions using regression models for continuous responses. These approaches are compared to standard probit analysis and to each other and to standard survival models from other types of studies using data from regulatory guideline studies for non-target terrestrial plants, fish sexual development, and fish early life stage studies, as well as extensive computer simulations based on realistic assumptions. All approaches will include comparisons using two ways to treat background mortality (Abbott or direct). Recommendations are made for how these and most survival data from guideline ecotoxicity studies should be analyzed in the future. Standard models for survival data from other disciplines, such as proportional hazard, Kaplan-Meyer, frailty models and sandwich estimators, are shown to be generally unhelpful in most ecotoxicity guideline studies.

WP275 Testing the emergent macrophyte, Glyceria maxima, in a water-sediment system: Progress towards development of an OECD Test Guideline
J. Davies, Syngenta / Environmental Safety; G. Arts, Wageningen Environmental Research / Environmental Risk Assessment; R.J. Isemer, Bayer Ag / Environmental Safety - Environmental Effects; J. Kubitza, BASF SE; M. Ratte, ToxRat Solutions GmbH & Co. KG
Data requirements introduced under EU Directive 1107/2009 stipulate that tests with aquatic plant species other than Lemna may be required for plant protection products which show selectively higher toxicity to either dicotyledonous or monocotyledonous plant species in terrestrial plant tests. In these cases, the recommended dicot and monocot species are Myriophyllum and Glyceria, respectively. OECD Test Guideline 239 for testing Myriophyllum spicatum in a water-sediment system was adapted to facilitate growth of the emergent, reed grass, Glyceria maxima, and ring-tested in 13 laboratories during 2016 and 2017 with the herbicide, isoproturon. Results from this ring-test were used to adapt the test protocol in terms of plant propagation recommendations, test system specification, test duration, assessment parameters and draft validity criteria. This revised protocol was used in a second ring-test with the herbicide, imazapyr, in 11 laboratories during the Summer/Autumn of 2018. Key findings indicated that shoot endpoints were less variable and more reliable than root endpoints while further work is needed to reduce overall control plant variability via increased standardisation of the test system and improved health of plant material at test initiation. In April 2019, this work was submitted to OECD and accepted as a Test Guideline project. This presentation will summarise results from the imazapyr ring-test and discuss progress towards delivery of the OECD TG.

WP276 The Evaluation of Seeding Density on Endpoint Sensitivity in OECD Vegetative Vigor Plant Guideline Testing
The OECD non-target plant testing guidance contains unclear language regarding the number of plants per replicate to be used in testing in support of agrochemical registration. This could potentially result in various interpretations of plant density by regulators, registrants and testing laboratories. A common concern across stakeholders is the effects of density on endpoint sensitivity in testing to be used for risk assessment purposes. Smithers conducted a trial exposing ten commonly used plant species at two different planting densities to a broad spectrum herbicide following standard OECD 227 vegetative vigor test methods. All plants were exposed to the same geometric series of application rates. The low
density group was generally more sensitive across species but the ECX values and related dose responses were comparable. The low density group had narrower confidence intervals for ECX values but higher coefficient of variances likely driven by increased replication. There was a 2-4 times difference in ECX values for the two density groups, which would be covered by the 5x safety factor used in EU herbicides risk assessments. The trials demonstrated that there were minor differences in the endpoint sensitivity across the two densities but that any differences would likely be mitigated in a risk assessment framework resulting in similar conclusions. Future work could include the examination of multiple planting densities as well as investigating chemicals with various modes of action.

**WP277 The strength and relevance of primary producer toxicity tests: Compelling evidence for recovery**

*C. Lau, M.L. Hanson, University of Manitoba / Department of Environment and Geography*

Herbicides are widely used in agriculture and may pose a threat to non-target plants and algae in aquatic ecosystem. Numerous studies have done to address these concerns on the effects of herbicides and the ability of plants and algae to recover following the cessation of exposure. We wanted to assess the strength and relevance of these studies; specifically as it relates to the evidence that recovery can occur in primary producers exposed to herbicide. A literature review was performed and 34 peer-reviewed journal papers were found (1984 - 2019) that examined a single compound and primary producer, with both an exposure and recovery phase. An objective scoring rubric was developed. Scores are given based on three main categories: (1) test substance, (2) test organism and experimental system, and (3) test design, statistics, and results, with a maximum score of 15. A total of 117 of test species were evaluated, that examined 35 different herbicides, with the top three tested being atrazine (n= 21), isoproturon (n=7), and cycloulsulfuron and diuron (n=3). The exposure durations for macrophyte were typically 7-14 days, with a 7 - 14 day recovery period. For phytoplankton, the exposure and recovery duration usually are 48 - 96 hours and 24 - 72 hours, respectively. The average score was 8 with a minimum and maximum of 2 and 14 marks, respectively. Half of the scores (55%) were 10 or greater, indicating a body of literature that is reasonably robust. In total, 83% of tests reported a no observed effect concentrations (NOEC; during the recovery phase) that were > 20 mg/L (which is above environmental concentrations for tested herbicides). This implies that primary producers could recover following an acute exposure to tested herbicides. We recommend that standard protocols for the assessment of recovery in macrophytes and algae be developed to improve the strength of methods for this element of data generation for risk assessment.

**Terrestrial Toxicology, Ecology and Stress Response**

**WP278 The Value of Avian Gross Pathology in Identifying Endocrine Disrupting Properties**


In June 2018, the European Chemical Agency (ECHA) and European Food Safety Authority (EFSA) published guidance recommendations that gross pathology findings from avian reproduction studies be used to support the assessment of potential endocrine disrupting properties of pesticides and biocidal active substances. These gross pathology findings should, when available, particularly reference any indications of differences observed in endocrine target organs, including thyroid, gonads and reproductive organs. In the open literature, little information is available on the utility of gross pathology data for informing endocrine evaluations. Here, we have compiled and analyzed the gross pathology data from the historical control groups of 51 northern bobwhite and 51 mallard reproduction tests to help establish the utility of such information. Evaluation of the incidence of gross morphology findings in untreated birds, may aid in the interpretation of some gross abnormalities being indicative of an endocrine interaction (e.g. reproductive condition), particularly when treatment response is pervasive. However, statistical analysis of the historical control data incidences of occurrence, indicates that gross pathology, by itself, is not likely to be useful for detecting endocrine effects as only abnormalities of relatively high prevalence (more than 20 to 30%, depending on variation in the prevalence in the control) could be reliably interpreted as a treatment response. Gross pathology changes may only be indicative, not diagnostic, of endocrine interactions making gross pathology observations due to endocrine-mediated effects, indeterminate from systemic toxicity. This work demonstrates the utility of historical control analyses in establishing the value and properties of apical endpoints for different regulatory applications.

**WP279 Heavy Metal Accumulation In the Tissue of Doves and Cattle egrets from three locations in Lagos State**

*I. Omoniyiowo, University of Lagos / VACC Technical Limited / Department of Zoology*

Heavy metals have high density and are poisonous at low concentration; they are introduced into the environment through anthropogenic sources and natural sources. This study aim to evaluate the activities of anti-oxidative enzymes and to determine the histology alteration on the liver and kidney of mourning dove (Zenaida macroura) and cattle egrets (Bubulcus ibis) which are prone to environmental exposure to lead, chromium, zinc and magnesium. A total of 12 juvenile Cattle egrets and mourning doves were collected at random at Olusosun (dumpsite), Amuwo Odofin (control site) and Ikorodu (industrial area). The birds were sacrificed and dissected. Blood samples, kidneys, livers and intestinal tract biopsy were collected. Liver and kidney were examined for histopathological alterations: level of metal was determined in the blood and intestinal tract samples using AAS. The levels of antioxidant enzymes were analyzed in the liver and blood samples. Results showed a significant difference in the value of lead in the three locations (P< 0.05). Manganese and zinc had no significance (P>0.05) and there was a significant difference between the value of chromium found in mourning dove and the locations (P< 0.05). There was also no significant difference between the Reduced glutathione Transferase (GSH) and Superoxide Dismutase (SOD) (P>0.05), with Catalase (CAT) showing a significant difference in the three locations (P< 0.05) and Malondialdehyde (MDA) value in the liver of mourning dove has a significant different between the locations. Histopathological studies showed a high level of stress in the liver and kidney of the bird. Therefore, these birds can be used as indicators of environmental pollution.

**WP280 Oxidative stress response of the seaside sparrow (Ammospiza maritima) following the Deepwater Horizon oil spill**

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The Deepwater Horizon (DWH) oil spill introduced massive amounts of oil into Louisiana saltmarsh ecosystems. In 2012-2013, reproductive and fledging success of the resident seaside sparrows (Ammospiza maritima) declined following oil exposure. A food-web link between oil exposure and this terrestrial ecosystem was discovered using carbon isotopic evidence. This begged the question of whether this oil exposure caused a direct toxic effect in the tissues of exposed seaside sparrows, with potential important implications for their fitness. The main toxic component of DWH oil are polycyclic aromatic hydrocarbons (PAHs), which are known to have carcinogenic, mutagenic and pro-oxidant effects in animals. Oxidation of biomolecules by radicals can alter the overall functioning of the organism, making the toxicity arising from an oxidative stress response an important one to investigate. Prooxidant action of oil stems from PAH metabolites reacting with molecular oxygen to create reactive oxygen species (ROS) via a redox cycling reaction. The unstable ROS can then cause oxidative damage to organic biomolecules, inducing oxidative
WP281 Tree Swallows as a Sentinel Species for Assessing Pre-Remediation Conditions at Randle Reef, Hamilton Harbour, Ontario

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As part of an assessment of pre-remediation environmental conditions at Randle Reef, several parameters relating to reproduction, health, and contaminants were studied in tree swallows (Tachycineta bicolor) nesting in Hamilton Harbour from 2013–2018. This species feeds on emergent aquatic insects in close proximity to its nesting site and has been used widely as an indicator of local contaminant conditions in the Great Lakes. Twenty-five nest boxes were installed at two locations in Hamilton Harbour, Randle Reef (adjacent to the proposed remediation site) and Bayfront Park (3 km west of Randle Reef), and at Long Point on Lake Erie (reference site). Various measures of reproductive success, e.g., clutch size, hatching success and fledging success per nest, were generally high at all study locations. Concentrations of sum PCBs and sum PBDEs were significantly higher in eggs from the two Hamilton Harbour locations compared to eggs from Long Point while mercury concentrations in eggs were not notably elevated at Hamilton Harbour locations. Contaminant burdens in eggs were below levels associated with adverse impacts on reproductive success. As a measure of PAH exposure, air monitoring was conducted from 2013–2017 using polyurethane foam passive air samplers (PUF-PAS) that were deployed near nest boxes. Concentrations of total PAHs in air were highest at the Randle Reef location followed by Bayfront Park with lowest concentrations at the reference site. Similarly, total concentrations of PAHs in stomach contents of nestlings (reflective of chick diet) were also highest at Randle Reef compared to the other two locations. Significant spatial variation in EROD activity (enzyme induced by PAH exposure and responsible for PAH metabolism) was found in liver of nestlings in one of three study years. Several other biochemical health effect endpoints associated with contaminant exposure have also been studied in nestlings. There was evidence of significant spatial differences in thyroid hormone concentrations (plasma) and oxidative stress (lungs) while no difference in immune function was found in nestlings among study locations. In 2019, monitoring plans will be scaled back when dredging of the Randle Reef site is expected to occur with post-remediation monitoring beginning again in 2020.

WP282 The Evolution and Challenges Inherent to Pesticide Testing with Passerine Species

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Passerine species comprise more than 50% of all bird species in the world. In 2008 the revised 40 CFR Part 158 pesticide data requirements (July 1, 2008; 72 FR 60957, October 26, 2007) included avian acute testing with one passerine species. The EPA 2012 OCSP 850.2100 guidelines followed up by suggesting the use of house sparrows (Passer domesticus), zebra finch (Taeniopygia guttata) or red-winged blackbirds (Agelaius phoeniceus). Eurofins (formerly Wildlife International, Ltd.) avian toxicology laboratory began testing with passerine species in 2008 and has conducted nearly 200 passerine tests to date. Testing with altricial species presents its own set of issues and concerns, including: 1) the husbandry and care of these species tends to be more complex and, 2) the interpretation and consequence when birds regurgitate a dose can be confounding. Here we examine how the use of passerine species in acute testing has evolved since the addition of regulatory requirements that include these species the development of husbandry and testing techniques that allow for the effective work with passerine species in a laboratory setting. The EPA guideline recommends against the use of wild-caught birds for acute toxicity testing. However, based on the relative ease of obtaining and keeping captive bred populations, Eurofins laboratory has chosen to work primarily with zebra finch and canary (Serinus canaria) passerine species. The environmental conditions, pen size, social behavior, and phylogenetic and taxonomic relatedness are some of the considerations when working with these species. Over the last 10 years we have conducted 98 tests with zebra finch and 86 tests with canary. Of these 184 tests conducted, regurgitation was noted during 100 (55%) of them, with 58 requiring follow-up with a dietary study due to regurgitation. The regulatory agency’s stance on how to interpret regurgitation has evolved with the issuance of 2012 OCSP guidelines and the EPA’s memo Guidance for Use When Regurgitation is Observed in Avian Acute Toxicity Studies with Passerine Species. Dietary tests are the appropriate choice when regurgitation is observed. These tests make it feasible to detect acute toxicity in passerines with regurgitation. As acute testing with passerine species continues to move forward the value and capabilities of testing with these species is likely to evolve as we expand the existing knowledge base and accrue a progressively robust historical database.

WP283 Impacts of metal contamination on the behavior and body condition of American Robin (Turdus migratorius) nestlings

K. Glynn, Eastern Michigan University / Biology

Many songbird species live in both urban and rural environments. These two habitats can have vastly different advantages and/or benefits, and thus may present tradeoffs. One songbird species that commonly lives in both habitats is the American Robin. The diet of this species consists mainly of terrestrial invertebrates, such as earthworms that reside in soil. An instance of environmental pollution such as the Flint water crisis, where lead was leached into the drinking water of residents in Flint Michigan in 2014, may have negative bio-accumulative consequences for these organisms. If American Robins are consuming earthworms in a location of known environmental pollution, they may therefore be exposed to elevated levels of lead and thus be facing an impact to their overall health and fitness. Much is known about the negative consequences lead has on neural development and reproductive health. We hypothesize that if American robins in Flint Michigan are exposed to elevated levels of lead, then their nestlings might be experiencing neurological deficits resulting in less favorable behaviors and/or lower body conditions. We propose to record nestlings in Flint Michigan, at an appropriate developmental stage, to observe and assess behavior across contaminated and uncontaminated sites. Blood samples will be collected to determine blood lead content across sites, and body measurements will be used to assess changes in body condition. Preliminary work has shown that American Robins in Flint have elevated blood lead levels. However, it is unclear how this may
be impacting their reproductive success and the overall health of their nestlings. This study will illuminate how anthropogenic environmental pollutants, such as lead, impact urban wildlife. Based on the evidence implicating lead as a toxic metal and the literature suggesting its universal negative effects across species and their offspring, it seems likely that lead exposure negatively impacts songbird nesting survival, and thus population health in urban environments.

WP284 Blood lead levels of wild songbirds following the Flint, Michigan drinking water crisis
D. Zahor, Eastern Michigan University / Biology
Anthropogenic metal pollutants emitted into the environment have the potential to harm organisms residing in the polluted ecosystem. Urban birds spend much of their time in human-dominated landscapes and could serve as bioindicators of metal pollution as well as possibly reflect human exposure. The Flint, Michigan drinking water crisis arose due to a lack of corrosion control which would have prevented lead leaching from pipelines into the drinking water. While human residents were alerted to avoid ingestion of lead-contaminated water, there was not a similar caution taken when watering lawns or otherwise allowing the drinking water to exit Flint homes and enter the environment. Although water levels are now reduced, lead is highly persistent, a neurotoxin, and tends to remain in the upper layers of soil where it is bioavailable to wildlife. Songbird diets vary widely, and species that forage on soil-dwelling organisms may be more prone to lead exposure. Similarly, if young are fed preferred items there may be differences in exposure between adults and juveniles. Finally, species that associate strongly with human structures may differ in exposure to lead. We describe blood lead levels in four species of urban songbirds: two omnivores that forage frequently for soil-dwelling organisms and two granivores, including an invasive and native species of each. We will discuss the influence of diet, age and ecological niche on lead levels in these urban songbirds in an area of known lead pollution. Understanding factors that increase a species sensitivity to pollution can better guide conservation efforts and raise public awareness surrounding pollution risks to wildlife.

WP285 Biochar soil amendment and chemical toxicity in portworms and earthworms
P. Voua Otomo, University of the Free State / Zoology and Entomology
1. Introduction Biochar has been regarded as an affordable means to decrease chemical toxicity in soil and water. Biochar is biomass pyrolysed in limited or complete absence of oxygen at temperatures above 250°C. Research evidence suggests that it is able to reduce the bioavailability and phytotoxicity of heavy metals and to have sorption and partitioning effects on various chemicals. In the present contribution, we assessed the efficacy of biochar in the alleviation of the toxic effects of sewage sludge, a nanosilver colloidal dispersion and a chloronicotinyl insecticide to two invertebrates. With regard to survival, a LC50 of 16.5 (1.8-26.7) µg sludge was observed for non-biochar amended soils whereas no LC50 was determined for biochar amended soils. This implied that biochar has the ability to alleviate the toxicity of sewage to Eisenia fetida. Conclusions Although the efficacy of biochar as a means to decrease chemical toxicity seems to vary depending on the species or chemical, biochar shows potential for use in the alleviation of the toxic effects of different chemical classes including metals, nanomaterials and organic compounds.

WP286 Can local enhancement in earthworms affect the outcome of the standard earthworm avoidance test?
A. Stander, University of the Free State / Department of Zoology; P. Voua Otomo, University of the Free State / Zoology and Entomology; A. le Roux, University of the Free State / Department of Zoology
Earthworms exhibit clumping behaviour in and out of the soil. However, it remains unknown if such social behaviour ultimately influences the outcome of ecotoxicological experiments in the laboratory. We performed several overnight avoidance tests to determine whether social behaviour (i.e., local enhancement) is a factor in pollution avoidance behaviour in the earthworm Eisenia fetida. The results showed that there was no clear influence of social behaviour on the choice or avoidance of Cd contaminated soils, although we suspect that 50 mg Cd/Kg might not have been high enough to elicit a significant avoidance response. Nevertheless, when offered a choice between clean undisturbed soil and previously inhabited soil, the worms preferred the previously inhabited soil (p < 0.01). Although the level of metal pollution investigated in this study did not disrupt or help predict social dynamics, local enhancement, perhaps driven by some sort of habitat imprinting, was successfully documented in Eisenia fetida.

WP287 Comparing the sensitivity of two springtail (Collembola) species to pesticides through multiple exposure pathways
W.J. Martin, P.K. Sibley, R.S. Prosser, University of Guelph / School of Environmental Sciences
Springtails (Subclass: Collembola) are one of the most frequently studied groups of test organisms in soil ecotoxicology due to their ease of culture, ecological importance, and predictable responses to contaminant exposure. Folsomia candida (Family: Isotomidae) is a globe-spanning Collembolan whose distribution includes agricultural soils, riparian systems, caves, and forests. It currently represents the majority of ecotoxicology arthropod studies, thanks in part to standardized test methods developed by several regulatory organizations. F. candida has been identified as relatively insensitive to exposure to some contaminants compared to other soil arthropods, specifically other springtail species. Arrhopalites caecus (Family: Arrhopalitidae) shares many of the traits that make F. candida an attractive laboratory test organism; they share a worldwide distribution, parthenogenetic life cycle, and can be found in a wide range of habitats, including cave systems, and forest leaf litter. Unlike F. candida, the sensitivity of A. caecus to environmental contaminants is largely unknown. These studies aim to characterize Arrhopalites caecus in the context of soil ecotoxicology. The sensitivity of A. caecus and F. candida exposed to insecticides in a soil matrix was first compared, representing the most common springtail exposure scenario. The results of this exposure suggest that A. caecus is more sensitive to acute insecticide exposure in soil matrices. In order to further characterize differences in sensitivity, these species were exposed to the insecticides.
through contaminated food in laboratory culture conditions. A feeding assay was developed for use in this investigation in order to eliminate differences in sensitivity based on habitat preference (soil for *Folsomia candida*, leaf litter for *Arrhopalites caecus*) and to characterize potential differences in detoxification mechanisms.

WP288 Egg Production and Hatching Success in a Widely Distributed Soil Springtail as Indicators for Recovery after Imidacloprid Exposure

**S. Sengupta, H. Leinaas, K. Borgå, University of Oslo / Department of Biosciences**

Soil remediation after pesticide application should include an assessment of the responses of ecologically relevant organisms. Collembolans constitute a keystone soil community group with strong effects on soil nutrient cycling. However, life-history traits of ecologically relevant collembolans are not commonly used end points in in toxicity tests, despite the close link of life-history traits to population performance and fitness. Here, we registered essential life history responses (i.e., reproduction) and assessed the recovery after sub-lethal exposure to the neonicotinoid pesticide, imidacloprid, in *Folsomia quadrioculata*, a collembolan often dominant in major habitat types. The collembolans were subjected to dietary exposure across imidacloprid doses by spiking the feed with 0–4290 μg L−1 aqueous solutions of imidacloprid. We used five replicates per treatment, each containing 20 adult collembolans. The dietary exposure lasted for 14 days at 15°C, followed by a non-exposed recovery period of 25 days. Mortality was recorded throughout the experimental period. In addition, the eggs laid were counted, and observed until hatching or censoring (30 days after collection). Effects of imidacloprid concentration on the time until first reproduction in the clean environment, egg production, and egg hatching success were analyzed. We expected increased recovery time with dose for all the end points studied. All the end points showed a negative effect of dose, except for survival, which was high throughout the experiment. Egg production stopped in many replicates during the exposure period. However, resumption of reproduction post-exposure indicated that the collembolans recovered gradually in the clean environment. Time until first reproduction in the clean environment increased with dose. Moreover, egg hatching success increased with recovery time. The findings suggest that survival or presence/absence data from the field should be supplemented with more detailed analysis of life-history end-points for assessing the status of soil remediation.

WP289 Best Practices for Dung Fauna Ecotoxicological Studies

**D. Hurgett, M. Terneus, Boehringer Ingelheim Animal Health / Drug Safety**

Dung fauna (e.g. certain flies and beetles) are critical members of the pasture ecosystem due to their role in the breakdown of dung and incorporation of organic matter into soil, as well as nutrient cycling. Given their importance within an ecosystem, investigations into the potential adverse effects associated with chemical exposure to dung fauna are important components of environmental risk assessments for production animal drugs. Draft and finalized OECD guidelines are available to allow for standardization of methodologies and analyses used to assess the potential for a new chemical entity (NCE) to adversely impact dung beetle and fly populations. However, the methodologies and data analyses described in peer-reviewed literature often do not utilize these validated guidelines, thereby making interpretation difficult and limiting the comparative assessment of studies/data. Population/ecological models for dung species can be developed and incorporated into higher tier assessments, thus providing a needed bridge between the laboratory and field. Field studies are highly complex and effort is needed to understand natural variability of the study site, as well as describing the attributes of a quality field study. As the field of dung fauna ecotoxicology is relatively new, it is important that the scientific community conduct laboratory and higher tiered assessments of sufficient quality and standardization to allow for clear interpretation. The purpose of this presentation is to discuss best practices when conducting laboratory and/or field ecotoxicological studies evaluating dung fauna. Applying best practices will facilitate a more consistent and robust assessment of potential dung fauna effects associated with a NCE.

WP291 Impact of Seasonal Environmental Variation on 2,4-D Fate and Metabolism in Urban Landscapes

**A.E. Gonzalez Vasquez, Molecular and Environmental Toxicology Center / Molecular and Environmental Toxicology, P. Koch, University of Wisconsin, Madison / Department of Plant Pathology**

The herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) is among the most commonly used pesticides on urban landscapes in the U.S. Although 2,4-D fate and breakdown has been well documented, interactions with the soil microbiome and simultaneous assessments of its transformation products in urban landscapes under seasonal environmental variations remains poorly understood. Field and controlled environment studies will be conducted in May and July of 2018, 2019, and 2020 to evaluate pesticide degrading activity and the formation of 2,4-D transformation products under varying environmental conditions. Analytical methods have been optimized for the analysis of 2,4-D and its primary transformation products in leaf, soil, and leachate samples using Liquid Chromatography-Tandem Mass Spectrometry. Quantification analysis of a 2,4-D-degrading gene found in soil bacteria, known as the tfdA gene, was also developed and validated using qPCR. We anticipate that seasonal environmental fluctuations will shift the soil microbiome structure, function, and diversity and lead to variations in tfdA gene quantification and 2,4-D breakdown in urban landscapes.

WP292 Chemical and Species Specific Application Rate vs Response Simulations to Support Pesticide Risk Assessment

**Y.B. Atalay, B. Sackmann, R.A. Pastorok, D.V. Prestiosi, Integral Consulting, Inc.**

A multi-model framework, incorporating several modeling phases, has been developed to assess pesticide risk across multiple ecological receptors. In the first phase, species-specific population models are calibrated to laboratory test results. The models are then extended to explore population-level responses under constant (and optimal) environmental conditions. The second and third phases build on the results of the first phase models using long-term environmental/field conditions and pesticide exposure profiles to assess potential effects of pesticides on populations and aquatic food webs. Biomass effects are characterized by integrating biomass within the exposure time period (i.e., calculating the area under the curve [AUC]) and expressing the difference between the control and exposure scenarios as a percentage. AUC provides an integrated, species-specific, measure of exposure effects and by varying the chemical dose, exposure effects for different environmental regimes can be compared. This approach is useful to support risk assessment procedures for pesticides and takes into account the entire application rate and response analysis to provide descriptive effects/response levels.

WP293 Concentration addition model tested by comparing observed to predicted response of barley grown in a mixture of Ni, Cu and Co on artificial soil

**A.E. Hunter, University of Guelph / School of Environmental Sciences; S. Siciliano, University of Saskatchewan / Department of Soil Science; B.A. Hale, University of Guelph / SES**

Metal contamination in soils most often occurs as mixtures of more than one metal. Although there have been numerous studies on how single metals are taken up by plants from soil, the accumulation and toxicity of metal mixtures remains largely unstudied and unknown. In the absence of more reliable models, the concentration addition model could be applied in risk assessment, though it is not well validated. To this end, a fixed ratio design was used to compare accumulation and toxicity of Ni, Cu and Co to barley grown on OECD artificial soil, as singles and in a mixture. The concentration addition (CA) model was used to predict the additive response and compared to the observed mixture response. Toxicity of
root and shoot endpoints was well predicted by the CA approach, and the predicted mixture response was not statistically different from observed. Accumulation of the mixture of metals was less easily predicted by the CA approach. Root accumulation was over predicted by CA, while shoot accumulation was under predicted by CA, for both especially at higher exposure concentrations. The difference in response between root and shoot accumulation may provide evidence for the idea that roots are largely a cation exchange surface where competition occurs between cations for exchange sites, while translocation of trace elements from roots to shoots is largely independent of the other trace elements in the xylem stream. These data suggest the usefulness of the concentration addition model in risk assessment.

WP294 Evaluation of The Impacts of Sulfuric Acid and Nitric Acid on The Rice Paddy Ecosystem Using Mesocosm System

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Damages of rice, the most consumed crop in South Korea, caused by chemical accidents have been reported, but the impacts of the accidents on rice paddy ecosystems have been neglected. Toxicity assessment of chemicals through laboratory-scale bioassay provides the limited information for the evaluating effects of them on ecosystem. We assessed the impacts of sulfuric acid (H₂SO₄) and nitric acid (HNO₃) on the rice paddy ecosystem using mesocosm composed of soil, sludge worm, rice (Oryza sativa), and golden apple snail (Pomacea canaliculata). We set up mesocosm system simulating the rice paddy ecosystem by filling 150 kg of paddy soil in pots and saturating them with water. Rice cultivation was carried out according to the cultivation technique provided by Rural Development Administration (RDA, Korea). Rice seeds were germinated in clean soil and seedlings were grown for 4 weeks. The seedlings were transplanted into the system and sludge worms and golden apple snail were inoculated into the system, on the 5th day after rice transplanting. After a week, H₂SO₄ and HNO₃ solutions were spilled into the system and the concentrations were adjusted to the predicted no-effect concentration (PNEC) and hazardous concentration for fifty percent of the species (HC₅₀) of each chemical, predicted through the previous studies. Soil pH and chlorophyll content of the rice leaves were measured for 4 weeks. On the 28th days after the chemical exposure, the species were collected, and the numbers and biomasses of living individuals were measured. The activities of soil microorganisms were also evaluated through the soil enzyme test. The impact assessment of the spilled chemicals on the rice paddy ecosystem was conducted by analyzing the effects of the chemicals and the interactions between the chemicals and species through comparison of the endpoints in the treatment and control groups. These results may provide basic information for assessing the impacts and estimating damages of the entire terrestrial ecosystem by chemical accidents.

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Benthic and Pelagic Harmful Algal Blooms and their Toxins: Detection, Fate, Effects, Monitoring and Management

RP001 An efficient and affordable laboratory method to produce and sustain high concentrations of microcystins by Microcystis aeruginosa

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Microcystis aeruginosa is a cosmopolitan cyanobacteria that continues to jeopardize freshwater ecosystem services by releasing the hepatotoxic microcystin-LR, which can ultimately cause death to humans and other fauna. Currently, our abilities to understand the mechanisms of microcystin toxicoology are limited by the lack of a method for producing high concentrations, which are central to large-scale and long-term research in natural systems. Here we present an efficient and affordable laboratory method to produce high concentrations of microcystin-LR and its demethylated counterpart [D-Asp3]-microcystin-LR by M. aeruginosa CPCC 300. Our observations suggest that steady production of microcystins depends on the availability of carbon throughout the experiment. Hence, we recommend experimental cultures remain axenic and vessels are ventilated to ensure the production of microcystins is uninterrupted. This method effectively demonstrates microcystin-LR and [D-Asp3]-microcystin-LR can be produced in the laboratory at concentrations found in the environment (1 to 300 μg L-1).

RP002 Determination of total microcystins (free and protein-bound) in fish tissue using Lemieux Oxidation

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Microcystins (MCs) are cyanobacterial toxins generated from harmful algal blooms (HABs). MCs are hepatotoxins found in freshwater system worldwide and are known for being hazardous to the living organisms. Studies show that MCs are bioaccumulative and exist in two different forms in biota: free and covalently bound to proteins. These toxins can be transferred through the food web to high trophic levels and to human; therefore, MCs can have potential risk to human health. More than 200 MCs structures have been reported. All these variants exclusively contain an unusual amino acid side chain abbreviated Adda (3-amino-9-methoxy-2,6,8-trimethyl-10-phenyldeca-4(E),6(E)-dienoic acid). Different approaches, such as Lemieux oxidation, have been explored for the extraction and analysis of free and bound microcystins in aquatic living organisms. Using this method, the oxidative product of Adda, 2-methyl-3-methoxy-4-phenylbutyric acid (MMPB), is analyzed. In this study, factorial design was applied to better optimize the Lemieux oxidation procedure and oxidize MCs in fish tissue (liver and fillet). Moreover, calibration standard, MMPB, was generated in situ by oxidizing four MCs standards spiked to blank fillet/liver. Also, matrix-matched calibration approach was applied to correct the co-elute matrix influence on ion suppression. Finally, 2DLC technique enabled to have the detection limit of microcystin as low as 5ng/g of dried fish. MMPB was analyzed using UPLC-Xevo G2-XS-QToF Mass spectrometer. The optimized oxidation condition along with the optimized solid phase extraction led to the highly linear calibration curve and the recovery ranged from 5 to 2000 ng/g.

RP003 Electron Beam Irradiation for the Remediation and Mitigation of Toxicity of Microcystin-LR in Drinking Water and Treatment Residuals

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Harmful algal blooms (HABs) are increasing in occurrence due to rising temperatures and nutrient pollution. These over growths of algae and cyanobacteria pose threats to human and animal health as they often produce an array of hepato- and neuro-toxins. Drinking water sources that are affected by a HAB provide a critical human exposure scenario. The cyanobacterium, Microcystis aeruginosa, is commonly associated with freshwater HABs and is responsible for producing a class of hepatotoxins termed microcystins. Of the over 80 variants of microcystin, microcystin-LR (MC-LR) is the most prevalent and most toxic. Microcystin’s biological activity comes from the unusual amino acid (2S,3S,8S,9S)-3-amino-9-methoxy-2,6,8-trimethyl-10-phenyldeca-4,6-dienoic acid (ADDA), which results in the permanent binding and inhibition of protein phosphatase 1 and 2A in humans. Current drinking water removal strategies rely on ozonation and while this may be sufficient for drinking water, it is not a feasible technology for remediating treatment plant sludges containing high amounts of microcystin. Our underlying hypothesis is that high energy electron beam (eBeam) irradiation technology, an advanced oxidation/reduction process, could be effective for the detoxification of microcystin-contaminated water, sludges, and sediments.

Our data suggests that aqueous samples treated with low eBeam doses (< 500 Gy) completely destroy MC-LR as determined through LC-MS/MS. These results were confirmed with the EPA standard method 546 ADDA-specific Enzyme-Linked Immunosorbent Assay (ELISA). Culture samples treated with eBeam required higher doses for inactivation (2 kGy) but still showed dose dependent decreases in toxicity with eBeam treatment. Interestingly, unlike bacterial cells, M. aeruginosa cells lysed within 16 hours of irradiation treatment. eBeam technology, which relies on accelerating electrons, does not involve the use of chemicals. Thus, eBeam technology has the potential to be a sustainable and more cost-effective alternative treatment strategy for such applications.

RP004 Evaluation of algal growth potential (AGP) of Anabaena flos-aquae with water samples from Valle de Bravo to determine Harmful Algal Blooms (HABs)

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Eutrophication in freshwater lakes are common worldwide and in Mexico; this phenomenon is mostly related to increased nutrient loading, through the discharge of crude and treated wastewaters and agriculture residuals. The excess of limiting nutrients as phosphorus and nitrogen promote the thriving of phytoplankters, some of them responsible for the synthesis of toxins, given place to HABs. The Valle de Bravo dam, located in the central part of Mexico, has a eutrophic status; in this, the cyanobacteria Anabaena has been reported as a HAB forming. The objective of the present study was to determine the AGP of Anabaena flos-aquae in monthly water samples obtained in different sampling stations from Valle de Bravo, during a 6-month cycle. The potential development of HABs was determined through the experimental variation of combinations of N, and P. Growth kinetics of this cyanobacteria was studied for 14 days, in a rich medium (BG11), a minimum medium (OECD), and in OECD medium added with PO4 (9.16x10-8M, 6.2x10-7M, 1.17x10-6M, 1.70x10-5M) at 25 °C and photoperiod 16:8. The water samples from Valle de Bravo were enriched with combinations of P (9.16x10-8M, 8.2x10-7M, 1.70x10-6M) and N (2.80x10-8M, 8.6x10-7M, 1.76x10-6M) to establish
the potential to develop HABs. Growth kinetics were performed for 96 hours at 25 °C and photoperiod 16:8. *Anabaena flos-aquae* accumulates 58% more biomass in the BG11 medium than in the OECD medium. The concentration of P that promotes the growth of the cyanobacteria was 1.17 x10^{-4}M. The maximum AGP of *Anabaena flos-aquae* in Valle de Bravo samples was achieved with the combination of 1.70x10^{-5} M P and 2.80x10^{-4}M N; this tendency was repeated along the time, so we conclude that the P is a nutrient that promotes the growth. The trifactorial ANOVA demonstrated significant differences in the biomass achieved in the water samples in the different sampling points. The differences of AGP in the water samples demonstrated the variability in the nutrients contained in the different sampling points; this could be related to changes in nutrients loading in the basin along the time. Although Valle de Bravo dam has a eutrophic status currently, HABs could be expected if P content increases; this is a factor to take into account to prevent risks during water supply for human consumption.

**RP005 Evaluation of the Algal Growth Potential of Microcystis aeruginosa in Water Samples from Valle de Bravo, México, for the Determination of HABs**

1.17 x10^{-4}M. The maximum AGP of *Anabaena flos-aquae* in Valle de Bravo samples was achieved with the combination of 1.70x10^{-5} M P and 2.80x10^{-4}M N; this tendency was repeated along the time, so we conclude that the P is a nutrient that promotes the growth. The trifactorial ANOVA demonstrated significant differences in the biomass achieved in the water samples in the different sampling points. The differences of AGP in the water samples demonstrated the variability in the nutrients contained in the different sampling points; this could be related to changes in nutrients loading in the basin along the time. Although Valle de Bravo dam has a eutrophic status currently, HABs could be expected if P content increases; this is a factor to take into account to prevent risks during water supply for human consumption.

**RP006 Generating ecotoxicity information on microcystins and prymnesins: A different approach**

There is a lack of information to estimate safe levels for aquatic life concerning the toxicity of natural toxins produced by cyanobacteria and algae. There is even less ecotoxicity information available for prymnesins, a toxin produced by the estuarine golden algae Prymnesium parvum. Given the uncertainty of standards for bacteria and algal toxins, the cost of using them to conduct acute and chronic toxicity tests and their potential impurities, a new approach is proposed using cultures and ambient samples. In this study we have used laboratory cultures of a toxin producing unicellular Microcystis aeruginosa and P parvum and non-toxin producing filamentous *Anabaena flos-aquae*. Each culture was centrifuged to remove each species from its culture media, then resuspended in moderately hard water. The toxin culture, *M aeruginosa* was then frozen/thawed three times at -80 °C following procedures used for ELISA analyses. The non-toxin strain was not lysed. Both 48-hour acute tests and 7-day short term chronic tests were conducted with Ceriodaphnia dubia. Neocloeon triangulifer, Hyalella azteca and larval Pimephales promelas on all strains. A similar lysing procedure was also used on lake water samples. Microcystin concentrations in the lysed samples as high as 74 µg/L did not cause any toxicity greater than the lab water controls to any of the 4-test species. A flos-aquae caused mortality greater than the controls to N triangulifer. For chronic tests 80 L of culture *Microcystis aeruginosa* were grown to achieve a cell density of 2.2625 x 106 cells/ml. No lysed M. aeruginosa treatment levels exhibited any adverse survival effects versus the moderately hard water controls in C. dubia, P. promelas or H. azteca tests. *N triangulifer* tests did not meet test performance criteria. The only adverse effects noted in these tests were the sub-lethal point estimate endpoints for reproduction inhibition (IC50~30.96% [1.37X106 cells/ml]) in the C. dubia bioassay. August 2017 Lake Harsha sample (total # of cells 300,000 cells/ml) was not acutely toxic to any of the 4-test species. P. parvum acute and chronic tests with the same 4 species. C. dubia tests did not meet test performance criteria. The only adverse effects noted in these tests were the sub-lethal point estimate endpoints for reproduction inhibition (IC50~30.96% [1.37X106 cells/ml]) in the C. dubia bioassay. August 2017 Lake Harsha sample (total # of cells 300,000 cells/ml) was not acutely toxic to any of the 4-test species. P. parvum acute and chronic tests with the same 4 species. C. dubia and N. triangulifer exhibited LC50s of 493,850 cells/ml and 121,761 cells/ml, respectively. Additional analyses will be provided based on toxin results and results from 2017 and 2019 whole lake sample tests.

**RP007 Non-targeted analysis of HABs: Linking chemical changes with differential toxicological response**

Harmful algal blooms (HABs) in estuaries and freshwater bodies are increasing in frequency, duration, and magnitude due to eutrophication, salinization, and climate change. However, recent work has shown that known toxins can fail to completely depict health threats of inland HABs, suggesting that additional toxins still need to be identified. Traditional bottom-up approaches to toxin identification, such as Toxicity Identification Evaluation, require time- and labor-intensive studies to systematically identify each component of a HAB mixture or simplify a toxic mixture through fractionation until the toxic component is identified. An alternative approach to hasten toxin identification was developed to alleviate the need to identify each component of the complex algal mixture. Instead, the entire chemical “fingerprint” of algal culture filtrates was examined through non-targeted analysis, and changes in the
LC-HRMS heatmap were linked to changes in toxicological response. Changes in the LC-HRMS heatmaps were then visualized using relative difference plots. These plots compare the intensities of a toxic/sample ion map to the intensities of a nontoxic/reference ion map where compounds with concentrations changing the most between samples are highlighted while compounds at the same concentration in both samples disappear. Prymnesium parvum cultures expressing various levels of acute toxicity were then analyzed using this approach to quickly identify constituents produced in higher amounts as a function of increasing toxicity. These peaks were compared to the peaks highlighted using statistical analysis available in two commercial software packages. Peaks that contributed most to correctly categorizing algal samples as toxic or non-toxic differed between the software packages, so a larger sample size of algae cultures were grown and analyzed in R.

RP008 Probabilistic Aquatic Hazard Assessment of Anatoxin-a with Bioconcentration Experiments in Ictalurus punctatus and Danio rerio

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Water contamination from the neurotoxic cyanotoxin anatoxin-a presents risks to global public health and the environment. Using published data, we calculated expected exceedances of guideline values (GVs) using environmental exposure distributions (EEDs) of surface water data (intra and extracellular toxins) from recreational and potable source waters. Anatoxin-a concentrations exceeded common GV's of 0.1, 1 and 300 μg/L 79.62%, 48.37% and 1.42% of the time, respectively, when blooms occur. 66% of occurrences were from lacustrine ecosystems compared to reservoir, river, coastal and other systems, with almost all data from Asia/Pacific, European and North American regions, highlighting the need for more monitoring efforts in diverse systems and in developing regions. Aquatic toxicity and bioaccumulation data were examined and compared to these environmentally relevant concentrations, though a lack of high-quality data highlights major research needs. Little has been done to describe the influence of pH on the bioconcentration of this ionizable weak base (pKa 9.4). For this reason, uptake of anatoxin-a was evaluated in 1-year old channel catfish (Ictalurus punctatus) exposed to 1 μg/L at two pH levels, 6.5 and 8.5, for 96 h followed by an isochronous depuration. Water, plasma and tissue samples were taken at multiple time points during uptake and depuration then analyzed for anatoxin-a using LC-MS/MS. Contrary to previous studies, we observed no uptake in plasma or tissue during either exposure. However, the exposure concentration was two orders of magnitude lower and represented a more environmentally relevant concentration. An additional uptake study is being conducted with embryonic zebrafish (both chorionated and dechorionated) at higher exposure concentrations and at a pH of 7 and 8.5. Understanding aquatic accumulation and hazards associated with cyanotoxins is vital with cyanobacterial blooms evidently increasing in magnitude, frequency and duration.

RP009 Prymnesium parvum differentially triggers sublethal fish antioxidant responses in vitro among salinity and nutrient conditions

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Significant fish kills have been attributed to *Prymnesium parvum* in coastal and inland waters around the world. However, specific mechanisms responsible for adverse outcomes resulting from this harmful algal bloom (HAB) species remain unclear. In the present study, an in vitro approach was used to examine cytotoxicity and antioxidant responses in fish liver (Hepa-E1 and PLHC-1) and gill (GIB and RTgill-W1) cell lines, following exposure to *P. parvum* grown at different salinities and nutrient concentrations. Cultures from high salinity compromised survival of hepatic cell lines exposed to high dilutions, whereas no significant cytotoxicity was observed for gill cell lines. With respect to control groups, catalase showed significant activity in both gill cell lines, especially RTgill-W1, following exposure to high salinity cultures. High levels of superoxide dismutase were measured in Hepa-E1 cells exposed to all experimental treatment combinations and in RTgill-W1 cells following exposure to high salinity conditions, with respect to non-exposed cells. Glutathione peroxidase activity was also detected at significant levels in Hepa-E1 cells after exposure to cultures from high salinity and the low salinity-low nutrients. Slight GPx increases were only observed in PLHC-1 and GIB exposed to *P. parvum* grown at high salinity. These results suggest that: 1. specific combinations of salinity and nutrient levels may contribute to production and potency of *P. parvum* toxins resulting in sub-lethal effects, and 2. sub-lethal responses are more prominent than cytotoxicity, and that oxidative stress may be a significant adverse effect of toxins produced by *P. parvum*.

Fate and Effects of Metals: Regulatory and Risk Assessment

RP010 Are international Sediment Quality Guidelines protective to tropical fish?

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Sediment quality guidelines (SQGs) used in tropical environments are frequently based in values developed for sub-tropical or temperate environments (e.g. Threshold Effects Levels - TEL and Probable Effects Levels - PEL, or Effects-Range Low - ERL and Effects-Range Median - ERM). The aim of this research was to assess histopathological responses in a tropical estuarine fish exposed to low, moderate and high concentrations of metals according to TEL and PEL. To achieve that, individuals of *Poecilia reticulata* were exposed to a contamination gradient of metal-spiked sediments (Pb, Hg, Cu and Zn), under controlled laboratory conditions, for 3, 7 and 14 days. Levels of metals in sediment were (i) sediment control (no addition of metals) (ii) low level (below TEL), (ii) moderate level (between TEL and PEL), and (iii) high level (above PEL), according to Canadian SQGs. Hepatic histopathological alterations were divided in four distinct reaction patterns and integrated through the estimation of individual histopathological condition indices. Results obtained for metal-exposed organisms were compared with sediment control. The sediments with “high level” were acutely toxic to the organisms causing full lethality within six hours of exposure. Liver histopathological damage was higher than control in the “moderated level” at 3 and 7 days (KW, p< 0.05). The most frequent injuries were congestion of sinusoids, hemorrhage, intracellular edema, hepatocyte hypertrophy, hyperplasia, cholestasis and apoptosis. These results showed that the loads of metals in sediment at permissible levels (between TEL and PEL) led to injuries in the histo-architecture of liver, a vital organ. Surprisingly, the histopathology results of individuals exposed for 14 days to contaminated sediment did not show differences with sediment control individuals. It may be a result of two possible processes: (i) individuals may have defense mechanisms, such as pollutant-sequestering type detoxification system or activation of the antioxidant defense systems; or (ii) organisms may have initiated a process of metal excretion after internal levels reach a certain toxic threshold. Histopathological assessments can provide a reliable and discriminatory data even when biomonitoring is a complex media as sediments. The results of this study suggest that care must be taken to use international SQGs in the sediment management of environments different from those they were derived.
focused on sediments because they act as a reservoir for the introduction of metals into the aquatic environment, especially in heavy metals. The Cienega of Tamasopo natural wetland, which was chosen for its geological characteristics, discharges, and populations along the wetland; 2 samples were taken, before the rains (M1: February 2017) and after the rains (M2: August 2017). 10 cm of the sediment was taken with a PVC tube 30 cm long and 10 cm in diameter. They were placed in plastic containers and transported at 4 °C to the laboratory and then frozen at -20 °C in an LG brand freezer. Once frozen, they were lyophilized for 5 days at 0.060 mBar, -48 °C on a LABCONCO FreeZone6 machine, and subsequently sieved at 420 and 500 μM. Elemental analysis of the samples was performed using dispersive wavelength X-ray fluorescence (WDXRF) on a Bruker model S8 TIGER spectrometer. The results provide information on the characterization and concentration of metals (% by weight and ppm) in sediments in the following order for sampling 1 (M1): C> Ca> Si> Sr> Fe> Na> K> Al> Mg> Mn> Sr> P and for sampling 2 (M2): C> Ca> Si> Na> S> Fe> Al> K Mg> P> Cl> Mn> Sr, which are relevant for subsequent studies on the accumulation and phytoremediation of metals in the Cienega of Tamasopo wetland.

A large water quality database, intended to be used for metal bioavailability corrections, was developed for European freshwaters. The process used to develop this database, and associated preliminary results, will be described. The collated data, obtained from European Union (EU) member states, provides a useful component for future bioavailability assessments. The database will be particularly useful for providing context for individual member states, especially in situations where water bodies cross national boundaries. Additionally, the database provides an opportunity to identify gaps in data coverage and allows member states to target and prioritize resources to enable robust bioavailability compliance assessments for metals. The database was developed using a step-wise process to systematically obtain, screen, and assess the quality of all available data. Data obtained were from EU member states, via various sources including centrally hosted data archives, data compiled by the European Environment Agency, and contacts at environment agencies throughout Europe. Initial data searches focused on obtaining as much information as possible; the targeted information was separated into categories. Essential data were pH, dissolved organic carbon and Ca; desirable data were Mg, Na, K, Cl, SO4^2−, total and dissolved Cu, total and dissolved Ni, total and dissolved Zn and total and dissolved Pb, and added value data were conductivity, hardness, Fe, Al and other trace elements. After compilation, an initial screening was performed to retain data with relevant sample/site information and the specific ‘essential data’. Following the initial screen, a quality assessment was implemented, which was based on the European Chemicals Agency guidance on use of measured data. Preliminary results demonstrate that although large amounts of data are generated on water quality throughout Europe, the public availability of these data, the water quality constituents assessed, the format in which data are provided, and the quality of the data are extremely variable. Where high quality data are available, they can be used for performing bioavailability assessments, which can then identify geographic locations or areas that may be specifically sensitive to metals. Furthermore, by collating all available data, and by retaining datasets with data gaps, it is possible to identify areas where data limitations hinder adequate bioavailability assessments.

Natural freshwater wetlands are becoming scarce as a result of the impact of human activities; most freshwater wetlands show significant changes in their ecology, mainly in relation to species composition, invasion of alien species, sedimentation, pollution, and the hydrological regime. This has resulted in high costs, both in terms of lives and economic well-being, for local communities, mainly through increased flooding, lower soil productivity and increased contamination by agrochemicals. Between 23 and 93% of the contribution of mineral particles in suspension is retained by the wetlands in the form of sediment. In recent years, attention has been focused on sediments because they act as a reservoir for the introduction of metals into the aquatic environment, especially in heavy metals. For this reason, the analysis of sediments and organisms is essential to evaluate the quality of these, because metals are considered pollution indicators. Sediments are important in geochemical investigations because it is important to know the conditions and concentration of pollutants, as well as their relationship. The contamination by heavy metals in sediment has been magnified with the increase of residual discharges to water bodies and agricultural activities. The Cienega of Tamasopo natural wetland, RAMSAR site No. 1814, has suffered discharges from the 15 surrounding populations (approximately 250 inhabitants) over several years and there is no comprehensive analysis of the water-plant-sediment relationship of the site to evaluate your current status. Five sampling points (S1-S5) were designed through the wetland, which was chosen for their geological characteristics, discharges, and populations along the wetland; 2 samples were taken, before the rains (M1: February 2017) and after the rains (M2: August 2017). 10 cm of the sediment was taken with a PVC tube 30 cm long and 10 cm in diameter. They were placed in plastic containers and transported at 4 °C to the laboratory and then frozen at -20 °C in an LG brand freezer. Once frozen, they were lyophilized for 5 days at 0.060 mBar, -48 °C on a LABCONCO FreeZone6 machine, and subsequently sieved at 420 and 500 μM. Elemental analysis of the samples was performed using dispersive wavelength X-ray fluorescence (WDXRF) on a Bruker model S8 TIGER spectrometer. The results provide information on the characterization and concentration of metals (% by weight and ppm) in sediments in the following order for sampling 1 (M1): C> Ca> Si> S> Fe> Na> K> Al> Mg> Mn> Sr> P and for sampling 2 (M2): C> Ca> Si> Na> S> Fe> Al> K> Mg> P> Cl> Mn> Sr, which are relevant for subsequent studies on the accumulation and phytoremediation of metals in the Cienega of Tamasopo wetland.

The U.S. Environmental Protection Agency (EPA) updated its aquatic life ambient freshwater quality criteria (AWQC) recommendation for aluminum. These 2018 final recommended aquatic life AWQC for aluminum supersede the 1988 recommended criteria. Literature searches for laboratory tests published from 1988 to 2017 identified new studies describing the toxicity of aluminum to aquatic life. The EPA supplemented these studies with additional data made available by researchers in late-2017 and 2018. The EPA conducted a full evaluation of available data to determine test acceptability for criteria development. There were insufficient data to establish an estuarine/marine aluminum criterion. This update to the recommended aluminum aquatic life AWQC establishes freshwater criteria magnitude values resulting from the interactions of aluminum and three water chemistry parameters: pH, total hardness, and dissolved organic carbon (DOC). Multiple linear regression (MLR) models were developed to characterize the bioavailability of aluminum in aquatic systems, based on the effects of pH, total hardness and DOC on aluminum toxicity. They used a dataset comprised of 22 chronic tests with the fathead minnow (Pimephales promelas), and 23 chronic tests with an invertebrate (Ceriodaphnia dubia) to evaluate the ability of MLR models to predict chronic toxicity of aluminum as a function of pH, total hardness and DOC water chemistry conditions. These three parameters are considered to be the most influential for aluminum bioavailability and can be used to explain the range of differences in the observed toxicity values. These datasets were supplemented in 2018 with an additional nine C. dubia toxicity tests and nine P. promelas toxicity tests to expand the range of water chemistry conditions for model development. Two models, one for invertebrates and one for vertebrates, were used to normalize freshwater aluminum toxicity values. These separate models correspond to effects on invertebrates and vertebrates due to differing effects of pH, total hardness and DOC on aluminum bioavailability and toxicity, and therefore enable the criteria magnitudes to be calculated as a function of the unique chemistry conditions at a given site. The updated aluminum criteria were derived using these MLR models to normalize the freshwater acute and chronic toxicity data.
RP014 Mercury concentrations in Dolly Varden (Salvelinus malma) living downstream of a formerly used defense site on St. Lawrence Island, Alaska

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Located west of the Alaska mainland in the Bering Sea, St. Lawrence Island is home to approximately 1,600 Siberian Yupik residents. The island also contains two formerly used defense sites (FUDS), one of which is located at Northeast Cape. Previous research reported local environments at the Northeast Cape FUDS having elevated concentrations of organochlorine pesticides, PCBs, and mercury (Hg). The current study is concerned with Hg contamination at the Northeast Cape. Hg is a toxic metal that acts as an endocrine disruptor in addition to causing neurological and reproductive harm in animals and humans. Due to its lipophilic nature, Hg bioaccumulates and biomagnifies through trophic food webs. Our current research focuses on the quantification of Hg concentrations in Dolly Varden (Salvelinus malma) trout living downstream of the Northeast Cape FUDS. The Dolly Varden was selected for both its relatively high trophic position as well as its cultural significance within the traditional diet of the Yupik residents. Dolly Varden samples were collected from the Suqitughneq (Suqi) River in 2013 and 2015, and stored at -80°C. Samples were sexed using previously described PCR techniques. Using a PerkinElmer FIMS 100 Flow Injector Hg system, Hg content of each sample was analyzed. Based on previous studies of sediments, we expect Hg concentrations in Dolly Varden living downstream of the Northeast Cape FUDS in the Suqi River to be significantly higher than those found upstream. The relevance of the current study is that residents of St. Lawrence Island face health disparities due in part to contaminant exposure. Our study will evaluate Hg concentrations in an important subsistence food, and also has relevance to contamination of higher trophic level wildlife.

RP015 Remote Estimation of DOC for Input into Metals Risk Assessment Models

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It is well established that water chemistry can influence the toxic effects of metals; in particular, dissolved organic matter (DOM) can decrease the toxicity of copper, nickel, lead and zinc. This effect, DOM as a toxicity-modifying factor, can quantitatively be predicted using established biotic ligand models (BLMs). For this modelling, DOM is represented by the measurable quantity of dissolved organic carbon (DOC; i.e., mg C/L). Many governments recommend use of the BLM, and other related bioavailability approaches, for establishing site-specific water quality criteria, or for risk assessment, but many local jurisdictions lack the ability to consistently and accurately measure DOC. Remote sensing is an active research field that might be able to address this practical data gap, and help risk assessors and water managers to quantitatively take DOC into account when establishing metal risks for surface waters. The basis for remote sensing of DOC is that dissolved organic matter has colour (referred to as CDOM). It has not yet been demonstrated that remote sensing can accurately convert measurements of CDOM to a prediction of DOC in freshwater environments. As a proof of principle, we propose to study remote, un-impacted, lakes in Quebec using both drone- and Landsat-based methods. Preliminary results were satisfactory and have demonstrated that is possible to explain 90% of the CDOM variance. The estimates of CDOM will be converted to DOC estimates and ultimately, via BLM modelling, to metals risk estimates (i.e., effects concentrations). This risk estimate will be compared to observed concentrations in samples of these same site waters. The comparison will allow us to assess the feasibility, and confidence intervals, of remote sensing as a tool for metals risk assessment, including copper, zinc, lead and nickel. Funding provided by ICA and NSERC.

RP016 Sensitivity analysis of the biotic ligand model: Implications for potential application of remote sensing to estimate dissolved organic carbon

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The biotic ligand model (BLM) is a tool used to quantitatively evaluate how receiving water chemistry affects the bioavailability of metals. Sensitivity testing can be used to understand how the model outputs vary in response to systematic changes in water chemistry inputs. This will allow users of such models to understand how accurate their input parameters must be for a specified level of confidence in the output. Our focus is on dissolved organic carbon (DOC), which is often the most limiting data for application of BLM approaches to metals risk management. When using remote sensing as a tool to measure DOC, the question stands of how well does DOC need to be estimated in order to produce accurate water quality criteria outputs? This study inputs average water chemistries for both cold and warm water regions with 1%, 10%, 25% and 50% variations in the mean values for all parameters, ignoring correlations between dependent parameters. The variation in the model output criterion continuous concentration for copper as a function of DOC, and other model outputs, will allow estimation of how well DOC needs to be estimated in the context of remote sensing, to be useful for water quality and risk assessments. This study will be Phase I, as correlations will be taken into account in future research. Funding provided by ICA and NSERC.

RP017 Study on Health Effect of Antimony by Short-term Exposure in Rats

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The objective of this study was to estimate the health risks caused by the short-term exposure of antimony orally in rats. Methods Sixty healthy Sprague-Dawley rats (male and female) were randomly divided into 6 groups. Rats were given orally antimony potassium tartrate every day with the concentration of 0.06, 0.35, 0.6, 6 and 60 mg/kg. The negative control group was administrated with deionized water. Rats were weighed weekly and sacrificed on the 14th day after exposure. Blood samples were taken from the abdominal aorta to detect blood biochemical indexes. The liver, kidney, spleen, thymus and thyroid glands were weighed and examined for pathology. Results Compared with negative control, the body weight of male rats in the group of 60 mg/kg was significantly decreased (P< 0.05). The liver-to-body ratio was elevated (P< 0.01) and the serum total cholesterol (TC) concentration was decreased (P< 0.01). There were significant differences (P< 0.05) between negative control and the group of 0.6 mg/kg in alkaline phosphatase (ALP), total protein (TP) and glucose (GLU). In the groups of 6 and 60 mg/kg, the concentration of serum T4 was decreased in the male rats (P< 0.05), and the concentration of serum FT4 was increased (P< 0.05), while the FT3 was decreased (P< 0.05) in female rats. Compared with the group of negative control and 0.6 mg/kg, the concentration of serum FT4 was decreased (P< 0.05) in the male and the FT3 was decreased (P< 0.05) in the female. Conclusion It can be caused metabolic changes, including abnormal glycolipid metabolism and thyroid hormone secretion by short-term oral exposure.
Effects of Abiotic Factors and Chemical Additives on the Toxicity of Environmental Contaminants to Aquatic Organisms

RP018 Effect of cutting pile discharges on the distribution and abundance of micro-benthos in soil and water samples
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During oil drilling, cutting piles which are contaminated with inert emulsion drilling fluids are discharged to the surrounding environment, the sea and the sediment. Hence ecotoxicological tests in an aqueous media will not reflect the conditions found where the discharges were made. Usually presence of fluids will modify the physical structure of the sediment, which will affect the benthic community (the primary food chain). An analysis of sediments from onshore drilling well sites of SPDC W12/14 (active and abandoned) and an adjoining river (Apari) located at 5° 42′ 24″ N and 6° 47′ in Umuajoma farm settlement Oguta 2, Oguta local government areas of Imo state were made. W12/14 is located about 1.2km apart. The adjoining River where discharges were made is 3m water depth and about 500m away from the wellheads. Sediment samples were collected adjacent to the wellhead and at increasing distances of 10m apart. Sediment samples were collected using a diver. Samples were frozen and kept dark until delivered to lab for analysis. Result obtained showed both bacterial and fungal heterotrophic isolates from W12 (active) 10m from wellhead were the least in percentage hydrocarbon utilizers while W14 (abandoned) wellhead gave the highest hydrocarbon utilizers of 0.74% and 5.68% respectively. The results obtained from sediment analysis of the adjoining river where discharges were made showed that AP7 had the highest % hydrocarbon utilizers and AP2 the least % hydrocarbon utilizers of 16.86% and 0.86% respectively. These findings present strong evidence of ecotoxicological effects that cutting piles have on the flora and fauna in the ecosystem especially at the benthic zone.

RP019 Effects of Polycyclic Aromatic Hydrocarbons and Abiotic Stressors on Fundulus grandis Transcriptomics
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Following the 2010 Deepwater Horizon oil spill, extensive research has been conducted on the toxicity of oil and polycyclic aromatic hydrocarbons (PAHs) in the aquatic environment. Many studies have identified the toxicological effects of PAHs in estuarine and marine fishes, however only recently has work begun to identify the combinatorial effect of PAHs and abiotic environmental factors such as hypoxia, salinity, and temperature. This study aims to characterize the combined effects of abiotic stressors and PAH exposure on the transcriptomes of developing Fundulus grandis larvae. F. grandis is a common estuarine species that is regularly exposed to fluctuations in water temperature, salinity, and dissolved oxygen levels, making it an ideal candidate for investigations into the effects of combined stressors in the estuarine environment. In this study, F. grandis larvae were exposed to varying environmental conditions (dissolved oxygen (DO) 2, 6 ppm; temperature 20, 30°C; and salinity 3, 30 ppt) as well as a low dose high energy water accommodated fraction (HEWAF) (ΣPAHs 15ppb). Whole larvae were sampled for RNA and transcriptional changes were quantified using RNA-Seq. Expression analysis revealed that multiple genes associated with cardiac and hepatic function were differentially expressed in larvae exposed to PAHs as well as those exposed to hypoxic conditions. Larvae exposed to PAHs also showed an upregulation in genes involved in xenobiotic metabolism. Results of this study will provide a holistic view of impacts of PAHs and common environmental stressors on early life stage estuarine species.

RP020 Enantioselective effects of 2, 2′, 3, 3′, 5′, 6 polychlorinated biphenyls (PCB-95) on GABAgentic and antioxidant transcriptome in zebrafish larvae
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Nineteen ortho-substituted PCBs are chiral and several have been found enantioselectively enriched in ecosystems. The biological and toxicological characteristics of enantiomers of chiral PCBs may differ, but these enantioselective effects of PCBs have not been fully characterized. PCB-95 (2′, 3′, 5′, 6 polychlorinated biphenyls) is one such chiral PCB of current environmental relevance, that has been known for its neurotoxic effects. PCB-95 is most potent toward modifying ryanodine receptor (RYR) function and Ca²⁺ signaling, however, there could be several other mechanisms that pose neurotoxic effects. In this study, we seek those mechanisms by performing transcriptomic analysis of the GABAgentic profile and the antioxidant system to investigate the enantioselective toxic effects of PCB-95. There is no information available for the adverse effects of embryonic PCB-95 exposure on the GABAergic system and antioxidant system during early development. PCB-95 enantiomers were separated using HPLC and assigned (+) and (-). Gross morphological alterations, tissue up-take, neurotransmitter levels were analyzed along with different GABA-related genes such as GABA (A) receptors, GABA transporters (Gat-1, Gat-3 and V-gat) and glutamic acid decarboxylase (GAD-2). Further, we analyzed genes encoding for antioxidant proteins such as Nrf2, Cu/Zn-superoxide dismutase (Cu/Zn-SOD), manganese superoxide dismutase (Mn-SOD), catalase (CAT), and glutathione peroxidase (GPx). Results suggested that the toxic effects of (-) PCB-95 is more prominent than that of the (+) enantiomer and the racemates. This would also clarify the health risks associated with enantiosomeric enrichment of PCBs in the environment. Further, these data provide a framework for further analysis of stereoselectivity of PCB-95 toxicity on developing nervous system to determine the exact mechanism by which PCB-95 affect the neurogenesis and embryonic of an organism.

RP021 Impact of salinity and temperature on bioconcentration of permethrin in pyrethroid-resistant Hyalella azteca and the subsequent effects on fish
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Global climate change leads to increased variability of environmental parameters in aquatic ecosystems. Two such parameters, salinity and temperature, can have a profound effect on aquatic ecosystem health. Anthropogenic pollutants in aquatic ecosystems may act in conjunction with these environmental changes, compounding the effects on aquatic biota. Some anthropogenic pollutants, such as insecticides, have also caused genetic-level changes to some populations of aquatic biota. While these genetic changes lead to greater resistance to the toxicity, an increased potential for trophic transfer of insecticides via bioaccumulation by resistant populations also may occur. This research aims to determine the influence of the changes in temperature and salinity on bioconcentration of permethrin (a pyrethroid insecticide) in pyrethroid-resistant Hyalella azteca. Bioconcentration experiments conducted at three temperatures (18, 23, and 28°C) and three salinities (0.2, 1.0, and 6.0 ppt) in a 3x3 factorial design involved placing H. azteca in beakers all spiked at the same sublethal concentration of 14C-permethrin. H. azteca were removed from the test at six different time points (3, 6, 12, 16, 24, and 36 h) and analyzed for total permethrin and metabolic products in order to generate a toxicokinetic curve. The data suggest an increase in bioconcentration at higher temperatures and at higher salinities. Subsequent fish feeding experiments with 14C-permethrin-dosed H. azteca similarly showed higher bioaccumulation at higher salinities and temperatures. Taken together, this study provides critical information on how changing environmental conditions can result in higher tissue concentrations in
Advancing the OMICS into Regulatory Frameworks: Case-Studies and Perspectives

**RP022 A novel pipeline for functional extrapolation of toxicity effects across species**
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There is a growing recognition that an improved functional understanding of both molecular targets and pathways in the context of the Adverse Outcome Pathway (AOP) framework will allow for a more informed extrapolation to unravel impacts across chemicals and species. Furthermore, growing interest in inferring toxicant impacts to higher levels of organization than individual species requires the development of new methods and models that allow covering the breadth of species that need to be considered across the many trophic levels. An increased understanding of cross-species conservation of pathways and toxicity effects would catalyze a tangible shift toward adopting Next-Generation Risk Assessment (NGRA) approaches. Genomes for a vast collection of different organisms are already publicly available, but there is still an overall lack of clear-cut functional annotation, often inferred from sequence-homology. It is also important to consider that even though upstream signalling processes are likely to be similar across species, downstream events may diverge, resulting in very different apical outcomes. A deeper understanding of the conservation of the physiological cascades of whole pathways across species is critical to assess conserved response patterns and associated (adverse) outcomes. In this perspective, protein families inferred on structural domains may offer a more relevant metric of relative functional conservation within a given pathway, than the individual gene level. The overall goal of this project is to facilitate the process of providing scientific evidence to the process of functional pathway re-construction, thus reducing the uncertainty inherent to cross-species extrapolation. Using available knowledge from different disciplines i.e. comparative biology, functional genomics and bioinformatics and chemistry, we created a new pipeline for functional extrapolation of toxicity effects across species to enable the identification of relevant pathway-conservation levels. We foresee that this approach will contribute in adding weight-of-evidence to support risk-based decisions using functional conservation of pathways across species and improving the confidence in how we can use data from multiple sources.

**RP024 EcoToxChip: A toxicogenomics tool for chemical prioritization and environmental management**
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Here we provide an overview of our Large-Scale Applied Research Program (LSARP) grant from Genome Canada that aims to develop, test, validate, and commercialize quantitative PCR arrays (EcoToxChips) and a data evaluation tool (EcoToxXplorer.ca) for the characterization, prioritization, and management of environmental chemicals and complex mixtures of regulatory concern. In Project Phase 1, EcoToxChips are being developed for laboratory model species representing the most important vertebrate groups in ecological risk assessment (fish-fathead minnow; bird-Japanese quail; amphibian-Xenopus laevis). Model species (adult and early-life stage, ELS) are being exposed via standardized tests to 8 environmental chemicals representative of natural resource/environment sectors of Canadian concern and also ones that impact a wide biological space (EE2, chlorpyrifos, benzo[a]pyrene, lead, fluoxetine, selenomethionine, trenbolone, HBCD) (Activity 1). An integrative systems approach based on functional ‘omics (combined global transcriptomic and proteomic profiling, targeted metabolome) and physiological analyses across levels of biological organization is being applied to characterize relevant toxicity pathways including adverse outcome pathways, AOPs (Activity 2); from this, and other resources, species-specific EcoToxChips consisting of 384 environmentally-responsive genes of regulatory concern are being informed, built, tested, and optimized (Activity 3). EcoToxChip performance will be validated (and further optimized) through an inter-lab study with our collaborators (Activity 4). Under Activities 5-7, knowledge from Phase 1 is being translated to 3 native species (i.e., fish: rainbow trout; bird: double-crested cormorant; amphibian: Northern leopard frog). EcoToxXplorer.ca provides intuitive bioinformatics support and is modeled upon our successful cloud-based tools (metaboanalyst.ca). To position the team advantageously with regard to the commercialization and institutionalization of the deliverables, our GE3LS research will produce and leverage social science knowledge about the phenomenon of “institutional entrepreneurship.” The anticipated socioeconomic benefits associated with the adoption of our deliverables include, more focused animal testing, improved regulatory decision-making, and cost-efficiencies. Here we provide a 36 month update of our project (www.ecotoxchip.ca).
**RP025 EcoToxDB: A toxicogenomics knowledgebase to query, browse and interrogate chemical-gene-exposure networks**  

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The EcoToxChip project aims to develop, test, validate, and commercialize quantitative PCR arrays (EcoToxChips) and a data evaluation tool (EcoToxXplorer.ca) for the characterization, prioritization, and management of environmental chemicals and complex mixtures of regulatory concern. EcoToxDB is a knowledgebase that provides convenient access to all gene expression profiles generated using the EcoToxChip (as well as a range of other data such as metabolomics, proteomics, transcriptomics, chemical residue values, histology). It is a resource to query and browse results of exposure studies of several key model and ecological species of relevance to the Canadian and international regulatory community. Currently, EcoToxDB holds data from six species, eight chemicals, 47 exposure studies, 409 samples and annotations for thousands of genes. EcoToxDB will promote understanding of the effects of chemical hazards on ecological receptors of regulatory concern or interest. In EcoToxDB, users will be able to build chemical-gene-exposure networks and explore deeper scientific questions. Data can be projected onto a 3D space for interactive exploration. EcoToxDB will be hosted on a MongoDB server and will be accessible through an intuitive web interface. A set of application programmable interfaces (APIs) will also be developed for efficient loading of data into other related applications. Through an associated FTP site, protocol files, and raw and processed versions of EcoToxChip internal data will be available for download. EcoToxDB.ca will contain demonstrations, FAQs, tutorials, and other resources to best assist all levels of users. The database is designed to help researchers and scientists explore results of exposure studies on ecological species. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

**RP026 Effects of early life stage exposure of largemouth bass to a common Chesapeake Bay contaminant (atrazine) or a model estrogen (17α-ethinylestradiol)**  


Endocrine disrupting contaminants (EDCs) are of continuing concern in the Chesapeake Bay watershed (CBW). The incidence of testicular oocytes in black bass from CBW has been correlated with atrazine. Fish early life stages are of particular concern in agricultural areas, as a spring influx of pesticides coincides with spawning and early development. Our objectives were to expose newly hatched largemouth bass (LMB, Micropterus salmoides) fry to graded concentrations of atrazine or the model estrogen 17α-ethinylestradiol (EE2) during sexual determination and differentiation (from 7 to 80 days post-spawn), and monitor histological development and transcriptomic changes in gonad tissue. Concentrations of atrazine during the course of the exposure averaged 0.91 (± 0.06), 9.87 (± 0.68), and 105.09 (± 8.57) μg ATR/L, while concentrations of EE2 averaged 0.84 and 7.34 ng EE2/L. We monitored sex ratios, growth, and development of the gonads through histological examinations. We measured global gene expression in gonad tissue of males and females, in order to develop testable hypotheses for potential biochemical pathways and cellular mechanisms leading to altered gonad development and ultimately impairment of reproductive function. We observed a 100 % female sex ratio in LMB exposed to EE2 at 10 ng/L, presumably due to sex reversal of males. Overall, there was an absence of response to ATR in growth, sex ratio, and gonad morphology. Many genes were differentially expressed (DE) between sexes. Overall, males were more responsive to treatments than females. Few DE genes were common between ATR treated males and females. Most responsive genes in males were downregulated. Most responsive genes in females were up regulated, particularly male specific genes in females. In the 1 ng/L EE2-exposed fish, of those contigs differentially expressed in gonad (3811 in males, 2120 in females), 721 were identified in both sexes. There was a strong correlation of log fold changes between males and females in these 721 contigs (R² = 0.92), suggesting that some pathways responsive to EE2 exposure are not sex-specific. We found differential expression in male gonad in LMB exposed to EE2 at 1 ng/L of several genes involved in reproductive development and function, including star, cyp11a2, vasa, wnt5b, cypla, and samhd1. Expression of star, cyp11a2, and cypla were also responsive to atrazine exposure.

**RP027 Effects of PFBS and PFBA exposure on Lipids during the Development of Rainbow trout (Oncorhynchus mykiss)**  

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Per-and poly-fluorinated chemicals(PFCs) are a concern in the 21st century due to their persistence in the environment. Perfluorobutane sulfonic acid (C4, PFBS) and perfluorobutanoic acid (PFBA) are among the most widely used short-chain perfluoralkyl sulfonic acids, which are applied in a variety of areas instead of the long-chain PFAS (Perfluorooalkylated substance). However, few studies focus on their potential effects on lipid metabolism in aquatic animals, since they play a vital role in the early development of fish. Lipids like cholesterol (TC), triglycerides (TG) and phosphatidylcholine (PC) are important for many biological functions including formation of cell membranes and synthesis of hormones, which could be disrupted by PFBA and PFBS. In this study, Early life stage of rainbow trout were exposed to the different concentrations of PFBS and PFBA, and samples were taken throughout development. We aim to find changes in functional lipids affected by PFBS and PFBA, which will alter the fat content of these cold water fish. Thermo obitrap LC-MS/MS was used to identify lipid profiles in these fish. Data consolidation, normalization, statistical analysis and databasing are also performed to get a more in-depth insight into the mechanisms of action of these chemicals. Our data could provide new information on lipid metabolism in trout and benefit future ecotoxicological assessment of PFBS and PFBA.

**RP028 Genome-wide analysis of cadmium-induced germline mutations over 1,123 generations**  

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Germline mutations provide the raw material for all evolutionary processes and contribute to the occurrence of spontaneous human disease. Yet despite interacting daily with an increasing number of chemicals that are potentially mutagenic, precise measurements of the rate that chemicals change the genome-wide rate and spectrum of germline mutation are lacking. A large-scale Daphnia pulex mutation-accumulation experiment was propagated in the presence and absence of an environmentally relevant cadmium concentration to quantify the influence of chemical stress on germline mutational processes. Cadmium exposure increased
the mutation rate in intergenic regions and decreased the exon mutation rate. The increased intergenic mutation rate under cadmium exposure was caused by an elevated rate of A:T → G:C mutations, while the decreased exon mutation rate is the result of a reduced C:G → G:C mutation rate in genes under cadmium exposure. Oxidative stress-associated G:C → T:A mutations are elevated by cadmium, but only in mutation clusters. We suggest the increased A:T → G:C rate in intergenic regions is caused by either the increased usage of error-prone DNA polymerase eta, or cadmium interference with the zinc-finger domain of Polymerase eta. Further, our results suggest the reduced generic C:G → G:C mutation rate under cadmium exposure is linked to cadmium reducing the prevalence of mutagenic 5-hydroxymethylcytosine positions. These results show that chronic, chemical exposure can drastically change the genome-wide rate and regional distribution of mutations. Our results demonstrate that a more concentrated effort is needed for understanding genome-wide, germline mutation patterns in the presence of chemical exposures in order to more accurately predict population outcomes and the occurrence of human disease.

RP029 gn thinking to inform the selection and organization of genes on the EcoToxChip

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Our Large-Scale Applied Research Program (LSARP) grant from Genome Canada aims to develop, test, validate, and commercialize quantitative PCR arrays (EcoToxChips) and a data evaluation tool (EcoToxXplorer.ca) for the characterization, prioritization, and management of environmental chemicals and complex mixtures of regulatory concern. To help ensure that project deliverables are adopted by end-users, design thinking steps are being incorporated throughout the project. The methods underpinning design thinking include 6 steps: 1) Collect data to understand users; 2) Determine how to address users’ issues; 3) Generate product ideas; 4) Build product prototypes; 5) Test prototypes; and, 6) Make product. At last year’s SETAC NA meeting we outlined how “micro-level” features of the project deliverables were identified, and here we detail how the initial version of the EcoToxChip (i.e., version 1 of the Japanese quail EcoToxChip) was realized. The design of the EcoToxChip was driven by information we gathered over the past two years from key users and user groups, and articulated in last year’s presentation. From these interactions, key design elements of the EcoToxChip include the need for a range of QC wells, target genes identified by regulatory users, toxicology scholars, and bioinformatic approaches, a range of methods to organize the genes (e.g., gene sets, toxicity pathways), and case studies demonstrating EcoToxChip performance alongside other platforms. The initial version of the EcoToxChip contains 370 gene targets and 14 QC wells (5 housekeeping genes plus 9 technical controls). The 370 gene targets included 76 genes based on input from the regulatory community (i.e., from interviews, literature reviews, and conference presentations) and 212 genes from toxicology scholars within the project team (i.e., genes from the Avian ToxChip plus manual curation of CTD, Reactome, Gene Cards, Path Cards, Qiagen RT2 Profiler Array for Molecular Toxicology), with 19 genes overlapping between the two groups. The remaining genes were selected from a meta-analysis of RNAseq data generated within the project from hepatic tissue of early-life stage Japanese quail following exposure to 8 different chemicals. A range of factors were considered in a tiered approach (e.g., fold-change, p-value, abundance, impacted by multiple chemicals, presence of gene in modules defined by the project team) from which genes were identified and prioritized for inclusion on the EcoToxChip. In addition to detailed information on the specific genes and how they were organized into modules, we will report on the technical performance of the v1 Japanese quail EcoToxChip (i.e., inter- and intra-lab variation, EcoToxChip vs. RNA-seq results).

RP030 Household Garbage Bio-decomposition Influences the Abundance and Diversity of Antibiotic Resistome and Microbiome

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The development of antimicrobial resistance (AMR) bacteria is one of the most serious threats to global public health. Studies have revealed that, landfill, as the most common and essential strategy for the disposal of municipal solid waste, appear to contribute significantly to the acquisition of AMR by bacteria by horizontal DNA transfer, and gradually become a huge potential reservoir for breeding antibiotic resistance genes (ARGs). However, until now, no holistic assessment, including ARGs abundance and diversity, has been performed on household garbage system that contrasts decomposition processes and microbial communities. To better understand the impact, we studied the dynamics of ARGs and the bacterial community composition during household garbage decomposition in a bench-scale bioreactor. The result showed that household garbage (meat, vegetables and fruits) decomposition changed the ARGs diversity. Antibiotic deactivation and efflux pump were the two most dominant resistance mechanisms, followed by cellular protection. The total enrichment of ARGs in meat is the highest, followed by vegetables and fruits. The trends in variation for each antibiotic type were different among different samples. In a word, ARGs were detected with increased abundance and diversity, and distinct patterns, and were enriched during decomposition. The compositions of bacterial communities displayed distinct temporal variations during decomposing at the phylum level. ARGs patterns were significantly correlated with bacterial community structures, suggesting that the dynamic of ARGs was strongly affected by bacterial compositions during decomposing. This study documented elevated diversity and abundance, remarkable enrichment of ARGs, and significant correlation between ARGs structures and bacterial community compositions in household garbage decomposing. These results imply that refuse decomposition may lead to the spread of ARGs.

RP031 The genome of the cosmopolitan rotifer Brachionus plicatilis: Genome-wide expression of CYP450s in response to chlorpyrifos and 2-ethyl-phenanthrene

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The marine monogonont rotifer Brachionus plicatilis is considered a suitable model organism for ecology, evolution, and ecotoxicology. In this study, we assembled an characterized the B. plicatilis genome. The total length of the assembled genome was 106.9 Mb and the number of final scaffolds was 716 with the N50 value of 1.15 Mb and a GC content of 26.75%. A total of 13,899 genes were annotated after manual curation. To demonstrate the use of whole genome data, we targeted one of the main detoxifying enzyme of phase I detoxification system and identified a total of 28 cytochrome P450s. Based on the phylogenetic analysis using the maximum likelihood, 28 B. plicatilis-CYPs were apparently separated into five different clades, namely, clan 2, 3, 4, mitochondrial, and 46. To better understand the CYPs-mediated xenobiotic detoxification, we measured the mRNA expression levels of the identified CYPs in response to chlorpyrifos and 2-ethyl-phenanthrene. In addition, xenobiotic-sensing nuclear receptor response element sequences were identified in the 5 kb upstream of promoter regions of 28 CYPs from the genome of B. plicatilis, indicating that these XNR are likely associated with detoxification potential in the rotifer. Overall, the assembled B. plicatilis genome presented here will
be a useful resource for a better understanding of the molecular ecotoxicology in the view of molecular mechanisms underlying toxicological responses, particularly on xenobiotic detoxification.

**RP032 Toxicogenomic Assessment of Complex Chemical Signatures in Double-Crested Cormorant Embryos from Varibly Contaminated Great Lakes Sites**

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Using omics approaches to monitor complex mixtures in the environment is challenging. The majority of these studies have focused on using well-characterized laboratory animals. However, there is a lack of studies using wild species that are naturally exposed to contaminated mixtures. Here, we examined the chemical residues (including 209 PCB and 8 PBDE congeners) and gene expression (47 genes using a ToxChip PCR array) in embryonic liver tissue of double-crested cormorants (DCCOs), a sentinel wild avian species that breeds extensively across North America. DCCO embryos were collected from 5 Great Lakes breeding colonies and one non-Great Lakes site. The objective was to assess the ability to predict complex chemical space by using transcriptomics responses measured in DCCOs. A gene regulatory network inference algorithm Context Likelihood of Relatedness (CLR) was used to infer/prioritize chemicals that may influence the expression of specific genes. For instance, the concentration of PCB-25 showed the highest relevance to dysregulation of the phase I metabolizing enzyme, CYP1A4. Furthermore, a partial least squares (PLS) regression model was applied to evaluate the performance of gene expression data for predicting chemical space. The best model used the expression of 20 genes to predict the concentration of several specific chemicals (e.g. PCB-25 and PCB-37). Overall, toxicogenomic evaluation in a wild avian species, the double-crested cormorant, may represent a novel approach for mixture assessment.

**Aquatic Toxicology, Ecology and Stress Response**

**RP033 Ex vivo Comprehensive Multiphase Nuclear Magnetic Resonance Spectroscopy of Intact Daphnia magna**

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Daphnia magna (water fleas) are freshwater, keystone species and are model organisms for environmental toxicology studies. These organisms can provide key insight into the toxic-mode-of-action of environmental toxins. To fully comprehend the effects of these pollutants, the natural biological changes within the Daphnia must be understood first. Nuclear Magnetic Resonance (NMR) spectroscopy is a non-invasive analytical technique which allows for the study of whole organisms both ex vivo and in vivo. Natural biological samples contain many different phases, for example a living organism contains liquids (blood, fluids), gels (tissues) and solids (bone, shell). Unfortunately, NMR research typically tend to focus on one aspect of the sample (solution or solid state). This research uses a novel NMR technique, Comprehensive Multiphase NMR (CMP-NMR), to study different phases (solids, solutions and semisolids) in unaltered samples. This study illustrates multi-phase spectral editing techniques to follow ex vivo samples of Daphnia magna over various life stages and over different generations. The research demonstrates how spectral editing approaches in combination with multiphase NMR help uncover novel information on biological processes. In summary, ex vivo NMR proves to be a very powerful approach to study whole organisms in a comprehensive manner and should provide very complementary information to in vivo based research.

**RP034 Examining the impacts of superparamagnetic iron oxide nanoparticles on Daphnia magna with an integrated in/ex vivo nuclear magnetic resonance approach**

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Superparamagnetic Iron Oxide Nanoparticles (SPIONs) are becoming environmental contaminants of considerable concern as their medical and industrial applications grow. SPIONs exhibit toxicity, especially in the aquatic environment, however the mechanism of toxicity, and the long-term impacts are not well understood. Daphnia magna (water fleas) are keystone species and model organisms for research. Due to their abundance in freshwater worldwide, and well understood life-cycle, they are one of the most common species used in toxicity testing. The goal of this research is to combine magnetic resonance imaging, relaxometry, and metabolomics (both in vivo and ex vivo) to provide a holistic and integrated understanding of SPION toxicity. SPIONs are commonly used in magnetic resonance imaging (MRI) as negative contrast agents, meaning they cause a localized darkening in the image. As such, MRI holds the potential to explain if the SPIONs compartmentalize within the organisms. However, MRI provides no information as to what chemical components within the organism bind with the SPIONs. As the SPIONs are paramagnetic they lead to faster relaxation with components in close proximity, and relaxation-chemical shift correlation can potentially identify the main components inside the organisms (protein, lipids, carbohydrates, etc.) that bind with them. Finally, metabolomics provides insight into how the organisms respond to exposure, which helps in the understanding of the toxic-mode-of-action of the nanoparticles. Here 1H-13C 2D nuclear magnetic resonance (NMR) spectroscopy is applied in vivo and ex vivo to identify metabolic fluxes during exposure. To increase the understanding of the toxic impacts of these nanoparticles, a range of SPIONs with different core and ligand sizes are studied, totaling nine samples. Results from imaging studies show darkening of all samples, with large variations in the relaxation values, indicating a higher rate of uptake with the largest SPION sizes. Preliminary results from the relaxometry studies show interactions with amino acids and proteins, likely due to the stress response of these organisms, but further elucidation of these results, combined with the metabolomics results providing insight on the toxic-mode-of-action are pending. To our knowledge this is the first time MRI, relaxometry, and metabolomics have been combined to provide a comprehensive overview of toxicity inside whole organisms.

**RP035 The determination of the optimal protocol for in vivo nuclear magnetic resonance studies of 13C enriched organisms for use in toxicity testing**

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The continual release of toxic chemicals into the environment provides an increased need for new analytical techniques that can identify why chemicals are toxic at a molecular level, and which ones cause detrimental biological impacts. The ultimate analytic solution is to “see inside” living organisms and extract molecular information directly using in vivo NMR.
Nuclear Magnetic Resonance (NMR) spectroscopy, which is the only modern tool with resolution that permits in-depth, non-destructive metabolic profiling. Owing to the sensitivity of 1H NMR, inverse detected multidimensional (2D) experiments are often ideal for in vivo studies, as such many modern NMR probes are optimized for this purpose. Despite its sensitivity, 1H detected NMR experiments can suffer from multiple drawbacks compared to 13C, such as reduced spectral width, faster relaxation, and complications from water requiring suppression, especially for in vivo samples. The increased sensitivity of NMR cryoprobe technology has greatly improved the capability of 13C detection which has great potential for metabolomic studies, offering a very interesting alternative for in vivo NMR studies of 13C enriched organisms. In this study we compare inverse (heteronuclear single quantum coherence or HSQC) and observe (two-dimensional heteronuclear 13C-1H NMR or HETCOR) experiments on inverse (triple resonance inverse probe or TCI) and observe (broadband observe probe or BBO) prodigy cryoprobes for collecting metabolic data on 13C enriched Daphnia magna. The key questions being: Which experiment identifies the most metabolites? Or are the two complementary and ideally run together? In in vivo research, data is continuously collected, as such cryoprobes cannot be changed during a study. Assuming both HSQC and HETCOR need to be run, is it best to run them on a TCI (optimal for 1H detected HSQC) or BBO (optimal for HETCOR but compromised for HSQC) probe? To answer these questions and determine an optimal protocol for in vivo studies, HSQC and HETCOR experiments are compared on TCI and BBO cryoprobes using the keystone species D. magna. The results will consider in detail the signal response of various metabolites in controlled and stressed conditions. This will assist in determining which experiment-probe conditions provide the most informative response trends within living organisms.

RP036 Exposure to glyphosate produces acute and transgenerational toxic effects in the cladoceran Daphnia exilis

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The use of agrochemicals has increased in the last decades in response to the higher food demands of a growing world population. Glyphosate is the herbicide most worldwide used; it is commercialized in more than 130 formulations that are applied to at least 100 different crops, including GMOs. The reported toxicity of glyphosate and its commercial formulations are mainly referred to acute effects, but little is known about glyphosate toxicity in freshwater biota across generations. The objective of this study was to determine the transgenerational effects produced by Faena(R), one of the most commercialized glyphosate formulations, in the cladoceran Daphnia exilis. Population growth, fecundity, metabolic biomarkers, and the size of progeny was measured. The acute toxicity of glyphosate in D. exilis was determined at 48 h; tested concentrations were 2, 3, 4, 5, 6 and 7 mg L-1 at 25°C, 16:08 h photoperiod, with no food supply during assays. In the chronic toxicity studies, D. exilis individuals were exposed to sub-lethal glyphosate concentrations equivalent to the LC0.1 (2.09); LC1 (2.49) and LC10 (3.15) (mg L-1), during 21 d at 25°C, 16:08 photoperiod, feeding with 8x105 cells mL-1 of the microalgae Pseudokirchneriella subcapitata (F1). Neonates of the third reproduction were used to prepare the F2 generation under the described experimental conditions for the same glyphosate concentrations. The determined median lethal concentration (LC50) was 4.22 mg L-1. Survival, accumulated progeny, and the number of clutches in F1 were significantly higher than values observed in F2. Age to first reproduction was significantly higher in F1 respect to F2 in the LC1 and LC10. The metabolic biomarkers in D. exilis exposed to glyphosate were determined only in F1 because herbicide inhibited the reproduction in F2. In F1 the carbohydrates content was decrease significantly in LC1 and LC10; nevertheless, proteins content was increase for the same concentrations. The lipids were not affected in any concentration of glyphosate. In general, the size of neonates (body and total lengths, and body width) was significantly decreased in F2 progeny. Glyphosate caused significant toxic effects in the second generation of D. exilis, indicating that because of transgenerational effects, the sensibility of individuals whose parents grown exposed to the toxicant, increased. Obtained results warn about accumulated effects in zooplankton populations exposed to chemical stressors.

RP037 Glyphosate (FAENA®) produced chronic toxic effects in the tropical cladoceran Ceriodaphnia rigaudi


Freshwater bodies are complex and sensitive systems which are stressed constantly by different pollutants. The use of pesticides produces negative impacts in non-target organisms, including aquatic biota. Glyphosate is the herbicide most worldwide used in agriculture, with no restrictions for the many of the commercial formulations; as a consequence, its occurrence in aquatic ecosystems is common. Different studies have demonstrated the toxic effects that glyphosate produce in hydrobiots. The toxicity of chemical stressors aimed to determine its ecological risk assessment; it is indispensable to establish their acute and chronic effects. The objective of this study was to evaluate the effects on reproduction and at the biochemical level produced in the freshwater cladoceran Ceriodaphnia rigaudi exposed to a glyphosate-based herbicide. Acute toxicity were determined (at 48 hours) obtaining the LC50 of 1.09 mg L-1. Demographic effects, and biochemical responses by chronic exposure at concentrations of 0.34, 0.44, 0.55, 0.62 and 0.72 mg L-1, were measured (complete life cycle). Glyphosate produced a delay of one day in the age at first reproduction at concentrations of 0.44, 0.55, 0.62 and 0.72 mg L-1, while total progeny decreased 35% in the higher concentration (0.72 mg L-1). The number of clutches was significantly reduced (p<0.05), and aboritions were recorded at the concentrations of 0.62 and 0.72 mg L-1. The concentration of macromolecules was in the order: lipids > proteins > carbohydrates. There was a significant increase (p<0.05) of lipids and proteins in the highest glyphosate concentrations (0.62 and 0.72 mg L-1), whereas carbohydrates decreased as the toxic concentration increased. The results obtained in this study demonstrate that glyphosate-based commercial formulations produce negative effects on non-target organisms during chronic exposures, warning about impairing consequences on natural aquatic ecosystems indirectly affected by glyphosate pollution.

RP038 Vallisneria americana Responses to Aquatic Glyphosate Exposure

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Glyphosate-based herbicides are heavily applied on land and freshwater bodies for control of broadleaf plants and grasses. Glyphosate molecules interrupt completion of the shikimate pathway by inhibiting 5-enolpyruvylshikimate-3-phosphate (ESPS) synthase, which prevents synthesis of three amino acids that are critical for plant growth and structural integrity. At sufficient exposures, amino acid concentrations are so diminished that the plant cannot grow and dies. All plant life, including seagrasses and aquatic plants, contain the shikimate pathway responsible for glyphosate’s functionality. We theorize that at low concentrations, non-target species including submerged aquatic vegetation respond to glyphosate exposure. Because of rapid hydrolysis in fresh water, lethality is not anticipated in submerged plants. However, we are interested in assessing whether sublethal exposure concentrations impact the fitness of submerged plants. In this study, we expose a native and ecologically significant Florida plant Vallisneria americana to a range of glyphosate concentrations in a laboratory setting. We will assess indicators of plant health that are known in other submerged non-target species to be affected by glyphosate, such as photosynthetic efficiency and biomass production. We will also take a novel approach to evaluating plant response by investigating shifts in phytochemical profiles such as lignins, flavonoids and alkaloids which require shikimate products for synthesis.
Because V. americana possesses glyphosate’s mode of action, we hypothesize that exposed plants will exhibit a dose-dependent decline in growth and photosynthetic capacity. We also anticipate that decreasing concentrations of shikimate-dependent amino acids will alter relative amounts of secondary compounds dependent upon these amino acids for their synthesis. As ecosystem engineers, seagrasses such as V. americana are critical in maintaining habitability of sensitive aquatic environments currently in decline. This experiment will provide insight into the potential role of aquatic glyphosate in V. americana decline. By looking at indicators of plant health as well as alterations in secondary metabolite profiles, we hope this study will illuminate whether glyphosate impairs the fitness and phytochemical defenses of submerged plant species.

RP039 Transgenerational effects in biomarkers of Daphnia curvirostris chronically exposed to glyphosate
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The presence of pesticides in freshwater ecosystems produces toxic effects in aquatic biota and can also affect their future generations. The use of biomarkers for the evaluation of toxic pollutants in hydrobiota is an important approach to determine transgenerational effects at the sub-individual level. We aimed to determine if the chronic exposure to the herbicide glyphosate, as the active ingredient (AI) and as the commercial formulation (FAENA(R)), produces transgenerational effects in the cladoceran D. curvirostris, through the evaluation of the content of macromolecules and the oxidative stress response. The acute toxicity of AI and FAENA(R) was determined. After this, five sublethal concentrations (equivalent to the LC_{0.01}, LC_{0.1}, LC_{1}, LC_{5}, and LC_{20}) were chosen to determine in the second generation (F2) transgenerational effects during 21 days. Also, remnant effects in the F2 growing in a medium free of the herbicide were assessed (progeny in the recovery phase, F2R). The concentration of macromolecules (proteins, carbohydrates, and lipids), the analysis of antioxidant enzymes (superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx)), as well as the oxidative damage products (oxidation of lipids and proteins), were determined. The results indicate that neonates and adults of F1 exposed to FAENA(R) showed a significant reduction in macromolecules content; in the F2 a smaller decrease was documented, and in the F2R, no effects were observed. FAENA(R) induced oxidative stress on neonates of D. curvirostris in F1, F2, and F2R denoted as a reduction in the antioxidant response (SOD and CAT) and oxidative damage increase. No changes in the evaluated biomarkers were observed in F1, F2, and F2R exposed to glyphosate as AI, so the ingredients produces the toxicity of glyphosate in the commercial formulation (FAENA(R)). Reduction in effects observed in the F2 exposed to FAENA(R) can be explained as a developed resistance to the toxic ingredients in the commercial formulation. The increase in liperoxidation in F2R indicates that the total recovery of the progeny was not possible, this can be related to the inherited damages of the parents exposed to FAENA(R). Glyphosate as AI did not cause alterations in the biomarkers, but the commercial formulation induced oxidative stress in the cladoceran, so special attention should be put on the negative effects that the adjuvants produced; for this reason, they should also be regulated.

RP040 Toxicity of two pesticides to a tropical freshwater shrimp Xiphocaris elongata (Xiphocaris elongata)
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In the tropical island of Puerto Rico, large quantities of different types of pesticides are used for agricultural activity and residential homes because they have a great effectiveness. Two pesticides commonly used in the island are glyphosate and malathion. These pesticides can exert neurotoxicity and developmental toxicity on aquatic organisms. For this reason, this study examined the toxicity of these two pesticides to tropical freshwater shrimp Xiphocaris elongata. The pesticides used were glyphosate, a herbicide applied to control grasses and field crops; and malathion, a persistent insecticide used against mosquitoes, leafhoppers and beetles. The results showed that malathion was most toxic to this freshwater shrimp with a 96-h LC50 of 7.74 μg/L (95% CI 7.63-7.85 μg/L). However, Xiphocaris elongata were less sensitive to glyphosate with a 96-h LC50 of 657.78 μg/L (95% CI 617.98-697.58 μg/L). The present study reveals that malathion may cause a significant impact on native freshwater shrimps in the island. Further studies are needed to establish the toxic effect of glyphosate and malathion to other aquatic organisms present in Puerto Rico.

RP041 Effects of Atrazine on the Function Biomarkers and Cyto-Architecture of the Liver in Juveniles of Clarias gariepinus (Burchell, 1822)
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The liver is the primary organ for the metabolism and detoxification of drugs and environmental chemicals. Sub-lethal toxicity of environmentally significant levels of atrazine concentrations (40μg/L, 60μg/L, 80μg/L, and 100μg/L) on exposed African catfish (Clarias gariepinus) juveniles was assessed for 28 days in a quality controlled laboratory procedure. The objective of this research was to determine the effects of atrazine on liver function biomarkers including alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Alkaline Phosphatase (ALP), Albumin (ALB), Total Protein (TP) and liver histopathology. The levels of plasma ALB, and TP in exposed specimens were observed to decrease with increasing concentrations of atrazine. However, the activities of ALT, AST and ALP showed significant (P < 0.05) increase with increase in sub-lethal concentrations of atrazine. To determine the negative health implications of atrazine exposure to Clarias gariepinus juveniles, a quantitative and qualitative histology-based health assessment protocol was used. The calculation of condition factors (CF) and hepatosomatic indices (HSI) were used to support the results of the qualitative and quantitative histological evaluation of liver tissue. Hepatic tissue assessment revealed marked histopathological alterations including structural changes (Necrotic/apoptotic liver tissue and poor hepatic cord structure) with effects in 39% of the liver tissues in the treatment groups; increase in melanomacrophage centers (29%); plasma alterations (vacuolation or fat inclusions 22%) of hepatocytes; hepatocyte nuclear alterations (97%); and necrosis of melanomacrophage centers (90%); and necrosis of liver tissue (27%). Results of CF and HSI showed significant decrease across treatment groups with increasing concentrations of atrazine in a dose-dependent pattern. Findings from this study suggest that atrazine interferes with liver function markers and disrupts cytoarchitectural components of the liver resulting in a noninfectious liver injury which may lead to repeated cycles of cell deaths and inflammation or eventual death of the exposed fish.

RP042 Analysis of photodegradation of benzobicyclon hydrolysate in the presence of relevant sediment and seawater ions
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Benzobicyclon (BZB) is a pro-herbicide recently approved for application on rice in California and undergoing research in anticipation of registration in southern states including Louisiana. BZB rapidly hydrolyzes in flooded fields to generate the active ingredient of the herbicide (BUTTE...), benzobicyclon hydrolysate (BH). Previous research has shown BH preferentially partitions into rice field water, while BZB is adsorbed in sediments. BH undergoes photolysis, and its half-life varies depending on the characteristics of the water. In distilled water, BH has a reported half-life of 78 hours, 38 hours in rice water, and 3.4 hours in 25
S-metolachlor are frequently paired with a “safener” which prevents the
Chemistry
S. Lanasa, Towson University; C.J. Salice, Towson University / Environmental Science & Studies Biology; A. East, Towson University / Environmental Sciences; J. Sivey, M. Niedzwiecki, Towson University / Chemistry

Chloroacetanilide is a group of herbicides with increasing use worldwide. They are used to control grass weeds that affect important crops such as corn, soybean and cotton. Acetochlor and S-metolachlor are the most common chloroacetanilide herbicides used. When applied, acetochlor and S-metolachlor are frequently paired with a “safener” which prevents the crop from being affected by the herbicide. Safeners are considered inert and, therefore, are not regulated or tested for toxicity. While the ecological toxicity of acetochlor and S-metolachlor have been well-studied safeners, however, have not. Runoff from agriculture fields has led to measurable concentrations of safeners in nearby freshwater systems. There is a lack of information needed to assess the potential risk safeners may pose to organisms in freshwater systems. The safeners we focused on where benoxacor (commonly paired with S-metolachlor), dichlormid and AD-67 (commonly paired with acetochlor). We conducted a series of 72-hour algae toxicity tests separately with the three safeners to find the EC50 (the effective concentration causing 50% growth inhibition) on a non-target algae, Raphidocelis subcapitata. AD-67 was the most toxic followed by benoxacor, and dichlormid showed toxicity only at high concentrations. ED50 values for all safeners tested were far above environmentally relevant levels. However, a difference in size of algae cells was observed during the toxicity tests. Images of algae were captured at the 72-hour timepoint and analyzed using ImageJ software to measure the total area of each cell. We found a size increase from the controls for each safener at concentrations lower than the EC50 value in all safeners tested, with the exception of benoxacor. Algal cell size was increased in all concentrations of AD-67, some of which are approaching environmental relevance. The changes seen in cell area suggest a potentially more sensitive endpoint than what is seen in standard toxicity tests. We are exploring the commonness and significance of the observed increases in algal cell size. Also, we are designing studies to determine if increases in algal cell size impacts Daphnia magna and algae dynamics. Results of these studies may lead to and improved understanding of the potential ecological effects of safeners.

RP043 Are “safeners” safe? Effects of unregulated inert safeners on population growth and size of non-target algae
S. Lanasa, Towson University; C.J. Salice, Towson University / Environmental Science & Studies Biology; A. East, Towson University / Environmental Sciences; J. Sivey, M. Niedzwiecki, Towson University / Chemistry

RP044 Mercury fluctuation in macroinvertebrate muscle in relation to the environmental variables in Buenaventura Bay, Colombian pacific
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The objective of the present investigation was to contribute to the understanding of the dynamic processes of bioaccumulation of mercury macroinvertebrate species in a tropical estuary. Four field samplings were carried out throughout four seasons in 2015, in four zones, in Buenaventura Bay and the total mercury content (T-Hg) in sediments and macroinvertebrate muscle was measured (dry weight). A total of 17 species of macroinvertebrates were collected, and concentrations of T-Hg in muscle fluctuated from 0.01±0.02 µg/g to 0.31±0.19 µg/g. When the conditions of lower salinity predominated in the estuary, there were higher values of T-Hg in both sediments and muscle of the blue crab Callinectes arcuatus and mantis shrimp Squilla autacuta, suggesting that mercury has an anthropogenic origin and could enter the estuary by the contribution of rivers by runoff during the rainy season. Nevertheless, the bioaccumulation process was greater in marine conditions than in low levels of salinity.

RP045 Trophic and biogeochemical dynamics of mercury in two fishery lakes in the Northwest Territories
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Kakisa Lake and Tathlina Lake, located in the Dehcho Region of the Northwest Territories, support commercially and culturally significant fisheries for the local Ka’agee Hu First Nation. Presently, Walleye (Sander vitreus) in Tathlina Lake have mercury (Hg) concentrations that are above Health Canada’s commercial sale limit of 0.5 PPM. Elevated Hg concentrations in food fishes can pose neurological, developmental, and reproductive health risks to the people who consume these fishes, depending on consumption levels and vulnerability; vulnerability is highest in children, pregnant women, and the elderly. Mercury-related health risks are greater for indigenous Dehcho residents than for southerm and westernized populations because subsistence fishing contributes significantly to their diets. Separated by 23 km of land, Tathlina Lake and Kakisa Lake are directly connected by the Kakisa River, but vary widely in many physical and chemical properties. Additionally, Tathlina Lake’s food fishes generally have higher [Hg] than Kakisa Lake’s. Differences in physicochemical dynamics and their related ecological processes could contribute to differences in fish [Hg] between the two lakes. Initial data do not satisfactorily identify the root cause for the differences in fish [Hg] between lakes. The purpose of this study is to relate analyses of food web structure, fish growth rates, and lake physicochemistry to [Hg], and attempt to determine why fish [Hg] are different between the lake systems. I predict that a difference in productivity of the lakes may partially explain the different Hg burdens. I expect that chlorophyll a, as a proxy for algal biomass, will be higher in Kakisa Lake than in Tathlina Lake, resulting in a lower [Hg] per unit of algal biomass in Kakisa Lake than in Tathlina Lake. This would demonstrate a bloom dilution effect, which can be verified by comparing [Hg] along food webs between lakes. I further expect that growth dilution contributes to the [Hg] disparity, which I will verify with fish age and fork length data. I predict that fish growth rates will be faster in Kakisa Lake than in Tathlina Lake. Finally, I predict that the rates of Hg biomagnification between the two lakes will be different. Stable isotope analysis will provide the basis for constructing a model of the food webs in each lake, and I will match that trophic information with [Hg] to quantify biomagnification rates.

RP046 Influence of growth rate and food web position on inter-individual variation in fish mercury concentrations in lakes of northern Ontario, Canada
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Fish mercury concentrations vary at multiple scales across the landscape due to a variety of environmental and ecological factors. We compared the relative contributions of three factors - body size, growth dilution, and food web position - to observed inter-individual (within-population) variability in mercury concentrations using data from 44 populations of lake trout (Salvelinus namaycush), 120 populations of walleye (Sander vitreus), and 20 populations of burbot (Lota lota) in 17 Ontario lake systems. Mercurypopulations were chosen to span a range of environmental conditions, including lake productivity, trophic position, and body size. The results showed that growth dilution was a major contributor to variability in fish mercury concentrations, with smaller fish having lower mercury levels than larger fish. Food web position also had a significant effect, with higher trophic level fish having higher mercury concentrations than lower trophic level fish. Body size was also a significant factor, with larger fish having higher mercury concentrations than smaller fish. Overall, these results highlight the importance of considering multiple factors when assessing mercury in fish populations.
vitreus), and 55 populations of lake whitefish (Coregonus clupeaformis) from lakes across northern Ontario, Canada. Relationships between fish mercury concentrations and various combinations of body weight, growth rate, and C and N stable isotope ratios were fitted with linear models, and the models were compared and ranked using Akaike's Information Criterion (AICc). For all three species, single predictor models ranked from strongest to weakest predictor were weight, growth rate, trophic elevation (inferred from δ15N), and primary energy source (inferred from δ13C). Top-ranked models included weight, growth rate and δ15N for lake trout and walleye (piscivores), but only weight and growth rate for lake whitefish (benthivore). All of these models received very strong support, based on Akaike weights (0.98. 0.99, and 0.79, respectively). For all three species, mercury concentrations were positively related to weight, negatively related to growth rate, and positively related to trophic elevation. Our study demonstrates that variation in mercury concentrations among individuals in northern fish populations is most strongly related to body size, and that the remaining variability is better explained by growth dilution than by food web position.

RP047 Effect of nickel on growth and function of manganese-oxidizing benthic bacteria

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Nickel (Ni) is a widespread pollutant in aquatic ecosystems that can impair diversity and ecological functions. In lotic systems, the cycling and toxicity of Ni are coupled to other elemental cycles that determine toxic metal speciation and sorption behavior, thus affecting Ni bioavailability. The mixture of competing oxidized and reduced ligands in natural sediments is largely driven by the redox metabolism of the sediment microbial community. Particularly, manganese (Mn) oxide formation and dissolution can be strongly influenced by microbial redox processes and influence Ni bioavailability to microbes and benthic invertebrates. Therefore, benthic microbes are key players in determining Ni fate and bioavailability, but they are concurrently susceptible to the toxic effect of Ni. Metal toxicity to microbes can lead to an energetic trade-off between metabolic and detoxification processes and result in decreased rates of redox reactions under high metal conditions, modifying the pool of solid-phase ligands. The sensitivity of benthic microbes to Ni toxicity and their potential influence on Ni bioavailability via metal redox cycling provides a unique interface with potential emergent feedbacks between toxicity and redox processes. This study aimed to determine the toxic effects of Ni on growth and function of Mn-oxidizing bacteria (MOB) isolated from sediments of urban and pristine streams. MOB isolates were inoculated on solid K media amended with 200 µM of nickel as Mn(II) and 10 µM, 100 µM, 1mM or 10mM of Ni. After a two-week incubation, pictures of the plates were taken and processed on ImageJ to obtain colony count, colony area (mm²), and presence/absence of Mn oxides. As Ni concentration increased, colonies became smaller and unable to produce manganese oxides. Average colony count was similar in 10 and 100 µM treatments (12.5± and 16±1 colonies, respectively), but decreased substantially at 1mM (2±1 colonies). No growth was observed at 10mM. Average colony area decreased by 61% and 81% from 10 to 100µM and 100µM to 1mM Ni treatments, respectively. The proportion of colonies oxidizing manganese relative to total colony count decreased by 7% from 10 to 100µM Ni. No manganese oxidation was observed in 1mM samples. Colony growth showed a more sensitive response to Ni, but the lower occurrence of Mn oxidation indicates that at sublethal Ni concentrations feedbacks can be expected and warrant further investigation.

RP048 Protective Effects of Ligands on Ni Toxicity to Purple Sea Urchin Embryos

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Nickel (Ni) toxicity in seawater is of concern because of Ni mining and processing in coastal regions. Ni speciation is vital to understanding Ni toxicity. The goal of this study was to characterize the complexation of Ni by ligands in relation to toxicity. Purple sea urchin (S. purpuratus) embryological development was used as the toxicity endpoint. It was predicted that the binding affinity (logKd) of ligands would be inversely correlated to toxicity using total dissolved Ni concentrations [Ni(d)] but that on a free ion concentration [Ni2+] basis, toxicity would not vary. A two-phased approach was used; first, ligands with known logKd values (EDTA, NTA, glutamic acid, L-, tryptophan, histidine, and citric acid) were tested to establish a proof of principle and then second, natural waters were characterized for binding capacity and Ni toxicity. [Ni(d)] was measured by graphite furnace atomic absorption and [Ni2+] was estimated using aquatic geochemistry modelling software (Visual Minteq) and also quantified using an Ion Exchange Technique. The EC50 for [Ni(d)] in unmodified artificial seawater was 3.5uM (95%CI 3.0-4.5). Results showed that: 1. addition of ligands provided protection, up to 6.5-fold higher [Ni(d)] EC50 for EDTA; 2. samples of natural seawater from eastern North America showed a range of [Ni(d)] EC50 values from 3 to 7 mM; 3. as predicted, EC50’s based on [Ni2+] were less variable and there were no significant differences among EC50 values. The results of this research contribute to the development of biotic ligand-based prediction models for estimating Ni impacts in seawater. Funding was provided by Natural Sciences and Engineering Research Council of Canada (NSERC), VALE and NiPERA (Nickel Producers Environmental Research Association).

RP049 Metallic elements in zooplankton from the Mozambique Channel, Indian Ocean

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Metals ascribed to pollution may increase their concentrations above the geological background and pose toxic challenges towards humans and biota. Zooplankton's role within the marine biogeochemical process is well known, particularly the redistribution of metallic elements through the water column, but little is known about their interaction with zooplankton. We determined concentrations of metals in zooplankton collected using a standard zooplankton net from the Agulhas II in 2017. Thirty-eight zooplankton samples were analysed using ICP-MS (EPA 3051A method) for 30 metallic elements along the coast of Mozambique, an understudied and economically important region within the Western Indian Ocean. Here, we will consider concentrations and ratio with calcium of eight metals (Cd, Cu, Hg, Mn, Ni, Pb, TI, Zn). Median concentrations for Cd in zooplankton were 0.28 mg/kg dm, for Cu 0.11 mg/kg dm, for Hg 0.25 mg/kg dm, for Mn 0.15 mg/kg dm, for Ni 0.23 mg/kg dm, for Pb 0.050 mg/kg dm, for TI 0.29 mg/kg dm, and for Zn 0.12 mg/kg dm, respectively. Of the eight elements, only Pb (p < 0.0001) concentrations showed a significant positive correlation with Ca, while Ni (p = 0.0136) and TI (p = 0.0056) showed significant negative correlations. An initial assessment indicated that the highest concentration found for Cd (80 mg/kg dm) along the Mozambique coast might be of concern.

RP050 The Impacts of pH on trace contaminant leaching and toxicity of coal ash in Planoribella duryi

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Coal fly ash is a major industrial waste that is primarily produced by coal-burning power plants. Ash contains multiple trace contaminants that have the potential to leach from the coal ash into waterways after rain events, causing undesirable effects on aquatic species in these ecosystems. Few laboratory studies have examined the relationship between acidified rainfall and the release of trace metals from coal ash and the impacts of
such rainfall on the toxicity of coal ash leachates on aquatic invertebrates. Thus, the goals of this study were to 1) evaluate the effect of varying pHs on the leaching of trace contaminants from coal ash and 2) examine the impacts of these leachates on the viability, development, and hatch rate of embryonic Planorberella duryi, a freshwater snail species commonly found in intermittent streams or shallow waters throughout North America. Briefly, 100g of coal fly ash obtained from a local coal ash repository was added to individual glass vessels containing 1L of synthetic water adjusted to pHs of 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, or 7.5. After 48 hours, all leachates were vacuum filtered and an aliquot analyzed for sulfuric, arsenic, calcium, cadmium, chromium, cobalt, iron, mercury, magnesium, manganese, lead, selenium, and zinc using ICP-OES. Embryonic P. duryi clusters (< 2hrs old) were then exposed to each leachate or pH-adjusted synthetic water for 10 days using a 48hr static-replacement assay, and the number of viable individuals and hatchlings in each cluster assessed daily. To examine the impacts on growth, photographs of each embryo were obtained on days 5, 7, and 10 and differences in shell diameter and pigmentation assessed using ImageJ. While this project is currently ongoing, we expect to find increases in aqueous trace contaminant concentrations as a result of decreased pH in leachates as well as decreased viability, growth, and hatching success. This study will provide important information regarding the potential impacts of acidified rainfall on the mobilization of trace contaminants and toxicity of coal ash leachates on aquatic invertebrates.

**RP051 Accumulation of Heavy Metals in Fish Downstream from American Zinc Products and the Rogers Energy Complex on the Broad River, NC**

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The communities of Rutherford and Cleveland county, North Carolina depend on the Broad River for fishing and recreational opportunities. The caught fish are often consumed as a form of sustenance. American Zinc Products (AZP) is an industrial and hazardous waste recycling plant that is located on the Broad River. Approximately 6.5 miles downstream from AZP is the coal-fired energy facility Rogers Energy Complex (REC). Members of the community were concerned that the coal ash basins that are located on-site at the REC were leeching into the Broad River, contaminating the water and aquatic species. In this study water, sediment, and fish tissue samples were collected and analyzed for heavy metal concentrations; one tap water sample was also taken from a home located directly downstream from REC. The results revealed that many of the water samples exceeded safe levels of lead and zinc for aquatic life according to the NC Department of Environmental Quality criteria. The tap water sample nearly doubled the EPA’s action level for lead. In the fish tissue samples the mean concentrations of arsenic, cadmium, chromium, selenium, and copper did increase compared to the reference site. Levels of arsenic, cadmium, and selenium were compared to safe consumption advisories set by the EPA; these values describe safe monthly limits with a serving size of 8 oz.

**RP052 Effects of three Culture Systems on Histopathological and Biochemical Characteristics of Clarias gariepinus (Burchell 1822)**

*E. Okeke, International Students Environmental Coalition / Institute of Ecology and Environmental studies; O.T. Aladesanmi, Obafemi Awolowo University / Institute of Ecology and Environmental studies*

Fisheries occupy a unique position in the agricultural sector of the Nigerian economy. In terms of Gross Domestic Product (GDP), the fishery sub-sector has recorded the fastest growth rate in agriculture to the GDP of Nigeria. Fishery business is very lucrative in Nigeria, hence it has attracted a lot of people using different methods and culture systems. Fish has the tendency to accumulate pollutants in significant quantity consequently serving as a source of health risk to man and other predators. Therefore, this study assessed water quality of three (tank, earthen and concrete pond) different culture systems of Clarias Gariepinus commonly used in Nigeria, as well as the conditions of the cultured fishes. Water and fish samples were collected from the three different ponds. The water samples were collected at three points i.e. the inlet, the mid-point and the outlet of the ponds respectively. These were referred to as Points A, B and C respectively in this study. Physicochemical parameters (pH, temperature, turbidity, dissolved oxygen, BOD, COD, TDS, EC and major ions) were determined in the water samples. Samples for heavy metal (Pb, Cd, Zn, Fe, Cr) analysis were first digested before metal determination using PG 990 Atomic Absorption Spectrophotometer. Condition factor, Protein concentrations and antioxidant enzyme activities in the fish from the three ponds were also determined using standard protocols. The results shows that there were significant variations in the concentration of metals in the three culture systems. Pb (0.11±0.003) and Cd (0.13±0.0045) concentrations were highest in the tank ponds compared to earthen and concrete ponds. While the concentrations of Cr (0.18±0.003) and Fe (1.01±0.003) were found to be highest in earthen ponds than in tank and concrete ponds. In contrast, there were no significant difference in the oxygen parameters of the water sample. The presence of metals above permissible in the tank and earthen ponds could be due to the material used for the tank ponds which constantly add metals to the pond and also the contaminated water that serves the earthen ponds. Elevated metal concentrations were also present in the fish tissues. Enzyme activities showed direct correlation with increase in metal concentration. Photomicrographs of the fish tissues showed varying degenerative conditions from mild to severe. The study concludes that different culture systems influence the conditions of the water and the fish.

**RP053 Contaminant pulses associated with snowmelt in Northern Utah, USA**

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Utah is dubbed as having the “greatest snow on earth” with average annual snowfall reaching 500 inches at many Northern Utah ski resorts. The Salt Lake valley, also located in this region, is notorious for poor air quality punctuated by frequent winter and summer inversions. Previous studies in other systems show that air pollutants can be integrated and stored in the snow pack and detected in snowmelt throughout spring and summer months. Data on these processes are lacking for the Salt Lake valley. With the Utah population projected to continue growing, it is likely to assume the amount of airborne pollutants will increase, thus an increase of toxicant presence in the snow pack. The purpose of this study is to better understand the fate and distribution of contaminants that could be integrated into snowpack and released into the environment via snowmelt. An array of samples were collected weekly from transects in Big Cottonwood Creek beginning in April, before mean daily temperatures were above freezing, and ending in September 2019. Collected media from each creek transect include, water, sediment, soil from within ten feet of creek bank, newly deposited snow if applicable, packed snow at least three feet below surface, and macroinvertebrates. Each compartment is analyzed for metals including Cadmium, Lead, Mercury, and Zinc as well as an assortment of PAHs. This year (2019) was a near record year with some ski resorts receiving over 700 inches of snow. Peak snowmelt is projected for the end of July. The increase in winter storms this season resulted in far fewer inversions. However, air pollution thatharbors combustion byproducts is still being created and potentially being distributed both locally and globally. While our chemical analysis is ongoing, it may not be indicative of historic trends of contaminant deposition in snowpack due to this years increase in precipitation.

**RP054 Adsorption of trace metals to Spartina alterniflora detritus in Galveston Bay salt marshes**

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Salt marshes are highly productive and biologically diverse habitats that are critical to estuarine ecological processes. Primary production is derived from emergent grasses, phytoplankton and benthic algae. Detritus from the marsh grasses provides an important source of nutrition for a
variety of transient and permanent marsh inhabitants, including many commercial fishery species in Galveston Bay. There are documented elevated levels of trace metals in Galveston Bay waters and sediment; studies have shown that detritus decaying on the sediment surface can become enriched with significant quantities of trace metals over time, which may be a significant dietary source of metals to benthic consumers. The objective of this research was to investigate the temporal adsorption of trace metals to Spartina alterniflora detritus during a 9-month decomposition period in Galveston Bay salt marshes, in order to provide new information on a potentially significant pathway for dietary uptake of trace metals in Galveston Bay. Transects were set up parallel to the shoreline at three marsh sites bordering West Galveston Bay (native reference, restored, and contaminated). Dead Spartina stems and sediment samples were collected from plots randomly placed along transects at each site. Leaves were removed from the stems, cut into 5-10 cm lengths, then dried and weighed in 2 g parcels and placed into 20 x 20 cm nylon mesh (3 mm) litterbags. Three litterbags were returned to each plot/transect/site from which the leaf material had been collected and secured to the marsh bottom. At intervals of 3, 6, and 9 months, litterbags were collected and returned to the lab, where the contents were rinsed with fresh water, dried, and weighed. The samples were acid-digested and analyzed for As, Cr, Cu, Ni, Pb and Zn by ICP-OES. Results indicate that the amount of time Spartina leaf detritus remains in the marsh correlates directly with the concentration of trace metals adsorbed and is likely to contribute to the trophic transfer of heavy metals in Galveston Bay.

RP057 A Closer Evaluation of Contaminant Distributions in Sediments of a Coastal Plain Stream Impacted by Industrial Runoff

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As part of an on-going stream monitoring program, an effort was made to identify sources of contamination that could be causing pulse through a headwater coastal plain stream on the Savannah River Site (Aiken, SC) with a history of industrial disturbance. Past studies of bioavailable contaminants conducted on this tributary found elevated levels of several trace elements in biota, despite not being particularly elevated in stream sediments. Those results were unexpected, but possibly due to stream bottoms being severely scoured of organic matter and fine sediment by flashy storm flows from extensive impervious surfaces in the watershed. Thus, we sought to determine potential upstream contaminant sources and establish a baseline to assess potential impacts of a new facility under construction. The primary concerns for possible contamination hot spots included the construction site in the mid reaches of the stream, a series of sedimentation basins along the valley rim, and a previously used coal combustion waste basin located in the headwaters. Sample sites were selected longitudinally along the entire stream and focused on channel depositional areas, scour pools, and basins where contaminants were most likely to settle out. In total, 165 sediment samples were analyzed for 18 trace elements. Elevated levels of trace metal concentrations were higher in upstream basins than below the new construction site, despite outfalls in this midstream section, suggesting the upstream basins as the source of contamination found accumulating in biota. Mapping of the contaminant distributions will aid future assessments and guide potential restoration work aimed at mitigating stream damage from the excessive runoff.

RP058 Trace Elements in Exuviae of Emerging Damselflies

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Damsel fly adults and their aquatic immature stages are an important part of food webs and provide a link between aquatic and terrestrial components. The H-02 wetland system was constructed on the Department of Energy’s Savannah River Site, SC to treat building process effluents and stormwater runoff. Constructed wetlands play an important role in the SRS environmental plan to achieve both federal and state regulatory compliance for the discharge of effluent waters. The H-02 wetlands were built to regulate pH and remove trace metals, primarily Cu and Zn, from the effluent line before release to state waters. The system consists of a retention basin, two wetland treatment cells, an effluent pool, and a discharge stream. Our previous work established contaminants accumulating in aquatic biota throughout and below the wetland system. As an aquatic nymph emerges from the wetland, contaminants can be shed with their exuviae (nymph exoskeleton) or be incorporated into their body and enter the terrestrial food web as adults fly away. Consequently, to determine the amount of contaminants exported from the wetland versus left behind, we analyzed trace element concentrations in emerging damselflies and their shed exuviae. Damselflies were collected from three sites in the retention basin. Traps were designed to sample both near-shore and pelagic habitats within each section. We analyzed accumulation of 16 elements in over 250 samples distributed across 5 coenagrionid damselfly species belonging to 2 genera. Patterns of elements that are primarily shed in the exuviae
versus those incorporated in the emerging damsselfly and thus exported from the system were compared. Differences in trace element accumulation were assessed at both the generic and species taxonomic levels. Comparing basin sections assessed effect of spatial relationship to outfalls, whereas comparing pelagic versus shoreline established habitat influences.

RP059 The impact of selected trace elements on the redox status markers in freshwater fish (Cyprinus carpio)  
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Toxic metals such as cadmium, lead, mercury, arsenic, or chromium are relatively well investigated. Their hazardous effect to metabolic and physiological system of all animals was confirmed. On the other hand trace elements such as aluminium (Al), Barium (Ba), lithium (Li), and molybdenum (Mo) are not completely investigated. The aim of this study was to assess possible relationships between redox status markers (glutathione-GSH, D-3-hydroxybutyrate-BHB, lipid peroxidation-MDA, protein carbonyls-PC, and uric acid-UA) and the content of Al, Ba, Li and Mo in carp blood serum. Blood samples (n = 38) were taken in spring (n = 19) and summer (n = 19) from aorta ventralis from each fish. The samples were allowed to coagulate at room temperature and centrifuged for 20 min at 3000 rpm. The concentration of Al, Ba, Li and Mo were determined using ICP-OES. GSH was evaluated by the Ellman method; Lipid peroxidation expressed through MDA production was measured with the help of the TBARS assay, modified for a 96-well plate and ELISA reader; BHB activity was measured using the Randox commercial kits. PC quantification was performed through the 2,4-dinitrophenylhydrazine (DNPH) method. BioLa Uric Acid commercial kit (Lachema, Czech Republic) and the spectrophotometer were used for the assay. Basic statistical analysis as well as Pearson’s correlations and ANOVA were performed using STATGRAPHICS Centurion ((C)StatPoint Technologies, Inc., USA). Factorial ANOVA showed us insignificant effect of season for elements content, however redox markers concentrations were affected (PC, MDA, UA - P<0.05), except GSH and BHB concentrations. Statistically significant correlation was found between the concentration of Li and PC (r=−0.54, P<0.05) in summer season. Similar tendency was observed between the concentration of Li and PC (r=−0.35, P<0.05) regardless of the season. Content of Al positively correlated with concentration of GSH (r=0.36; P<0.05) and UA (r=0.39; P<0.05). Weak and insignificant correlations were detected between trace elements and investigated redox markers in spring season. Our results demonstrated low effect of studied elements on the redox markers, however further studies are necessary to test eco-toxicology interactions between other biomarkers (haematology, serum chemistry) and other trace elements in natural conditions. This work was supported by the Slovak Research and Development Agency under the contract No. APVV-16-0289 and VEGA 1/0539/18.

RP060 The Effects of Anti-Sea Lice Therapeutants on Marine Benthic and Pelagic Species Under Varying Environmental Conditions  
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The aquaculture industry’s use of chemicals, including those used in disinfectants, anti-fouling paints, and feed additives has resulted in the contamination of local net pen areas. Of immediate concern are those compounds used in disease and parasite control, including anti-sea lice pesticides (Salmosan(R) and Paramove(R) 50) and drugs (SLICE(R) and Ivomec(R)). Acute (1-h/3-h exposure) bioassays (for the determination of toxicological parameters (LC50, EC50, NOAEC, LOAEC values) were conducted on natural assemblages of zooplankton, and specific pelagic larvae including Spot prawn (Pandalus platyceros) and herring (Clupea harengus pallasi) larvae. Exposures to either Salmosan(R) or Paramove(R) 50 in water were conducted under varying oxygen (10-100% O2 saturation) and temperature (7, 11, 16°C) regimes. In additional experiments, sediment dwelling amphipods and polychaete worms (Pacific species: Eohaustorius estuarius and Alitta virens) were subchronically (30-d) exposed to either SLICE(R), Ivomec(R), or a combination of the two in sediments under a range of oxygen concentrations and temperature as above to determine their lethal (LC50, EC50, NOAEC, LOAEC values) and sublethal (behaviour [e.g. orientation, paralysis, distance per unity t], feeding [e.g. reaction time, feeding motions, feeding response to food odors], oxygen consumption) toxicity. Threshold values for lethal and sublethal toxicity were determined for all chemicals and in each case, hypoxic conditions, and conditions of higher temperatures resulted in significant increases in chemical toxicity. This data specifically addresses information gaps needed for proper assessments of the environmental consequences of sea lice pesticide formulation use to be made.

RP061 In vivo toxicity of polyhexamethylene guanidine phosphate in zebrafish: A phenotype and genotypic assessment  
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Polyhexamethylene guanidine phosphate (PHMG-P) has a strong penetration in our households, particularly due to its resilient bactericidal properties. After a range of skin irritation tests, it has been considered safe and hence, applied in shampoos and lens cleaners. The use of PHMG-P in humidifiers lead to a tragic event in South Korea and epidemiological studies has linked the use of PHMG-P as a humidifier disinfectant to provoking pulmonary fibrosis. A different exposure route brings about an entire different mechanism and currently, little is known about the mechanisms by which PHMG-P exerts its toxic effects. To bridge this research gap, we applied an omics approach using RNA sequencing analysis as well as phenotypic assessments to determine the effects of PHMG-P on zebrafish. Exposure concentration was determined at 0.1, 0.2, 0.3, 0.4, 0.5, 1 and 2 µg/mL based on preliminary acute toxicity tests. Upon the administration of PHMG-P to zebrafish eggs ~3 hours after fertilization, the results of the test showed mortality at 96 hours for concentration of 2 µg/mL, and an LC50 value of 1.18 µg/mL at 96 hours. RNA sequencing analysis revealed that exposure to 0.4 µg/mL of PHMG-P for 96 hours was associated with upregulation of genes related to apoptosis, immune and inflammatory responses, and downregulated genes associated with oxidation-reduction, among other processes. The pathway analysis shows links to numerous pathways including cytokine-cytokine receptor interaction and ECM-receptor interaction. Real-time PCR and matched findings obtained in previous studies confirmed this. These findings on how PHMG-P exerts its toxic effects should help in alleviating future antagonistic effects. In addition, it will help comprehend PHMG-P-induced toxicity and its relation with pulmonary diseases.

RP062 Effect of pesticide TFM and its metabolites in fish mitochondria  
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Sea lamprey (Petromyzon marinus) is a parasitic and invasive species in the Great Lakes. The chemical 3-trifluoromethyl-4-nitrophenol (TFM) is used to control the population because it is selectively toxic to sea lamprey. TFM toxicity is believed to be caused due to the impairment of mitochondrial ATP production through the uncoupling of oxidative phosphorylation. The specificity of TFM in sea lamprey has been attributed to a limited capacity to eliminate TFM through glucuronidation compared to other fish species. TFM also undergoes phase I biotransformation to reduced 3-trifluoromethyl-4-aminophenol (TFMa) and accumulates in sea lamprey liver. Our hypothesis was that TFMa present at higher concentrations in the sea lamprey inhibits mitochondrial oxidative phosphorylation, not only during ATP production but at all levels in the electron transfer chain, and this contributes to the specificity of TFM in this species. We characterized the toxicity of TFM, methyl-phenol and their amino metabolites in the mitochondrial metabolism of the heart of sea lamprey.
We measured mitochondrial oxygen consumption after exposure in order to determine the effect in the ATP production and in mitochondrial complexes I and II. We also determined the effect of TFM and metabolites on the mitochondrial membrane permeability by measuring the transmembrane potential after exposure. Mitochondrial bioenergetics were heavily affected when exposed to increasing concentrations of TFM, methylphenol, and amino methyl-phenol at the different protein complexes examined, which suggests that the mode of action of these compounds goes beyond the uncoupling of complex V (ATP-synthase) at the end of the electron transport chain but at an earlier stage. The transmembrane potential was greatly reduced by TFM and methyl-phenol, but it was not affected by the amino metabolites.

RP063 Effects of the gill microenvironment on toxicant speciation and uptake by fishes: A case study using the piscicide TFM
M.P. Wilkie, S.L. Hepditch, L. Tessler, O. Bizeanu, Wilfrid Laurier University / Biology

Invasive sea lamprey (Petromyzon marinus) populations are controlled using a piscicide, 3-trifluoromethyl-4-nitrophenol (TFM). Applied to infested streams, TFM targets larval lampreys, which have a low capacity to detoxify the agent. However, non-target adverse effects and mortality can occur during TFM applications, particularly following decreases in water pH. A weak acid, with a pKa of 6.07-6.38, total TFM (TFM_{tot}) exists as un-ionized TFM-OH or ionized TFM-O. As water pH decreases, TFM-OH, the bioavailable form of TFM_{tot}, increases leading to greater uptake and toxicity. Similarly, TFM toxicity is higher in low alkalinity waters, but the reasons are unclear. Our goal was to determine how water alkalinity and the chemistry of the gill microenvironment, defined as the expired water crossing the gills, influenced TFM uptake and TFM-OH bioavailability to lake sturgeon (Acipenser fulvescens) and rainbow trout (Oncorhyncus mykiss). Using radio-labelled TFM (^{14}C-TFM), we observed that TFM uptake by lake sturgeon was highest at pH 6.5 versus pH 9.0, confirming that uptake takes place by diffusion as un-ionized TFM-OH. Similarly, TFM uptake was greatest at low (<50 mg CaCO_3 L^{-1}) compared to moderate (~150 mg CaCO_3 L^{-1}) and high alkalinity (~250 mg CaCO_3 L^{-1}). As water pH was circumneutral (pH 7.8-8.2), differences in bulk water pH could not explain our findings. Instead, we hypothesized that greater acidification of the gill microenvironment resulted in higher TFM-OH bioavailability in low compared to higher alkalinity water. To test this hypothesis, trout were implanted with opercular catheters, allowing us to measure the pH of water expired across the gills (the microenvironment). At low alkalinity, expired water pH was 1.0-1.5 pH units lower than inspired (bulk) water pH, likely due to acid (H^+) excretion and CO_2 excretion across the gills. Notably, acidification was less at moderate alkalinity, and eliminated at high alkalinity. Thus, lower TFM uptake at higher alkalinitities was due to higher water buffering capacity, which reduces or prevents acidification of the expired gill water. Our results demonstrate that opercular catheters, which are easy to install and cause minimal stress to fish, allow accurate measures of water chemistry and toxicant bioavailability within the gill microenvironment. Using this approach, we also show that water-buffering capacity can profoundly affect toxicant bioavailability in the gill microenvironment.

RP064 Biochemical biomarkers in shrimp (Litopenaeus vannamei) exposed to chlorpyrifos
B.E. Jaramillo-Colorado, University of Cartagena / Chemistry Program; E. Duarte-Restrepo, University of Cartagena / Agrochemical Research Group / Chemistry Program; L. Duarte-Jaramillo, University of Cartagena / Agrochemical Research Group

Chlorpyrifos (O,O-diethyl-O-(3,5,6-trichloro-2-pyridyl)-phosphorothioate) residues were detected in sediments of Cartagena Bay. This pesticide comes from the Dique channel (Magdalena River) and spills of industries of the Mamonal sector in Cartagena, Colombia. Chlorpyrifos (CPF) is an organophosphorus pesticide (OP) extensively applied to control pests and agricultural practices, but they also adversely affect non-target fauna. It is the second largest selling OP and found to be more toxic to the marine organisms than organochlorine compounds. The effect of this OP on the shrimp (Litopenaeus vannamei) was evaluated. LC50 (96-hours) was determined. Lipid oxidation levels (LPO) and activities of catalase (CAT), glutathion peroxidase (GpX), glutathion-S-transferase (GST) were assessed on the muscle, hepatopancreas and gills from adults exposed to two sublethal CPF concentrations (0.7 and 1.3 μg/L) for four days. Furthermore, acetylcholinesterase (AchE) inhibition was determined in the brain. LC50 (96-hours) was 2.10 μg/L of CPF. Shrimp exposed to two sublethal CPF concentrations showed an increase of CAT activity in the three tissues, a decrease of AchE activities in the brain and an increase of GST activity in the hepatopancreas, while LPO increased in all tissues. These results show that L. vannamei could be used as biomarkers to monitor OP pesticides in aquatic environments.

RP065 Assessing the impacts of methoxychlor exposure on the viability, reproduction, and behavior of the seminole ramshorn snail (Planorbella duryi)
T.E. Frankel, University of Mary Washington / Earth and Environmental Sciences; M. Bohannon, University of Maryland / Environmental Science and Technology; J. Frankel, Howard University / Biology

In this study, the effects of short-term methoxychlor exposure on the viability, reproduction, and locomotor behavior of adult Seminole ramshorn snails (Planorbella duryi) was assessed. To examine impacts on viability and behavior, individual snails were exposed to a water control, vehicle control, 12.5, 50, 100, 250, 500, or 1000 μg/L of methoxychlor for 48hrs and differences in mortality and locomotor behavior were examined. To determine impacts on reproduction, pairs of snails were exposed to a vehicle control, 12.5, 50, 100, and 250 μg/L of methoxychlor for 9 days and the number of egg clutches and viable embryos laid quantified every 24hrs. To verify nominal vs. actual concentrations, water samples were collected and methoxychlor concentrations determined using gas chromatography. Complete mortality was observed in the 500 μg/L and 1,000 μg/L treatments after 48hrs and in the 250 μg/L treatment after 9 days. Significant decreases in the number of egg clutches were observed in all treatments, and the number of embryos laid decreased starting in the 25 μg/L treatment. Decreases in average speed, mobile speed, and total distance travelled as well as a significant increase in frozen events were also observed. Our results suggest that methoxychlor exposure causes detrimental effects on several non-lethal endpoints in an alternative model aquatic invertebrate species and that the analysis of locomotor behaviors serves as a reliable, sensitive endpoint for future ecotoxicology testing.

RP066 Effects of pesticides with different mechanism of toxicity in the freshwater prawn Macrobrachium borellii
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Synthetic pyrethroids like cypermethrin (CYP) are extensively applied for control of agricultural pests and disease vectors. However due to its harmful consequences to non-target organisms, the bioinsecticides represents a benign and desirable alternative to the environment. Among them the biological insecticide produced from Bacillus thuringiensis israelensis (Bti) is mainly used for the control of mosquito vectors of diseases like dengue. Anyway, pest organisms have developed resistance mechanisms to such kind of insecticides so last generation pesticides, such as the tetramic acid spirotratrum (STM), have recently emerged. Due to the limited information available on the effect of these compounds on non-target species, the effect of CYP, Bti and STM on the freshwater prawn Macrobrachium borellii was analyzed. Initially, the LC50-96 h was determined in adult prawns (males and females in non-vitellogenic state), by serial dilutions of the three insecticides. A negative control without insecticides was included. Then, in order to determine metabolic disorders that could be
used as biomarkers of pollution, prawns were exposed to sublethal concentrations of CYP (0.006 and 0.02 μg/L), Bti (0.04 and 0.4 mg/L) and STM (0.5 and 1.7 mg/L) for 4 days. The levels of lipid peroxidation (LPO) and protein oxidation (OP), as well as the presence of histopathological changes were evaluated in the hepatopancreas. The LC50-96 h values were 0.8 and 8.2 mg/L for Bti and STM respectively, and 0.12 μg/L for CYP. All three insecticides significantly affected the LPO and OP levels in this organ (p < 0.05). Pesticides caused histopathological alterations in the hepatopancreas of the exposed prawns, such as atrophy in the epithelium of the digestive tubules, necrosis of the epithelial cells, and the infiltration of hemocytes into the connective tissue between the intertubular space. This study showed that *M. borellii* is less sensitive than other crustaceans to CYP. In addition they are the first results of sensitivity to *Bti* and STM in this taxonomic group. Considering that the hepatopancreas is the main organ for toxicant metabolism in crustaceans, these results indicate that oxidative status in *M. borellii* is very sensitive to these insecticides. Therefore, this prawn could be proposed as useful bioindicator to monitor freshwater environments that are exposed to these pollutants.

**RP067 A comparison of alternative 96-hr Hyalella azteca water exposure protocols for the sensitivity to the pyrethroid bifenthrin**

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The Central Valley Regional Water Quality Control Board (California, USA) adopted a pyrethroid basin plan amendment and total maximum daily loading (TMDL) limits in 2018 requiring monitoring by publically owned treatment works, stormwater dischargers, and irrigated agriculture. As the goal of the monitoring is to determine the extent to which pyrethroids cause water column toxicity, water samples are analyzed for pyrethroids, organic carbon, and acute toxicity to *Hyalella azteca*in 96-hr bioassays. In order to appropriately determine if toxicity is due to pyrethroids, sufficiently sensitive methods must be applied and an environmentally relevant, yet cost effective, toxicity testing protocol must be used; it is imperative that the toxicity test design does not mask the toxicity of these extremely hydrophobic pesticides. There are currently two toxicity tests based on limited guidance in the 2002 EPA acute testing manual that are under consideration: the method applied for Surface Water Ambient Monitoring Program (SWAMP) studies and a method refined by the Southern California Coastal Water Research Program (SCCWRP) during a stormwater inter-calibration study. Both methods require static renewal testing with solution renewals at 48 hours. The SWAMP method includes the addition of food throughout the testing, whereas the SCCWRP method requires feeding 2 hrs before solution renewal. As demonstrated by others, substantial loss of pyrethroids to the walls of the bioassay test chamber is a significant concern. This loss, amplified by the 48-hour renewal test design could result in the SWAMP and SCCWRP protocols underestimate pyrethroid toxicity. Furthermore, the inclusion of food in the test chambers throughout testing (i.e., SWAMP method) could reduce the dissolved phase pyrethroids to which the organisms are exposed. To address this concern, a study was performed in which these two toxicity methods were compared to a modified SCCWRP protocol with daily solution renewals and feeding 2 hours prior to each renewal, with bifenthrin used as the toxicant. All testing was performed concurrently using the same bifenthrin stock solutions prepared daily. Stock solutions and representative samples collected during the testing were analyzed for bifenthrin using negative chemical ionization, GC/MS with selected ion monitoring (EPA 625.1M). The results of this testing will be presented, along with the ramifications for monitoring under the pyrethroid TMDL.

**RP069 Assessing the impacts of sulfoxaflor exposure on the viability, growth, behavior, and hematocrit of the seminole ramshorn snail (Planorbella duryi)**

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Sulfoxaflor, a sulfoximine insecticide, has seen increased utilization as an effective tool against sap-feeding insect species that have developed resistances to other control agents. However, few studies have been conducted to examine the impacts of sulfoxaflor exposure on viability and non-lethal endpoints in freshwater aquatic invertebrates. As such, this study examined the effects of sulfoxaflor exposure on the viability, growth, locomotor behavior, and hematocrit of juvenile seminole ramshorn snails (*Planorbella duryi*). Individual juvenile snails (> 1 day post hatch) were exposed to a water control, vehicle control, 0.1, 1, 10, 100, and 1000 μg/L of sulfoxaflor for six weeks using a weekly static replacement exposure method. Mortality, defined as a lack of response to footpad contact, was assessed daily. To examine the impacts of sulfoxaflor on growth, a photograph of each snail was taken weekly and the shell height and width analyzed using ImageJ. A 15 minute video recording of each snail was obtained on weeks 3, 4, 5, and 6 and differences in locomotor behaviors assessed using automated behavioral analysis software. At the end of the exposure period, hemolymph from each individual was collected in heparin-treated glass capillary tubes, centrifuged, and packed cell volume determined using a microhematocrit capillary tube reader. While this study is still ongoing, we expect to observe significant decreases in growth, locomotor behaviors, and packed cell volumes in individuals exposed to sulfoxaflor in a dose-dependent manner. Findings from this study will help to elucidate the effects of sulfoxaflor contamination on aquatic invertebrates while also providing support for future studies to examine the presence and concentrations of sulfoxaflor in aquatic ecosystems.

**RP070 Lethal and sub-lethal effect of copper sulphate pentahydrate on two successive generations of Culex pipiens mosquito (Diptera: Culicidae)**

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The *Culex pipiens* mosquito is an important public health vector of many diseases. It usually inhabits large ponds and sometimes is found in small water bodies. Copper may enter water when used as a biocide in antifouling paint formulations or from agricultural and urban uses. Copper sulfate is used as a fungicide, algicide and for root treatment, and is especially widely used in rice fields in California. We studied lethal and sub-lethal effects of copper sulfate pentahydrate on the immature stages of two successive generations of *Culex pipiens* using laboratory toxicity testing. Larval mortality rate increased with increased concentrations during both generations. During the 1st generation, mortality rates increased gradually from control to 100% at 1 mg/L. The 2nd generation showed a marked increase in mortality rates of the larval stage relative to generation one, especially at the higher concentrations of 0.25 and 0.5 mg/L. The larval LC50 level of the second generation was 40% lower than the first. Copper sulfate exposure delayed development in both generations, and pupation rate also decreased with increased concentrations in both generations. This study showed higher sensitivity of *Culex pipiens* to copper toxicity than other mosquito species. The higher sensitivity of the 2nd generation is a relatively novel finding because multi-generation studies are rare in comparison to short-term tests. More such studies are needed to determine if exposure of the parents to toxicants is usually detrimental to offspring.
RP071 Acute and chronic toxicity of three neonicotinoid alternatives to the amphipod Hyalella azteca

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Neonicotinoid pesticides are widely used across North America in agriculture, turf and ornamental applications. Although they are effective insecticides, their use has been associated with negative effects on non-target aquatic organisms and bans on some neonicotinoids have been implemented in Canada. As a result, the use of neonicotinoid alternatives has increased, although presently there is little information available on their toxicity to aquatic invertebrates. The objective of this study was to determine the acute and chronic toxicity of three neonicotinoid replacements, specifically flupyradifurone (butenolide), sulfoxaflor (sulfoximine) and chlorantraniliprole (ryanoid), to the freshwater amphipod, Hyalella azteca. Toxicity tests were conducted using a static-renewal, water-only method for a duration of 28 days. The endpoints chosen were survival and growth of the amphipods. Survival was assessed weekly and growth was assessed at the end of the experiment. Results for survival and growth for flupyradifurone, sulfoxaflor and chlorantraniliprole, respectively, were as follows: acute (7 d) LC50s were 26, 206 and 516 µg/L, chronic (28 d) LC50s were 20, 188 and 420 µg/L, and EC50s (28 d) were 16, 150 and 346 µg/L. Toxicity varied among compounds, with flupyradifurone being the most toxic and chlorantraniliprole being the least toxic. The reductions in survival and growth were similar between chronic and acute exposures for the three compounds tested. We compared our results to a recently conducted study on the toxicity of neonicotinoids to Hyalella and found that flupyradifurone was intermediate in toxicity, while sulfoxaflor and chlorantraniliprole were comparable to or less toxic than the least toxic neonicotinoid. Although there are few data on environmental concentrations of these neonicotinoid replacements, the information that does exist indicates the levels in surface waters are in the low µg/L range, lower than the effect concentrations observed in this study.

RP072 Imidacloprid modifies the mitotic kinetics and causes both aneugenic and clastogenic effects in the macrophyte Bidens laevis L.

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Imidacloprid (IMI) is a neonicotinoid insecticide widely used in agricultural activities all around the world. This compound is transported from croplands to surrounding freshwater ecosystems, producing adverse effects on non-target organisms. Because of the relevance of aquatic macrophytes in the above-mentioned environments and the lack of studies of potential effects of IMI on them, this work aimed to assess the mitotic process and potential genotoxicity in the aquatic macrophyte Bidens laevis L. Although the analysis of the Mitotic Index (MI) showed that IMI was not cytotoxic, the Cell Proliferation Kinetics (CPK) frequencies evidenced modifications in the kinetics of the mitotic process. Indeed, the anaphases ratio decreased at 10 and 100 µg/L IMI, while at 1000 µg/L an increase of prophases ratio and a decrease of metaphases ratio were observed. Regarding genotoxicity, IMI produced an increase of the abnormal metaphases frequency from 10 µg/L to 1000 µg/L as well as an increase in clastogenic anaphases-telophases frequency at 100 and 1000 µg/L. In addition, aneugenic anaphases-telophases and C-mitosis frequencies also increased at 1000 µg/L, confirming the effects on the mitotic spindle. Considering the genotoxic effects on B. laevis through two different mechanisms (aneugenic and clastogenic) and the wide spread use of IMI in agriculture, these mechanisms of toxicity on macrophytes should be considered among other recognized effects of this insecticide on aquatic biota.

RP073 Canadian Water Quality Guidelines for Aquatic Life Protection for Five Neonicotinoid Insecticides


Neonicotinoid insecticides (NNIs) are nicotine-based systemic compounds that are widely used in agriculture, either in field applications or as seed treatments, predominantly on wheat, corn, soybean, canola and horticultural crops. They are also used for killing insects in homes, controlling fleas on pets, and protecting trees from invasive insects such as the Emerald Ash borer. Studies show that they are toxic to non-target organisms, are mobile and may persist in the environment. NNIs are highly water soluble and may be present at concentrations that cause adverse impacts to aquatic life, specifically sensitive indicator species used in water quality determination. The use of NNIs has been controversial and research continues on the impacts of NNIs to the environment, particularly to non-target species. In Canada, five NNIs (acetamiprid, clothianidin, imidacloprid, thiacloprid, thiamethoxam) have been approved for various uses. The Canadian Pest Management Regulatory Agency (PMRA) has been re-evaluating three NNIs (imidacloprid, clothianidin, thiamethoxam) due to concerns with their impact on pollinators and aquatic life, resulting in restrictions on their use. PMRA is continuing to evaluate these three NNIs to determine if further actions are needed. Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life were derived for the five NNIs approved for use in Canada. CWQGs are nationally approved limits in the water column where no adverse toxic effects are expected to aquatic plants and animals. Both short-term benchmark concentrations and long-term exposure guidelines were developed. CWQGs are used to assess the quality of water, to identify areas where presence of chemicals may present a risk to aquatic life and to assess the success of risk mitigation activities. A set number of chronic toxicity studies are required to develop CWQGs using a species sensitivity distribution approach, and these were lacking at the start of this project. The Ontario Ministry of the Environment, Conservation and Parks commissioned additional toxicity data to develop CWQGs for four NNIs (acetamiprid, clothianidin, thiamethoxam and thiacloprid) and update the 2007 interim guideline for imidacloprid, as recent studies suggested it did not provide an appropriate level of protection.

RP075 Persistent organic pollutants in Hawaiian false killer whales: variance in relation to life history and social group

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False killer whales (Pseudorca crassidens) are long-lived, slow to mature, apex predators, and therefore susceptible to bioaccumulation of persistent organic pollutants (POPs). Hawaiian waters are home to three distinct populations/stocks: pelagic, Northwestern Hawaiian Islands (NWHI), and main Hawaiian Islands (MHI). Following a precipitous decline over recent decades, the MHI population was listed as “endangered” under the Endangered Species Act in 2012. This study assesses the risk of POP exposure to these populations by examining pollutant concentrations and patterns from blubber biopsy samples (n=56) related to life history characteristics (i.e., sex, age class, reproductive status). Samples (MHI n=45, NWHI n=8, pelagic n=3) were analyzed for polychlorinated biphenyls (PCBs), dichlorophenyltrichloroethanes (DDTs), polychlorinated diphenyl ethers (PBDEs), and some organochlorine pesticides. Pollutant
levels were generally similar among populations. For MHI individuals, 66.7 percent of all whales (all adult males, 50% of adult females, and 66.7% of juveniles/subadults) contained summed PCB concentrations greater than or equal to the suggested threshold for associated deleterious health effects in marine mammals. Based on long-term sighting histories, 8 of 24 MHI adult females have never been reported to give birth. These individuals are likely characterized by reproductive senescence associated with age, or impaired reproductive capabilities linked to high POP exposure. Juvenile/sub-adults had significantly higher concentrations of some contaminants than those measured in adults. Further, for individuals biopsied twice over 2-3 years, adults accrued more POPs while a subadult female lost some POPs (e.g., PCBs, DDTs). This loss is likely attributed to growth dilution, where metabolized contaminants are redistributed to other organs or within the bloodstream. Consequently, juveniles/sub-adults may be at greater risk to negative health effects (e.g., thyroid disruption, immunocompetence) as they undergo critical physiological development. Our results provide invaluable insight into the ongoing risk these contaminants pose to the MHI population’s viability, as well as consideration of risk for the NWHI and pelagic stocks. Additionally, MHI whales exhibit cohesive social organization that could make them more vulnerable to increasing anthropogenic threats; it is important to account for this vulnerability when assessing population-level concerns.

**RP076 Comparative toxicity of organic marine contaminants (PCBs, crude oil, corexit, B[a]P, PFOA) in gray whale skin cell cultures**

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Gray whales (Eschrichtius robustus), unlike more pelagic species, migrate past and feed close to dense coastal human populations which increases their risk of exposure to organic marine contaminants. Polychlorinated biphenyls (PCBs) are persistent organic pollutants historically manufactured as industrial insulators. Crude oil is present in the marine environment via anthropogenic (oil spills and leaks) and natural (seeps on the sea floor) sources. Corexit is used as a dispersant during oil spills. PAHs are produced during the incomplete combustion of petroleum or wood whereas PFCs are components of flame retardants. PCBs, polycyclic aromatic hydrocarbons (PAHs) and per/poly-fluorinated compounds (PFCs) have been detected in cetacean (whale and dolphin) blubber. Cell culture is invaluable in toxicological research as it can be established minimally invasively from a single biopsy and allows for multiple investigations. This is critical for research on protected species such as the gray whale. Our goal is to understand whether these contaminants are cytotoxic to gray whale skin fibroblasts and whether these xenobiotics may be of concern for the species. We collected skin biopsies from three free ranging gray whales off the coast of California. Skin fibroblasts were cultured from the epidermis. Fibroblasts were maintained in DMEM/F12 media supplemented with 15% cosmic calf serum, 1% penicillin/streptomycin, 1% glutamax, and 0.1% sodium pyruvate. Cells were dosed with either PCB 126 in concentrations of 10uM, 1uM, 0.1uM, or 0.01uM or media accommodated fractions of crude oil and/or Corexit. Time points of exposure were 24h, 48h, 72h, and 96h. Cytotoxicity was investigated using MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) and LDH (lactate dehydrogenase) assays. Viability was significantly reduced after exposure to PCB 126 at a concentration of 10uM at various exposure time points (p< 0.05). Preliminary results suggest that cellular viability was also reduced after exposure to Corexit at all time points. Additionally, results from an earlier portion of this study indicated that cellular viability was significantly reduced after exposure to either benzo[a]pyrene (B[a]P) or perfluorooctanoic acid (PFOA) at various concentrations and time points of exposure (p< 0.05). Results are allowing us to compare cytotoxicity between contaminants and identify those that are cytotoxic and/or cytotoxic at environmentally relevant concentrations. Further investigation is underway.

**RP077 Measurement of nine steroid hormones in fin whale blubber biopsies via LC-MS/MS**

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The fin whale Balanoptera physalus in the Gulf of California is considered resident and genetically isolated from other populations from the Pacific and Atlantic Oceans. Its low genetic variability, as well as the small number of individuals in the population (325; 95% IC: 248-427), it vulnerable to changes in its habitat, as well as disease. The measurement of steroid hormones in cetacean populations has proven to be useful in assessing the reproductive fitness of wild ranging populations, which helps evaluate the health of the population as well. There are very few studies about fin whale reproductive biology, which are key aspects to the population’s survival in the future. Therefore, the goal of this study was to measure ten steroid hormones via liquid chromatography mass spectrometry (LC-MS) in fin whale blubber biopsies obtained from free ranging individuals in the Gulf of California to determine a season of reproduction, as well as to assess stress in individuals in certain reproductive stages. Blubber biopsies were obtained from field work during 2015-2018 along the Gulf of California. Sex of the individuals will be investigated via PCR and electrophoresis analysis. Hormones were extracted using a liquid-liquid extraction method specifically designed for blubber and analyzed via a triple quadrupole LC-MS. Testosterone, progesterone, 17-estradiol, androstenedione, aldosterone, 17-hydroxyprogesterone, cortisol, cortisone and corticosterone were detected and quantified using 50 mg blubber samples. Extraction efficiencies ranged from 63-89% and RSD from 0.71-18%. Estrone was the only hormone consistently below our limit of detection. Genetic sexing analysis is underway, and we subsequently plan to investigate the influence of this life history parameter on hormone levels in this species.

**RP078 Reproductive and stress hormone analysis in small whale blubber samples using liquid chromatography mass spectrometry**

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The simultaneous analysis of multiple steroid hormones in cetaceans (whales, dolphins, and porpoises) provides valuable reproductive and fitness data useful in their conservation and management. Minimally invasive blubber biopsies can be collected from free ranging animals, including large whale species. A critical aspect of endangered and protected species research is the use of minimal tissue mass which allows for multiple investigations from biopsies. The goal of this project was to analyze a hormone panel to explore the endocrinology of gray (Eschrichtius robustus) and fin (Balaenoptera physalus) whales using small mass samples compatible with blubber biopsy collection. Blubber biopsies and samples were collected from free ranging and stranded gray (n=52) and fin (n=9) whales off the coast of California, Baja California, and from the Gulf of California. Androstenedione, aldosterone, cortisol, cortisone, hydroxyprogesterone,
RP079 Cytotoxic effects of HBCD on liver organ cultures of the fathead minnow (Pimephales promelas)

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Hexabromocyclododecane (HBCD) is a cycloaliphatic flame-retardant additive that is applied as a thermal insulator in extruded and high-impact polystyrene foams. HBCD is a ubiquitous organic contaminant with the characteristics of persistent organic pollutant due to its potential to bioaccumulate, long-range transport and toxicity. The aim of this work was to determine the in vitro cytotoxicity of HBCD in the fathead minnow (Pimephales promelas) using liver transplants and to investigate the molecular mechanisms for these effects. Toxicity of nine different concentrations of HCBD (0.00032, 0.0016, 0.008, 0.04, 0.2, 1, 5, 25 and 125 mg HBCD/L) were tested by using the LDH assay after 6 and 24 h of incubation. The expression of genes with a key role in the regulation of apoptosis, oxidative stress, cytoprotective responses to reactive oxygen species (ROS), and xenobiotic metabolism was also measured in liver explants after exposure to 0.00032, 0.0016, 0.008, 0.2, and 25 mg HBCD/L. After 6 h, a concentration-dependent increase in cytotoxicity was found between 0.008 and 1 mg/L, followed by a decrease between 1 and 25 mg/L. The cytotoxicity reaches 100% at a concentration of 125 mg/L. After 24 h, HBCD showed a biphasic response with a concentration-dependent decrease in cytotoxicity between 0.0016 and 1 mg/L that returned to baseline levels at 5 mg/L. Then, cytotoxicity increases at concentrations greater than 5 mg/L to reach a maximum value at 125 mg/L. Changes in the expression of genes related to apoptosis; apoptosis, oxidative stress, protection against ROS and xenobiotics, might suggest an explanation for the observed dynamics of HBCD cytotoxicity in liver organ cultures.

RP080 Relative Potency Factors of Brominated Dioxins Based on Japanese Medaka Early-Life Stage Toxicity Test

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Polybrominated dibeno-p-dioxins and dibenzofurans (PBDDFs) have been detected from biotic and abiotic matrices. Since PBDDFs are contaminated in brominated flame retardants as impurities, they can be released into environment via wastewater discharged from flame retardant fiber manufacturing or e-waste recycling processes. Brominated dioxins are thought to cause similar biological effects as chlorinated dioxins, however, information of their effects on aquatic organisms is limited. In the present study, we conducted early-life stage toxicity tests using Japanese medaka (Oryzias latipes) in order to derive toxic equivalency factors (TEFs) of PBDDFs. First, we exposed medaka embryos to 2,3,7,8-tetrachloro dibenzo-p-dioxin (TCDD) at different doses and durations to fix the experimental conditions. Then, using the fixed conditions, the toxic effects of 2,3,7,8-tetrabrominated dibenzofuran (tetrabDF), 2,3,7,8-tribrominated dibenzofuran (tribDF) as well as TCDD were evaluated, and TEFs of each brominated compound were calculated. TCDD-exposed fish showed typical symptoms called blue-sac disease, including yolk sac and pericardial edema, subcutaneous hemorrhages, and craniofacial malformations. EC50 for normal hatchling and LC50 at 21 or 28 days post-fertilization in TCDD exposure test were 249, 220, or 73.8 µM, respectively. TetrabDF exposure caused similar phenotypic effects to TCDD in medaka embryos and larvae, and its EC50 and LC50 values were 8720, 7500, or 4580 µM, respectively. On the other hand, tribDF induced none of the effects observed in the TCDD exposure test. Based on these results, TEF values of tetrabDF or tribDF ranged from 0.0171 to 0.0293 or < 0.000119, respectively. Previous in vitro studies demonstrated that tetraBDF had relatively high potency (REP: 0.10-0.97) causing TCDD-like effect, while triBDF had much less (REP: 0.00003-0.0013). These results agreed with our present study. TEF values obtained in the present study will be used for risk assessment and management of brominated dioxins in aquatic environment.

RP081 Chronic sub-lethal toxicity of two emerging isopropylated triarylphosphate (ITPs) isomers flame retardants in the amphipod Hyalella azteca

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Since the phase-out of polybrominated diphenyl ethers (PBDEs), replacement mixtures containing different isopropylated triarylphosphates (ITPs) have been used increasingly as flame retardants as well as plasticizers in paints, textiles and in a large range of other commercial products and applications. Despite their widespread use, toxicity data on ITP mixtures are still very scarce, mainly because the relative composition of these commercial mixtures remained largely uncharacterized until very recently. In the last couple of years, individual ITPs contained in commercial flame retardant mixtures (e.g. Firemaster 550) were characterized; 2-isopropylphenyl diphenyl phosphate (2IPPDP) and bis-(2-isopropylphenyl) phenyl phosphate (B2IPPPP) were the most dominant isomers reported (27% and 11%, respectively). These ITPs have been reported in house dust, human urine, urban and rural air and in Arctic snow, indicating persistence and long-range transport potential of these chemicals. Despite their environmental presence, the toxicity of these two compounds in aquatic organisms remains to be elucidated. The goal of this study was to fill this gap by evaluating the effects of B2IPPPP and 2IPPDP in the freshwater amphipod Hyalella azteca. Organisms...
were exposed chronically (28-d) through sediments spiked with sub-lethal doses of each compound at 0, 10, 100 and 1000 µg/g. Transcriptional responses were measured using RNA-sequencing in organisms exposed to the highest dose in order to identify the molecular pathways impacted by each compound. Further dose-response analyses using qRT-PCR on candidate genes and biochemical measurements of suitable protein biomarkers will help better understand the modes of action of ITPs in freshwater organisms.

RP082 Physiological and molecular outcomes of dietary exposure to the flame retardant, BDE-99, in the Atlantic killifish (Fundulus heteroclitus)

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Polybrominated diphenyl ethers (PBDEs) are a class of flame retardants that were used widely in a variety of consumer products before being largely phased out in the early 2000s. However, they are persistent, bioaccumulative, and ubiquitous environmental pollutants. A prominent PBDE congener, BDE-99, is predicted to alter metabolic homeostasis through perturbation of peroxisome proliferator-activated receptor alpha (PPARα) signaling in fish. To better understand adverse outcomes from exposure to BDE-99 and their underlying mechanisms, we assessed the effects of dietary exposure to BDE-99 in the Atlantic killifish (Fundulus heteroclitus). Adult wild-caught killifish were fed diets amended with a range of concentrations of BDE-99 (0, 150, 375, or 750 ng/g fish ww/day) or clofibrate acid (known PPARα agonist; 80 µg/g fish ww/day) for 38 days. Fish length, weight, and fecundity were measured at three time points throughout the exposure period. On days 10 and 39, subsets of fish were sampled, and tissues (gonads, liver, abdominal fat, and brains) were weighed and archived for molecular and chemical analyses. Bioaccumulation was assessed to relate all endpoints to measured internal dose on a per individual basis. As expected for PPARα agonism, energetic reserves (fat and liver mass) were affected. At the termination of the exposure, reproduction was significantly impaired by all concentrations of BDE-99 compared to control. Genome-wide gene expression profiling (RNA-seq) is providing insight into the molecular pathways that are functionally involved in the observed growth, energetic, and reproductive impacts of BDE-99 dietary exposure. Ultimately, outcomes measured at the molecular, organ, and individual levels will be used to inform bioenergetic models to predict effects of BDE-99 on killifish populations. Ongoing transgenerational experiments are testing for impacts propagated across generations from these parental exposures.

RP083 2,2',4,4',5-Pentabromodiphenyl ether impairs the vision development of larval zebrafish

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Polybrominated diphenyl ethers (PBDEs), though has been banned from using ten years ago, can be detected ubiquitously in different environmental medium and organisms, like surface water, outdoor and indoor dust, serum, breast milk and so on. Large numbers of laboratory and epidemiological studies have proved PBDEs possess reproductive, developmental, endocrine disrupting and neurobehavioral toxicities and exert such effects mainly by interfering with thyroid pathway and retinoic acid pathway. Considering that retinoic acid is especially important for eye development, PBDEs may pose great harm to the visual system of animals and human beings, yet few studies involved adverse effects on vision. This study focused on the negative effects that 2,2',4,4',5-penta-bromodiphenyl ether (BDE-99) brought to the vision development of larval zebrafish. Phototoxic and locomotor tests were used to identify the light sensitivity of larval zebrafish. The results showed embryos exposed to high dose were less likely to move to the illuminated areas and were less active when experiencing the transition from light to dark, indicating light sensitivity of larval zebrafish were impacted. Given that larvae at 5 days post fertilization serve functionally as an all-cone retina, genes expressing cone opsins were examined by qRT-PCR. After exposure to high dose BDE-99, almost all the expression levels of the tested genes were significantly downregulated, ranging from 0.44±0.08 to 0.64±0.05 fold, except one expressing opsin sensitive to middle wavelength was upregulated, implying that the vision development was severely impaired. Our results demonstrated that BDE-99 disrupted the vision development of larval zebrafish and the visual system could be a potential target of environmental pollutants, thus more attention should be paid to this new toxicological endpoint.

RP084 The naturally halogenated compounds and POPs compositions in squid differ between the Indian and South Atlantic oceans

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Muscle tissue of Cape Hope squid (Loligo reynaudii) from three sites in the Indian and Atlantic oceans along the South African coast were analyzed for halogenated natural products (HNP)s and anthropogenic persistent organic pollutants (POPs). The most prevalent HNP (2,3,3',4,5'-heptachloro-1'-methyl-1,2'-bipyrrole; Q1), was quantifiable in all squid samples with mean concentrations of 100, 96 and 43 ng/g lipid mass, respectively, at the Indian Ocean (site A) and, two sites in the South Atlantic Ocean (sites B and C). Also, the bromine containing HNPs 1'-methyl-1,2'-bipyrrole, 2,4,6-tribromophenol (2,4,6-TBP, up to 28 ng/g lipid mass), polybrominated methoxy diphenyl ethers, MHC-1, TMPB and, other HNPs were also detected. HNP concentrations were generally more than one order of magnitude higher than POPs, consisting mostly of polychlorinated biphenyls (PCBs). PCB 153 was the most abundant PCB congener in Cape Hope squid from the Indian Ocean, and PCB 138 in samples from the South Atlantic Ocean. ANOVAs indicated significant (P < 0.05) differences between catch sites. Multivariate analyses discriminated between the sites. Halogenated natural products and, POPs could thus be further investigated as a stock discrimination tool. Of the POPs analyzed, only PCB 118 has a toxic equivalency factor, with toxic equivalents of 0.00037 (site A), 0.000030 (site B) and, 0.00019 (site C), respectively.

RP085 The sulfate metabolite of 3,3'-Dichlorobiphenyl (PCB-11) impairs Cyp1a activity and increases hepatic neutral lipids in zebrafish larvae (Danio rerio)

M. Roy, University of Massachusetts, Amherst / Environmental Health Sciences; P.R. Duche, University of Massachusetts, Amherst; K.C. Hornbuckle, University of Iowa / Civil and Environmental Engineering; A.R. Timme-Laragy, University of Massachusetts / Environmental Health Sciences

3,3'-Dichlorobiphenyl (PCB-11) is a lower-chlorinated PCB congener that is a byproduct of diarylde pigment manufacturing, and both PCB-11 and its metabolites have been detected in human samples. Our previous research in zebrafish (Danio rerio) demonstrates that static exposures to 20 µM PCB-11 starting at 1 day post fertilization (dfp) can stunt liver growth, and in co-exposures with other aryl hydrocarbon receptor (Ahr) agonists, PCB-11 can inhibit Cyp1a function to either prevent or exacerbate cardiovascular and craniofacial malformations, depending on the co-exposure. In this study, we tested whether two prevalent PCB-11 metabolites, OH-PCB-11 and PCB 138 in samples from the South Atlantic Ocean. ANOVAs indicated significant (P < 0.05) differences between catch sites. Multivariate analyses discriminated between the sites. Halogenated natural products and, POPs could thus be further investigated as a stock discrimination tool. Of the POPs analyzed, only PCB 118 has a toxic equivalency factor, with toxic equivalents of 0.00037 (site A), 0.000030 (site B) and, 0.00019 (site C), respectively.

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RP086 Combined toxicities of tributyltin and polychlorinated biphenyls on the development and hatching of Japanese medaka (Oryzias latipes) embryos via in ovo noneinjection

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Tributyltin (TBT) and polychlorinated biphenyls (PCBs) are typical organic pollutants that co-exist in the aquatic environment. Despite increasing awareness of their combined impacts, knowledge about their potential interactive effects remains limited. In this study, we investigated the effects of TBT-PCB mixtures on the survival, development, and hatching of embryos of Japanese medaka (Oryzias latipes). Our goal was to assess the interactive effects of TBT and PCBs on early-life-stage fish. We used in ovo noneinjection to simulate the maternal transfer process and to control exposure doses at 0, 7.5, 15, 30 ng/g-egg (for both toxins). A factorial design (4 A 4) corresponding to the above doses was used to define the formulation of mixtures. Results showed that injection of mixtures of TBT and PCBs into fertilized eggs caused significantly elevated rates of mortality, yolk-sac shrinkage, swim-up failure, and deformities of medaka embryos/larvae. TBT and PCBs interacted synergistically to induce the above developmental abnormalities. In contrast, exposure to only TBT increased the hatching times of embryos, whereas exposure to only PCBs decreased the hatching times. The dose ratios, dose levels, and interactive effect of TBT and PCBs in a mixture played significant roles in determining the final impact on time-to-hatching. Our results suggested that in ovo exposure to a mixture of TBT and PCBs may interact synergistically to induce developmental abnormalities in fishes.

RP087 Contaminants, Reproduction and Deformities in Snapping Turtles in the Hamilton Harbour Area of Concern (Canada)

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Contaminant burdens, reproduction and development were examined in the eggs of snapping turtles (Chelydra serpentina serpentina) within the Hamilton Harbour Area of Concern (AOC) from 1984 to 2016. Clutches of freshly-laid eggs were collected within the AOC, artificially incubated in the laboratory and assessed for hatching success and hatching deformities. Several legacy contaminants, including PCBs and mercury, and polychlorinated diphenyl ethers (PBDEs) were also measured in a subsample of eggs from these clutches. From 1986 to 1990, as mean percentages per clutch, hatching success ranged from 66.5-89.2% and deformities ranged from 1.9-21.4% whereas from 2012 to 2016 at two AOC locations, improvements were evident and hatching success ranged from 81.4%-94.7% and deformities ranged from 4.6%-16.1%. No significant differences were found for both of these endpoints between AOC locations and the Great Lakes reference site in three of four years when this could be assessed. During this period, contaminant burdens in eggs from the AOC also dropped significantly with sum PCB concentrations declining exponentially from, on average, 5.1 ppm in 1984 to 1.5 ppm in 2014. Such large declines in concentrations of sum PCBs and other organochlorines in eggs since the mid-1980s provide evidence that exposure to these compounds has decreased in snapping turtles foraging in the AOC. Current and historic cumulative total concentrations of sum PCBs, organochlorine pesticides and sum PBDEs indicate that eggs from the Hamilton Harbour AOC were among the most contaminated relative to other AOCs within the Canadian Great Lakes. Burdens in eggs were dominated by PCBs with p,p’-DDE being the second most abundant halogenated hydrocarbon. Several factors relating to both anthropogenic activities and physical attributes of the Harbour likely influenced spatial patterns of contaminants which is consistent with the history of contamination in this area. Mercury concentrations in eggs from Hamilton Harbour were relatively low compared to burdens at other Canadian Great Lakes AOCs. Currently, there is no evidence of adverse effects for the two reproduction and development endpoints examined in snapping turtles in the Hamilton Harbour AOC that can be attributed to local contamination within the AOC.

RP089 Polycyclic Aromatic Hydrocarbon in clarias gariepinus exposed to roofing sheet industrial effluents

E.J. Nweze, C.U. Ogbonna, I.N. Onwurah, University of Nigeria / Department of Biochemistry

This study aims to ascertain the presence and composition of polycyclic aromatic hydrocarbons in Clarias gariepinus exposed to roofing sheets industrial effluents. Matured Clarias gariepinus samples were collected from Ekwuru River in Emene Enugu Nigeria using simple fishing implements. Triplicate samples were collected from the point of discharge of effluents into the river, upstream and downstream all 10metres apart. Control fish samples were also collected from a privately owned fish pond. The samples were weighed, processed and prepared for Gas Chromatography analysis of PAH compounds present in the samples as well as their concentrations through the equipped Flame Ionization Detector (FID). It was observed that in all, a total of eleven (11) PAHs were present in the fish samples of which 10 of them were in the United States Environmental Protection Agency (USEPA 16PAH) list of toxic hydrocarbons to aquatic lives and mammals. Downstream samples showed the presence of only one (1) carcinogenic compound Benzo (a) pyrene as recognized by the International Agency for Research on Cancer. Anthracene was the most prevalent parent compound found in the test samples. The overall concentration of PAHs in the downstream fish sample was 0.1003Mg/ml while the upstream sample was 0.0977Mg/ml. The control fish sample contained five polycyclic aromatic hydrocarbons (although the concentrations were quite marginal), namely: acenaphthene (0.0008Mg/ml), fluorene (0.0004Mg/ml), anthracene (0.0374Mg/ml), xylene (0.0020Mg/ml) and benzo (g,h,i) perylene (0.0008Mg/ml). it can be observed that roofing sheet industrial effluents has a significant negative impact on the aquatic life of Ekwuru.

RP089 Differential gene expression responses after aryl hydrocarbon receptor (AhR) agonist exposure in resistant and reference Fundulus grandis populations

P. Brews, Baylor University / Environmental Science; E.M. Oziolor, University of California, Davis / Environmental Toxicology; C.W. Matson, Baylor University / Environmental Science

Gulf killifish (Fundulus grandis) populations from the Houston Ship Channel (HSC) have evolved resistance to the teratogenic effects of exposure to aryl hydrocarbon receptor (AhR) agonists including
polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). This resistance is associated with reduced AhR induction after exposure as measured through CYP1A1 activity. In similarly resistant Atlantic killifish (F. heteroclitus) previous studies have found differences in expression of other cyp1 genes and components of the AhR signaling pathway after exposure. However, similar studies have not been conducted in F. grandis. The goal of this study was to use gene expression analysis to better characterize the differential responses of resistant and reference F. grandis embryos after exposure to several AhR agonists. Exposure compounds included PCB-126 and two PAHs (benzo[a]pyrene (BaP) and benzo[k]fluoranthene (BkF)). Expression responses after exposure differed between populations and between exposure compounds. In general, higher doses of PCB-126 were needed to elicit a response in resistant embryos than in reference embryos. There was also a difference in response timing between the two populations. Responses to PAH exposures were more similar between the populations and included downregulation of some genes that were upregulated by PCB-126 exposure. Several of these genes were also previously shown to be upregulated in F. heteroclitus after similar PAH exposures. Overall, the results show that the response of F. grandis embryos to AhR agonist exposure differs between populations and between PCBs and PAHs. These results will help further the understanding of the molecular processes that confer resistance in F. grandis.

**RP090 Polycyclic aromatic hydrocarbon levels of selected seafoods from crude oil exploration communities in Bayelsa State Nigeria**

J. Ifemgie, Chukwuemeka Odumegwu Ojukwu University / Biochemistry; C.K. Uhama, Enugu State University of Science and Technology / Biochemistry

This study was carried out to evaluate the polycyclic aromatic hydrocarbon (PAH) levels of seafoods from three selected crude oil exploration communities of Bayelsa State. The seafood samples (Catfish, periwinkles and water snails) were freshly collected from the study sites Azikolo, Amassoma and Yenagoa (control), transported to the laboratory and processed for analysis. Polycyclic aromatic hydrocarbon levels were determined in edible tissues of selected seafoods using Gas Chromatography-mass spectrophotometer. The result of the investigation revealed that the total mean concentrations of these PAHs in the three seafoods were highest in Azikolo (33.6 μg/kg), followed by Amassoma (23.46 μg/kg) and lowest in Yenagoa (3.96 μg/kg). Low Molecular Weight PAHs were generally predominant in seafoods from Azikolo, whereas High Molecular Weight PAHs were predominant in seafoods from Amassoma. Generally, catfish accumulated more PAHs with the total average concentration of 25.89 μg/kg, followed by periwinkles (20.63 μg/kg) and finally, water snails (12.70 μg/kg). However, the mean concentration of Biomarker PAHs (known as PAHs - Benzo[a]pyrene, Benzo[a]anthracene, Benzo(b)fluoranthene and Chrysene) of fish from Azikolo (13.53 μg/kg), periwinkles from both Azikolo (12.22 μg/kg) and Amassoma (26.09 μg/kg) were significantly higher (P< 0.05) compared with these samples from Yenagoa. The PAHs values of the samples from Azikolo and Amassoma exceeded the European Commission (EC) recommended limit of 12 μg/kg suggesting that sea foods remain a major endogenous source of PAHs among the people of the area.

**RP091 Regioselective Effects of Oxygenated Polycyclic Aromatic Hydrocarbons on Red Blood Cell Concentrations in Japanese Medaka Embryos**

P. Tanabe, C.A. Mitchell, V. Cheng, D.C. Volz, D. Schlenk, University of California, Riverside / Environmental Sciences

Previous studies have demonstrated that exposure to oxygenated polyaromatic hydrocarbons (oxyPAHs) at critical developmental time points can impair red blood cell (RBC) concentrations in a regioselective manner, with 2-hydroxychrysene being more potent than 6-hydroxychrysene. Japanese medaka embryos were exposed to 2 or 6-hydroxychrysene (10-70μM) or 50μM phenantherene (a positive control) from 2 hours post-fertilization (hpf) to 10 days post-fertilization (dpf). Following exposure, RBC concentrations were quantified by staining fixed embryos with o-dianisidine (a hemoglobin-specific dye), imaging stained embryos using brightfield microscopy, and analyzing images within ImageJ. Exposure of embryos to 50 and 60uM phenanthrene resulted in a significant decrease in hemoglobin concentrations compared to vehicle controls. Ongoing studies are comparing these results with oxy-PAHs. Future studies will evaluate the role of biotransformation in the regioselective toxicity of each metabolite. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).

**RP092 Oxidative stress produced by paracetamol, aluminum and their mixture in root meristematic cells of Allium cepa**

K. Ruiz-Larg, Escuela Nacional de Ciencias Biológicas, IPN / Laboratory of Aquatic Toxicology Department of Pharmacy; M. Galar-Martinez, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional; S. García-Medina, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional; E. Gasca-Pérez, Cátedra CONACYT IPN / Laboratory of Aquatic Toxicology Department of Pharmacy; S. Cano-Viveros, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional / Laboratory of Aquatic Toxicology Department of Pharmacy; L.M. Gómez-Ólivan, National Autonomous University of Mexico / Farmacia Pharmaceutical products, as well as metals, are two of the groups that have been detected most frequently in surface and groundwater worldwide. One of the drugs that has been reported in water bodies is paracetamol, which is also one of the most widely used drugs in the world, and has an important role due to its intrinsic toxicity. On the other hand, aluminum is one of the most abundant elements in the earth’s crust; it is freed naturally in aquatic ecosystems as a result of erosion of rocks and soil, however, in recent years the environmental levels of this have increased due to various anthropogenic activities. The test of Allium cepa is a bioassay in plants recognized worldwide and it is considered as an efficient indicator to determine the toxic effects of the chemical compounds found in aquatic ecosystems. The objective of this project was to evaluate the oxidative stress induced by paracetamol, aluminum and their mixture in root meristematic cells of Allium cepa, because the contaminants are not found in the environment in isolation, but forming complex mixtures that modify the toxic response. For this, specimens of A. cepa of 25 to 30 mm diameter were used, cleaned and germinated in purified water under laboratory conditions for 72 h. The bulbs of A. cepa were exposed to paracetamol (0.003 ppm), aluminum (0.270 ppm) and the mixture of both at environmentally relevant concentrations during 2, 6, 12, 24, 48 and 72 h. Afterwards, the roots were cut, homogenized and oxidative stress was determined by evaluating the degree of lipoperoxidation, the content of hydroperoxides and oxidized proteins, as well as the activity of antioxidant enzymes superoxide dismutase, catalase and glutathione peroxidase. The results showed modifications in the activity of antioxidant enzymes as well as damage to lipids and proteins.

**RP093 Acute and chronic toxicity evaluation of nortriptyline in zebrafish (Danio rerio) adults using multiple endpoints**

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In the last decade, several substances began to appear in quantifiable concentrations in different ecosystems, named as emerging pollutants. Psychiatric drugs are among the world’s leading prescription medicines for humans and their presence in aquatic environments has raised concerns about their potential harmful effects in non-target organisms. Nowadays, toxicological studies, mainly the chronic type, are still scarce for most of psychiatric substances. In this context, we evaluated the acute (4 days) and chronic effect (28 days) of the tricyclic antidepressant nortriptyline (NTP)
in zebrafish adults using several methodologies and cells/tissues: comet/ 
micronucleus tests for erythrocytes; biochemical test for head and muscle; 
histology for liver, gill and kidney; and gene expression microarray for 
brain. Acute toxicity was assessed at higher NTP concentrations (ranging 
from 0.5 to 2 mg/L), while the chronic analysis was conducted with low 
concentrations (0; 0.01; 0.001 mg/L). Acute exposure induced mortality 
(lethal concentration 50 of 1,1 mg/L) and decreased acetylcholinesterase 
activity in zebrafish heads, however, it was not genotoxic. On the other 
hand, chronic exposure did not generate genotoxic or histological dam-
age, as well as alterations in acetylcholinesterase activity. Nevertheless, 
the genomic analysis showed 184 and 66 differentially expressed genes 
between the controls and the groups exposed to 0.01 and 0.0001 mg/L of 
NTP, respectively. Genes related to oxidoreductase activity and neural regu-
lation were altered in the NTP concentration of 0,0001 mg/L. Moreover, 
genes associated with locomotion, immune system process and also oxire-
ductase activity were deregulated in the brains of animals exposed to 0,01 
mg/L of NTP. Our results showed drastic effects of NTP exposure only in 
the very high concentrations, which are not identified in the ecosystems. 
Nonetheless, the microarray data indicated that very low environmental 
concentrations of NTP may be toxic at long-term exposures.

**RP094 4-Epianhydrotetracycline development toxicity to zebrafish 
embryo-larval and transcriptome analysis**

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and Engineering; J. Zhao, Tongji University / State Key Laboratory of 
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Science and Technology*

Tetracycline is widespread in the environment due to the extensive using. 
It is very difficult to completely mineralize under field conditions, for 
instead, the majority of tetracycline is transformed into by-products.

4-Epianhydrotetracycline (4-EATC) is a primary by-product in tetra-
cycline degradation process and it may pose a potential environmental 
risk. Up to now, however, the toxicology information of 4-EATC is rare.

In this study, zebrafish embryo-larval had been employed to evaluated 
4-EATC developmental toxicity, including lethal and sub-lethal effects 
and different expression genes obtained by high-throughput transcript-
omic sequencing after 96h exposure. The result shown that 4-EATC 
significantly affects zebrafish embryo-larva stage development and in 
a dose-dependent manner. In lethal effect, the highest mortality occurred 
in 8 - 24 hours post fertilization, the 96h LC50 of 4-EATC to zebrafish 
embryo-larval was 29.13mg/L, this value is much lower than tetracycline 
in our previous research. In sub-lethal effects, the 96h hating rate and 48h 
heart rate of zebrafish embryo was decreased significant in higher concen-
tration 4-EATC treatment groups, furthermore, zebrafish embryo-larva 
abnormality had been observed even in the lowest concentration 4-EATC 
treatment group (1.25mg/L), the 96h EC50 of abnormality was 8.57mg/L, 
the most sensitive sub-lethal effect caused by 4-EATC was pericardial 
edema. Transcriptome determine result shown 430 different expression 
genesis caused by 4-EATC, and enrichment significant on 7 KEGG path-
way: cAMP signaling pathway, Tryptophan metabolism, Arachidonic acid 
metabolism, Mineral absorption, Proximal tubule bicarbonate reclamation, 
GABAergic synapse and Phototransduction, the highest enrichment 
ratio of KEGG pathway was Phototransduction. The overall result 
indicated that 4-EATC has stronger toxicity than tetracycline and could 
affect zebrafish embryo-larval development even in low concentration, 
Furthermore, 4-EATC could regulate gene expression and result in the 
toxic effect on organisms, but the underlying mechanisms needed further 
investigation.

**RP095 Evaluating Effects of Bioactive Contaminants Associated 
with Waste Water Treatment Plant Effluent Discharge to the South 
Platte River**

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Previous studies have detected numerous organic contaminants - includ-
ing biocides and pharmaceuticals - in the South Platte River near Denver, 
CO, at concentrations that rank among the highest in the nation. Regarded 
as contaminants of emerging concern (CECs), some of these compounds 
can disturb biological pathways in exposed species. Bi-monthly sampling 
and analysis of surface water samples in 2018, documented increased 
centrations of multiple CECs downstream of a waste water treat-
ment plant (WWTP). In vitro bioassays conducted on the same samples 
detected estrogen receptor (ER; 2.9-88ng/L E2-EQ) and glucocorticoid 
receptor (GR; 17-117 ng/L Dex-EQ)-mediated activities downstream 
of the WWTP. Peroxisome proliferator activated receptor gamma 
(PPARγ)-mediated activities were also detected using a multifactor-
rial Attagene assay, but not a targeted PPARγ transcriptional activation 
assay. Additional bi-monthly water sampling in 2019 was used to further 
characterize the spatial and temporal distribution of GR and PPARγ-
related bioactivities along the river. In addition to bi-monthly monitoring, 
fathead minnows (Pimphales promelas) were exposed in situ for five days 
at six locations upstream and downstream of the waste water discharge (2018). In 2018, despite the ER-mediated biological activity detected in 
vitro, no significant differences in the expression of male hepatic vitel-
logenin were found between sites. Consistent with the general lack of 
detectable PPARγ-regulated activity, there were no significant effects 
on PPARγ-related gene expression in the adipose tissue of females. No 
native-related differences in GR-related gene expression were detected 
in females, despite GR-activity in the in vitro assays, suggesting either 
limited bioavailability or limited potency of GR-active contaminants, 
in vivo. Fathead minnows will be exposed in situ again in August 2019. 
Results will provide new insights into the significance of GR-and PPARγ 
active contaminants in this system. The contents of this abstract neither 
constitute nor reflect USEPA policy.

**RP096 A Comparison of the Growth and Photosynthetic Toxicity of 
Human Pharmaceuticals to the Chlorophytes, Raphidocelis subcapitata 
and Chlorella vulgaris**

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The discharge of pharmaceuticals via wastewater into the environment 
remains a great concern due to the threat posed to the photosyn-
thetic organisms that are vital for the functioning and sustenance of 
the aquatic food web. In an effort to compare the photosynthetic 
and growth responses of green algae to priority human pharmaceuticals, 
*Raphidocelis subcapitata* and *Chlorella vulgaris* were exposed to 
idocaïne, ifosfamide, cyclophosphamide, erythromycin, clarithromycin, 
ciprofloxacin, amoxicillin and sulfaflomethoxazole for 96 h. Ifosfamide 
and cyclophosphamide were non-toxic to both endpoints whereas lido-
caine showed more acute and chronic toxicity towards growth (EC50, 
99-104 mg/L; NOEC < 25 mg/L) than photosynthesis (178-354 mg/L; 
NOEC, 100-200 mg/L) in both microalgae. Amoxicillin had no effects 
on microalgal growth but was chronically toxic to algal photosyn-
thesis. Interestingly, sulfaflomethoxazole exhibited similar toxicity towards 
growth and photosynthesis with the toxicity parameters (EC10, EC20 
and EC50) for growth in consonance with those of photosynthesis for
each of the microalgae. Ciprofloxacin was toxic to growth (EC₅₀, 16.4 mg/L) in *Raphidocelis* and showed a high risk quotient (RQ) value due to high PEC in hospital effluent. Erythromycin and clarithromycin posed the highest threat with RQ well above 1 in *Raphidocelis* biomass. Erythromycin was more acutely toxic to photosynthesis (EC₅₀, 24.6 µg/L) than growth (EC₅₀, 160 µg/L) of *Raphidocelis* while eliciting similar chronic responses using both endpoints. Clarithromycin (EC₅₀growth, 6.1 µg/L) and erythromycin were highly toxic to *R. subcapitata*, strongly inhibiting growth and photosynthesis in this study at environmentally relevant concentrations. Consequently, their release into the environment after normal therapeutic use should be of great concern due to their adverse effects on the phytoplankton community.

**RP097 Wild fish grow faster downstream of a municipal wastewater treatment plant (WWTP)**

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Municipal wastewater effluent (MWWE) is a major concern for aquatic organisms due to a variety of contaminants, including pharmaceuticals and personal care products (PPCPs), that have been linked to adverse effects. In the Grand River watershed, Ontario (Canada), rainbow darter (*Etheostoma caeruleum*) are a small-bodied fish species that have been used extensively to study impacts of MWWE exposure. Fish exposed to wastewater effluent are impacted across various levels of biological organization but the associated nutrient input on fish growth has not been explored at this location. Growth is an important indicator of fish health and is used by the Canadian Environmental Effects Monitoring (EEM) program to understand impacts of metal mining and pulp and paper effluent on fish health. To improve the quality of the final effluent, major infrastructure investments have been made at the Waterloo municipal wastewater treatment plant in 2017. This study aims to understand the impact of MWWE on growth of rainbow darter in the Grand River before and after upgrades using von Bertalanffy growth curves. Growth curves and parameters are compared to assess whether fish downstream of MWWE grow differentially from fish upstream. Preliminary results suggest fish grow faster downstream than upstream for both males and females. Understanding and quantifying these differences in growth attributed to wastewater effluent can allow for detection of subtle but important impacts. Use of these small bodied fish can be used as an endpoint for a regional monitoring program to provide another indicator of fish health and allow linkages between exposure and biological responses.

**RP098 Assessing the Toxicity of Atovaquone to Freshwater Invertebrates**

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Atovaquone (C₂₃H₂₂ClO₄) is a pharmaceutical used as an anti-malarial drug and in anti-HIV cocktails. Little is known about the environmental fate of Atovaquone and whether it affects non-target organisms in waterbodies receiving municipal wastewater effluents. This study investigated the effect of Atovaquone to two freshwater invertebrates, *Chironomus riparius* (midge larvae), and *Elliptio dilatata* (freshwater mussel). Because no analytical methods were available to quantify Atovaquone in environmental samples, methods were developed to quantify Atovaquone in water and complex matrices (sediment and biota). Sediment samples were mixed with ethyl acetate, acetonitrile and formic acid and extracted using sonication; water samples were diluted with acetonitrile. All sample extracts were analyzed using liquid chromatography-tandem mass spectrometry (LC-MS/MS), using deuterium-labelled Atovaquone for quantitation. *C. riparius* was exposed to sediment-associated Atovaquone for 10 d per Environment Canada's EPS 1/RM/32 test method (Environment Canada, 1997) using a field-collected reference sediment spiked with Atovaquone. Two chironomid exposures were conducted (range finding and definitive). The definitive test included six (nominal) concentrations (0, 10, 100, 500, 1000, 2000 mg/kg) and a 2% acetone solvent control (SC). There were no significant differences in chironomid survival across treatments; however multiple comparison tests indicated that growth was significantly reduced at 2000 mg/kg compared to controls. Adult *E. dilatata* were exposed to aqueous solutions of Atovaquone for 14 d with exposure solution renewal every 24 hours. Because Atovaquone was largely insoluble in water the effectiveness of various solvents (dimethylsulfoxide (DMSO), acetone, methanol, ammonium hydroxide-methanol) were explored. The first mussel range finding toxicity test included six treatments (SC, 0, 200, 1000, 2000, 20000 µg/L) with DMSO (2%) as the solvent. Atovaquone was toxic to *E. dilatata* at concentrations of 1000 µg/L (nominal). Additional range finding exposures with mussels are underway as is analysis of Atovaquone in surface water and municipal wastewater effluents. The data generated in this study will contribute to the environmental risk assessment of this compound in the Canadian environment.

**RP099 Oxidative stress induced by metformin in liver and blood of Cyprinus carpio**

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The widespread occurrence of emerging contaminants in water resources could lead to ecological risk and affect human and aquatic life even at small concentrations. Pharmaceuticals, such as metformin, enters the environment through different pathways and have been found in surface water, wastewater stream, and various environmental compartments. Metformin is a long term administered biguanide which has proven to be an effective and convenient pharmaceutical treatment of diabetes mellitus type II. The number of metformin prescription has increased over the years with the growing number of people diagnosed with diabetes, which has led to finding it, in various water bodies. *Cyprinus carpio* is a very important organism from an ecological and economic point of view. In Mexico, this species inhabits 80% of the freshwater bodies and is consumed by a large number of people. In the current study, *C. carpio* was exposed to 11.694 µg/L of metformin for 12, 24, 48, 72 and 96 hours, and oxidative stress (lipid peroxidation degree, oxidized and hydroperoxide content and antioxidant enzymes activity) was measured in liver and blood. Differences between the control and exposed groups were observed, finding increments in oxidized products and alteration of antioxidant enzymatic activity as a reflect of the damage induced by this contaminant.
RP100 Exposure of juvenile catfish (Clarias gariepinus) to acetaminophen induces dose-dependent and persistent disruption in gonadal development

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Acetaminophen is the most commonly taken analgesic world-wide and as a result of the consumption, it has been detected at relatively high concentrations in both wastewater effluents and surface water. In this study, the effect of acetaminophen has been investigated by the toxicity assay using Clarias gariepinus. The acute (96 h) and chronic (28 days) toxicity assays have been performed using the catfish. The lethal concentrations of acetaminophen with 50% mortality (LC50) have been determined as Mean percentage mortality for the exposed juveniles of C. gariepinus for the different test concentrations (100, 300, 500, 700µg/L) were 0, 0, 29 and 100%, at 24 hours; 0, 19, 86 and 100%, at 48 hours, 0, 29, 90 and 100%, at 72 hours; and 0, 33, 95 and 100%, at 96 hours exposure. 100% mortality was observed in the highest concentration (700µg/L) of acetaminophen. Mean mortalities were significantly different (p<0.05) between the control and treatment concentrations with significantly (p<0.05) higher mortalities recorded in the highest concentration (700µg/L). The estimated LC50 values observed for 24, 48, 72 and 96 hours were 518.81, 424.98, 378.16 and 348.11 µg/L respectively. The effect of acetaminophen on the reproductive responses in the fish has been studied from the expression level of four biomarkers (Gonad pathology, Vtg, testosterone and estradiol) after 28 days exposure to the varying concentrations. The results show that Fish exposed to acetaminophen exhibited high vitellogenin induction, intersex and female-biased sex-ratio. Acetaminophen reduced testosterone levels in all exposed groups and increased estradiol levels at higher concentration. An anti-androgenic effect was observed since a decrease in testosterone levels of exposed fish and an increase in levels of estradiol was found in the higher concentrations. This evidence supports the hypothesis that acetaminophen is involved in the observed endocrine disruption effects.

RP101 Tributyltin Affects Retinoid X Receptor-Induced Lipid Metabolism in the Marine Rotifer Brachionus koreanus

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To examine the effects of tributyltin (TBT), a model obesogen, on lipid metabolism in the marine rotifer Brachionus koreanus, we carried out life-cycle studies and determined the in vitro and in silico interactions of retinoid X receptor (RXR) with TBT, the transcriptional levels of RXL and lipid metabolism-related genes, and the fatty acid content. The lethal concentration 10% (LC10) was determined to be 5.12 µg/L TBT, and negative effects on ecologically relevant endpoints (e.g., decreased lifespan and fecundity) were detected at 5 µg/L TBT. Based on these findings, subsequent experiments were conducted below 1 µg/L TBT, which did not show any negative effects on ecologically relevant endpoints in B. koreanus. Nile red staining analysis showed that, after exposure to 1 µg/L TBT, B. koreanus stored neutral lipids and had significantly increased transcriptional levels of RXR and lipid metabolism-related genes compared to the control. However, the content of total fatty acids did not significantly change at any exposure level. In the single fatty acids profile, a significant increase in saturated fatty acids (SFAs) 14:0 and 20:0 was observed, but the contents of omega-3 and omega-6 fatty acids significantly decreased. Also, a transactivation assay of TBT with RXR showed that TBT is an agonist of Bk-RXR with a similar fold-induction to the positive control. Together, these results demonstrate that TBT-modulated RXR signaling leads to increased transcriptional levels of lipid metabolism-related genes and the synthesis of SFAs but decreases the content of polyunsaturated fatty acids (PFAs). Our findings support a wider taxonomic scope of lipid perturbation due to xenobiotic exposure that occurs via NRs in aquatic animals.

RP102 The Unresolved Dose-Response Challenge: Causal Linkage Between Exposure and Site of Toxic Action

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Aquatic toxicology assumes a constant exposure-organism-target dose relationship such that exposure is a suitable surrogate for target dose. However, previous work indicates exposure-based testing data can deviate 10 to 1000-fold from critical body residue (CBR) dose metrics due to the influence of toxicity modifying factors. Since both toxicity target sites and concentrations are largely unknown, a simple fish-based exposure model was modified to include a hydrophobic target based on neutral narcosis (~5 mmol/kg at 5% lipid content), which enabled examination of dose-surrogate relationships and toxic causality. A fixed organism size (CiT) was subdivided into hydrophilic (CiW, water) and total hydrophobic (CiTH, lipid) phases; the latter composed of non-target (CiNT) and target (CiTH) volumes. The target site is assumed constant for 50% mortality. Thus, the influence of total body lipid content and body size on exposure water, CBR, and target dose metrics can be parsed for steady-state toxicity and the number of molecules in the target and other phases can be quantified. Default is a 0.3 g fish at 5% lipid. Setting the toxicity target to 0.001 of the lipid phase, 1.0 density assumed, the volumes of the hydrophilic, nontarget hydrophobic, and target hydrophobic phases are 2.85*10^7, 1.49*10^8, and 1.50*10^11 m3, respectively. Assuming that nontarget lipid is independent of the water and target phases, changing the non-target phase by 0.2 and 4 times, produces toxicologically-equivalent fish of 0.288 and 0.345 g and ~1.04 and 17.4 % body lipid, respectively. Although various model results can be calculated, the target dose is a tiny proportion of the total fish concentration. It can vary widely, including setting it to zero, and the difference on the whole-body estimate is below the detection limit of the number of significant digits available. Problems related to this signal-to-noise issue (CiHT vs CiT), especially for experimental validation, are reviewed.

RP103 Toxicity of tributyltin and triclosan in tributyltin-binding protein 2 knocked-out medaka, Oryzias latipes

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A concentration of free-form drug form blood is critical to exert its toxicity. Binding protein in blood, i.e., acid alpha acid glycoprotein (AGP) or albumin bind with drug and might play an important role in detoxification of them. However, few studies were performed on this topic. Tributyltin-binding protein type 2 (TBT-bp2) is the homolog of AGP which bind to small hydrophobic molecules and suspect to play an important role in transportation, detoxification, and excretion of xenobiotic compounds. In this study, we established a homo strain of TBT-bp2 knockout (KO) (-/-) medaka, Oryzias latipes, using CRISPR/Cas9 system in F2 generation, to analyze the function of TBT-bp2, tributyltin and triclosan (TCS) was exposed to TBT-bp2 KO (-/-) medaka for 94 hours in a semi-static system and evaluate their toxicity on survival and alternation of behavior. Using mRNA-seq, no expression of TBT-bp2 was confirmed in the liver of TBT-bp2 KO (-/-) medaka. Compared with wild type medaka, the survival, swimming speed and number of vocal sound were decreased in the TBT-bp2 KO (-/-) medaka exposed to TBT or TCS (p<0.05). These results indicated that TBT-bp2 play important roles in detoxification of TBT and triclosan. mRNA-seq and GO analysis shows that TBT-bps might be linked with cyp450 and complement systems. TBT-bps is proposed as a detoxification system for xenobiotic compounds.
The AOP (adverse outcome pathway) approach offers an attractive framework for developing a mechanistically-based alternative testing methods. Well-defined AOPs can simplify the identification of assays affecting key events, which have high analytical value for an adverse outcome (AO) of interest. Aromatase (Cyp19a1) is a steroidogenic enzyme that plays a role in converting aromatizable androgens into bioactive estrogens. However, to date, most studies link the molecular initiating event (MIE) of aromatase interruption by chemicals subject to the AO of reproductive impairment are closely related with female fish. Thus, current study aimed to unravel the mechanism of chemical aromatase-induced endocrine disruption by illustrating the MIE perturbations responsible for the observed effects in male zebrafish (Danio rerio). In this study, we evaluated changes in estradiol (E2), vitellogenin (Vtg) and testosterone (T) caused by four different chemicals, Atrazine (ATZ), Di-hydro testosterone (DHT), Metformin (MET) and Prochloraz (PRO) to construct an aromatase activity (ARO) screening test. Three days post-fertilized larvae stage of zebrafish was exposed for 4 days (200 larvae/each crystal disk beaker) and 3 different concentrations for each chemical (ATZ: 10^-5 M - 10^-7 M, DHT, MET and PRO; 10^-6 M - 10^-8 M) was applied. Meanwhile, adult fish exposure (~7 mo) was exposed to the different chemicals (ATZ 10^-5 M; DHT, MET, MET and PRO were 10^-6 M respectively) for 21 days. We predict that the aromatase inducer chemicals will affect reproduction mechanisms and the levels of some enzymes/proteins including aromatase, estradiol (E2) and vitellogenin (VTG). Expected results could help to construct the conceptual model (AOP development) leading from aromatase interruption by chemicals to reproductive impairment in environment, which is the most progressive aromatase related AOPs developed so far.

RP105 Morphometric Effects of Individually Tested Various Weathered and Pure Microplastics on Sac Fry Zebrafish

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Microplastics (5mm to1nm) and plasticizers are ubiquitous in waterways, beaches, sediments and biota across the world. It is estimated that since the emergence of plastic in the 1950s, ~18 trillion pounds of plastic have been produced. Ingestion of microplastics by various marine species and accumulation of plasticizers has been documented and is of growing concern. Additionally, microplastics act as a carrier for the transport of persistent organic pollutants and biota, increasing the hazard to aquatic species. Microplastics vary in composition based on their monomeric component and the specific plasticizer, i.e. chemical additives that increase the plasticity, rigidity or other qualities of plastics. The toxic effects associated with the components that comprise the polymerized microplastics are not yet well characterized. The results presented here examine gross morphological variations in sac fry zebrafish as a result of exposure to weathered microplastics and pure plastic polymers. Embryos were exposed from 3 hours post fertilization (hpf) to 96 hpf with samples of weathered microplastics from estuaries in Newark Bay, NJ, as well as commercially available pure plastics at concentrations of 1 µg/mL or 10 µg/mL. The Newark Bay microplastics were analyzed via pyrolysis GC-MS to determine composition. Pyrolysis GC-MS determined that the three samples were composed primarily of polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC). Morphometric data were statistically analyzed, significant changes were noted between the controls and the treated groups in the embryonic zebrafish samples for the Newark Bay, Fenton treated, weathered samples. The commercial microplastics tested included: PE (LD low, MD medium and HD high density), poly styrene (PS), polyvinylchloride (PVC), sodium polyacrylate (SPA), polypropylene (PP), polyethylene terephthalate (PET), polyurethane (PU), and poly-methyl methacrylate (PMMA) polyethylene(co-vinylacetate) (PEVA), and polystyrene(co-acrylonitrile) (PSAN). Significant changes were seen in total body length in Newark Bay as well as pure microplastic treatment groups. Significant changes were seen in pericardial sack size in Newark Bay as well as pure microplastic treatment groups. Some significant changes were seen in interocular distance in the pure microplastic treatment groups.

RP106 The influence of polyethylene nanoplastics on the toxicity of methoxychlor on D. magna

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Nanoplastics (NPs), defined as plastic particles < 0.1 mm, have become an emerging concern in aquatic environments due to their multiple pathways of entry into rivers and streams. NPs may originate from the manufacturing of beads for personal care products as well as from the fragmentation of larger plastic items. Due to their small size they are easily ingested by aquatic organisms, resulting in detrimental health effects such as digestive tract obstructions, feeding debilitation, and overall energy depletion. Due to their high surface area and physicochemical attributes, NPs have also been shown to sorb and mobilize organic pollutants such as pharmaceuticals and pesticides, suggesting that interactions between these two types of pollutants may result in an altered biological response compared to the effects of each individual contaminant. This study assessed the potential synergistic or antagonistic effects of polyethylene nanoparticles and the organochlorine pesticide methoxychlor on the viability and mobility of Daphnia magna. Adult D. magna were exposed to either 1) virgin 10-20um polyethylene pellets (0, 12.5, 25, 50, or 100 mg/L), 2) methoxychlor (0, 1.0, 2.5, 5.0, or 10 µg/L), or 3) various combinations of the same pellet and methoxychlor concentrations for 48 hours. Juveniles (< 24hrs old) were exposed to the same treatments for 7 days using a static exposure method. Mortality and paralysis were assessed per 24 hours of exposure for both exposure assays. To assess mobility, exposed individuals were recorded in a light-controlled behavioral chamber for 3 minutes. Recordings were analyzed using ToxTrac to quantify average mobile speed, acceleration, and distance traveled by each individual. Mobility was assessed after 24 hours of exposure for the 48 hour assay and after 7 days of exposure for the 7 day assay. While this project is currently ongoing, we expect to find a significant difference in mobility parameters and mortality rates when exposed to the combination of polyethylene pellets and methoxychlor compared to the effects from each contaminant alone. Thus far, few studies have examined the ability of NPs to influence the toxicity of organochlorine pesticides and other chemical pollutants in aquatic invertebrates. Additionally, this is the first study to assess the impacts of NPs on locomotor behavior in D. magna, using automated analyses. As such, this study will help elucidate the span of which plastic pollution may impact aquatic systems and its relationship with pesticide contamination.

RP107 Suborganismal responses of the aquatic midge Chironomus riparius to polyethylene microplastics

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Microplastics (synthetic polymers with less than 5 mm) are now ubiquitous and persistent in freshwater ecosystems. Once in freshwaters, microplastic particles undergo fragmentation, biofouling and sedimentation processes reaching high concentrations in sediments where they can be ingested by sediment-dwelling invertebrates. Deleterious effects of microplastics have been described at organismal level (e.g. growth,
development). Notwithstanding, molecular, biochemical, cellular and physiological alterations can be used as early warning indication of sub-lethal effects providing information regarding the mechanisms of action of microplastics. This study aimed to assess and describe the potential effects of microplastics in the aquatic midge Chironomus riparius using biochemical responses and gene-expression tools. Fourth instar C. riparius larvae were exposed for 48 h to a gradient of concentrations (from 0.025 to 20 g kg\(^{-1}\)) of different size (up to 48 mm) polyethylene (PE) microplastics. Assessed biochemical endpoints included oxidative stress and damage responses (enzymatic and non-enzymatic responses, lipid peroxidation), and energy reserves and consumption (electron transport system activity) while the gene expression evaluation (Real Time PCR analysis) was developed using an array designed with 42 genes related to essential routes in invertebrates such as endocrine system, detoxification response, stress response, immune response, DNA repair and apoptosis. Results showed that short-term exposure to environmental relevant concentrations of PE microplastics impaired energy reserves, altered energy consumption, and triggered responses related to oxidative damage and genes involved in different routes have modified their mRNA level, being able to generate important alteration in their development and response against stress situations. Such results agree with the previously reported responses at organismal level and highlight the potential adverse effects of microplastics for freshwater benthic communities considering the ecological role of C. riparius within these habitats.

**RP108 Microplastic Content in Oysters (Crassostrea virginica) from Charleston Harbor, South Carolina (USA)**

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Microplastics (< 5 mm) are ubiquitous in coastal waters and abundances as high as thousands of particles/m\(^2\) are present on shorelines worldwide. A previous survey of Charleston Harbor, South Carolina (USA) reported an average of 414 ± 77 microplastic particles/m\(^2\) in intertidal sediments (Gray et al. 2018). The objective of the present study was to characterize the abundance and distribution of microplastics in oysters (Crassostrea virginica) collected from those state-managed, commercially harvested intertidal oyster grounds contributing substantially to annual landings statewide. To achieve this objective, three locations were selected within the Folly River based on historic shellfish harvest landings, and three sites within each location were sampled. Oysters, sediment, and surface water samples were collected at each site. In the laboratory, for each oyster sampled, both gills were dissected from the other oyster tissues, and both were subsequently digested using 10% KOH solution. Microplastic particles from all three sample types were characterized based on shape, size, and color, and a subset of samples were analyzed using micro-Raman spectroscopy to identify polymer type. The ultimate utility of these results will be in providing the rationale for estimating human exposure levels to microplastics following the consumption of oysters.

**RP109 Assessing the trophic ecology and movement of walleye using stable isotopes in the southern Grand River, Ontario**

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Lake Erie supports the largest commercial and recreational walleye fishery of the Great Lakes, which contributes greatly to the Ontario economy annually. Walleye are also a valuable ecosystem component that require a diverse mesotrophic environment to maintain stable populations. The walleye population of the southern Grand River in eastern Lake Erie is degraded due to the compounding impacts of habitat and water quality degradation and restricted access to spawning grounds by a low-head dam, making the Grand River a priority management area for walleye restoration. To investigate factors influencing the year class success of the southern Grand River walleye population, this study used stable isotope analyses of nitrogen and carbon to test for spatial changes in the trophic ecology and condition factor of young-of-the-year (YOY) walleye among river segments of varying habitat quality. Sampling for YOY walleye was conducted during the growing season of 2018 and 2019. Significant variation in trophic position and carbon source were observed between the lotic upper river segment, the degraded Dunnville Dam reservoir, and the lake-effect zone at the river mouth. YOY walleye condition was significantly greater at the river mouth compared to upstream sites. Moving forward, this study will link our understanding of YOY walleye to mature walleye spawning activity using acoustic telemetry data, which can be used to determine the movement patterns and spawning habitat of mature walleye in the southern Grand River. This project will aid in advancing biomonitoring and management practices that protect and enhance both the health of the southern Grand River and the Lake Erie walleye fishery.

**RP110 Tracing Origin of Pollution Using Isotope Fingerprints**


Protecting our environment from contamination is a global challenge, one that requires international focus and collaboration for our air, water and land resources. The natural and synthetic materials in our air, water and on our land have a fingerprint, a unique chemical signature that allows them to be identified and differentiated from one another. Consequently, we are able to interrogate samples, chemically, to determine where they came from, allowing measures to be developed and executed to reduce and remove environmental pollution. In this presentation we explain how stable isotope fingerprints of carbon, nitrogen, sulphur, oxygen and hydrogen are used to identify the origin of air, soil and water pollution, in the context of investigations focused on understanding pollution source and pollution events. Data are shown that illustrate how isotope fingerprints offer conclusive answers on questions associated with where pollution came from: this is known as the understanding the point source of the pollution. Specifically, we focus on air pollution as measured on filter papers and on nitrates measured from soils and waterways, and illustrate, how isotope fingerprints can differentiate pollution source. In addition, an overview of the interpretation of isotope fingerprints and the technology used is also provided. Specifically, we focus on Isotope Ratio Mass Spectrometry (IRMS), a technique used to visualize the isotope fingerprints within pollutants.

**RP111 Do you see what I see? Tracing indirect effects using stable isotope and elemental analysis**

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Alterations in trophic interactions or food web structure are hard to detect using traditional approaches. Stable isotope signatures and elemental composition, both providing information on the assimilated food source, appear as promising tools. To test for their suitability in an ecotoxicological context, in a first experiment, the omnivorous amphipod Gammarus fossarum was given the choice to feed either on black alder leaves or prey on mayfly larvae (Baetis sp.). This trophic interaction was assessed under exposure towards the neonicotinoid thiacloprid (0.75 µg/L). We used a multi-factorial design (thiacloprid x leaves) to assess the effect of all factors - individually and in combination. Consumption of leaves and Baetis were monitored for two weeks and stable isotope signatures and elemental composition were determined for both resources as well as the consumer (i.e., G. fossarum) at the end of the experiment. In a second experiment, we tested if chemical stress could affect stable isotope signatures by exposing gammarids towards thiacloprid (0, 0.75, or 6 µg/L) for up to six weeks while providing them with a single food source (i.e., leaves or Baetis). In the first experiment, exposure towards thiacloprid affected the food choice of G. fossarum: a higher consumption...
of **Baetis** was observed, while this was not reflected by gammarids’ elemental composition. However, the nitrogen content of **Gammarus** was increased by thiacloprid when only fed **Baetis**. Elemental analysis thus seems unsuitable to trace changes in dietary interactions due to chemical stress. In contrast, stable isotope signatures well reflected the increased predation success and no differences in signatures were observed between exposed and unexposed animals when only one food source was offered. Moreover, the second experiment revealed that even after six weeks of exposure towards 6 µg/L, a concentration significantly reducing gammarids’ physiological fitness and increasing their mortality rates, stable isotope signatures differed only minimally (< 0.5 %) when compared to the control. Although further experiments with different test systems (i.e., combinations of consumers and resources as well as contaminants) seem necessary to draw final conclusions, our data suggest that stable isotope analysis is indeed a promising tool to trace indirect effects of chemical stressors in affected food webs.

**RP112 Is labelling aquatic food webs with stable isotopes not so harmless after all?**

**J.P. Zubrod, M. Konschak, S. Lüderwald, R. Schulz, University of Koblenz-Landau; M. Bandschuh, Institute for Environmental Sciences University of Koblenz-Landau; Department of Aquatic Sciences and Assessment**

Heavy stable isotopes (such as 15N) are commonly used to trace the flow of energy, nutrients, and matter in food webs while assuming that their enrichment does not affect the physiology of consumers. However, recent evidence (Andriukonis & Gorokhova, 2017, Scientific Reports) implies that algal growth was negatively correlated with 15N concentration in medium, while at an intermediate level of labelling (3.5 at%) growth lag phase was shortest (effect size [ES] ~10%). To test if this phenomenon is universal in aquatic food webs, which would question the use of 15N as an indicator for labelling to be rather unfavorable. This observation is supported by leaf litter decomposition being lowest for this treatment during the second experiment. Generally, the experiment followed OECD 211 but with 6 animals cultured in 150 mL medium with a replication of five. In the second experiment, we assessed if heterotrophic microorganisms show similar effects as observed for algae. Black alder leaf material was subjected to colonization and decomposition by a natural microbial community (particularly fungi and bacteria) for 12 days with medium containing increasing 15N concentrations (n=15). During the first experiment, reproduction of **D. magna** was not affected (ES 0.5%). However and contrary to literature, survival was reduced by 10% compared to the control at 3.5 at%, indicating this level of labelling to be rather unfavorable. This observation is supported by leaf decomposition being lowest for this treatment during the second experiment (ES >10%), though differing non-significantly to the control (i.e., 0.37 at%). Currently, we are analyzing preserved samples of both experiments (e.g., physiological condition of **D. magna** and microorganisms) to verify the identified trends (i.e., detrimental implications in the survival of a primary consumer and the functioning of microbial decomposers at 3.5 at%). As our data and the literature, nonetheless, indicate that relevant heavy stable isotope concentrations (i.e., up to 35 at%) do not affect biological and ecological responses considerably, labelling with 15N still seems well-suited to trace the flow of energy, nutrients, and matter in aquatic food webs.

**RP113 Factors influencing variation in Hexagenia rigida sensitivity**

**N. Mason, Alma College / Environmental Studies; A.D. Harwood, Alma College / Environmental Studies / Biology**

The burrowing mayfly (**Hexagenia** spp.) is an important member of freshwater benthic ecosystems, therefore, methods have been in development for their use as a test species in both sediment and water-only exposures. However, **Hexagenia** toxicity data can have more variation than other species (e.g. **Hyalella azteca**). One potential explanation for this variation could be lack of standardization in raising animals for testing. For example, there is no standard age or hatch time, only size. Therefore, the objective of the current study was to evaluate the effects of hatch date, age, and size on the sensitivity of **Hexagenia rigida** to stress. **H. rigida** were separated into early hatchers (first 3 days of hatching) and a mix across hatching days. At 8 and 12 weeks post-hatch, nymphs were separated by size (5-8 mg or 15-20 mg) and exposed to a stressor, either NaCl or lack of artificial burrow for 96 h. Lack of artificial burrows did not cause significant mortality in any treatment. This indicates that it may not serve as an effective means of evaluating stress in these organisms. Hatch date and age did not significantly affect **H. rigida** NaCl sensitivity. However larger nymphs were less sensitive to NaCl at 8 weeks, which is consistent with previous research. Differences between sizes were not significant at 12 weeks. While other chemical stressors should be evaluated, this may indicate that the effects of size may diminish with age. If variations in age do not impact toxicity, this allows for comparisons among studies with different rearing methodologies and flexibility in raising mayflies for toxicity studies.

**RP114 Comparing the sensitivity of the burrowing mayflies Hexagenia limbata and Hexagenia rigida to toxicants at three different life stages**

**A. Hedges, Environment and Climate Change Canada / Water Science and Technology Directorate; L. Brown, Environment and Climate Change Canada / ACRD; A.J. Bartlett, Environment and Climate Change Canada / Water Science and Technology Directorate**

Use of the mayfly genus **Hexagenia** in toxicity testing has undergone several cycles of prominence marked by frequent use in research, as well as periods of relative scarcity, and there is currently increased interest in exploring the use of **Hexagenia** as a model organism. Original research into these species, driven by the near extirpation of **Hexagenia** from the western basin of Lake Erie in the 1950s, highlighted the benefits of using mayflies as indicators of ecosystem health as they thrive in mesotrophic bodies of water. Historically, the two species of burrowing mayfly **Hexagenia limbata** and **Hexagenia rigida** were indistinguishable as they often co-occur in the environment, are morphologically similar, and exhibit similar life cycles. Recent advancements have allowed the two species of **Hexagenia** to be reliably identified, and thus the relative toxicity of contaminants to each species can be evaluated. The aim of our research was to determine if any differences in sensitivities exist between the two species, as well as to develop methods for testing potentially more sensitive life stages and endpoints. Toxicants were chosen that encompass varying modes of action and are well documented in the toxicity literature to ensure the development of robust methods. Compounds included a salt (potassium chloride), a metal (copper chloride), and an organic contaminant (the neonicotinoid insecticide imidacloprid). The life stages of interest in this study were developing eggs, hatchlings (< 24 h old), and nymphs that were several weeks old (5-8 mg wet weight). Tests involving developing **Hexagenia** eggs were conducted in 12-well plates for a 14 d duration to determine time to hatch, total percent hatched, and percent hatching. Hatching tests were also conducted in 12-well plates to assess survival, but for a 7 d duration. Nymph tests were 96-h water-only exposures conducted in 600 mL beakers to measure survival and growth. Testing is ongoing; however, preliminary results indicate only minor differences between the two mayfly species, and that exposure to a contaminant as nymphs that are several weeks old results in the greatest toxicity while exposure as eggs results in the least toxicity. The assessment of differences in contaminant toxicity between **Hexagenia limbata** and **Hexagenia rigida** and the development of methods involving more sensitive life stages and endpoints will allow for better assessments of risk and increased environmental relevance.
RP115 Shedding light on the toxicity of benzotriazole ultraviolet stabilizers and a benzothiazole to aquatic invertebrates

Benzotriazoles (BZTs) and benzothiazoles (BZThs) are high production volume industrial chemicals that are primarily used as ultraviolet stabilizing additives and vulcanization accelerators for rubber, respectively. These compounds are environmentally persistent, have the potential to bioaccumulate, and have been detected in environmental samples; however, the available toxicity information for aquatic invertebrates is scarce. Therefore, our objective was to conduct spiked-sediment exposures to assess the toxicity of three BZTs and one BZTh to *Hyalella azteca*, *Hexagenia spp.*, *Tubifex tubifex*, and *Daphnia magna*. Test compounds were UV234 (phenol, 2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl); CAS RN 70321-86-7), UV326 (phenol, 2-(5-chloro-2H-benzotriazol-2-yl)-6-(1,1-dimethylpropyl)-4-methyl; CAS RN 3896-11-5), UV329 (phenol, 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl); CAS RN 3147-75-9), and MBTS (2-mercaptobenzothiazole disulfide; CAS RN 120-78-5). Maximum nominal sediment concentrations tested were 100 and 1000 mg/kg (dry weight) for BZTs (UV234, UV326, and UV329) and BZTh (MBTS), respectively. Depending on the species, tests were 21-42 d in duration, and survival, growth, and reproduction were examined. Chemical analysis of water and sediment is ongoing; therefore, results are currently based on nominal sediment concentrations. Survival of *Hyalella*, *Hexagenia*, *Tubifex*, and *Daphnia* was not significantly different between controls and treatments for any of the four compounds tested. Growth of *Hyalella* and *Daphnia* was also not affected; however, growth of *Hexagenia* was significantly reduced compared to controls at 1-100 mg/kg UV234 and 1000 mg/kg MBTS. Cocoon production of *Tubifex* was unaffected by BZTs, as was cocoon hatch success with the exception of 1 mg/kg UV326, which was significantly lower than controls. Juvenile production of *Tubifex* was significantly reduced compared to controls at 10 and 100 mg/kg UV329. Cocoon production, cocoon hatch success, and juvenile production in *Tubifex* were all significantly lower than controls at 1000 mg/kg MBTS. *Daphnia* reproduction was unaffected by BZTs, but increased significantly compared to controls at 1000 mg/kg MBTS. The results of this study will be compared to environmental concentrations, and will support environmental risk assessments to determine the impacts of these compounds on aquatic organisms.

RP116 Validation of Pulsed Exposure Toxicity Methods at San Diego Regional Naval Bases
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Episodic discharges such as stormwater require environmentally-relevant, scientifically-defensible, and conservative toxicity test designs to assess potential for receiving water impacts. Permittees in highly industrialized areas are increasingly required to conduct 96-h (or longer) toxicity tests on stormwater collected at end-of-pipe associated with events that are generally less than 24-h. This project is currently evaluating alternative toxicity test designs for episodic exposures that would require minimal modification to standard methods, yet increase realism towards protection of beneficial uses from episodic discharges. The feasibility of using site-specific rainfall runoff duration is being evaluated, and additional measures associated with time-varying discharges, to derive more environmentally relevant toxicity exposure regimes for stormwater compliance. The pulsed exposure methodology was validated to ensure that it is indeed representative and protective of actual site conditions during dynamic runoff events. This was performed through end-of-pipe monitoring of stormwater/episodic discharge samples along with concurrent in situ toxicity testing at select locations. SEA Rings served as the platform for exposing the same species selected for the laboratory exposures, and house passive sampling devices and water quality loggers (e.g. salinity, temperature, dissolved oxygen) for characterization of the stormwater runoff and assessment of potential confounding factors. In situ validation of the pulsed exposure method was performed at San Diego Regional Naval Bases during two storm events. Three SEA Rings were deployed at the two targeted sites: 1 within the first meter of the surface, 1 at about 2-3 meters, and 1 at the sediment surface. For laboratory exposures, receiving water samples were collected prior to the storm to be used as renewal water for the respective stormwater samples. Receiving water was also collected right in the midst of the storm while stormwater samples were collected for side-by-side testing. All samples were tested using the mysid (*Americamysis bahia*) acute survival test as well as the more sensitive chronic sea urchin (*Stronglylocentrotus purpuratus*) embryo-larval development test. All samples had the treatments of 6, 12, and 24 hr pulsed exposures and also were tested using the standardized 96 hr static-renewal exposure. All samples/exposures were tested in a dilution series of 25, 50 and 100%. Following pulsed exposures, organisms were transferred to uncontaminated seawater for the remainder of the 96-h exposure period. This ESTCP & NESDI funded project was introduced at SETAC in 2017 and this presentation will summarize results to date and future plans to assess proposed WET test modifications within NPDES requirements for episodic discharges.

RP117 Derivations Studies for an Environmentally Relevant Approach for Stormwater Toxicity Testing Compliance Monitoring
M. Colvin, Naval Information Warfare Center Pacific / Energy and Environmental Sustainability; K. Kowal, San Diego State University Research Foundation; N. Hayman, G. Rosen, NIWC Pacific / Energy and Environmental Sustainability; J. VanVoorhis, Wood Environment Infrastructure Solutions, Inc. / Toxicology; C. Stranksy, Wood / Environment Infrastructure Solutions Inc

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and this presentation will summarize results to date and future plans to assess proposed WET test modifications within NPDES requirements for episodic discharges.

**RP118 Effects of different lighting source of light emitting diode and fluorescent light for growth inhibition tests with cyanobacteria and diatom**


Currently, algae growth inhibition tests are commonly performed using a growth chamber with a fluorescent lamp (FL) as the light source because the test guidelines require continuous lighting with uniform fluorescent illumination. However, FL is one of the mercury-added products that the Minamata Convention (adopted in 2013) requires to reduce or prohibit to produce, in-port and export them because mercury is harmful to humans and environmental organisms. On the other hand a light emitting diode (LED) does not contain mercury which provides the photosynthetically effective wavelength range of 400–700 nm and an adequate light intensity for algae growth. In the near future, LED will be used as a light source instead of FL in algae growth inhibition test.

At SETAC North America 39th Annual Meeting, we showed the results of our investigation whether LED can be used as a substitute for FL for green alga (*Pseudokirchneriella subcapitata*) study. The results of the *Pseudokirchneriella subcapitata* growth inhibition tests using LED was the same as the test using FL. However, we have not investigated on other algae, cyanobacteria, diatom, marine algae and lemmna yet and these algae require different wavelengths respectively. Hence, in this study we investigated whether LED can be used as a substitute for FL for cyanobacteria (*Anabaena variabilis*) and diatom (*Navicula pelliculosa*) tests by using LED and FL with different wavelengths respectively. These algae growth inhibition tests were conducted according to OECD TG 201. We performed tests on each of the five chemicals using either LED or FL at the same time.

Sodium chloride, cadmium chloride, potassium dichromate, 3,5-dichlorophenol and pentachlorophenol were used for the tests because these chemicals have different mode of actions and are assigned as reference substances in the test guidelines. In this meeting, we will show the test results of *Anabaena variabilis* and *Navicula pelliculosa*.

**RP119 Building an Aquatic Research Facility (Wet lab): Challenges to achieve and maintain good water quality in support of aquatic toxicology studies**

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Operating an aquatic facility (wetlab) that is able to provide high water quality for use with aquatic organisms in toxicology, ecological, and behavioral studies, is challenging. Although not all wetlabs are built the same, there are common challenges that managers of these facilities face. These include complex issues dealing with dechlorination processes, filtration systems, water chemistry readings/results, recirculation vs flow through systems, temperature maintenance, animal care practices and husbandry (under the guidance of the Canadian Council for Animal Care (CCAC)), new species challenges, species decontamination procedures, and the costs to maintain these facilities. In the Aquatic Life Research Facility (ALRF), operated by Environment and Climate Change Canada in Burlington, Ontario, several of the noted challenges have been resolved or refined in order to ensure a high water quality standard required for toxicity testing and other ecological research. Water samples were taken before and after changes to the water treatment system, and in each instance, water quality improved after modifications were implemented. Changes that were applied include improvements to the dechlorination process, reduction of supersaturation, implementation of a refined controls system, addition of back-up systems and regular maintenance of the piping system. These modifications along with the constant re-evaluation of processes have all been applied with the goal to obtain the highest water quality needed to ensure the upmost care and welfare of animals housed and tested in the facility. Aquatic research facilities are found across several government, university, hospital and private institutions.

With diligent monitoring of water quality, refining methods and systems, collaborating with experts from other facilities, and working with local Animal Care Committees, these challenges can be overcome, resulting in healthy animals and good, repeatable, scientific results.

**RP120 Toxicity evaluations of chemicals in seawater using the hyalid amphipod, Ptilohyale barbicornis**

S. Uno, Kagoshima University / Faculty of Fisheries; K. Hayakawa, T. Mikami, Kagoshima University; E. Kokushi, Kagoshima University / Faculty of Fisheries

Until now, many kinds of aquatic organisms have been used to evaluate the toxicities and risks of chemicals in water systems. However, most of those are freshwater biota, and the tests with seawater organisms are limited. In new condition, the risk assessment of chemicals even in seawater are almost conducted with freshwater biota. However, in fact, the physiological functions are much different between those organisms, and their sensitivity for the individual chemicals is possibly too different between seawater and freshwater organisms. Therefore, the independent evaluations for seawater biota are required recently. The hyalid amphipod, *Ptilohyale barbicornis*, inhabits in seawater and brackish water area, and likes to stay in the gaps of mussel community. Their keeping and breeding are easy even in the laboratory, and we expect to use this invertebrate in the toxicity tests of chemicals as an index organism in seawater area.

In fact, freshwater amphipod such as *Hyalella Azteca* has been using the toxicity tests of chemicals frequently, and the application for *P. barbicornis* in the tests is similar with *H. Azteca* except for using seawater. In the present study, we conducted the acute toxicity tests with *P. barbicornis* because of the evaluations of a few chemicals such as dichlorophenols, chlorpyrifos in seawater, and others and compared their sensitivities were compared with other test organisms. *P. barbicornis* tends to be carnivorous, and frequently feeds on each other, when they are kept a limited space. Therefore, we prepared the small glass cuvette for keeping the individual amphipod, and exposed each chemical to individual amphipod in a vessel. The results of toxicity tests suggest that the sensitivities to chemicals are almost similar to other invertebrates such as Daphnia.

**RP121 Determination of optimal cultural conditions for Pomacea paludosa-a considerable species for aquatic toxicology research**

P. Hitch, Loyola University Chicago; T. Hoang, Loyola University, Chicago / Institute of Environment and Sustainability

A number of studies have been conducted with Pomacea paludosa to understand its life cycle, including growth, development, reproduction, and the ecological importance of its presence in the natural ecosystem, as well as its sensitivity to environmental contaminants. This sensitivity allows them to be used in toxicology research. To be considered a model organism for aquatic toxicology research and testing, a laboratory culture method should be developed. This study sought to determine favorable conditions, such as water quality for growth and breeding of the snail within a laboratory setting by culturing the snails in three different qualities of water, classified as soft water (hardness of 40-48 mg/L as CaCO₃), hard water (hardness of 160-180 mg/L as CaCO₃), and very hard water (hardness of 280-320 mg/L as CaCO₃). The experiments were conducted in 10 gallon aquariums and under static renewal conditions at a temperature of 30°C in the Loyola Ecotoxicology and Risk Assessment Laboratory. Survival, growth, reproduction, and mineral content were the measured endpoints of the study. The results shows that snails cultured in hard water grew larger and experienced a lower mortality rate within an amount of time than snails cultured in soft and very hard waters. Concentrations of Ca, Mg, and Na in the soft tissue of very hard water cultural snails were highest while these concentrations in the shell of the very hard water cultural snails were lowest. These results suggest that although snails need minerals (e.g., Ca) for shell development and growth, exceeding minerals in water doesn’t seem to support biological function of the snail. While this study reveals that hard water might be optimal for snails to grow, another study should be conducted to determine whether a static or flow-through culture is optimal for the snails to grow and reproduce.
**RP122 Evaluation of Microcystin-LR effects to juvenile fathead minnows**


Cyanobacterial blooms are increasing in frequency and intensity and are linked to increased eutrophication from urbanization, agriculture and industrial nutrient enrichment. Microcystin is one of the most common classes of algal toxins found in waters of the United States. The objective of this study was to evaluate the toxicity of Microcystin-LR (MC-LR) to the fathead minnow *Pimephales promelas* (FHM). Three 14-d bioassays were conducted with high concentrations of MC-LR ranging from 100 µg/L to 240 µg/L. In our initial bioassay, an inverse toxicity response was observed between Days 5 and 11 with 100% mortality in all test concentrations by Day 11. To investigate possible mechanism for this response, the second bioassay varied the feeding rate of the brine shrimp. However, survival of FHM in our second bioassay ranged from 85-100% in all MC-LR in all concentrations across both feeding rates, and survival of FHM in the third bioassay, set up to mimic our first bioassay, ranged from 95-100% across all 5 concentrations. To evaluate if exposures to MC-LR in the third bioassay, which was prepared with a fresh feeding solution, stressed the FHM, we evaluated brine shrimp survival, thus potentially affecting the uptake of MC-LR through the FHM diets, we exposed brine shrimp for 5-hrs at MC-LR concentrations in the third bioassay. Survival of brine shrimp in the MC-LR 25 and 50 µg/L treatments were significantly higher compared to the control. Concentrations of algal toxins measured with enzyme-linked immunosorbent assays (ELISA) generally were within 40 to 64% of the nominal MC-LR concentration across all three bioassays, demonstrating that differences in survival among tests were not caused by differences in waterborne MCLR concentrations. Ongoing analyses will further document MCLR exposure by determining bioaccumulation of MCLR in fish tissue and evaluate potential sublethal effects of MCLR on fish growth and swimming behavior.

**RP123 Tile Drainage and Anthropogenic Land Use Contribute to Harmful Algal Blooms and Microbiota Shifts in Inland Water Bodies**

L. Mrdjen, Ramboll; S. Fennessy, J. Slonczewski, Kenyon College; J. Lee, The Ohio State University College of Public Health

Freshwater harmful algal blooms (HABs), driven by nutrient inputs from anthropogenic sources, pose unique risks to human and ecological health worldwide. A major nutrient contributor is agricultural land use, specifically tile drainage systems, including tile drainage discharge. Small lakes and ponds are at elevated risk for HAB appearance, as they are uniquely sensitive to nutrient input. HABs introduce exposure risk to microcystin (MC), hepatotoxic and potentially carcinogenic cyanotoxins. To investigate the impact of anthropogenic land use on small lakes and ponds, 24 sites in central Ohio were sampled over a 3-month period in late summer of 2015. MC concentration, microbial community structure, and water chemistry were analyzed. Land use intensity, including tile drainage systems, was the driver of clustering in principle component analysis, ultimately contributing to nutrient deposition, a driver of HABs. Relative abundance of HAB-forming genera was correlated with elevated concentrations of nitrate and soluble reactive phosphate. One location (FC) showed MC concentrations exceeding 875 µg/L and large community shifts in ciliates (Oligohymenophorea) associated with hypoxic conditions. The prokaryotic community at FC was dominated by Planktothrix sp. These results demonstrate the impact of HABs in small lakes and ponds, and that prevailing issues extend beyond cyanotoxins, such as cascading impacts on other trophic levels.

**RP124 Cyanobacteria and microcysts alter zooplankton community structure: a case study in Lake Zumpango, Mexico**

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Environmental factors play an important role in structuring aquatic ecosystems. Global warming causes expansion and permanence of cyanobacteria, often toxic strains, which alter the abundances of zooplankton community structure, especially in eutrophic reservoirs. Lake Zumpango formed the northern zone of one the most important reservoir of the great lake of Mexico’s valley during the 1500’s. Nowadays the Lake is filled with partially treated waste water from Mexico City causing an excessive increase of phosphates and nitrates (0.7-3.4 and 0.9-28.8 mg L-1, respectively) promoting a persistent bloom composed mainly of high densities of cyanobacteria such as Planktothrix sp., Microcystis sp., Cylindrospermopsis sp. and Dolichospermum sp. causing alterations of zooplankton abundances and diversity favoring tolerant organisms or with adaptations to minimize the deleterious effects associated with microcystin concentrations. We measured monthly, over one year, physico-chemical variables and microcystin fractions (particulated and diluted) with the Envirologix ELISA Kits. Zooplankton samples were collected monthly by filtering 80 L from superficial water with a 40 µm mesh size. We recorded 20 rotifer and 7 microcrustacean species where Keratella cochlearis (<1200 ind L-1) and Acanthocyclops americanus copepoids (>300 ind L-1) had the highest densities. Highest abundance of Microcystis aeruginosina and microcystin concentrations were found in October and December (34.13, 27.17 µg L-1) which correlated with the lowest observed value of Shannon-Wiener diversity index (1.3 Bits ind-1). Multifactorial analyses showed that some dominant microphagous rotifer species were positively related with the presence of cyanobacteria and their secondary metabolites which related to findings from laboratory tests. The relations obtained have been discussed with emphasis on the importance of regular monitoring of water bodies in Mexico to test the ecological impacts of cyanobacterial blooms.

**RP125 Biochemical effects in the green microalgae Chlorella vulgaris during the bioremoval of the azo dye Direct Blue 15**

P.d. Antuna-González, Escuela Nacional de Ciencias Biologicas, IPN / Experimental Biology; M. Hernández, Instituto Politecnico Nacional / Zoology; F. Martínez-Jerónimo, Escuela Nacional de Ciencias Biologicas, IPN / Laboratory of Experimental Hydrobiology

Each year, 800,000 tons of dyes are produced; from this amount, 30% are discharged into water bodies as industrial effluents. Synthetic dyes obtained from benzidine are carcinogenic, mutagenic, and have genotoxic potential so they can affect the aquatic biota. The bioremoval of colorants using microalgae is an alternative method to avoid water pollution. The objective of this study was to evaluate the capability of Chlorella vulgaris to bioremove the Direct Blue 15 (DB15) dye employing different concentrations by Day 11. To investigate possible mechanism for this response, the second bioassay varied the feeding rate of the brine shrimp. However, survival of FHM in our second bioassay ranged from 85-100% in all MC-LR in all concentrations across both feeding rates, and survival of FHM in the third bioassay, set up to mimic our first bioassay, ranged from 95-100% across all 5 concentrations. To evaluate if exposures to MC-LR in the third bioassay, which was prepared with a fresh feeding solution, stressed the FHM, we evaluated brine shrimp survival, thus potentially affecting the uptake of MC-LR through the FHM diets, we exposed brine shrimp for 5 hrs at MC-LR concentrations in the third bioassay. Survival of brine shrimp in the MC-LR 25 and 50 µg/L treatments were significantly higher compared to the control. Concentrations of algal toxins measured with enzyme-linked immunosorbent assays (ELISA) generally were within 40 to 64% of the nominal MC-LR concentration across all three bioassays, demonstrating that differences in survival among tests were not caused by differences in waterborne MCLR concentrations. Ongoing analyses will further document MCLR exposure by determining bioaccumulation of MCLR in fish tissue and evaluate potential sublethal effects of MCLR on fish growth and swimming behavior.

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time of bioremoval. The inoculum has a variable effect on the elimination process, depending on the time and xenobiotic concentration. The concentration of photosynthetic pigments increased significantly in dye concentrations greater than 15.92 mg L\(^{-1}\). Likewise, there was a rise in protein concentration per cell in the greatest concentration of DB15. An increase in lipid concentration in the inoculum of 6x10\(^6\) cells mL\(^{-1}\) and a decrease in 3x10\(^6\) cells mL\(^{-1}\) were observed. Dye concentration, time, and the number of cells are factors that influenced the capability of C. vulgaris to bioremove DB15; nevertheless, the photosynthetic pigments and macromolecules content were affected in response to the xenobiotic. C. vulgaris can be useful to remove DB15, but toxic effects could be expected.

**RP126 Effects of urbanization on water quality and instream biota in Northern Utah, USA**

C. Fender, D. Kimberly, Westminster College / Biology

It is widely acknowledged that urbanization can degrade water quality of inland waterways. Increased acidification, sedimentation, and habitat fragmentation are some stressors from urbanization that can directly affect the health of instream biota. Over the past decade, Utah has consistently ranked as one of the fastest growing states in the nation. Moreover, the vast majority of Utah’s population (>80%) resides within a densely packed 100-mile corridor. This has led to an increase in development near sensitive habitats, such as alpine streams. This study sought to better understand the impacts of urbanization on City Creek and Emigration Creek, which are very close to Salt Lake City. During the summer of 2018, we surveyed macroinvertebrates every river mile from headwaters to mouth in each stream. The majority of sampling was done using hester-dendy plates, which is an artificial substrate that promotes invertebrate colonization. In addition to collecting and distributing plates on a monthly basis, dissolved oxygen and temperature were also collected. As a proxy for urbanization, we quantified the percent impervious surfaces within a quarter mile radius of each transect. Results from this study suggest that macroinvertebrate diversity decreased along a gradient from the forested headwaters to more urbanized landscapes downstream. Additionally, upstream transects were characterized by greater family diversity and a greater proportion of sensitive families, such as Sphaeriidae and Lepidostomatidae. Conversely, transects among urbanized areas were less diverse and characterized more by tolerant organisms. This data supports many other studies that show shifts in macroinvertebrate communities from rural, forested sources to more impacted sections close to urban centers. If development in Utah continues to spread into upper reaches of these sensitive habitats, we can expect greater impact on total stream health in the future.

**RP127 Rapid Bioassay Screening of Effluent Discharges from a Mobile Offshore Drilling Unit to the Marine Environment**


A study was performed to evaluate the potential biological impacts from 6 types of miscellaneous discharges from a remote arctic oil and gas mobile offshore drilling unit (MODO). Samples were initially evaluated for toxicity using a rapid (< 1 h) initial screening test (echinoderm [Dendraster excentricus] fertilization test), and if toxicity was found, further testing was conducted using 3 chronic whole effluent toxicity (WET) tests. For an initial toxicity screening test to be an effective tool, the test should be adequately sensitive, and results should include a low incidence of false positives. The EC25 results from WET tests were reviewed as indicators of either observed toxic effects or false positives from the screening test. Screening of effluent samples for toxicity prior to rigorous sampling and investigation, particularly in challenging logistical situations such as this study, can be an effective method of reducing unnecessary effort, cost, and testing of vertebrate species, while continuing to safeguard aquatic ecosystems. This study established the usefulness of the echinoderm fertilization test for effluents discharged into marine waters. Additional tests for marine and freshwater discharges need vetting and there seems to be potential for expanded application within the regulatory framework. California and Gulf of Mexico general permits for offshore oil and gas exploration and point source extraction (CAG280000 & GMG290000, respectively) both require a 7-day chronic fish survival and growth test. An appropriate screening assay, such as the echinoderm fertilization test, could be used to reduce the testing of vertebrate species tested as mandated by these permits.

**RP128 Interactions Between Oil Exposure and Immune Function Relevant for Pacific Herring Population Collapse**

J. Gill, UC DAVIS College of Biological Sciences / Department of Environmental Toxicology; T. Linbo, NOAA Fisheries / Northwest Fisheries Science Center; P. Hershberger, US Geological Survey / Western Fisheries Research Center; J. Incardona, NOAA / Fisheries; A. Whitehead, University of California, Davis / Environmental Toxicology

The population of Pacific herring (Clupea pallasi) in Prince William Sound (PWS) collapsed in the early 1990’s, following record high biomass levels. Cause(s) of the decline remain uncertain; however, surveillances indicate that the decline occurred concomitantly with epizootics of infectious and parasitic diseases. The contribution of the 1989 oil spill to this collapse remains controversial. Here, we test two general hypotheses to evaluate possible connections between the 1989 oil spill and the observed disease epizootics, including: 1) oil exposure caused genotype-selective mortality, where surviving genotypes had compromised immune function that facilitated disease outbreaks (evolutionary impact); 2) oil exposure during early life impaired the development of the immune system such that adults were more susceptible to disease (developmental impact). To test hypothesis 2, we exposed herring embryos to oil during embryogenesis, reared the larval survivors through metamorphosis to juveniles, and exposed metamorphosed juveniles to an endemic pathogen. This experiment included groups from three different populations, including PWS and two other populations that never experienced an oil spill or pathogen-induced collapse, to address hypothesis 1. For sub-lethal oil exposures, we measured dose-response impacts on heart rate and genome-wide gene expression in developing embryos. For pathogen exposures we measured mortality, infection rates, and genome-wide gene expression in post-metamorphosis juveniles. These responses were contrasted between populations. Additionally, new genomics resources were developed, including a reference genome and reference transcriptome for Pacific herring. We present data showing population similarities and differences in their sensitivity to oil and pathogen. Transcriptomics data provide mechanistic insight into the effects of very low oil exposures throughout sequential stages of embryogenesis. These data provide insight into the potential interactions between contaminant exposure and disease that may be relevant for Pacific herring and other wild species.

**RP129 Assessing the Impact of Crude Oil Exposure on the Bioturbation Rate of the Ghost Shrimp Lepidophthalmus louisianensis**

A. Kascak, P.L. Klerks, University of Louisiana, Lafayette / Department of Biology

The ghost shrimp, Lepidophthalmus louisianensis, is an infaunal bioturbator that lives along the northern coast of the Gulf of Mexico (GoM). Ghost shrimp are often present in high numbers and move large amounts of sediment - thereby causing numerous biotic and abiotic changes to the local ecosystem. The GoM is also home to a robust fossil fuel industry, resulting in accidental releases of oil into the environment. It is therefore important to assess the effect of oil on ghost shrimp bioturbation. We are doing this using microcosm experiments and quantifying two bioturbation measures. The first is the rate at which sediment particles at the sediment surface are getting buried (“burial rate”). This rate is measured using a luminophore trace technique utilizing fluorescently coated inert particles initially placed on the sediment surface. The burial rate will be quantified using a biodiffusion/
bioadvection model that accounts for the ghost shrimp’s upward con-
voyer form of bioturbation. This will be assessed for both a surface and
subsurface oil exposure. The second bioturbation measure is the rate at
which subsurface sediment is expelled from a burrow (“expulsion rate”).
This rate is assessed with a sediment trap placed over the burrow open-
ing, catching expelled sediment, in an experiment in which oil is placed
on the sediment surface. All experiments include three oil treatments: an
oil-free control, a light, and a light to medium oiling (oiling terms
based on criteria used during assessments of the Deepwater Horizon
refinement in REEs industry steadily grow, inducing amounts of REEs
alone of extracted samples from environmental and biological matrices,
it is difficult to accurately determine the bioavailability of REEs and
then reflect their cell-based effects as well as subsequent toxicity risks.
Therefore, understanding the species, degrees of REEs contamination and
pollution characteristics regarding of entirely environmental matrix and
biological samples in study sites and successfully culturing the primary
cells from critical tissues in aquatic organisms of ecological niche, the
field exposure were performed to analyze the subcellular distributions of
REEs and adverse effects of chemicals combined with cell-based in vitro
assays and in situ tests. Further, the dynamic exchanges, translocation
and mobilization of typical REEs were then clarified among the “vari-
os particles, water and cells in exposed organisms” interfaces of matrix.
Moreover, coupled with chemical analysis to quantify the mitochon-
dria components within culture wells of primary cells and molecular
approaches to assess the expression of responsive genes in field exposure,
the mechanisms of associated toxicity were elaborated and the interactive
relationships were then obtained between REEs bioavailability and in situ
stress. Simultaneously, the high throughput assays of cell-based evalu-
ation and in situ monitoring are proposing to be established considering
the consistency of framework as protocols among cell culture, field tests,
exposure effects and high throughput in situ identification. Overall, the
outcomes support full-scale evaluations of environmental prevention and
ecological retrieval and thus provide robust tool to scientifically mine
and refine of REEs, further improving accuracy towards future ecological
re-establishment as powerful tools and more comprehensive pollution
monitoring assessments and relevantly high throughput in situ identifica-
tions in complex scenarios (This research was supported by a grant from
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RP130 Long Term Exposure to Bleached- Kraft Pulp Mill Effluent at
Jackfish Bay, ON
S. Williams, K.R. Munkittrick, Wilfrid Laurier University / Biology;
M.E. McMaster, Environment and Climate Change Canada / Water
and Science Technology Directorate / Aquatic Contaminants Research
Division
Jackfish Bay, on the north shore of Lake Superior (48°50’N, 86°58’W),
was identified as an Area of Concern (AOC) in 1987 due to changes in
its chemical and biological integrity associated with the volume of
effluent discharged from a pulp mill in Terrace Bay, ON. Studies from the
late 1980’s have documented impacts to white sucker (Catostomus
commersoni) populations exposed to the mill effluent including: reduced
reproductive fitness, delayed sexual maturation, and altered levels of
circulating sex steroid hormones. The purpose of this study was to 1)
examine whole-organism and histological impacts in white sucker popula-
tions following chronic exposure to bleached-Kraft mill effluent (BKME)
at Jackfish Bay, ON and 2) compare the results of this study to previous
studies. Gill nets were set during the gonadal recrudescence period (August
2018) to collect suckers from the exposure site (Jackfish Bay) and the
reference site (Mountain Bay). During the pre-spawning period (May
2019), white sucker were collected from Sawmill Creek (Jackfish Bay)
and Little Gravel River (Mountain Bay) using hoop nets. In both sampling
sessions, 20 individuals (10 males, 10 females) were collected and the
following whole-organism parameters were measured: liver somatic index
(LSI), gonad somatic index (GSI), condition factor (k), mass (g), body
length (cm), age (years), fat and tubercle index. Histological parameters
included blood smears, proximal intestine, anterior kidney, spleen, gonad
and stomach. Collections from the gonadal recrudescence period showed
that fish at Jackfish bay were longer (males) and heavier (both sexes),
with a larger LSI (both sexes) and smaller GSI (males) and had a larger
fat index (males) and more tubercles (males). Collections from the pre-
spawning period also showed that males at Jackfish Bay were heavier,
longer a larger GSI and no difference in male LSI. Females at Jackfish
Bay had larger LSI but no significant difference in female length, weight
and GSI. Histological analysis showed no significant difference in
melanomacrophage activity in spleen and anterior kidney between sites in
either sex and further analysis on the remaining tissue is underway. These
findings indicate that the health of white sucker inhabiting Jackfish Bay
are adversely affected at the whole-organism level. The mill is expected to
switch process types (from BKME to dissolving pulp) in the near future
and as such, my study will serve as a baseline for which future studies
will compare.

RP131 Bioavailability of typical anthropogenic REEs and high
throughput identification of in situ effects based on cell-based
in vitro assays
Z. Wang, Jiangxi University of Science and Technology
With the rapid development of innovative technology and extensive usage
of rare earth elements (REEs) in agricultural fertilizers, the mining and
refinement in REEs industry steadily grow, inducing amounts of REEs
and their chemical compounds have been discharged into aquatic environ-
ments, and focusing on relevant exposure risk of environmental health.
While, traditional methods are mostly based on the chemical analysis

RP132 The Protective Effects of Carbon: Why are carbon sources
effective at reducing toxicity of a common fungicide?
M. Barry, A.M. Isabella, A. East, Towson University / Environmental
Sciences; C.J. Salice, Towson University / Environmental Science &
Studies Biology
Test species like Daphnia magna are used to assess ecological effects
of chemicals in freshwater systems. The strobilurin fungicide, pyraclos-
tribin, is highly toxic to D. magna, however, toxicity is ameliorated in a
carbon-amended (fed) environment compared to a carbon-free (unfed)
environment. These results suggest that the presence of carbon provides
a bioenergetic advantage to daphnia that increases resistance to pyra-
clostrobin. Alternatively, pyraclostrobin may become less bioavailable as
it sorbs to the carbon. To better understand the role that carbon plays in
ameliorating toxicity of pyraclostrobin, D. magna were exposed to pyra-
clostrobin and several sources of carbon: algae, snail waste, lettuce and
control (no carbon). However, if pyraclostrobin levels
were exposed to pyraclostrobin. Alternatively, pyraclostrobin may become less bioavailable as
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ameliorating toxicity of pyraclostrobin, D. magna were exposed to pyra-
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ameliorating toxicity of pyraclostrobin, D. magna were exposed to pyra-
clostrobin and several sources of carbon: algae, snail waste, lettuce and
clostrobin. Alternatively, pyraclostrobin may become less bioavailable as
the lettuce. We hypothesized that if excess assimilated energy
is allocated to metabolic processes (e.g. resisting the stress of pyraclos-
tribin exposure), then the daphnia fed algae would be most resistant to
pyraclostrobin in several sources of carbon: algae, snail waste, lettuce and
clostrobin. Alternatively, pyraclostrobin may become less bioavailable as
the lettuce. We hypothesized that if excess assimilated energy
is allocated to metabolic processes (e.g. resisting the stress of pyraclos-
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pyraclostrobin in several sources of carbon: algae, snail waste, lettuce and
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pyraclostrobin in several sources of carbon: algae, snail waste, lettuce and
clostrobin. Alternatively, pyraclostrobin may become less bioavailable as
the lettuce. We hypothesized that if excess assimilated energy
is allocated to metabolic processes (e.g. resisting the stress of pyraclos-
tribin exposure), then the daphnia fed algae would be most resistant to
pyraclostrobin in several sources of carbon: algae, snail waste, lettuce and
lettuce treatment and our treatment with no carbon. Studies like this can be used to better understand the role that resource environments play regarding toxicity, which can help to refine risk estimates for D. magna.

RP133 DFO’s National Contaminants Advisory Group: Highlights on research investigating the biological effects of contaminants in aquatic environments
C. Dubetz, Government of Canada; T. Pretorius, J. Leblanc, Government of Canada / Fisheries and Oceans Canada
As a science-based federal government department, Fisheries and Oceans Canada (DFO) requires scientific evidence to facilitate the sound management of Canada’s fisheries and to advance sustainable aquatic ecosystems while fostering economic prosperity across maritime sectors and fisheries. The National Contaminants Advisory Group (NCAG) provides scientific information and advice to DFO on priority issues related to the biological effects of contaminants on aquatic species. The main functions of the group are to facilitate research projects through external researchers, to synthesize results and to develop science advice in support of DFO decision-making. Current priority research themes are: (1) oil and gas, (2) pesticides, (3) aquaculture and (4) contaminants and issues of emerging concern. The NCAG has funded a variety of multi-year research projects at Canadian universities and not-for-profit research institutions. A summary of NCAG supported research projects and their highlights is presented.

RP134 The study of acute and delayed toxicity of ethylenediamine in aquatic animals for environmental risk assessment
S. Park, S. Kim, Korea Institute of Toxicology (KIT) / Gyeongnam Department of Environmental Toxicology and Chemistry; Y. Dong-Hyuk, Korea Institute of Korea (KIT) / Global Environmental Regulation and Compliance Center
Ethylenediamine (EDA) is a widely used for chemical synthesis process. The occurrence of this to the water environment can result in a corrosive and toxic mist, and cause serious damage to health. However, its toxicity data were not sufficient to evaluate the environmental risk assessment. This study investigated acute and delayed toxicity effects of EDA on aquatic ecosystem after chemical accident in water environment. Chironomus (Glyptotendipes tokunagai) and two fish species (Zacco platypus and Aphycypris chinensis) were used for semi-static and closed semi-static acute toxicity test. The result showed that Pale chub (Z. platypus) was particularly sensitive to EDA with a NOEC of 40 mg/L and chronic EC20:EC5 ratios and chronic EC20:EC5 ratios were averaged at the species level for each chemical and regressed along species mean acute values and species mean chronic values, respectively, to determine if within-species variation in sensitivity was influenced by species sensitivity. With an increased emphasis placed on the use of C-R models to develop point estimates to inform aquatic life criteria derivation and risk assessment, this work may provide insight into how the same C-R models can also be used to further consider variation in sensitivity within individual species and taxa.

RP135 Determination of biomarkers in the oyster Crassostrea virginica (Gmelin, 1791) of the Gulf of Mexico
M. Del Carmen Guzman Martinez, P. Ramirez Romero, Metropolitan Autonomous University / Hidrobiologia
This is a monitoring study to observe the effects of oil pollution. Using biomarkers The oyster Crassostrea virginica was chosen as a bioindicator organism. The aim of the present work was to evaluate the DNA damage, the lysosomal stability and the determination of the activity of the enzyme acetyl cholinesterase (AChE) in the oyster Crassostrea virginica organisms were collected from five lagoons of the Gulf of Mexico. For the comet analysis, the method of Singh (1988) was used with some modifications. For the determination of the lysosomal stability, observations were made at 15, 30, 60, 90 and 180 minutes. For the determination of acetylcholinesterase were divided into two groups, the first group was obtained the digestive gland was homogenized and the activity of AChE was determined. The other group was kept in depuration for a period no longer than three months. For the comet analysis all the cells of all the study sites had damage. For the lysosomal stability, significant differences were detected in the retention time of the organisms of the different localities analyzed. Regarding the AChE activity, there were significant differences in the localities of Pueblo Viejo and Tamiahua, which shows an alteration in these organisms since the lower the activity, the greater the contamination present in the environment. The biomarkers chosen were an excellent tool to know the effect of contaminants on organisms.

RP136 Acute toxicity Testing Using Catfish And Tilapia
B. Gbadamosi, University of Lagos, Akoka, Lagos, Nigeria / Zoology
The toxicological evaluation of commercial liquid soap - a domestic cleaning agent, was carried out against Africa Catfish - Clarias Gariepinus and Nile Tilapia - Oreochromis Niloticus. The catfish had a mean weight of 6.10g and a standard length of 4.8-6.0cm. The Nile tilapia had a weight of 5.4-11.0kg and a standard length of 5.3-7.0cm. After a series of range finding tests, the catfish were exposed to lethal concentrations of 0.01ml/L, 0.02ml/L, 0.04ml/L, 0.06ml/L and 0.08ML/l. While the Nile Tilapia was exposed to lethal concentrations of 0.001ml/L, 0.002ml/L, 0.004ml/L, 0.060ml/L and 0.008ml/L. On the basis of 96 hours, the LC50 of liquid soap on the Africa Catfish was found to be 0.029 and the lethal concentration on the Tilapia was found to be 0.032. When the fishes were exposed, we observed erratic swimming, respiratory disturbance, loss of equilibrium, lethargies and ultimately death. The mortality of these fishes on exposure to the liquid soap indicates that an indiscriminate discharge of this effluent to the surrounding should be highly discouraged.

RP137 What Influences Within-Species Variation in Sensitivity to Chemical Exposures?
C. Dubetz, Government of Canada; T. Pretorius, J. Leblanc, Government of Canada / Fisheries and Oceans Canada
Concentration-response (C-R) curves are commonly assessed to quantify point estimates (e.g., LC50) to inform sensitivity across species and taxa; however, their use to assess within-species variation in sensitivity receives less attention. For example, the USEPA 1985 Guidelines for deriving aquatic life water quality criteria focuses heavily on the use of point estimates (e.g., LC50 values) to construct acute species sensitivity distributions on a chemical-by-chemical basis but considers a universal factor of 0.5 sufficiently representative of the variation between LC50 and LC10 values for all taxa and chemicals. The goal of our work was to determine if within-species variation in sensitivity to a pollutant is influenced by 1) pollutant type and 2) species sensitivity itself. We obtained all available raw data from studies used to derive the USEPA acute and chronic cadmium and ammonia aquatic life criteria. Raw data were fit to C-R curves using R software to calculate curve-specific acute LC50:LC5 ratios and chronic EC20:EC5 ratios that served as surrogate measures of within-species variation in sensitivity. Acute LC50:LC5 ratios and chronic EC20:EC5 ratios were species represented in both the cadmium and ammonia datasets were compared to determine if within-species variation in sensitivity is influenced by chemical type. Acute LC50:LC5 ratios and chronic EC20:EC5 ratios were averaged at the species level for each chemical and regressed along species mean acute values and species mean chronic values, respectively, to determine if within-species variation in sensitivity was influenced by species sensitivity. With an increased emphasis placed on the use of C-R models to develop point estimates to inform aquatic life criteria derivation and risk assessment, this work may provide insight into how the same C-R models can also be used to further consider variation in sensitivity within individual species and taxa.
RP139 Effects of chronic 17β-estradiol exposure on the marine polychaete Capitella teleta
A. Murillo, J. Otoo-Appiah, J. Wilson, McMaster University / Biology
Capitella teleta is a marine lophotrochozoan used as an indicator species for pollution due to its high growth rate in contaminated sediments. An in vitro reporter assay has previously shown that the C. teleta estrogen receptor is ligand activated by estradiol (EC50 = 9.2 nM). However, in vivo biological effects of estrogen have not been investigated. This study investigated the biological effects of chronic exposure to 17β-estradiol (E2) in C. teleta over different life stages to explore potential roles in development and reproduction. C. teleta were exposed to control conditions, 0.1% vehicle control, and two doses of E2 (0.367 nM and 36.7 nM). Exposures began at pre-metamorphosis (5 days postemergence or dpe) or sexual maturity (70 dpe). Prior to exposure, animals were reared in control conditions. Survival, sex ratio, and body volume were monitored weekly from 35 dpe until they reached sexual maturity. At maturity, paired worms (1 male and 1 female) remained isolated in control conditions, and were checked for survival, time to first brood tube appearance and number of larvae per brood tube formed. These data will help elucidate the role that estradiol may play in endocrine signaling in development and reproduction of C. teleta.

RP140 Could human activities be affecting Munida gregaria larval distribution along the Beagle Channel, Tierra del Fuego, Argentina?
L. Xaus, Wilfrid Laurier University / Biology; M.L. Presta, F.L. Captamin, CONICET / Institute of Biodiversity and Experimental and Applied Biology
Munida gregaria - the squat lobster - has been subject of numerous studies during the past 20 years. In the last decade their density has increased dramatically, becoming one of the most abundant decapod species in the Southwestern Atlantic Ocean. By feeding upon algae, detritus and sediment and particulate organic matter and being prey of many top predators, this species represents a trophic shortcut in the marine food web. The squat lobster exhibits phenotypic plasticity that allows it to exploit resources in both the neritic and benthic environments. Here, we analysed the spatio-temporal variations in M. gregaria larvae by means of samples collected seasonally at the coastal and external zones of Ushuaia Bay (inner Beagle Channel), the former one being highly impacted by urban discharges. Also, we provide baseline data regarding the abundance of M. gregaria larvae along the Beagle Channel, including the inner and outer sectors, during the springtime of 2014 and 2015. Results from 2012 showed the highest zoae abundances during late winter (September) (8.46 ind.m3) coinciding with maximum values of salinity and chlorophyll-a. Mean abundance of larvae was similar between the coastal and external zones of the bay; except in late winter, when larvae were more abundant at the external zone. In regards to the spatial distribution of M. gregaria larvae along the Beagle Channel, highest larval abundances were found at the outer sector during both years, with values being significantly higher in 2014 (max: 143.16 ind/L) than in 2015 (max: 3.96 ind/L). Previous experimental studies in Ushuaia Bay have reported that, crustacean larvae can suffer inhibition in the moulting process and anomalies in the swimming behaviour caused by petroleum hydrocarbons and heavy metals, two contaminant present in the coastal zone of this bay. Considering that there is little knowledge on the sensitivity of M. gregaria larval stages to aquatic contaminants, we recommend further experimental and field studies about the potential effects of human activities on this species in order to better understand the spatial patterns observed in this study.

RP141 Application of Phase I TIE Techniques in the Identification of Wood Extractives Toxicity in a Saw Mill Effluent
A.M. Briden, B.C. Jorgenson, Pacific EcoRisk
The cause of unknown chronic toxicity to Selenastrum capricornutum (now Raphidocelis subcapitata) in a sawmill effluent was investigated and elucidated through the execution of a toxicity identification evaluation (TIE) targeting wood extractives such as tannin and lignin associated with log deck runoff. Removal of color through the application of anion exchange chromatography completely eliminated growth inhibition. Removal of color was similarly correlated with the removal of tannin and lignin. A simple relationship between growth inhibition and absorbance of light in the visible spectrum was developed to assist in field tuning of log deck runoff management practices and the passive treatment of wood extractives.

RP142 Effects of DNA methylation associated with EE2 induction of estrogen receptor alpha expression in fathead minnows (Pimephales promelas)
J. Ferke, University of Cincinnati / Department of Biological Sciences; R. Flick, US Environmental Protection Agency / ORD/NERL/EMMD; J. Martinson, M. See, US Environmental Protection Agency / Office of Research and Development; E. Pilgrim, US Environmental Protection Agency / NERL Ecological Exposure Research Division; A. Biales, US Environmental Protection Agency / ORD/NERL/EMMD
Exogenous estrogens can interfere with endocrine function and cause decreased fecundity, fitness, and sperm production in fish, as well as feminization of male fish. Physiological effects and alterations of gene expression resulting from estrogen exposure have been thoroughly described in fish. However, little is known about epigenetic alterations, such as DNA methylation, although these changes are believed to be what links gene expression with the development of adverse effects at higher biological levels. This study investigates DNA methylation changes of a nuclear estrogen receptor (ERα) in brain and liver tissue in fathead minnows (Pimephales promelas) exposed to either 2.5 ng/L or 10 ng/L of the synthetic estrogen, 17α-ethynylestradiol (EE2). Methylation differences were assessed across all CpG sites in a 2.5KB region encompassing exon 1 and 1.5KB upstream of the start site of the ERα gene by targeted deep sequencing of bisulfite treated DNA isolated from treatment groups. Additionally, DNA methylation was assessed from fish depurated for 7 and 14 days to better understand the kinetics of methylation. Lastly, ERα methylation status and relationship to dose-dependent gene expression changes fish were evaluated. Results from this work will provide information about tissue-specific gene regulation in response to estrogens and how alterations in methylation status are associated with gene expression.

RP143 The Impacts of Environmental Chemicals on Telomere Length and Adverse Effects in A549 Cells
A.E. Kiflay, University of Copenhagen / Environmental Health
Human exposure to environmental chemicals is associated with cardiovascular disease, lung cancer, chronic respiratory disease and mortality. In this study, we investigated the exposure of one group of chemicals (oxidizing agents) can lead to adverse effects and change the telomere length as a mechanism of health effects in lung epithelial cells in cell cultures. We selected four oxidizing agents such as Potassium Bromate (KBrO3), Hydrogen peroxide (H2O2), Sodium dichromate (Na2Cr2O7) and 4-Nitroquinoline 1-oxide (4NQO) that can cause DNA damage. The compounds are suggested to be used as positive controls for the generation of DNA strand breaks and/or oxidatively damaged DNA. We measured cytotoxicity effects of cell metabolic activity, cell membrane damage and cell proliferation after 24 hours exposure to all chemicals and oxidative stress levels (ROS generation and antioxidant defense) were measured in short term and long-term exposures after 3 hours exposure to all chemicals and the effect of long-term exposure on the telomere length. The results can be summarized as (1) the short-term exposure for KBrO3 leads to low cytotoxicity and oxidative stress effect; (2) the H2O2 causes no cytotoxicity effects and moderate oxidative stress effect; (3) the Na2Cr2O7 leads to high cytotoxicity and moderate oxidative stress effect and (4) the 4-Nitroquinoline 1-oxide (4NQO) leads to high cytotoxicity and oxidative stress effects. The long-term exposure for all the chemicals induces moderate oxidative stress effect in the cells. Long term exposure to all chemicals are associated with no significant change on the telomere length as observed in A549 cells.
RP144 Lack of Latent Effects to Daphnia magna From Exposure to Chlorantraniliprole
A. Samel, FMC Corporation / Environmental Sciences; A. Gerke, Eurofins-EAG Laboratories; M. Woodward, K. Brugger, FMC

Latency is defined as delayed effects of exposure to a molecule after the exposure period is completed or the molecule is no longer detected in the field/area of interest (i.e., water, soil, sediment, etc.). It is the responsibility of the registrant to provide evidence of a lack of latency. The 2013 OECD Aquatic Guidance Document allows registrants to use the acute endpoint for long-term risk assessments if effects are rapid (i.e., first 96 hours of the chronic test) and if latency is not a factor. Because Daphnia magna is the most sensitive of the aquatic organisms exposed to chlorantraniliprole in laboratory studies, the determination of latent effects is based on studies conducted to this test organism. For chlorantraniliprole, the short-term and long-term aquatic risk assessments in the European Union are based on the acute (EC50) endpoint from the Daphnia magna acute toxicity test. This is based on the rapid onset of immobility observed in the daphnid chronic test; immobility is the driver for the NOEC determination. It was, therefore, asserted that there was a lack of latency from exposure to chlorantraniliprole. To determine if latency is a real concern, a study was conducted with Daphnia magna. The study consisted of a short-term (48-hr) exposure to the aquatic invertebrate Daphnia magna followed by a subsequent 19-day test-material-free period. The 48-hr exposure time is consistent with the regulatory Daphnia magna acute toxicity guideline and 21-days total time is consistent with the regulatory Daphnia magna chronic toxicity test guideline. The acute 48-hour EC50 from the guideline test and the latency test considered equivalent. The NOEC values from the guideline chronic daphnid test and the latency test are also considered equivalent. It can be concluded that the results from this higher tier test support the lack of any latent effects to Daphnia magna exposed to chlorantraniliprole. Therefore, it is acceptable to use the acute endpoint for the long-term aquatic risk assessment.

RP145 Fish and invertebrate use of invasive Phragmites in a Great Lakes freshwater delta
A.G. Wynia, Environment and Climate Change Canada / Aquatic Contaminants Research Division; D. Redick, J. Midwood, S. Doka, Fisheries and Oceans Canada / Great Lakes Laboratory for Fisheries and Aquatic Sciences; C. Jacobs, Walpole Island First Nation / Walpole Island Heritage Centre; T. Whillans, Trent University / School of the Environment

Invasive Phragmites australis sspp. australis (herein “Phragmites”) has established and rapidly spread throughout many coastal areas of the Great Lakes. Known to displace native vegetation communities as it forms large, monotypic stands, Phragmites has a bad reputation when it comes to losses of biodiversity and habitat provision for wildlife. However, the extent to which Phragmites provides habitat for fish and invertebrates in coastal freshwater wetlands remains relatively unquantified. Thus, this study assessed whether fish assemblages and invertebrate communities in stands of Phragmites differ from those in stands of two native emergent vegetation communities, Typha spp. and Schoenoplectus spp. The findings showed significant differences in habitat variables among the vegetation communities in terms of water depth, macrophyte species richness, stem density and water quality. While abundance of the functional feeding group filterer-collectors was found to be significantly less in stands of Phragmites when compared to Schoenoplectus, no difference was observed in invertebrate taxa richness among vegetation communities. Lastly, no difference in fish assemblage or invertebrate community was detected when using multivariate analyses, implying that invasive Phragmites provides habitat that appears to be as valuable for fish and invertebrates as other emergent vegetation types in the St. Clair River Delta. The findings of this study will ultimately benefit the literature on invasive Phragmites and its role as fish habitat in freshwater wetlands, and aid management agencies in decisions regarding control of the invasive species.

RP146 Physicochemical assessment of quality underground water samples collected from Ogbete Area in Enugu State, Nigeria
F. Nwobodo, Unaffiliated

Water contamination is significantly becoming a global challenge which must be tackled with all seriousness and maximum amount of energy as life itself is dependent on water. This study examined the contamination level the well water from Ogbete areas of Enugu State in order to ascertain the safety level for human use and possible health consequences associated with the use. Four major locations were sampled during the time of this research and in all the places, Carters street had the highest pH 5.23 which is below the WHO standards limits for drinking water. For conductivity in the four location sampled, it was discovered that the prison training school had the highest conductivity 1445 μS/cm, which is below the WHO limits (8-10,000 μS/cm). The other three locations were below the WHO limits for conductivity, Carters street (285 μS/cm), Moore house (295) and Redcross way (340). For TDS (Total dissolved solids) of the four location sampled, it was discovered that all the four sample were within the standard set by WHO (1000 mg/l). For TSS (Total suspended solids), all the four locations, carters street, prison training school, Moore house and Redcross way were within the standards set by WHO (500 mg/l). For Nitrate, Prison training school was not detected and the other three location, carters street (1247.839 mg/l), Moore house (185.918 mg/l) and Redcross way (19.685 mg/l) were above the standards set by WHO (5.0 mg/l). For alkalinity, the four locations were all below the standards set by WHO (150 mg/l). Results shows that most of the physicochemical, biological and heavy metals parameters considered in this study were significantly above the permissible or allowed by WHO. The result of the statistical analysis showed significant differences among the sampling points. From the results of the above survey, the well water in areas in puvire are not safe for consumption.

Emerging Environmental Contaminants: Human Exposure and Associated Risks

RP147 Particulate Matter Concentration During the Wet Season as Indicators of Atmospheric Pollution in Enugu Urban, Enugu State, Nigeria
C. Okudo, C. Okoye, N. Ekere, University of Nigeria, Nsukka / Pure & Industrial Chemistry

The particulate matter in the atmosphere which alters the original state of the atmosphere making it harmful to man, animals and other life forms constitutes what is known as atmospheric pollution. Particulate matter pollution include PM10 which is in-halable particles 10 micrometers or less in diameters and PM2.5 which is fine in-halable particles generally 2.5 micrometers or less in diameters. It has been identified particularly that Particulate Matter (PM) in the air is the main cancer causing component. Therefore, the purpose of the study is to determine the level of particulate matter pollution in Enugu Urban. Particulate Matter PM10 and PM2.5 concentration was studied bimonthly from April to September, 2018 using CASELLA CEL instrument (Micro Dust Pro). The study area was Enugu Urban from eight locations categorized under, Industrial, Commercial, High density residential, Low density residential areas and one location categorized as rural area. The result of the study shows the ranges in mean value in concentration of particulate matter PM10 and PM2.5 as follows: PM10 for April/May ranges from 49.7±2.9 μg/m3 to 218.0±12.7 μg/m3 while PM2.5 ranges from 14.2±0.7 μg/m3 to 90.0±8.5 μg/m3, PM10 for June/July ranges from 24.8±2.5 μg/m3 to 427.3±13.3 μg/m3 while PM2.5 ranges from 13.7±0.8 μg/m3 to 258.3±13.3 μg/m3, PM10 for August/September ranges from 33.2±0.9 μg/m3 to 304.0±3.9 μg/m3 while PM2.5 ranges from 17.2±1.1 μg/m3 to 210.5±3.0 μg/m3. The PM10 and PM2.5 concentration in almost all the areas studied are above the WHO limits of PM10 -50.1 μg/m3 to 210.5±3.0 μg/m3, The PM10 and PM2.5 concentration in almost all the areas studied are above the WHO limits of PM10 -50 μg/m3 and PM2.5-25 μg/m3. Therefore the
populace of study area is exposed to high volume of inhalable particulate which have great health risk. This high concentration of particulate matter in the study area may be attributed to increase in population and other anthropogenic activities. Therefore periodic monitoring and pollution abatement measures must be strictly adhered to.

**RP148 Elemental Characterization of Particulate Matter in Different Micro Environments of Urban and Rural Areas in Lagos State Nigeria**

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The need for comprehensive periodic air quality measurements to assess the extent of airborne particulate matter and trace metals exposure in residential areas in Lagos State in view of the urbanization and different energy cooking source cannot be overemphasized. Total Suspended Particulates (TSP) was collected from July 2017 to April 2018 by gravimetric sampling technique in different indoor-outdoor micro environments of a residential area in Lagos and was analyzed by Atomic Absorption Spectroscopy (AAS) method. High base-line concentrations were obtained with an indoor range of 833.33-1944.45 µg/m³ and outdoor range of 1111.11-1944.45 µg/m³ during the wet season. During the dry season, it ranged from 1111.1-2777.78 µg/m³ in the indoors and 1388.89-2222.22 µg/m³ in the outdoors. Elemental concentrations were subjected to enrichment factor analysis (EF) and principal component analysis (PCA) for source identification. EF analysis was used to assess the relative contributions of natural and anthropogenic metal inputs to the air in the area while, PCA identified road dust and combustion activities as the predominant sources of pollutants emission to the environment.

**RP149 Seasonal Variation Of Heavy Metals In Sediments, Water, Shiny Nose Fish, Shrimp And Periwinkle in Esuk Ekpo Eyo Beach, Akpabuyo, Southern Nigeria**

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The seasonal variation of heavy metal (Cr, Cu, Pb, Cd, Ni) pollution in sediments, water samples and shiny nose fish (Polydactylus quadrifilis), shrimp (Parapeneaeopsis atlantica) and periwinkle (Tympanotonus fuscatus) of Esuk Ekpo Eyo Beach, Akpabuyo, Cross River State, Southern Nigeria was investigated using AAS spectrophotometer. The mean concentrations (mg/l) of Cr, Cu, Pb, Cd, Fe and Ni in sediments for dry and wet season were 1.040.658 mg/l and 0.5460.406 mg/l for Cr, 0.462000.071mg/l and 0.0200.010mg/l for Cu, 0.3440.001594mg/l and 0.02850.0062mg/l for Pb, 0.019170.01693mg/l and 0.021330.01089mg/l for Cd, 0.17520.0112mg/l and 0.15030.1216mg/l for Ni, 64.003.964mg/l and 39.914.187mg/l for Fe. The mean concentrations (mg/l) of Cr, Cu, Pb, Cd, Fe, Zn and Hg in water samples during dry and wet season were 0.12380.0866mg/l and 0.197660.1644mg/l for Cr, 0.028660.0060mg/l and 0.03820.0265mg/l for Cu, 0.030830.0172mg/l and 0.036830.0225mg/l for Pb, 0.037160.0301 and 0.0421660.0710mg/l for Cd, 4.3522.7mg/l and 7.2212.49mg/l for Fe, 0.05080.0214mg/l and 0.071160.0072mg/l for Zn, 0.0140.001mg/l and 0.024000.0077mg/l for Hg. The concentrations (mg/l) of Cr in shiny nose fish, Fe in shrimp and Cd in periwinkle for dry and wet season were 0.0190.007mg/l and 0.036 0.0011mg/l for Cr, 0.3270.001mg/l and 0.7400.001mg/l for Fe, 0.0210.007 and 0.0090.004 for Cd in periwinkle. The estimated daily intake of these metals in Fish, shrimp and periwinkle analyzed using the estimated daily intake formula were all below the JECFA recommended daily intake limits. Physicochemical analysis was carried out to determine the values of pH, TOC, TOM, silt, clay and sand for sediments, also pH, turbidity, TDS, TSS, EC and salinity for water samples. The pollution load index calculated for sediment showed moderately severe enrichment for dry season and minor enrichment for wet season while the modified degree of contamination of the geo-accumulation index in the sediments were less than 1.5 hence no contamination. The results of Pearson’s correlation matrix showed that significant correlations were observed among variables at 0.05 levels.

**RP150 An investigation of the distribution and human health risks associated with metal levels in classroom dusts of nursery schools in Abeokuta, Nigeria**

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Many studies have reported evidence of anthropogenic inputs by potentially toxic elements (PTE) in urban dusts of cities around the world. Extensive work has been carried out to study PTE behaviour in developed countries but not much attention has been given to PTE investigation in urban dusts of developing countries such as Nigeria. Of major concern is the potential impact on children because they represent the most sensitive and vulnerable group due to their small body size, developing nervous systems, and high absorption rate. To this end, work was carried out to study PTE levels in urban classroom dusts of Abeokuta, Nigeria. Dust samples were collected in May and June 2017 from forty two nursery and primary schools of Abeokuta, Nigeria to assess the potential adverse effects of the exposure of children to PTE through classroom dusts. In each of the classrooms, about 50 g of bulked dust samples were collected, sieved, acid digested and analysed by Microwave Plasma Atomic Emission Spectrometry (MP-AES). Results showed that dusts studied were characteristically unpolluted as the average PTE concentration at each site did not exceed the soil guideline values. Considering the pollution assessment tools employed, some soil samples showed some form of anthropogenic input from PTE. Health risk assessment was employed to assess PTE exposure from ingestion, inhalation, and dermal contact. Result indicated that the highest risk is associated with ingestion followed by dermal contact and inhalation. For non-carcinogenic effects, the summation of hazard quotient value for the PTE studied was less than the safe level of 1; suggesting minimal or no risks. Only Cr and Ni were considered for carcinogenic risks evaluation and results obtained were below the 1 x 10-6. This study has revealed that the exposure of children to PTE from the investigated classroom dusts would not pose any serious health implications but continuous monitoring is necessary to keep the PTE contents low in the classroom dust.

**RP151 Inter-varietal variation in lead uptake by rice, relationship with the essential elements and the risk assessment; an assessment of 10 rice varieties**

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Lead poisoning is a serious public health issue globally and Nigeria is currently ranked first among the countries of the world that are adversely affected. There have been many interventions but exposure through food consumption especially rice is still a big issue. Moreover, there is very limited data, if any on the transfer of lead in different rice varieties grown in Nigeria where lead contamination is one of the most significant public health concerns. The overarching aim of this project is minimisation of lead in rice farm that has been previously characterised in Dareta village Zamfara State Nigeria. The rice and their respective soil samples (n=600) were analysed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The mean concentration of Pb in the rice was 0.74 ± 0.33 mg/kg and it varied significantly across the varieties ranging from 0.03 mg/kg to 2.51 mg/kg. The mean concentration of Ca, Fe, Cu, Mg, K, Zn, Mn, Co, and Se were 131.45±18.38 mg/kg, 25.43±17.33 mg/kg, 4.66±1.28 mg/kg, 901.99±104.31 mg/kg, 2025.95±242.99 mg/kg, 25.05±3.99 mg/kg, 23.24±2.99 mg/kg, 0.07±0.03 mg/kg, and 0.11±0.02 mg/kg. The ranges...
Bisalayi also demonstrated good yield and it is commonly planted. The lead accumulation among the rice varieties was in the order of bisalayi < Nerica-L34 < Wita-4 < Sipi-692033 < Nerica-L19 < Art-15 < Ita-315 < Art3-7L < Ncro-49 < Irat-170. Bisalayi also demonstrated good yield and it is commonly planted among the farmers in the northern Nigeria. Lead concentration was significantly different (p < 0.01) among all the 10 rice varieties but similar in the soil samples. All the rice varieties accumulated lead above the international permissible limit of 0.3 mg/kg. The inter-varietal variation (IVV) of lead in rice (IVV = the product of dividing the mean lead concentration ratio in the highest accumulation variety by the mean lead concentration ratio in the lowest accumulation variety) was 13%, 9% for calcium (Ca), 2% for Iron (Fe), 182% for potassium (K), 58% for magnesium (Mg), 161% for Zinc (Zn), 78% for Selenium (Se), 77% for Manganese (Mn), 10% for Cobalt (Co) and 385% for Copper (Cu). The Estimated Daily Intake (EDI) for Pb was compared with the United State Food and Drugs Administration (FDA) maximum ingestible daily allowable limit of lead (Pb-MIDAL) to evaluate percentage contribution of lead by each variety to human body evaluate how many folds the lead is being ingested above the international standard. The EDI of the essential elements were also used with the United State Department of Agriculture (USDA) essential elements’ Recommended Daily Intake (RDI) to assess the percentage contribution of each essential element by each variety of rice to human body. There was no significant difference across the EDI of Pb and the essential elements P>0.05. Some rice varieties contributed essential elements significantly to the RDI while some were not good sources of some of the essentials. Carcinogenic and Non-Carcinogenic Risk Assessment was also carried out.

RP152 Heavy metal(loid) distribution patterns in paddy cultivated lands of CKDu prone area in North Central Province of Sri Lanka

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The results depicted that irrigation water is the major contribution factor for heavy metal(loid) distribution in the study area. Therefore, regular soil and irrigation water quality monitoring is a prerequisite to reduce heavy metal(loid) accumulation in paddy soil and avoid possible adverse effect through food chain transfer to the residents in the study area. Heavy metal(loid)s in paddy soils varied considerably with the concentration of Pb>As>Cd. Median concentration of As was 0.64 mg/kg with range of 0.27-1.33 mg/kg, Cd was 0.03 mg/kg with range of 0.01-0.08 mg/kg and Pb was 3.13 mg/kg with range of 1.42-6.12 mg/kg. Therefore, Pb possess a risk through transferring soil to rice grain while As and Cd remaining at lower risk. Spatial distribution pattern showed that total heavy metal(loid) s content was higher closer to major irrigation tanks and the surrounding of irrigation channels. Spatial distribution of these metals were lower towards the distant parts of irrigation channels (Figure 1) which is located in north-east and southern part of study area. Paddy cultivated lands in Madirigiriya divisional secretariat of Polonnaruwa district which highest number of CKDu patients were reported in the NCP was selected for the study and 69 soil samples were collected covering entire the division. 0.5 g of each soil sample was digested with concentrated HCl:HNO3 (3:1) in microwave digester. Digested aliquots were analysed for heavy metal(loid)s using inductively coupled plasma mass spectrometry. Spatial variation map for total heavy metal(loid)s of Cd, As and Pb was developed using ArcGIS 10.3.1 version. Heavy metal(loid)s like arsenic (As), cadmium (Cd) and lead (Pb) are toxic to plants and animals resulting in numerous harmful effects to plants and also chronic diseases in human beings. Chronic effects of toxic heavy metal(loid)s is believed to be a factor for the Chronic kidney disease of unknown etiology (CKDu) prevailing in North Central Province (NCP) of Sri Lanka. Paddy is the major agricultural commodity in CKDu prone area and paddy farmers are the major population at high risk of developing CKDu. Therefore, spatial variation of paddy soil heavy metal(oid)s in Madirigiriya area was studied to identify pattern of toxic heavy metal distribution in paddy soils to minimise the future risks of CKDu.

RP153 Risk assessment of heavy metals in canned meat products

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In this study, five heavy metals of public health importance were determined in canned meats commonly consumed in Nigeria using Atomic Absorption Spectrophotometer (AAS). Eleven brands of canned meats were collected from major markets in Enugu, Nigeria and were analysed in triplicates for the heavy metal Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Mercury (Hg). The results obtained in dry weight showed that Pb values ranged from (0.56mg/kg-0.13mg/kg), As (1.46mg/kg-0.55mg/kg), Cd (0.82mg/kg-0.43mg/kg), Cr (0.39mg/kg-0.10mg/kg) and Hg was not detectable in any of the samples. It was observed that the concentration of Pb, As, Cd and Cr in the canned meat samples were higher when compared to the Provisional Tolerable Weekly Intake recommended by FAO/WHO with As and Cd having higher means than Pb and Cr. Also, based on an individual percentage level of exposure, results showed that As and Cd had higher percentages when compared to Pb and Cr. Estimated average daily intake and target hazard quotient (THQ) were also calculated and the ranges obtained for samples 1-11 for Pb (8.26-1.92), As (11.9-22.56), Cd (4.24-2.22), Cr (3.44-0.01) were greater than 1 with exception only seen in samples 8-11 for chromium (Cr) with As having the highest values. Food contamination may therefore, not necessarily be linked with the canning materials. It may however, be associated to the source of the products or other environmental factors. These reported levels therefore calls for concern both on the part of the Government and Nutrition educators with immediate solutions to help eradicate this problem.

RP154 Quantification of metal and metalloid exposure in rodent fur and human hair from Yuma, Arizona

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Yuma, Arizona is an agricultural hub located on the borders of Arizona, California, and Mexico and produces more than 175 crops consumed nationally and globally. Pesticides are applied year-round to maintain high agricultural yields and represent a source of significant exposure to Yuma residents, especially migrant farm workers who comprise the bulk of the agricultural labor force. Previous work in these communities has focused on a limited set of contaminants, such as lead, but little is known about concentrations of other contaminants, including metals and metalloids used in pesticides. This research, funded by the Flinn Foundation, examines the metal and metalloid concentrations in the fur of 300 wild-caught rodents and the hair of 300 human participants from Yuma County. Utilizing inductively coupled plasma-mass spectrometry and cold vapor atomic absorption spectroscopy, contaminants including lead, manganese, and mercury were detected at concentrations associated...
with neurotoxicity in children and adults in both human hair and rodent fur. These preliminary results demonstrate that local wild-caught rodents are an acceptable model for human exposure for the three elements of concern and suggest neurotoxicity exposure in this population. Future directions include using laser ablation inductively coupled plasma mass spectrometry to establish a temporal basis of exposure in subjects and distinguish between exogenous and endogenous contamination. Additionally, neurohistology and gene expression of sensitive nuclei of local wild-caught rodents exposed to differing concentrations of the contaminants will potentially elucidate the timing, geography, and risks of exposure and lead to effective mitigation strategies.

**RP155 Pulmonary exposure to endocrine disruptors sorbed on urban airborne particles of different sizes: chemical and in vitro biological approaches**

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Since industrial development, emissions of molecules into the atmosphere have diversified and intensified, leading to an increase in air pollution, to which humans are chronically exposed, especially in urban areas. Indeed, the link between exposure to air pollutants and many cardio-pulmonary diseases is now well established, and it believes to be mainly due to airborne particles. The finer the particles are, the deeper they can penetrate the respiratory tract. Thus, the currently regulated particulate matter (PM) are those with a diameter of less than 10μm (PM10) and less than 2.5μm (PM2.5); they can reach the thoracic part of the respiratory tract and the pulmonary alveoli, respectively. Besides their size, their composition has an impact on the resulting health effects: particles are constituted of an inorganic fraction and an organic fraction that can sorb biological material or semi-volatile organic compounds. Amongst the latter, many are suspected or proven endocrine disruptors. These can contribute, individually or in mixture, to the intrinsic endocrine-disrupting potential of air pollution and might cause hormonal disturbances in humans. In this context, the project aimed at studying the health hazards associated with exposure to urban airborne particles according to their size and composition in bioactive endocrine disruptors, during cold and warm seasons. Since January 2019, atmospheric particles belonging to 3 particle-size classes (total suspended particles, PM10, and PM2.5) have been collected at 3 urban sites in Paris. First, each class of particles has been chemically characterized for a wide range of endocrine disruptors (59 molecules). Then, the collected particles have been tested for their bioactivity using various in vitro bioassays (transactivation assays for estrogenicity, anti-androgenicity or dioxin-like effect testing, genotoxic assay). The initial results indicate that the finest fraction chosen, PM2.5, supports the highest concentrations of the 59 organic pollutants analyzed (for phthalate compounds, up to 5 times more compared to the PM10 fraction). Moreover, the related bioassays show that it is the PM2.5 fraction that presents the greatest endocrine-disrupting potential compared to the PM10 fraction. These initial results, by considering both the distribution of endocrine disruptors and the biological effects by particle size, raise new questions about the health risks associated with atmospheric particles.

**RP156 Determination of Uptake Coefficients for Ozone on Brake Wear Particulate Matter: Implications for Predicting and Improving Air Quality**

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Particulate matter (PM) in the atmosphere is an important contributor to air pollution; it has been linked to respiratory diseases and is classified as carcinogenic. In urban environments, one of the largest sources of atmospheric PM is from traffic. Traffic emissions are classified as exhaust PM (from tailpipes) or non-exhaust PM (e.g. from brake, tire, and road abrasion). Exhaust emissions are currently decreasing due to heightened regulations, and as such non-exhaust PM is predicted to become the dominant contributor to traffic PM in the coming years. One of the major components of non-exhaust PM is brake wear, and studies performed to date have focused on its toxicity, size, composition, and amount emitted into the atmosphere. However, little is known about the reactivity of these airborne particles with gas-phase species present in the atmosphere. In this study, we investigated the uptake of ozone, an important component of photochemical smog, on brake wear using a coated-wall flow tube. Because the uptake of ozone on other atmospheric surfaces has been shown to display a light enhancement, we determined uptake coefficients of brake wear under both dark and light conditions by intermittent exposure to UV radiation. We found that ozone displays significant uptake on brake wear under dark conditions and that this uptake is enhanced upon illumination. In an attempt to assess the range of brake wear reactivities in the environment, we performed experiments using three brake pad types (ceramic, metallic, and organic), the composition of which was characterized using X-ray fluorescence, and over a range of relative humidities. Understanding the interaction of ozone with brake wear will be important for assessing current ozone regulations and informing future regulations for brake wear emissions, thus improving air quality.

**RP157 Retention and Release Characteristics of Biosolids-borne Azithromycin and Ciprofloxacin**

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Azithromycin (AZ) and ciprofloxacin (CIP) are commonly prescribed antibiotics frequently detected in municipal biosolids at relatively high concentrations and identified by the USEPA as contaminants of emerging concern. The land application of municipal biosolids is an agronomically beneficial practice but is also a potential pathway of CIP and AZ release into the environment. Understanding retention-release behavior is crucial for assessing the environmental fate of and risks from land-applied biosolids-borne target antibiotics. However, retention-release data for CIP and AZ are limited, as is literature addressing the influence of biosolids characteristics on retention-release of AZ and CIP. The present study utilized batch equilibriums to assess retention and release of a range of environmentally relevant concentrations of CIP and AZ in ten biosolids of varying characteristics. The biosolids included Class A and Class B materials with a range of physiochemical characteristics (e.g. pH, CEC, OM, and Fe and Al content and forms). The relationship between biosolids characteristics and partitioning was examined via multiple linear regression using the penalized and shrinkage method LASSO. Retention was linear (R2 > 0.99 (AZ) and > 0.96 (CIP)) and sorption coefficients (Kd) ranged between 52 and 370 L kg⁻¹ for AZ and between 430 and 2300 L kg⁻¹ for CIP. Desorption also varied but was highly hysteretic, with hysteresis coefficients (H) ranging between 0.01 and 0.15 for AZ, and <0.01 for CIP in all biosolids examined, suggesting limited bioaccessibility. Multiple linear regression analysis linked AZ sorption behavior to total iron content and CIP sorption behavior to oxalate extractable aluminum and total phosphorus content. Limited models predicting AZ and CIP behavior based on biosolids physiochemical characteristics are presented.

**RP158 Discovery of Emerging Halogenated Contaminants of Concern in Great Lakes Lake Trout**

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Halogenated contaminants are typically the largest fraction of persistent, bioaccumulative and/or toxic (PBT) chemicals in the Great Lakes. Legacy halogenated contaminants (e.g. PCBs) have been monitored, but many additional halogenated compounds may still be undiscovered. To
understand the impact of unknown PBT halogenated chemicals in Great Lakes, top predator fish (trout) were analyzed using an atmospheric pressure gas chromatographic (APGC) coupled with a quadrupole time-of-flight (QToF) instrument that produces soft ionization full scan high resolution mass spectrometer (HRMS) data. An Isotopic Profile Deconvoluted Chromatogram (IPDC) algorithm was developed to screen for halogenated compounds using the distinct identifiable mass spectral signatures in HRMS data. The IPDC algorithm employs several data reduction techniques including a false positive prediction by neural network, a mass defect filter, a boiling point prediction, and a ranking system for when several candidate molecular formula represent an isotopic feature. The IPDC algorithm detected approximately 224 features associated with legacy contaminants in Lake Michigan Lake Trout collected in 2016 sample and produced a list of 256 unknown isotopic features for future investigations. A temporal trend of the uncategorized halogenated futures were produced to compare between sites years (2005/2006 vs. 2015/2016) to determine spatiotemporal impact of halogenated and potential PBT compounds in Great Lakes.

**RP159 Occurrence of dimethylmonothioarsinic acid in aquatic environment and associated risk**

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Dimethylarsenic acid (DMA) is less toxic, however classified as a possible carcinogen because of metabolic transformation to highly toxic dimethylmonothioarsonic acid (DMMTA). DMMTA can occur in aquatic environment by both chemical and biological thiolation of DMA or oxidation of dimethylthioarsinic acid (DMDTA). The purpose of this study is to assess conditions where highly toxic DMMTA can be formed. Kinetics forming DMMTA in abiotic condition were tested in laboratory by varying concentrations of reactive chemicals and pH condition. In previous study, DMA thiolation to form DMMTA was evaluated to the second order reaction of DMA and hydrogen sulfide at pH 6.0. This experiment was conducted under excess sulfide condition, therefore concentration of hydrogen sulfide was lowered close to natural condition in this study. For the biotic reactions, plant exposed to DMA was decomposed in anaerobic condition. Then, arsenic speciation was conducted to observe an occurrence of highly toxic DMMTA. This research was supported by the National Research Foundation of Korea (grant number NRF-2019R1A2C2007092).

**RP160 Methods for analysis of a novel brominated flame retardant, tris(tribromonopentyl) phosphate, using high-resolution orbitrap mass spectrometry**

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The use of organophosphate ester (OPEs) flame retardants has increased since regulation of polybrominated diphenyl ether (PBDE) flame retardants in the early 2000s. Several OPEs are chlorine-substituted such as tris(1-chloro-2-propyl) phosphate (TCP), tris(2-chloroethyl) phosphate (TCEP), and tris(1,3-dichloroisopropyl)phosphate (TDICP). These three substances are of emerging concern due to their persistence, hydrophobic and ubiquitous presence. While these Cl-containing OPEs have garnered attention, brominated OPEs seem less prominent, potentially due to classification of tris(2,3-dibromopropyl) phosphate as a potential carcinogen and its subsequent ban from use in children’s clothing over four decades ago. However, one particular brominated OPE, tristribromonopentyl) phosphate (CAS 19786-97-1, molecular formula C15H24Br9O4P, molecular weight 1018.47 g/mol, acronym TTBrNP) is currently in production and used as an additive flame retardant in polypropylene fibre applications including automotive carpeting, office partitions and synthetic hair appliances. TTBrNP is on Canada’s Domestic Substances List and is scheduled for ecological risk evaluation. As such, a need for analytical methodology emerged. The goal of this study was to develop sensitive, quantitative methods for TTBrNP in water, sediment, and biota. Using ultra high performance liquid chromatography coupled with high-resolution orbitrap mass spectrometry (70,000 resolution), TTBrNP detection was optimized via chlorine-assisted atmospheric pressure chemical (APCI) ionization. The validated extraction methods consisted of solid phase extraction (SPE) for environmental water and ultrasonication assisted extraction in acetone for sediment and biota. Analysis of TTBrNP was applied to environmental samples in the Hamilton Harbour, Ontario, Canada and all samples were < LOD. Accumulation and effects of TTBrNP were evaluated in a laboratory-based waterborne sub-chronic exposure of tadpoles. TTBrNP was consistently detected in tadpoles at all treatment levels. However, overall the propensity for bioaccumulation of TTBrNP was low with whole body bioaccumulation factors corresponding to 16 ± 1 L/kg, suggesting biotransformation and/or limited bioavailability due to hydrophobicity. Debromination and hydrolysis of other flame retardants has been shown. Future work will assess degradation products of TTBrNP.

**RP161 Occurrence of Parent and Nitro-PAHs in Soils of an Industrial City and Associated Cancer Risks**

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Exposure to carcinogenic polycyclic aromatic hydrocarbons (PAHs) in industrial soils could have huge health effects on workers. Apart from parent PAHs, their derivatives, such as nitrated (N)-PAHs, are more toxic even at comparatively lower concentrations. Most PAH derivatives are immediate acting carcinogens that require no enzymatic activation to elicit toxic effects. This study, therefore, investigated the soil concentrations of 13 PAHs and 3 nitrated PAHs (N-PAHs) in soils (n = 14) within the industrial area of the industrial heritage city of Newcastle, Australia. In addition, the potential health impact of PAH and N-PAH exposures was determined through the estimation of the excess lifetime cancer risk (ELCR). The mean concentrations of Σ3N-PAHs and Σ13PAHs in industrial soils were 0.40 ± 0.12 µg/g and 92.14 ± 107.48 µg/g respectively and the most abundant N-PAH and PAH were 1-nitronaphthalene (0.20 ± 0.11 µg/g) and benzo (a) anthracene (21.5 ± 27.8 µg/g). Pearson correlation analysis of Σ13PAHs and Σ3 N-PAHs showed a weak positive correlation (r = 0.18, p = 0.05). Computed ELCR values (8.2×10-7) of accidental ingestion of industrial soils was, however, lower than the USEPA high risk value of 1.0×10-4. This study has shown a reduced risk of cancer development in Newcastle industry workers through accidental soil ingestion.

**RP162 Evaluating the Nocuous Effects of Uranyl Nitrate on Primary Dermal Fibroblast Viability, Metabolism, Proliferation, and Migration**

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The increased demand for uranium to serve military and nuclear purposes have left Navajo Nation residents at elevated risk of chemical exposure by contaminating their bathing and drinking water. Uranium chemical toxicity has been regularly studied in kidney and lung epithelium; however, testing of percutaneous exposure has been limited. Using soluble and biologically active depleted uranium, in the form of uranyl nitrate, we demonstrate cytotoxicity on primary human dermal fibroblasts. Dermal fibroblasts were selected because of their roles in skin health and healing. We exposed the cells to uranyl nitrate at environmentally relevant concentrations based on observed levels in the Southwest United States ranging from 0.1 uM to 300 uM (39.4 - 118,212 ppb). Cells were exposed to uranyl nitrate or control solution in cell culture media at standard growth conditions. Exposure outcomes were evaluated for cell viability, metabolic activity, pro-apoptotic markers, and proliferation rates at 24, 48, and 72 hours. Exposure to uranyl nitrate revealed a dose-dependent decrease in cell viability measured by CyQuant Direct(TM) and concomitant decrease in mitochondrial activity measured by
Flame retardants are chemical mixtures added to materials after manufacturing to reduce the amount of time it would take a small open flame to ignite the item. These compounds are volatile and continuously leach out of materials into the environment. Therefore, they are ubiquitously detected in household dust, wastewater, rivers, sediment and soil. Flame retardant metabolites are also consistently detected in urine of adults and children participating in national and regional public health studies. Since they have long range transport and persist in the environment toxic flame retardants, such as polybrominated diphenylethers, have been removed from the market. Compounds with limited toxicological data are being used as replacements, including 2-ethylhexyl-2,3,4,5-tetrabromobenzoxate (TBB) and bis(2-ethylhexyl)-2,3,4,5-tetrabromophthalate (TBPB). TBB and TBPB, have been identified by EPA as priorities in the Toxic Substances and Control Act work plan due to critical gaps in toxicity and exposure data. They occur as part of the Firemaster (TM) 550 and BZ formulations and are reported to be endocrine disruptors, primarily mimicking thyroid hormone activity. Whether they act as antiandrogens remains to be determined, however, our preliminary data suggest that TBB and TBPB can inhibit androgenic activity. Thus, we hypothesize that BPs act as antiandrogens by inhibiting androgen receptor (AR) function and causing disruption of androgen mediated processes, including cell growth and testicular development. Aim 1 will determine the mechanisms by which BPs inhibit AR-mediated transcription of target genes. Preliminary data using an AR-driven luciferase reporter assay suggest that TBB is a competitive inhibitor of AR in the androgen-dependent prostate cancer cell line LNCAp. Further mechanistic studies are being conducted in prostate cancer cell lines. In addition, elucidation of the antiandrogenic effects of BPs on testis development will be done using the model organism, zebrafish (Danio rerio). These studies will determine the AR mechanisms by which BPs act as antiandrogens.

RP165 Emissions and Occupational Exposure Risk of Halogenated Flame Retardants from Primitive Recycling of E-Waste

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The production and usage of non-polybrominated diphenyl ether (PBDE) halogenated flame retardants (HFRs) have substantially increased after the ban of several PBDEs. This has resulted in widespread environmental occurrence of non-PBDE HFRs, further amplified by emissions from primitive recycling of obsolete electronics (e-waste). In the present study, chamber experiments were conducted to characterize 15 HFRs (Σ15HFR) from thermal treatment and open burning of typical e-waste. Emission factors of Σ15HFR were 2.6 x 10^3-3.9 x 10^3 ng g^-1 in thermal treatment, slightly higher than those in open burning (8.8 x 10^3-10 x 10^3 ng g^-1). Greater output over input mass ratios of Σ15HFR were obtained in thermal treatment than in open burning. Particulate and gaseous HFRs dominated the emissions in thermal treatment and open burning, respectively, largely due to different temperatures used in the two processes. Particulate HFRs were primarily affiliated with fine particles (Dp ≤ 1.8 μm) peaking at 0.56-1.0 or 0.32-0.56 μm in both thermal treatment and open burning. Occupational exposure to most FRs was relatively low, but several PBDEs may pose potential health risk to workers in e-waste home-workshops. Potentially accruing emissions and health risks of non-PBDE HFRs from primitive recycling of e-waste remain a great concern.

RP166 Human exposure assessment of decabromodiphenyl ethane in different areas of China

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Decabromodiphenyl ethane (DBDPE) is predominant substitute of decabromodiphenyl ether (deca-BDE), which is widely used as a flame retardant in the electrical and electronic products (EERPs) in China, the biggest manufacturer of both DBDDE and EERPs. Current studies have indicated that DBDPE has similar characteristics of persistent organic pollutants (POPs), and its concentration in the environment of China has exceeded that of deca-BDE. Based on the data survey, interval linear programming and emission calculation, the study investigated the stock and flows of DBDPE in China from 2006 to 2016, including its production,
use and emission; And then conducted an assessment of human exposure to DBDPE in different areas of China by integrated modeling through dynamic substance flow analysis and multimedia simulation. Our results indicated, during 2006–2016, ~230 thousand tonnes (kt) of DBDPE were produced in China, ~196 kt of which was released to the environment from the production, use and disposal activities of DBDPE and EEPs containing it. Except for areas with intensive EEPs production, processing or use in EEPs manufacture, i.e., Guangdong and Shandong, the indoor concentration of DBDPE was higher than that of the outdoor in general areas in China. The environmental concentration of DBDPE in the suburban area is lower than that in the urban area currently, but the urban/suburban concentration ratio of DBDPE was decreasing slowly over time, showing a trend of spatial homogenization and increasing level of overall environmental pollution of DBDPE in China. That also means the increasing possibility of DBDPE contamination on food supply mainly from suburban areas, thus elevating the exposure to DBDPE for people in either urban or suburban areas. The main exposure pathways of DBDPE to people living in different regions are different; for instance, in North China areas, far-field exposure dominates, whereas in South China areas, near-field exposure does. We found that children were at higher health risk than that for adults. As business as usual from now to 2026, while children in all different regions would be in high exposure risk, adults would also face to nonnegligible risk in China.

RP167 Biomonitoring of environmental phenols in human urine from seven Asian countries, Greece and the United States
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Environmental phenols (EPs), are commonly used for several purpose such as antimicrobial preservatives in personal care products, and are degradation products. For examples: Chlorophenols (CPs) are used in the production of pesticides and preservatives; Parabens, esters of para-hydroxybenzoic acid, are commonly used as antimicrobial preservatives in cosmetics and personal care products. Although several studies report exposure of humans to EPs in Western countries, little is known about exposure of humans to EPs in Asian countries. In this study, we determined concentrations of six parabens and eight chlorophenols in 300 human urine samples collected from nine countries. Additionally, we estimated daily intakes (DI) and potential health risks of EPs. Of the 300 samples analyzed from nine countries, 97.7% and 100% of the samples contained at least one CPs and parabens. For CPs, 2,4-dichlorophenol and 2,4-dichlorophenol were found at the highest median concentrations (median for all nine countries: 1.78 and 0.34 ng/mL, respectively). Urine samples from Japan had the highest concentration of total CPs (median: 16.7 ng/mL) with 2,5-dichlorophenol accounting for 93.1% of the total concentration. For parabens, ethyl-paraben, methyl-paraben, and propyl-paraben were detected frequently at 100, 98.0, and 80.3%, respectively, with representative median concentrations of 0.68, 7.02, and 1.21 ng/mL, respectively, for all nine countries. Urine samples from females (total median concentration: 32.3 ng/mL) contained significantly higher concentrations of parabens than did those from males (5.46 ng/mL). Urine samples from Korea (total median concentration: 227 ng/mL) had the highest concentrations, which were one to two orders of magnitude higher than those found in other countries (3.67 - 29.1 ng/mL). The estimated DI for precursors of dichlorophenols and parabens (on the basis of concentrations measured in urine) varied widely, but several samples showed values higher than the acceptable DI of precursors of 2,4-dichlorophenol and propyl-paraben recommended by the United States Environmental Protection Agency. Our results suggest that EPs exposure is ubiquitous in Asian countries, and some person exceed acceptable DI. The assessment of the global exposure sources and further assessment of potential health risk of these chemicals is needed.

RP168 Prioritizing chemicals for toxicity testing for reproductive effects using non-targeted analysis data of prenatal exposures and literature review
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Maternal chemical exposures are of particular importance because pregnancy is a critical period of unique susceptibility to biological perturbations. About 40,000 chemicals are listed on the inventory of the Toxic Substances Control Act (TSCA), which includes nearly all chemicals registered for use in the US. For the vast majority of reported chemicals, there is very limited to no information about human exposures and/or the potential to adversely affect human health. Only about 350 chemicals (approximately 1%) are biomonitoried regularly via U.S. NHANES. Recent advances in non-targeted analytical techniques enabled us to screen biological samples for a broad spectrum of chemical compounds. We published a proof of concept study scanning for about 700 environmental organic acids in blood samples from pregnant women in San Francisco, confirming the presence of numerous organic chemicals in women's blood. We found that over half of the candidate chemicals matched to formulas in our environmental organic acids database that have not been biomonitoried by U.S. NHANES. As biomonitoring advancements move towards large-scale chemical screening, we need to develop approaches to select which of these chemicals to subsequently test for toxicity. We are using a yeast screening assay and a C. elegans assay for developmental and reproductive toxicity. Our chemical selection was based on four main criteria: (i) chemicals suspected to be important for human health, (ii) chemicals of interest to policy makers, (iii) chemicals from non-targeted analysis and (iv) positive and negative controls for the toxicity testing. For the first two criteria we followed a structured literature review approach, where we searched for chemicals of interest to academic and governmental organizations in the environmental health field. For the third criterion we used chemicals that were detected in our previous studies on suspect screening of blood samples from 200 women in San Francisco. For the fourth criterion, we used chemicals that are known to be reproductive and/or developmental toxicants in rodents and in nematodes. With the selected chemicals, we composed a database that will serve as a guide for further toxicity testing. The database consists of about 160 chemicals from various chemical groups, with the largest ones being per- and polyfluoroalkyl substances, pesticides and flame retardants. Our results will eventually be used to develop predictive algorithms for reprod/developmental toxicity.

RP169 Characterization of Electronic Cigarette Liquids by 1D and 2D NMR Spectroscopy
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Electronic cigarette (e-cig) liquids (e-liquid) have unknown quantities of unidentified chemicals used as solvents, flavors and preservatives. While some of them are classified as “generally regards as safe” chemicals when used as food additives, their effects when inhaled are largely unknown. This extraordinary variability in e-liquids have substantially influenced the robustness and accuracy of studies investigating the characterization of e-liquids chemical content. Apart from nicotine and major solvents (propylene glycol and glycerin), other chemicals with potentially harmful effects may be present in e-liquids. Thus, it is important to understand
the chemical constituent of e-liquids as there may be a dependence on e-vapor chemical content and this can substantially impair the toxicological and risk assessment process of e-cigarettes and their potential implications to human health. This study assesses the functional characteristics of different e-liquids from varying commercially available products by harnessing the unique molecular fingerprint obtained by nuclear magnetic resonance (NMR) spectroscopy, to estimate the prevalence of known compounds (nicotine, propylene glycol and glycerin) and identify the molecular structure of other unknown compounds. We used a series of 1D and 2D homonuclear (1H–1H COSY) and heteronuclear (1H-13C HSQC and 1H-13C HMBC) NMR experiments. A total of 43 commercially available e-liquids representing 96% of the retail market based on popular flavor and nicotine content were analyzed. 50 μl of e-liquid was mixed with 350 μl of ultrapure water and 200 μl of deuterated phosphate buffer (pH7.4). Spectra of samples from NMR were processed using Advanced Chemistry Development (ACD) NMR Spectrus Processor software. For all the flavors, the spectra width was divided into 6 regions and integrated for all flavors to identify functional groups. Results showed presence of known compounds, multiple signals corresponding to aliphatic, hydroxylated aliphatic, alene and aromatic functional groups were found in the 1D (proton) spectra. The 2D NMR analysis was able to decipher the connectivity between functional groups. NMR spectroscopy is able to determine the functional groups of certain chemicals in e-liquids. These chemicals may be precursors of e-vapor toxicants produced during the heating of e-liquid. Also, these chemicals illustrate need for further studies and control over the chemical constituents and properties of e-liquids.

**RP170 Evaluation of the Use of Tree Leaf Bioactives to Improve Productivity and Mitigate Greenhouse Gas Emissions in Ruminant Farming**

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In the last two decades, there are global worries concerning the environmental impact of greenhouse gases (GHGs) especially carbon dioxide (CO₂) and methane (CH₄) emitted during ruminant farming. These gases contribute significantly to global warming which causes environmental degradation. Many strategies have been exploited by researchers to optimise ruminant production via enhancing dietary feed with the aim of improving animal health, reduce energy loss and decrease GHG emissions using feed additives such as antibiotics. However the ban of the use of antibiotics by European Union in 2006 due to the associated risk factors such as toxic effects to the host animals, adaptability of rumen microbes and detrimental effects on humans have led to renewed impetus for the search of alternative feed additives without any potential harmful effects. Recently, leaf tree bioactives are being exploited as safer and effective feed additives to improve animal health and inhibit rumen methanogenesis. Today, there are substantial scientific evidence that tree leaves have promising potentials to enhance animal productivity and reduce CH₄ production. Leaves from trees comprise of various bioactives such as tannins, alkaloids, phenolics, saponins and essential oils that have great potentials to favourably modify rumen fermentation and improve reproduction, milk production, meat quality and reduce GHG emissions during ruminant farming. This study therefore evaluates and summarises all the available research works on the use of leaf bioactives to improve productivity and reduce GHG emissions in ruminant production.

**RP171 Photochemistry at the surface of urban road dust: Implications for contaminant lifetime and atmospheric composition**

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In both Canada and the United States, dust resuspension from paved and unpaved roads is the largest anthropogenic source of primary fine particulate matter. Because road dust contains a variety of toxic species, many studies have focused on its composition and potential health effects; by contrast, little is known regarding its atmospheric reactivity. Here, we use a molecular probe technique to show that illumination of urban road dust leads to the production of singlet oxygen, an important atmospheric oxidant. In particular, we show that the production of singlet oxygen increases with decreasing particle size, and provide evidence that light-absorbing organic carbon participates in singlet oxygen production. We also present results from investigations of the interaction of ozone, a representative urban pollutant, with road dust. We find that the uptake of ozone by road dust is higher than that by desert-sourced dust, and is enhanced in the presence of light. Further, we provide evidence for the participation of road salt (i.e. chloride) in the observed chemistry. Together, our work provides evidence that photochemistry at the surface of road dust can influence both the lifetimes of dust-associated pollutants and the composition of the surrounding atmosphere. As vehicle exhaust emission regulations become more strict in coming years, the relative contribution of road dust to urban particle matter loadings will increase, and the road dust-mediated processes described here will only increase in importance.

**Alternatives Assessment and Informed Substitution: The Transition to Safer Chemicals, Materials, Processes and Products**

**RP172 Stakeholder engagement to support the PFAS in Food Packaging Alternatives Assessment**

J. Rhoades, SRC, Inc. / Environmental Health Analysis; C. Hard, SRC, Inc.; C. Rudisill, SRC, Inc. / Environmental Health Analysis; B.J. Penttila, Washington State Department of Ecology

PFAS substances are used in food packaging primarily for oil, grease, and water resistance and can migrate into food during use, or leach into the environment during disposal. In 2018, Washington State passed a new law to prohibit all PFAS in plant fiber-based food packaging. The ban takes effect following the identification of safer alternatives as specified in the toxics in packaging law (RCW 70.95G). An alternatives assessment (AA) is being conducted to identify and assess alternatives to PFAS in Food Packaging. There are a diverse number of parties that have a stake in the transition from PFAS to non-PFAS alternatives in food packaging including chemical manufacturers (PFAS and non-PFAS), food packaging manufacturers, suppliers, NGOs, trade organizations, retailers, purchasers/users, and end-of-life managers. Incorporation of stakeholder interests is an important component of the AA process. For this assessment, the process for stakeholder engagement follows guidelines in the IC2 stakeholder involvement module. Stakeholders were identified and recruited through an internal initial screen and solicited on the WA PFAS CAP website. Stakeholders were asked to participate in a web-based survey to determine the type of input and information they could provide. The general approach of stakeholder engagement includes building a rapport, mapping out the knowledge-base and obtaining input and information to help inform base-case PFAS chemical selection, alternatives candidates identification, scoping, manufacturing considerations, consumer concerns, and input on AA modules (hazard, exposure, performance, cost & availability assessments). Because some of this information is proprietary.
to some stakeholders, a confidential business information (CBI) protocol was developed by WA State to facilitate the sharing of information necessary to conduct the assessment. The formal stakeholder process includes engagement through email, one-on-one telephone discussions, webinars, online surveys, and targeted group phone discussion. Pertinent information is provided for stakeholder review and comment. This presentation highlights the stakeholder engagement process for the AA for PFAS in food packaging, how stakeholder input was incorporated into the assessment, and the challenges associated with obtaining information required for the assessment.

**RP173 Selection of a Representative PFAS for Washington State’s Food Packaging Alternatives Assessment**

C. Hard, SRC, Inc.; J. Rhodes, C. Rudisill, SRC, Inc. / Environmental Health Analysis; B.J. Penttila, Washington State Department of Ecology

The Washington State Law RCW 70.95G passed in 2018 prohibits the use of all per- and polyfluorinated substances (PFAS) in plant fiber-based food packaging. The function of PFAS in direct food contact packaging is to impart oil, grease, and/or water resistance to the material. The ban goes into effect two years after the identification of safer alternatives are identified. Data on PFAS-based and PFAS-free food packaging products will be collected and compared in order to inform the decision as to whether safer alternatives to PFAS food packaging are available. The alternative assessment will be based on consideration to chemical hazard, exposure, performance, cost, and availability. As there are currently 19 PFASs approved by the U.S. Food and Drug Administration for use in food contact materials (FCMs) to impart oil, grease, and/or water resistance, an exhaustive assessment of all of these substances is not practical. In order to provide adequate comparison between the candidate alternatives, a representative PFAS formulation, known as a “base case” was identified. The process of choosing the base case involved mapping the U.S. Food Contact Notifications (FCNs), reviewing published monitoring studies, and incorporating stakeholder input. Mapping the FCNs required the identification of all PFAS substances used for direct food contact plant fiber-based packaging that met the functional requirements and obtaining representative structures for these substances so that they could be categorized and compared. This led to the finding that all approved FCN’s were for PFAS polymers, with a majority of these being side-chain fluorinated compounds. The use of C6 side-chain polyfluorinated chemistries in food packaging was supported by independent research, monitoring studies of detected compounds found in FCM’s, and initial stakeholder comments. The base case for the alternatives assessment will be chosen based on its ability to meet the functional requirements, its approval for a wide range of food types and conditions, and access to existing published data available regarding substance identity, environmental fate, production, disposal, and hazard.

**RP174 Alternatives Assessment of Perovskite Compositions and their Methods of Fabrication for Photovoltaic Applications**

M. Llanos, McGill University / Department of Geography; N. Basu, McGill University / Faculty of Agricultural and Environmental Sciences

As non-renewable energy resources are becoming increasingly difficult and costly to source, the need for competitive renewables intensifies. Among these are solar cells, showing exponential growth in installed capacity over the past decade. Perovskite-based solar cells have emerged as a new category of photovoltaics, gaining traction in the scientific community due to their high power conversion efficiencies, attractive combination of physical properties, and potential for low cost manufacturing. Despite this, perovskite technology has not yet been commercialized, in part due to concerns surrounding the toxicity of lead (Pb) in the benchmark composition CH3NH3PbI3. Concerns also exist regarding the use of toxic solvents (e.g. dimethylformamide) in the popular solution-based approach to fabricating CH3NH3PbI3. This study conducts an alternatives assessment of 32 perovskite solar cells and their methods of fabrication to determine safer alternatives to the benchmark CH3NH3PbI3 on the bases of hazard, performance, and costs. This alternatives assessment is conducted using the U.S. National Research Council’s Framework to Guide Selection of Chemical Alternatives. This study includes the collection and comparison of 5 performance indicators, estimated levelized costs of energy (LCOE), and hazard data from 142 data points within 8 categories of which to date an average of 32.5% have been filled for each chemical. As the demand for solar panels increases, this research could be utilized to inform and promote the sustainable development of this technology, ultimately guiding the entrance of perovskite solar cells into the photovoltaic market.

**RP175 Effects of Two Bisphenol A Alternatives, Bisphenol AF and DD-70, on Pipping Success, Development, and mRNA Expression in Chicken Embryos**

H. Gyasi, University of Ottawa; T. Sharin, Environment and Climate Change Canada / University of Ottawa; D. Crump, J. O’Brien, Environment and Climate Change Canada / National Wildlife Research Centre

Reports of Bisphenol A (BPA) estrogenic activity has resulted in increased efforts to find suitable BPA alternatives for use in consumer and industrial products. Bisphenol AF (BPAF) and 1,7-bis-(4-Hydroxyphenylthio)-3, 5-dioxaheptane (DD-70) are two potential chemical substitutes for BPA; however, there are few studies on the ecotoxicological properties of these compounds. Here, we conducted egg injection studies to determine effects of these two compounds on avian embryonic viability, development, and hepatic mRNA expression at two distinct developmental periods (midincubation [day 11] and pipping [days 20-21]). BPAF or DD-70, dissolved in dimethyl sulfoxide, were injected into the air cell of unincubated, fertilized chicken embryos at four concentrations up to a maximum of 114 and 88.2 µg/g for BPAF and DD-70, respectively. Embryonic concentrations of BPAF and DD-70 decreased between midincubation and pipping indicating embryonic uptake and metabolism. The estimated median lethal dose (LD50), based on embryonic viability at midincubation, was 210.4 µg/g (95% confidence interval = 89.3-495.7 µg/g) for BPAF and 128.6 µg/g (95% confidence interval = 30.94-534.4 µg/g) for DD-70. DD-70 did not alter physical development whereas exposure to 114 µg/g BPAF significantly increased gabbler size. Gonad weight in males and gonadal somatic index in both sexes were decreased by both BPAF and DD-70, although these effects were not significant. Significant changes in hepatic gene expression, measured using PCR arrays, were observed at both developmental stages. Impacted genes were related to several toxicity pathways including xenobiotic metabolism, lipid and cholesterol homeostasis, thyroid hormone pathway and response to estrogen. Overall, our results show that BPAF and DD-70 caused effects on viability, development and gene expression in an avian species; however, these were observed at much greater concentrations than those currently detected in the environment. Several lines of evidence suggested estrogenic activity, which indicates a concern for chronic low dose toxicity and therefore, warrants further investigation.

**RP176 In-Silico Risk Assessment of Several Pesticide Transformation Products Generated by Exposure to an Advanced Oxidative Process**

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Advanced oxidative processes (AOPs) are gaining popularity in produce post-harvest treatment due to their ability to extend product shelf life through reduction in biological contamination. While this is beneficial to consumers and producers alike, consideration must be given to what these treatments may be doing to pesticide residues on the surface of produce. Whereas commercial pesticide residues have been thoroughly investigated for their potential toxicity during their development and registration, in most cases very little is known about their transformation products (TPs). The current study selected several widely used pesticides (boscdil, captan, fenbuconazole, glyphosate and pyraclostrobin) and...
exposed them to an AOP utilizing ultra-violet light, ozone and hydrogen peroxide. The AOP was able to reduce the concentration of parent pesticides with boscalid and pyraclostrobin being reduced by 39% and 7% by 3% hydrogen peroxide and 75% and 100% by 40 min of ultra-violet irradiation respectively. Using targeted and untargeted mass spectroscopy techniques and the literature, structures were identified for the detected TPs. In-silico toxicity assessments of the TPs, extrapolation of the abundance of TPs relative to the maximum residue limit for the parent residue and statistics on human produce consumption enabled a preliminary risk assessment of pesticide transformation products on the surface of produce created by an AOP.

Structural Fires and Wildfires: Environmental Hazards and Firefighter Health

RP177 Revisiting the assessment of toxicity of wildland fire-fighting chemicals: A focus on short duration, high concentration exposures

During the application of fire-fighting chemicals, misapplications can occur such that chemicals are inadvertently applied to surface water. Misapplications to flowing waterbodies such as streams and rivers may result in aquatic organisms experiencing a relatively brief, pulsed exposure to an initially high concentration, especially for organisms close to the misapplication site. In general, as the retardant plume moves downstream, the peak concentration decreases and the exposure time increases as mixing and dilution continually modify the plume characteristics. Aquatic organisms downstream of a misapplication experience very different exposures depending on their proximity to the spill. Moreover, each organism experiences a continuous range of concentrations as the plume moves downstream. To capture the physics of river mixing, a new spill calculator was developed using the advection-dispersion model for use in estimating effects of misapplications of fire retardant. The model predicts distance and timing of downstream concentrations to allow for the assessment of the potential effects on threatened and endangered species and critical habitat. Maximum concentrations and durations of exposure were estimated from the model using real-world misapplication data. Traditionally, toxicity testing for species of interest typically involves a standard 96-hour exposure to a constant concentration. However, to better understand the potential toxicity of high-concentration, short exposure duration events, 30-60 day post hatch rainbow trout (Oncorhynchus mykiss) were exposed to an AOP utilizing ultra-violet light, ozone and hydrogen peroxide respectively. Using targeted and untargeted mass spectroscopy techniques and the literature, structures were identified for the detected TPs. In-silico toxicity assessments of the TPs, extrapolation of the abundance of TPs relative to the maximum residue limit for the parent residue and statistics on human produce consumption enabled a preliminary risk assessment of pesticide transformation products on the surface of produce created by an AOP.

Current Methods in Teaching at the Interface of Chemistry and Toxicology

RP178 “Toxic” Discourse: Separating Truth from Half-Truth in the Classroom
A.M. Simpson, Penn State Erie, The Behrend College / Biology

In an age where information is gleaned largely from social media, the generation of students in our classrooms faces a daunting challenge: distilling accurate information from a swarm of sources. In many situations, it is difficult to discern the validity of these sources of information, particularly when students are still working to build a foundational understanding of how the world works (i.e., natural and social sciences). Environmental activism— even with its noble intentions— can occasionally fall victim to the passion of its advocates, whereby activist groups share ideas and concerns in ways that can be misleading. To assess the ability of our students to critically interpret popular science media, a class activity will be incorporated into two separate courses at Penn State Erie during the Fall 2019 semester. One course will be composed of upper-classmen/ women and cover the principles of toxicology, while the other course will contain strictly non-science majors and cover basic human anatomy and physiology. In each course, the students will be shown a short video produced by an advocacy group depicting the dangers of “toxic chemicals” in society. Following the video, the students will work together in small groups to synthesize their takeaway messages from the content; these responses will be recorded and compared between the two courses. This comparison will provide preliminary insight into how our students interpret online content. Indeed, as scientists and educators, we are tasked with training our students to think critically and apply their education when consuming potentially misleading information. It is imperative that we prioritize the development of these skills in the classroom.

RP179 Accessing integrated chemistry and toxicity data via the USEPA CompTox Chemicals Dashboard
A.J. Williams, C. Grulke, R. Judson, A. Richard, K. Paul Friedman, J. Dunne, J. Edwards, US Environmental Protection Agency / National Center for Computational Toxicology

The USEPA National Center for Computational Toxicity (NCCT) has been generating and building software applications and web-based chemistry databases for over a decade. During this period the center has analyzed thousands of chemicals in hundreds of bioassays, has researched high-throughput physicochemical property measurements and investigated approaches for high throughput toxicokinetics. Over the past few years some of the data have been delivered through prototype web-based “dashboards” for public consumption. The latest of these web applications, the CompTox Chemicals Dashboard, is an integrated access point to obtain information associated with 875,000 chemical substances and providing experimental and predicted data of various types. This includes physicochemical and fate and transport data, bioactivity data, exposure data and integrated literature searches. Real-time predictions and generalized read-across are possible and advanced search capabilities are available to support EPA-related projects including mass spectrometry non-targeted analysis. This presentation will provide an overview of the CompTox Chemicals Dashboard and the efforts to provide a seamless experience for both chemists and toxicologists. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

RP180 Improving student learning in introductory STEM courses supports the interdisciplinary goals of One Health
C. Singleman, Queen’s College / Center for Teaching and Learning; J. Valad, P. Johnson, S. Avila, E. Fernandez, Queen’s College

The concept of One Health focuses on understanding the intersection between human, animal, and environmental health. The pursuit of interdisciplinary research to fulfill the goals of One Health requires strong foundational STEM education. Thus, recent declines in numbers of students pursuing STEM degrees is concerning. A common hypothesis cites the lack of underrepresented minorities in STEM fields as a factor in this decline. Through a partnership between Queens College (QC) and Queensborough Community College (QCC) we aim to increase retention of underrepresented students in STEM majors by redesigning introductory STEM courses to improve student learning and engagement. Teaching approaches differ greatly at the two institutions, not only between departments but also between campuses. This program connects teaching faculty and fosters improved communication stressing cohesive education within the disciplines. Through a Department
of Education grant, HSI-STEM Bridges Across Eastern Queens works with faculty in STEM disciplines to redesign introductory courses in biology, chemistry, environmental science, geology, math, and physics. Each campus’ redesign team has developed unique strategies for course redesign. Some redesigns used small-scale active-learning activities in class, while one course implemented a complete overhaul creating invisi-
tive lab activities reflecting challenges and troubleshooting of independent research. As each department has approached their redesign differently, we can evaluate implementation and effectiveness of course modifica-
tions using a randomized control trial model, where some sections of the course are modified and others are taught without modifications. Tracking student retention in STEM majors at both colleges is essential as up to 70% of the transfer students to QC come from QCC. Establishing better communication between colleges and departments fosters a consistent learning environment for students pursuing STEM education and careers, regardless of their transfer status. How students are educated early has a significant impact on choices they make for the remainder of their college experience and their careers. Redesigning introductory STEM courses to expose these students early to dynamic ways of thinking about scientific challenges will not only enable them to be better thinkers, but also better scientists who have the tools to approach complex problems faced in inter-
disciplinary studies.

Oil Toxicity Testing: Current Experimental and Analytical Methods, Exposure Metrics and Risk Interpretation

RP181 Flow-Through Passive Dosing and Fluorometry to Generate and Confirm Dynamic Exposures in Toxicity Tests used for Spill Effects Model Calibration
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Aquatic hazard assessment of petroleum substances rely on use of water accommodated fractions (WAFs) that are intended to provide constant lab exposures over the course of the test period. However, if spilled, field exposures of these substances are typically shorted, highly dynamic and modulated by the fate properties of the hydrocarbon constituents. Consequently, adverse effects observed in lab tests cannot be extrapolated to quantify effects in the field. To improve spill impact predictions, a time-variable effects (TVE) model is needed. The objective of this work is to describe a flow-through passive dosing system than can be used to generate high fidelity dynamic dissolved hydrocarbon exposures that can be evaluated in toxicity tests. Application of this system to evaluate acute sub-lethal and lethal TVE of 2-methyl naphthalene to juvenile rainbow trout under multiple time variable exposure scenarios is described.

Integration of fluorometric analyses of test media over time provided a simple, cost-effective analytical tool to confirm dynamic exposure concentrations across tests. Collective TVE for the different exposures investigated are used to illustrate how such data can inform calibration of a TVE model that is based on the target lipid model framework which has been widely used to predict effects of hydrocarbons under constant expo-
sure regimes. Future research needs for addressing the role of different potential organismal or environmental modulating factors on time-
dependent toxicity and extending this work beyond single compounds to petroleum substances is highlighted.

RP182 Chasing and assessing oil spill toxicity accurately: A novel approach
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An in situ exposure and effects tracking system was developed for assessing oil spills. This NOAA funded project is on-going and the preliminary technology is being tested in oil seeps near Santa Barbara, CA. The assessment tool combines two demonstrated systems, the SEA Ring (Sediment Ecotoxicity Assessment Ring, SERDP project ER-201130) and the Drifting Exposure (DrEx) Systems (under SERDP ER-201432). A combination of the in situ bioassay capabilities of the SEA Ring, and the tracking and sampling capabilities of the DrEx provide a robust approach that allows for real-time toxicity assessments at oil spill sites. The system is called the Drifting Exposure and Effects Assessment Ring (DEEAR) and comprised of a GPS float with iridium modem, the drifter drogue, the SEA Ring exposure system, and ancillary sensors and samplers. The DEEAR is a multi-system, pumping ambient water (and oil/dispersants if present) through organism exposure compartments, for up to two weeks. In addition, passive sampling devices, such as solid phase microextraction fibers (SPMEs) and polyethylene sampling devices (PEDs) can be placed within the exposure compartments to capture organic contami-
nants for laboratory analyses. It is equipped with a UV fluorescent sensor to identify the presence of oil compounds and verify whether or not the system is within the spill. The sensor responses are logged continuously during deployment with potential to interface to the Iridium modem and provide real-time monitoring. The system is being tested with a variety of invertebrates and early life stage fish. This technology may enhance future assessments to ascertain adverse toxicity of oils and dispersants in a more effective manner.

RP183 Oil toxicity evaluated in non-model organisms and by non-standard toxicity testing
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Open ocean oil spills necessitate evaluation of toxicity using pelagic organisms because they appear to be more sensitive than costal and standard model species used for toxicity testing. Understanding sublethal organ and cellular specific responses to oil exposure in these organisms will improve impact and risk assessment. It is currently unknown how ambient PAH and blood PAH concentrations are related in any aquatic organisms, making it difficult to assess exposure of individual organs and cells. Consequently, oil exposure studies on individual organs and isolated cells may be challenging to evaluate in the context of environmentally relevant PAH exposures. Circulating levels of PAHs are products of uptake and clearance from the blood stream, and the relationship between ambient and circulating levels will depend on the compound in question. In the present study, circulating PAHs in the blood of mahi-mahi (Coryphaena hippurus), a pelagic teleost fish, were quantified following a 24h exposure to dilutions of high-energy water accommodated fractions (HEWAF) of crude oil. Blood PAH concentrations were surprisingly high, and in many cases exceeded those of the exposure water. Further, PAHs in the blood were associated mainly with blood plasma proteins, rather than blood cells or plasma fluid. These results provide new perspectives on recent studies reporting effects of PAHs on isolated heart cells from mahi-mahi as well as bluefin tuna following exposures to HEWAFs in physiologi-
salines. For the first time, we are now able to relate environmental concentrations of PAHs to those affecting internal organs in marine
organisms and the results lend support to studies of isolated cell systems. This research was made possible by a grant from The Gulf of Mexico Research Initiative to the RECOVER consortium.

**RP184 Fluorescence monitoring for characterization and quantification of oil in various contaminated water samples for the study of oil fate and toxicity**

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Polycyclic aromatic compounds (PACs), including their alkylated forms, are among the most significant components of oil to be monitored in water following a spill. Recent reviews of oil toxicity testing have highlighted the need for monitoring concentrations of key oil contaminants in toxicity experiments. The conventional method for analysis of PACs in water is GC-MS, but results may not be available for weeks or months, and in a commercial lab may cost $300 to $700 per sample, compromising the number of samples that can be analyzed. We have developed a new fluorescence spectrophotometry method for analysis of oil-related PACs in water samples that provides rapid (hours), inexpensive (<$5 per sample) and quantitative results. It allows the routine analysis of hundreds of samples for detailed descriptions of PAC concentrations among treatments, over time, and between replicates, plus rapid feedback to adjust experimental conditions. The results can be calibrated by a small number of GC-MS analyses to provide a comprehensive analysis program for a project. Our method preserves water samples with ethanol to combine PACs in water, oil droplets, and particulates into a uniform liquid phase. This improves signal uniformity and increases fluorescence by 10-fold compared to fluorescence in water only. The simplest application is screening samples for PACs, where only samples above a threshold fluorescence signal are sent for GC-MS analysis, avoiding the waste of analytical resources on ‘non-detects’. The fluorescence spectrum can demonstrate deviations in PAC compositions between the original oil and water samples; water typically contains a higher proportion of low molecular weight PACs than oil. In cases where the water sample spectrum does not match the source oil, GC-MS results can be used to calibrate the fluorescence response to the actual PAC composition.

**RP185 Crude Oil and PAH Components Impact the Cholesterol Biosynthetic Pathway and Cardiac Development in Fish Embryos**

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In 2010, the Deepwater Horizon (DWH) oil operation released over three million barrels of crude oil into the Gulf of Mexico. The timing of the spill coincided with the spawning of many marine species in the region including mahi-mahi (Coryphaena hippurus). Previously, RNA-sequencing and subsequent mRNA analysis in oil-exposed mahi found a significant increase in the abundance of transcripts along the cholesterol biosynthetic pathway, including HMG-CoA reductase (HMGCR) and squalene synthase (FDFST) - enzymes key to cholesterol formation. Recent studies have also demonstrated a significant decrease in total cholesterol in mahi embryos treated with high energy water accommodated fractions of surface oil from DWH. Cholesterol is essential to maintaining membrane stability in eukaryotic cells, and disruption of this equilibrium may have implications for ion channel function in polycyclic aromatic hydrocarbon (PAH)-exposed cardiomyocytes. To better characterize mechanisms underlying oil-induced cholesterol declines, zebrafish embryos were exposed until 72 hours post-fertilization (hpf) to three concentrations of phenanthrene (a reference PAH), with subsequent qPCR analyses of HMGCR and FDFST as well as cholesterol-specific whole-mount immunohistochemistry. Imaging with fluorescence microscopy revealed a significant decrease in antibody-bound cholesterol (14.2% ± 0.6) in the larval body with an even greater reduction in the heart (43.6% ± 1.9). This reduction corresponded with phenanthrene-induced pericardial edema and bradycardia, as well as increased yolk size. Studies are currently underway to address whether the reduction in cholesterol observed at 72hpf is a result of the maldeveloped heart, which then impairs yolk utilization, or if changes in cholesterol may be impacting downstream development, including heart formation. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).

**Occurrence and Fate of Contaminants in the Environment: A Session in Honor of Dr. Derek Muir**

**RP186 How many chemicals in commerce have been determined in environmental media? A 40-year bibliographic analysis**

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An estimated three-hundred thousand chemical substances are inventoried and regulated globally, with thousands of new substances added to these registries each year. Despite the best efforts of environmental chemists over the past forty years, the number of chemicals detected in environmental media is poorly known, but can be estimated to be on the order of thousands while the number of routinely monitored chemicals is far smaller, hindering efforts to accurately assess chemical risk. To address the disparity between known and possible environmental contaminant chemical space, high-throughput and broad-spectrum unknown chemical screening approaches are now applied. Measuring progress in the detection of unexpected or previously unreported contaminants requires detailed and systematic analysis of previously reported contaminants, which remains lacking. Therefore, we have conducted a systematic review of contaminant occurrence reports in the scientific literature with the goal of defining and chemically classifying known environmental contaminant chemical space. We have constructed a comprehensive database of known contaminants by surveying the Chemical Abstracts Service CPlus database over the years 1978-2018 and leveraging metadata annotations to extract substances associated with analytical studies and occurrence in environmental media. The database query yielded 72,922 citations and 101,430 Chemical Abstracts Registry Numbers (CASRN). Removing duplicate CASRN gave 23,600 substances. Where possible, CASRN were parsed to discrete 2-D chemical structures and mapped to various commonly used chemical identifiers (e.g., InChI, InChI key, PubChem, DTXCID). Chemical structures or identifiers were then compared to publicly available chemical registries and inventories (e.g., REACH, TSCA, OECD, EPA IUR), chemical-class specific databases (e.g., DrugBank, Pesticide Action Network) and mass spectral libraries (e.g., NIST, MassBank). We highlight here results of on-going analysis focused on determining the link between chemical registries and databases and contaminant discovery, delineation of commonly occurring chemical use-classes and substructure motifs in known contaminant chemical space, and understanding structural determinants for detection and the impact of reporting on the subsequent detection of structurally related substances. Results will inform efforts to identify novel environmental contaminants through bottom-up analytical approaches and will highlight a useful framework for performing comprehensive retrospective analysis of scientific literature related to contaminant occurrence.
RP187 Compositional space: A guide for environmental chemists on the identification of persistent and bioaccumulative organics using mass spectrometry

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Since 2001, twenty-eight halogenated groups of persistent organic pollutants (POPs) have been banned or restricted by the Stockholm Convention. Identifying new POPs among the hundreds of thousands of anthropogenic chemicals is a major challenge that is increasingly being met by state-of-the-art mass spectrometry (MS). The first step to identification of a contaminant molecule (M) is the determination of the type and number of its constituent elements, viz. its elemental composition, from mass-to-charge (m/z) measurements and ratios of isotopic peaks (M+1, M+2 etc.). Not every combination of elements is possible. Boundaries exist in compositional space that divides feasible and improbable compositions as well as different chemical classes. This contribution explores the compositional space boundaries of persistent and bioaccumulative organics. A set of ~305,134 compounds (PubChem) was used to visualize the compositional space occupied by F, Cl, and Br compounds, as defined by m/z and isotope ratios. Persistent and bioaccumulative organics, identified by in silico screening of 22,049 commercial chemicals and 184,600 mixed halogenated alkanes, reside in more constrained regions characterized by a higher degree of halogenation. In contrast, boundaries surrounding non-halogenated chemicals could not be defined by composition alone. The use of sophisticated computational methods will be described to bridge this gap. Finally, a script tool (R code) was developed to select potential POPs from high resolution MS data. When applied to household dust (SRM 2585), this approach resulted in the discovery of previously unknown perfluoroalkyl flame retardants, viz. the ring-closed and decarboxylated analogues of 2,3,4,5-Tetrachloro-6-(3-(tridecafluorohexyl)sulfonyloxy)phenylaminocarbonylbenzoic acid (CAS: 68815-72-5). These were likely high volume chemicals used in the production of milk-white polycarbonate plastics used in computer cases and other electronics. Their ultimate fate may well be degradation into perfluoroalkyl sulfonic acids, which are notoriously persistent and bioaccumulative.

RP189 The Leaching of Additive-derived Flame Retardants (FRs) from Plastics in Avian Digestive Fluids: The Significant Risk of Highly Lipophilic FRs

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Plastics can be incidentally ingested by birds and can serve as sources of additive-derived environmental pollutants in birds. Many indigestible matrices, such as soil and sediment, are also ingested by many bird species. The bioaccessibility of environmental pollutants in co-existed plastic debris and other indigestible matrices for birds are still unclear. This study investigated the leaching of incorporated flame retardants (FRs) from different sizes of recycled acrylonitrile-butadiene-styrene (ABS) in avian digestive fluids, and explored the impact of co-ingested sediment on the leaching of FRs in digestive fluids. High levels of polybrominated diphenyl ethers (PBDEs) 153, 183, 197, and 209, 1,2-bis(2,4,6-trimethoxy)ethane (BTBPE), and decabromodiphenyl ethane (DBDPE) were detected in recycled ABS plastics. The positive and significant correlations between the leaching proportions and log KOW of FRs in ABS suggested that the ingested plastics incorporated with FRs might be important source of highly lipophilic FRs in birds. The leaching tests with mixtures of FRs incorporated plastics and sediment revealed that hexa- to deca-BDEs, BTBPE, and DBDPE were prone to migrate from plastics to sediment in the avian digestive tract, which led to less bioaccessible fractions of FRs in gut fluids. Thus, the findings in the present study provided insights into the transfer of additive-derived FRs from plastics to birds, and indicate the significant contribution of FR-incorporated plastics to bioaccumulation of highly lipophilic FRs.

RP190 Occurrence and distribution of organophosphate flame retardants in sediment and bivalves from Korean coastal waters

W. Choi, S. Lee, H. Lee, Hanyang University; H. Moon, Hanyang University / Marine Sciences and Convergence Engineering

Organophosphate flame retardants (OPFRs) are well-known alternatives of brominated flame retardants (BFRs); e.g., PBDEs and HBCDDs) regulated by domestic and global authorities. OPFRs have been highly consumed in industrial and commercial products as flame retardants and plasticizers. In this study, 18 OPFRs were measured in sediment and bivalve samples collected from 50 locations along the Korean coasts in 2016 to investigate occurrence, distribution, and a potential for bioaccumulation of these contaminants in coastal environment. Total concentrations of OPFRs in sediment and bivalves from all sampling locations ranged 0.67 to 346 (mean: 71.0) ng/g dry weight and from 1.60 to 203 (mean: 41.2) ng/g dry weight, respectively, indicating wide ranges of contamination status depending on the sampling site. Tris(1-chloro-2-propyl)phosphate (TCP) and tris(2-butoxyethyl)phosphate (TOEPO) were predominant contaminants in sediment samples, whereas TCP and tris(2-ethylhexyl)phosphate (TEHP) were predominant in bivalve samples. Highest concentrations of OPFRs were found in sediment and bivalves collected near industrial complexes and largest harbor zones, indicating potential contamination source of these contaminants in coastal environment. Significant correlations (r=0.389-0.884, p < 0.05) were found for nine OPFRs in sediment samples. Total organic carbon (TOC) in sediment was significantly correlated with individual OPFRs.
RP191 In Situ Microbial Degradation of PBDEs in Sediments Revealed by Positive Matrix Factorization and Compound-Specific Isotope Analysis

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Polybrominated diphenyl ethers (PBDEs) are a class of environmental pollutants that have frequently been detected in various environmental samples. However, little is known about the fate of these compounds, and in particular, about the microbial degradation potential in situ. In the present study, positive matrix factorization (PMF) and compound-specific isotope analysis were used to investigate the in situ biodegradation of PBDEs in sediment cores collected from a pond at an e-waste recycling site in South China. The potential microorganisms relevant to the degradation of PBDEs were also assessed to aid in the understanding of in situ biodegradation. The PMF results suggested that reductive debromination took place in the sediments. The debromination signal (ratio of the concentration of factor 5 (PMF result) to the total PBDE content) was positively correlated with the relative abundance of Dehalococcoidetes at different core depths. The clear 13C enrichment of five PBDE congeners positively correlated with the relative abundance of Dehalococcoidetes at different core depths. The clear 13C enrichment of five PBDE congeners with increasing core depth indicated that a measurable change in isotope fractionation might have occurred during PBDE biodegradation. The in situ biodegradation was further validated by the widespread detection of mono-BDE congeners (BDE 2, BDE 3) and diphenyl ether in the sediments. This study provides new evidence to enhance our understanding of the in situ biodegradation of PBDEs and suggests that the extensive removal of bromine from PBDEs was mediated by indigenous microorganisms at the e-waste site.

RP192 Anthropogenic and natural polybrominated diphenyl ethers of aerosols and marine fish liver samples: Implications for long-range transport and exposure

J. Bautista, Memorial University / Chemistry; N. Babichuk, Memorial University / Environmental and Occupational Health; A. Sarkar, Memorial University / Faculty of Medicine; C. Young, York University / Department of Chemistry

The usage of polybrominated diphenyl ethers (PBDE) as fire retardants in furniture and electronics have become a health concern. These species are known to act as endocrine disruptors. Recently, natural PBDE analogues produced from phytoplankton, blue mussels, and sponges have been discovered which may contribute to a greater PBDE pool. Methoxy- and hydroxy- PBDEs found in marine environments are identifiable among other environmental PBDEs and may have more significant health impacts than anthropogenic PBDEs. Previous work has assumed the impact of natural PBDE analogues is limited to ocean environments; however, PBDEs may also be transported into the atmosphere through the formation on marine aerosols. Hence, long range transport (LRT) may also be possible through the atmosphere, leading to exposure far from the ocean. The atmospheric fate and potential health impacts of these species depends on the aerosol size on which they are found. Size-selected marine aerosols were collected with a nano-Micro Orifice Uniform Deposition Impactor (nano-MOUDI) setup from a rooftop atmospheric site in St. John’s, Newfoundland (NL). Aerosols ranging from 10 nm to 10 um in diameter were sampled over a year to capture seasonal impacts. PBDEs can also undergo LRT through the oceanic migration of marine fish via the bioaccumulation within their livers. Known economic fishery staples of cod fish and Greenland halibut occupy different food webs and niches that may describe how PBDEs are distributed. Fish liver samples (2014) were taken around NL island from the Gulf of St. Lawrence and the open Atlantic Ocean. Samples were solvent extracted and analyzed using gas chromatography coupled to mass spectrometry (GC-MS). Temporal trends will be discussed in this session, as well as implications of aerosol concentrations and fish consumption to human exposure and long-range transport for both anthropogenic and natural PBDEs.

RP193 Understanding the photolysis of oxybenzone: Rates and degradation products

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Recently, much controversy has arisen over the use of sunscreens containing the active ingredient oxybenzone due to its reported potential adverse effects on coral. However, since most of the research on this compound has focused on its toxicological effects, comparatively little is known about its behavior and ultimate fate in the environment. Nevertheless, it is important to understand how and into what oxybenzone degrades in order to both better understand its persistence and prevalence in the environment. One of the major degradation pathways for organic compounds in surface waters is photodegradation. In this study the direct photolysis of oxybenzone was measured using a Suntest XXL® weathering chamber, which mimics sunlight, allowing for the study of oxybenzone’s behavior under more realistic environmental conditions than a typical UV reactor. In order to test for both direct photolysis and degradation mediated by other aquatic species, the test was carried out in deionized (DI) water, a sodium chloride salt solution, a nitrate salt solution, water with added dissolved organic matter, and seawater taken from Biscayne Bay. Samples were taken over a period of a week and analyzed using liquid chromatography-orbitrap mass spectrometry. Both the degradation of the parent compound and the formation of degradation products were monitored. After one week in the Suntest, oxybenzone in DI water did not show any significant degradation compared to a dark control, leading to the conclusion that direct photolysis is not an important mechanism for degradation of oxybenzone in the environment, and that its decay is most likely mediated by other reactive species in the water column.

RP194 A stratified multi-year European-wide voluntary product stewardship monitoring project to determine D4 and D5 in influents

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In January 2018, the European Union issued a REACH restriction on the use of octamethylcyclotetrasiloxane (D4) and decamethylcyclopenta- siloxane (D5) in wash-off personal care products (PCPs), with a 2-year phase-out period. The goal of the restriction is to reduce the amount of D4 and D5 released into the aquatic environment. The Silicone Industry in coordination with government agencies initiated a monitoring program to assess the amount of D4 and D5 being released to residential wastewater treatment plants (WWTPs). The field sampling and analytical methods used in this project are based upon protocols developed for the EPA Enforceable Consent Agreement (ECA) Siloxane Monitoring project on D4 (2014). After conducting a method validation process, an analytical procedure was established, which achieves sub-ppb detection levels. A quality control scheme ensures that sources of contamination or analyte losses are identified and minimized. Six WWTPs were selected across Europe, representing different use-patterns of PCPs. Three time
Polycyclic aromatic hydrocarbons (PAHs) are a group of toxic compounds in the environment. PACs sources in the environment include biogenic, petrogenic and pyrogenic and are generally a mixture of multiple sources mixed in environmental monitoring matrices. Most monitoring programs only analyze the PACs include the 16 EPA parent PACs. When including all other unsubstituted and substituted PACs, there are thousands of potential congeners which could be measured to assess both toxicity and source allocation. In this study, 59 river sediment samples obtained from across southern Alberta, Canada were analyzed by gas chromatography-tandem mass spectrometer (GC-MS/MS) and two-dimensional high-resolution time of flight mass spectrometry (GCxGCxHRToFMS) for comprehensive PAC chemical fingerprinting. Chemical fingerprinting helps distinguish between different sources of PAH in the environment. Data collected by these two techniques were statistically analyzed to determine the chemical patterns (fingerprints) of the predominant sources in the river systems. In addition to the conventional use of native PACs for source identification, patterns of individual alkyl PACs identified using the GCxGCxHRToFMS were also investigated to determine if additional source designation could be determined. Recent research has shown that these individual alkyl PACs can be more toxic than their unsubstituted analogs. Therefore, this information can aid in the evaluation of potential risk and used in risk assessment. Preliminary evaluation of data shows dominant petrogenic sources from coal type sources. In addition, we identified high creosote like signatures in samples collected from urban areas.

RP196 Chemical fingerprinting of polycyclic aromatic compound sources in sediments using gas chromatography high resolution time of flight mass spectrometer
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Polycyclic aromatic compounds (PACs) are ubiquitous contaminants in the environment and many of them have been identified as carcinogens. The associated toxicity of PACs makes monitoring and identification of sources of PACs in the environment important for assessing exposure to humans and wildlife. PACs sources in the environment include biogenic, petrogenic and pyrogenic and are generally a mixture of multiple sources...
RP198 Halogenated Phenolic Compounds in Wild Fish from Canadian Areas of Concern

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Concentrations of halogenated phenolic compounds were measured in the plasma of brown bullhead (Amietius nebulosus) from four Canadian Areas of Concern along the Detroit River-St. Lawrence River corridor, to assess exposure to suspected thyroid-disrupting chemicals. Hydroxylated PCBs (OH-PCBs) were detected in every sample collected in three of the AOCs; the detection frequency was lower in samples from the Detroit River AOC. The OH-PCBs most frequently detected were pentachloro, hexachloro, and heptachloro congeners, which are structurally similar to thyroid hormones. Pentachlorophenol (PCP) was detected at highest concentrations (1.8ng/g) in the plasma of fish from Prince Edward Bay, the Bay of Quinte Lake reference site, and Hillman Marsh (the Wheatley Harbour reference site), suggesting local sources of contamination. Elevated PCP concentrations were also detected in the plasma of brown bullhead from exposed sites in the Toronto and Region AOC (0.4-0.6ng/g). Triclosan was regularly detected in the Toronto and Region AOC (0.05-0.9 ng/g), consistent with wastewater emission. Greater concentrations were occasionally detected in the plasma of brown bullhead from the Bay of Quinte AOC. Concentrations of PBDEs were highest in the Toronto and Region AOC, and at two of the Bay of Quinte AOC exposed sites near Trenton and Belleville. Distribution patterns reflected the properties and usage of the compounds under investigation and the characteristics of each AOC.

RP199 Optimization and Validation of LC-MS Method for the Separation and Quantitation of Mixture of Seven Active Pharmaceutical Compounds

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Electrospray ionization liquid chromatography-mass spectrometry method was optimized and validated for separation of lamivudine(LVD), acetaminophen(ACM), vancomycin(VAN), ciprofloxacin(CPX), sulphotahemoxazole(SPZ), diclofenac(DCF), and ivermectin(IVT) all belonging to different therapeutic group. Mobile phase composition and ratio, mobile phase pH, flow rate, injection volume, and column oven temperature were optimized and tested. Optimum separation was achieved on a RP C18 column, (2.1x100 mm, 3 um), in a gradient stream mobile phases consisting of 0.1 % formic acid in Millipore water(A) and acetonitrile(B). The gradient program started with 5% B to 80% B in 12 min; then reducing to 50% in 14 min, followed by an increase to 65 % in 17 min, and finally down to 5 % in 19 mins. The optimum conditions for effective separation of the seven compounds were; 0.4 mL/min flow rate, 38øC column oven temperature and an injection volume of 1 µL. The MS analyses were performed in the positive electrospray ionization mode ESI (+) for all pharmaceuticals. Resolutions within the peaks were: 4.28, 1.26, 2.47, 3.31, 10.21, and 11.19 for LVD, ACM, VAN, CPX, SPZ, DCF and IVT respectively. Excellent linearity was observed for all of the standard calibration curves within a linear range of 0.01-1.00 ng/ µL and the correlation coefficients were above 0.99 (n=5). The sensitivity achieved for the method allowed for LODs(ng/ µL) ranging from 0.01(LVD) to 0.05(CPX) and their respective LOQs; 0.04 to 0.15. Intra and inter day analyses were used to define the method/instrument precision, which in all cases were ≤ 10 % (RSD, n=5).

RP200 Mercury and persistent organic contaminant trends in predatory fish and sediments in Great Slave Lake; climate and other drivers

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Great Slave Lake (GSL) is a core biomonitoring site under the Northern Contaminant Program, providing important information on concentrations and trends of mercury and persistent organic contaminants (POCs) in lake trout and burbot in a large subarctic Canadian lake. Both species are important in local subsistence fisheries and lake trout in the commercial and sport fisheries. Fish were caught from the West Basin (WB), which is a relatively productive due to the Slave River influence, and the East Arm (EA), which is less productive because of its deeper, low conductivity waters. Legacy POCs concentrations declined over 1993-2017, particularly HCH and DDT and as anticipated with reduced global usage. POCs declined at a more rapid rate in WB than EA fish where trends of decline were not statistically significant for many POCs. The higher rate of decline in the WB than EA fish may be related to the higher concentration of particulates in the former, which rapidly transported POCs to the lake floor reducing contaminant loss through the GSL outflow into the headwaters of the Mackenzie River. Similarly, POCs concentrations tended to be lower in WB fish than EA fish. In contrast, mercury concentrations were slightly higher in WB than EA fish, possibly because of mercury inputs from the Slave River and/or greater mercury methylation rates in the warmer waters of the WB. Mercury showed a general trend of increase, which was related to climate trends, primarily temperature, and increasing lake productivity, as evidenced from sediment core studies. Warming trends may also be impacting trends in POCs as compounds stored in the watershed, both in the immediate vicinity of Great Slave Lake and upstream in the developed regions of Saskatchewan, Alberta, and British Columbia and elsewhere, are mobilized and transported north through river and atmospheric pathways. While increasing productivity may reduce POC and mercury concentrations through growth biodilution, a richer forage-fish food base and enhanced mercury methylation rates may counteract this. Fish condition factor and stable isotope data are used to explore trends in fish growth and trophic feeding.

Fate and Effects of Metals: Biogeochemical Perspective

RP201 Developing and Testing RNA-Cleaving DNAzymes for Bioavailable Metal (Pb2+) Sensing

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The on-site and real-time detection of metal ions is important for environmental monitoring and risk assessment. For appropriate management decisions, it is necessary to specifically sense the bioavailable fraction of metal rather than total metal. DNA-based sensors (so called DNAzymes) are a promising new technology for possible bioavailable metal monitoring that have not yet been fully tested in real waters. In clean, buffered, laboratory waters specific DNAzymes interact with specific metal ions and produce signal (e.g., fluorescence) that can be used to determine total metal concentration. In more complex, natural, solutions it is likely that the free ion concentration is reduced by complexation (e.g., to dissolved organic matter, DOM) and the signal would not be proportional to total metal, but possibly proportional to the bioavailable fraction of total metal; i.e., the fraction of metal available to interact with the DNA. Our research utilizes an existing metal specific RNA-cleaving DNAzyme for Pb2+ (GR5) in test waters representative of natural solutions. In GR5 lead
acts as a specific co-factor in DNA catalyzing the cleavage of RNA-containing fluorogenic substrate. In these samples we systematically vary pH, calcium and DOM concentrations and assess changes in DNAzyme generated fluorescence signal compared to calculated lead speciation. Also, to directly compare to bioavailable lead, our new DNAzyme-based approach is applied to exposure solutions from Daphnia magna toxicity tests. Our testable hypothesis is that DNAzyme fluorescence responds to bioavailability if the dose-response curves for survival (y-axis) at various conditions collapse to one curve when the exposure (x-axis) is represented as the lead-specific DNA response, rather than total lead. After this assessment of DNAzyme responses in natural waters, it will be possible to start to develop tools for real-time, on-site detection of bioavailable metals. Funded by Global Water Futures.

RP202 Heavy Metals and Trace Metals Profile of Infertile Women and Women with History of Miscarriage in A Nigerian Population
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Extensive heavy metals exposure remains in developing economies such as Nigeria, where current environmental and industrial policies/regulations are not resolutely enforced. Regardless of signals that environmental heavy metals exposure may play important role in the pathogenesis of infertility and miscarriage in humans, it has been adequately investigated in human population from a developing economy like Nigeria. The aim of this study is to determine the role of blood Lead, Arsenic, Cadmium, Chromium and Mercury in development of infertility and miscarriage in Nigerian women. Blood Mercury, Arsenic, lead, Chromium and cadmium levels were determined by Atomic Absorption Spectrophotometry (AAS) in Twenty (20) infertile women and 20 women with history of miscarriage attending Gynaecological Clinic at IMSUTH Orlu, Imo State, Nigeria, who were age-matched with 20 female controls after obtaining their Informed Consent. Data obtained were subjected to Statistical Analysis using SPSS version 21. There were significant increases in blood Cd, Pb, As, Hg and Cr (p=0.000, p<0.000, p=0.034, p=0.000 and p=0.000 respectively), but no significant different in Al (p=0.163) in infertile women compared to controls. Blood Cd, Pb, As, Hg and Cr were significantly higher (p=0.000, p=0.000, p=0.031, p=0.018 and p=0.001 respectively) in miscarriage versus control. There was no significant difference in blood Al (p=0.163) in miscarriage compared to controls. The blood levels of Cd, Pb, As, and Hg were significantly higher (p=0.01, p=0.012, p=0.040 and p=0.010 respectively), in infertility compared to miscarriage. There were no significant differences in the blood chromium and aluminium (p=0.118, and p=0.163) in infertility compared to miscarriage. The blood levels of Zn, Cu, Se, Mn and Co were significantly lower (p=0.000, p=0.038, p=0.000, p=0.0003 and p=0.000 respectively) in infertile women compared to control. Blood Pb was significantly correlated with Cd and Al (r=0.493, p=0.027 and r=-0.590, p=0.006 respectively) in women with history of miscarriage. There were significant correlation of As with Hg, Cr and Al (r=0.648, p=0.002 and r=-0.454, p=0.044 respectively) in infertile women. Blood Zn was significantly correlated with Pb (r=0.675, p=0.001) in infertile women. Correlation of Se with Al was significant (r=-0.455, p=0.044) in infertile women. Cu was significantly correlated with As (r=-0.550, p=0.012) in infertile women. There was significant correlation of Cu with As and Cr (r=-0.523, p=0.018 and r=-0.528, p=0.017 respectively) in women with history of miscarriage. It appears that increases in blood heavy metals parallels decreases in trace metals in both female infertility and miscarriage, thus may be implicated in incidence of both disorders.

Toronto Flood Protection and River Building Project

RP203 Toxicological Assessment of Aquatic Receptors in Surface Water and Porewater
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Plans are underway to flood protect and revitalize underutilized brownfield lands in the Toronto Port Lands through re-naturalizing the mouth of the Don River and extending the river south and west; however, due to the former industrial use of the Port Lands, the planned river route and related redevelopment infrastructure traverse through a heavily contaminated area containing non-aqueous phase liquid, as well as other contaminants. As a result, an evaluation of potential risks to aquatic receptors from migration of groundwater-to-surface water and ground-water-to-porewater pathways was completed. The contaminant drivers identified for the evaluation were petroleum hydrocarbons (PHC) F1 and F2. Measured and predicted groundwater concentrations were compared to conservative ecological benchmark concentrations to identify risk to aquatic receptors. Based on the comparison, significant risk management measures, remedial activities, or both would be required to manage theoretical risks associated with groundwater contamination through these pathways. Therefore, the evaluation of these exposure pathways was refined through a bioassay study to provide additional lines of evidence to support the selection of an appropriate site-specific benchmark that would be protective of aquatic receptors following future predicted fate and transport. The toxicity testing involved collecting and testing groundwater from wells that exhibit worst-case PHC groundwater concentrations within 30 metres of the planned river route. These existing groundwater concentrations acted as surrogates for future surface water and porewater concentrations in the extended Don River. Based on the toxicity test results, site-specific groundwater ecological benchmarks for PHC F1 and PHC F2 were derived to be protective of the groundwater-to-surface water and groundwater-to-porewater exposure pathways. The benchmarks were initially identified as a range of target values based on the site-specific PHC mixture in groundwater. The range was proposed instead of a single bench-mark concentration, in order to account for uncertainties associated with the test procedures (for example, volatile groundwater concentrations, and consistency in groundwater sample handling during the bioassay). The benchmark ranges were then carried forward for further refinement through groundwater modeling and the design process. The final range recommended for PHC F1 was >143 to 1,400 μg/L and for PHC F2 was >335 to 802 μg/L.

Broadening the Scope of Chemical Assessments Using Toxicokinetic Data

RP204 Bioaccumulation of hydrophobic linear siloxane compounds in rainbow trout (Oncorhynchus mykiss)
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Given the wide use of hydrophobic siloxane compounds, more care is being taken by legislators around to globe to regulate any potential bioaccumulative and toxic substances in the environment. Likewise, the abundance of the global production of siloxanes demonstrates the importance of these bioaccumulation studies and how best to aid in the addition of the knowledge of how these compounds interact in the environment. Also, with the current guidelines set by government bodies, only one chemical is tested at a time. The present proposal aims to help prove the importance of chemical mixture studies in the hopes of showing the complex nature of a cocktail of chemicals within the environment and any given organism that comes in to contact with said chemicals. The main objective of this study has been to determine in vivo and in vitro biotransformation rates of various siloxanes in rainbow trout fish. Alongside these, concentration-dependent biotransformation will be assessed by
reviewing the depuration rate constant over time at varying concentrations to determine if $K_1$ is dependent on the concentration of siloxanes within the organism. Preliminary results have shown varying results between the cyclic and linear siloxanes. Specific plans for these studies are as follows: (1) run individual siloxane exposures to juvenile rainbow trout fish (D4, D5, D6, L3, L4, L5) at a concentration of 4.5 mM siloxane/g food for and update duration lasting 21 days. Since the depuration rates for the cyclical siloxanes are very slow, and through previous work done in our lab, this high concentration should suffice to represent a depuration rate value, this will also save time and cost for the project. Also, the depuration phase will be extended out further than that of the linear siloxanes. (2) After analysis of linear samples have been completed, subsequent studies will be run at lower and varying concentration to determine if depuration rates are concentration-dependent. (3) The final in vivo experiment will be run as a mixture of all 6 siloxane compounds at various concentrations to determine if the presence of multiple compounds will alter the depuration rate of other compounds.

**RP205 Assessment of in vitro intrinsic clearance and the prediction of bioaccumulation for plant protection products**

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The potential use of in vitro methodologies to predict the bioaccumulation of chemicals in fish is of particular interest to the scientific community. Recent mandates in the European Union and other geographies to reduce the number of vertebrate organisms used in regulatory testing have spurred the investigation and development of in vitro methods to predict fish bioaccumulation (e.g., OECD Guideline 319A, Determination of in vitro intrinsic clearance using cryopreserved rainbow trout hepatocytes). However, at present, there is still a lack of data regarding the ability of the methodology to predict bioaccumulation in whole fish. We investigated numerous plant protection products across multiple classes of chemistry and modes of action to determine if the in vitro - in vivo extrapolation is possible. Results indicate that the in vitro intrinsic clearance method based entirely on liver metabolism tends to over-predict fish bioaccumulation. However, this result was not unexpected since there are multiple pathways in which a fish could metabolize an exogenous compound. Overall, the in vitro intrinsic clearance method using rainbow trout hepatocytes does present a promising alternative method to the in vivo fish bioaccumulation study for the eight plant protection products assessed. A better understanding of the other sites of metabolism need to be better investigated and understood to better predict bioaccumulation in fish.

**RP206 CBD = Cannabinoid Biotransformation Discoveries: Towards an understanding of cannabinoids (CBD) biotransformation in fish using in vitro technologies**


Biotransformation of chemicals using in vitro technologies is increasing and essential to chemical risk assessment. In vitro technologies such as those described in the OECD TG 319A and 319B using trout liver subcellular fractions and cells can be applied to test metabolism, determine a Bioconcentration Factor (BCF) and identify metabolites of the different cannabinoids. Acceptance and legalization of industrial hemp, cannabinoids (CBD and THC) and marijuana is rapidly growing in North American countries and around the world. In many instances, new regulations will be considered and implemented after the fact. Likewise, in vitro technologies to test chemicals for risk assessment is increasing and widely accepted due to the reduction in the use of number of animals, cost and time of experimentation. While CBD has brought to light benefits in treating human ailments, there is notable lack of discussion around the environmental impact that these compounds will bring on the environment and freshwater supplies in many areas worldwide including North America. There is a need for more research to fill the information gaps that haven’t been covered due to the previous illegal status of these compounds. Freshwater treatments updates will need to be in place in order to keep up with the cannabinoids and metabolism products. However, before these can be implemented, the objectives of our initial studies are to understand basic cannabinoids metabolism, in particular CBD. Using the fish liver S9 and hepatocyte in vitrometabolism technology in different species of fish including trout will help better understand potential impact in aquatic environments. The main objectives of this project are to expose trout liver S9 factions and cryopreserved hepatocytes with CBD and determine if there is: a- metabolism and the extent of it (metabolic rate) in trout and b- differential metabolism of the different cannabinoids. Hatchery raised rainbow trout were maintained at 13°C. Fish were acclimated to laboratory conditions (1 month), euthanized and livers were perfused with a saline buffer (HBSS) at pH 7.8. After each perfusion, liver S9 factions and cryopreserved hepatocytes were prepared following protocols established for rainbow trout. CBD was then exposed to the biological material and incubations performed at different times and conditions according to the OECD TG 319A and 319B. Cannabinoid analyses is ongoing and conducted using chromatographic methodologies.

**RP207 Biotransformation of chemicals in different species using in vitro metabolism approaches**

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Biotransformation of chemicals in different species is relevant in bioaccumulation assessment and is an area that requires research. Recently, OECD Test Guidelines (TGs) 319A and 319B were approved for in vitrometabolism assessment of chemicals using rainbow trout liver S9 and cryopreserved hepatocytes for chemical risk assessment. Although these TGs were developed using rainbow trout, the methodology can be adapted and used across species. Aquatic and terrestrial organisms display a wide range of feeding modes, reproductive strategies and live in variety of environments. For the present study we used liver S9 sub-cellular fractions from a variety of organisms including aquatic (rainbow and brown trout, Siberian sturgeon, bowfin, carp, alligator gar and American alligator) and terrestrial (rat, mouse, monkey and human). We compared fish species that inhabit different environments such as the alligator gar that resides in high temperature waters (> 30°C) with low DO, and a wide range of salinities to rainbow trout, the reference fish for in vivom and in vitrometabolism and bioaccumulation studies. Trout, sturgeon, gar and alligator were maintained for 2 to 4 weeks under corresponding natural temperature and photoperiod regimes prior to euthanasia and liver S9 preparation. Bowfin were obtained from the field and rat, mouse, monkey and human liver S9 sub-cellular fractions were acquired from commercial sources. Fish were euthanized and livers perfused with a buffered clearing solution (pH = 7.8), excised, homogenized, and centrifuged to obtain liver S9 according to the OECD TG 319B. Liver S9 fractions of the different fishes were used in metabolism studies with a pharmaceutical (diclofenac), pyrene (PAH), a pesticide and to determine conventional enzyme activities (EROD, GST). Alligator gar and bowfin EROD and GST activities were similar to rainbow trout and exhibited significant metabolism of pharmaceuticals such as diclofenac. Alligator (reptile) did not metabolize pyrene as expected. The highest pyrene metabolic activity was observed in human and mouse S9. Ancient fishes such as alligator gar and bowfin diverged from the teleost evolutionary line prior to the teleost genome duplication (TGD), thus these ancient fishes may possess unique adaptations to cope with xenobiotics. This is an ongoing study and other species of regulatory importance such as the bluegill, carp and largemouth bass will be included.
Environmental Risk Assessment of Pharmaceuticals: Connecting Across Disciplines

RP211 Occurrence of fluoroquinolones drugs residues in river water by liquid chromatography

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Antimicrobials are an important class of pharmaceuticals that have been found in natural water and fluoroquinolones (FQs) are an example of this group. FQs antibiotics are widely used in the treatment of infectious diseases, to improve livestock growth and in the aquaculture. They can reach the environment through untreated wastewater, animal excreta, disposal of unused drugs or by the direct discharge of aquaculture products. Even in trace quantities, they are able to impact the aquatic systems because they are toxic and may result in bacterial resistance. In view of this problem, the purpose of this study is to investigate the occurrence of FQs residues such as levofloxacin (LEV), ciprofloxacin (CIP) and norfloxacin (NOR) in Anil River, located in Sao Luis, Maranhao, Brazil. The research was developed at Federal Institute of Maranhao, using samples of surface water collected on May and December 2017 from river in different days and in two sites (A and B), according to National Water Agency (ANA) recommendations, stored in amber glass bottles and refrigerated at 2°C for 24h. Before being analyzed, the pH were adjusted to 3 with H3PO4, afterward the samples were filtered and prepared by solid-phase extraction process with HLB® Oasis cartridges. The obtained extract was evaporated to dryness using nitrogen and then reconstituted in mobile phase used on chromatographic process. The analyses were performed on a Shimadzu LC20-AT high performance liquid chromatograph equipped with a Shimadzu RF-20A fluorescence detector, using a Luna C18 column (250mm x 4.6mm; 5μm), flow rate 1.2mL/min, temperature column at 35°C, excitation wavelength of 280nm and emission wavelength of 450nm, mobile phase was methanol and buffer (0.04M NaHPO4, pH 3) in gradient mode. All samples revealed contamination by at least one of FQs in a range of concentrations 15.8-100.6 μg.L-1 (LEV), 11.4-112.7 μg.L-1 (CIP) and 10.3-67.7 μg.L-1 (NOR). LEV was not found on site A, NOR was detected in all samples and CIP was present in May on both places and only on place A in December. The presence of LEV, CIP and NOR antibiotics confirms the contamination on Anil River by domestic sewage, because these drugs are widely used in several types of human infections. The result demonstrates the importance of effective actions against contamination on rivers by domestic sewage, since they could have compounds such as FQs, that may cause a strong negative impact to aquatic organisms.
RP212 Occurrence of antibiotics and related resistance genes in the feed and in the digestate of biogas plants


Manure is commonly used to feed biogas plants in the aim of the energetic valorisation of organic waste. Despite the several advantages offered by this practice, a new environmental concern could emerge. In fact, antibiotics are frequently used in livestock farming and a notable fraction of these chemicals is mostly excreted in unchanged and/or as active metabolites in animal waste. The residual antibiotics that persist after the biogas production can act as environmental contaminants when the digestate is used as soil fertilizers: they can have biocidal effects on susceptible natural microbial populations and/or promote the resistance gene spread. The AZeR0 Project (AOA) is a three-year joint collaboration between the Water Research Institute of the National Research Council (CNR-IRSA, Italy) and the lab of Biomass and Biotechnologies for Energy of the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA, Italy). Its main objectives are: 1) to assess the occurrence of some of the mostly used veterinary antibiotics (e.g. sulfamethoxazole-SMX and ciprofloxacin-CIP) in cattle manure and digestate; 2) to study the kinetics of antibiotic biodegradation during the anaerobic digestion process; 3) to evaluate the antibiotics degradation in aerobic conditions, once the digestate is spread on soil. Feed and digestate samples were collected from various livestock farms equipped with biogas plants in the Lazio Region (Italy). They were analysed in order to verify the occurrence of residual SMX and CIP concentrations by liquid chromatography couples with MS-MS detection, to evaluate the structure and composition of the natural microbial community and to detect the presence of resistance genes (e.g. sul1, sul2, sul3, intI1) by qPCR. The preliminary results showed that SMX and CIP occurred both in cattle manure and digestate. CIP was found at higher concentrations (1 - 7 mg/kg soil) than SMX (0.04-0.25 mg/kg soil) confirming its higher environmental persistence. Resistance genes sul1, sul2 and the proxy intI1 were detected both in cattle manure and digestate. A significant correlation between sul1 and intI1 presence was found.

RP213 Updates to the proposed Canadian framework for the environmental risk assessment of active ingredients in drugs and addition of cumulative trigger

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Currently, manufacturers and importers of active ingredients in drugs must notify under the New Substances Notification Regulations: Chemicals and Polymers or the New Substances Notification Regulations: Organisms (collectively the NSNRs) under the Canadian Environmental Protection Act, 1999 in order for the Government of Canada to conduct an environmental risk assessment. However, there are concerns and gaps within the current NSNR system for active ingredients in drugs which Health Canada wishes to address. As a result, a new proposed Canadian regulatory framework is being developed specifically for active ingredients in human and veterinary drugs regulated by the Food and Drugs Act to assess risks to the environment and to human health resulting from environmental exposure. Under this proposal, active ingredients in drugs would be subject to notification and assessment at three different stages (i.e. import/manufacture, investigational uses - for organisms only - and at market authorization). Health Canada has recently updated the proposal based on valuable feedback received from industry stakeholders via a Cost-benefit Analysis Survey that was distributed in 2018. The changes focus on further streamlining the proposal with a view to decreasing potential costs to both industry and government and to address concerns and gaps identified by industry. This presentation will describe these changes, with an emphasis on how the changes to the notification requirements at the import/manufacture stage will enable Health Canada to conduct cumulative assessments on active ingredients in drugs across the industry. The purpose will be to obtain feedback from international counterparts, industry stakeholders and meeting attendees, on the most current modifications to Health Canada’s regulatory proposal for environmental risk assessment of active ingredients in drugs.

RP214 Quorum sensing inhibitors attenuate the antibiotic-induced bacterial resistance mutation

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The indiscriminate use of antibiotics has exacerbated the emergence and spread of antibiotic resistance genes (ARGs), which is seriously threatening global public health. Quorum sensing inhibitors (QSIs) are attractive alternatives to antibiotics due to their inhibitory properties on bacterial pathogenicity and the advantage of not developing resistance. While QSIs have broad prospects of application, their potentials in affecting the emergence of ARGs in bacteria were hardly studied. In this work, we investigated two representatives of QSIs, i.e., cinnamaldehyde (CIN) and 4-nitropyridine-N-oxide (NPNO), for their effects on the antibiotic-induced mutation of E. coli against rifampicin. The antibacterial activities of the two QSIs and tetracycline (TET) and chloramphenicol (CHL) were examined by bacterial growth inhibition tests using 96-well plates, then the mutation rates of E. coli exposed to QSIs, antibiotics, and their combinations were determined at sub-inhibitory concentrations using Luria-Delbruck protocol (p0 method). It was found that the antibiotics at sub-inhibitory concentrations stimulated the resistance mutation of E. coli, with mutation rates significantly higher than those of the spontaneous mutations. On the contrary, QSIs alone induced a slight decrease in the mutation rates of E. coli. With respect to the combined exposures, QSIs exhibited remarkable antagonistic effects on the antibiotic-induced mutations, with mutation rates reduced by 75% in some cases. Our research revealed the capacity of QSIs to attenuate the antibiotic-induced resistance mutation of bacteria, which is likely a common property for QSIs. Since resistance mutation is a major approach for the emergence of ARGs, the replacement of antibiotics with QSIs may provide an opportunity to prevent the emergence and spread of ARGs.

RP215 Nonsteroidal Anti-inflammatory Drugs Manufacturing Industry Effluent Induced Malformations on Xenopus laevis

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Over the past decade the presence of pharmaceuticals has been detected in bodies of water, on concentrations of ng/L-mg/L. Industrial effluents are one of the main sources of emerging pollutants such as pharmaceuticals to waste water treatment plants as well as bodies of water, the group of NSAIDs is one of the most widely consumed worldwide and therefore its production is high as well as the elimination of waste that comes from its manufacture; usually waste water treatment plants installed in industries are not able to remove all the residues that results of the production of pharmaceuticals so these elimination products can reach water bodies and get in contact with aquatic organisms, inducing adverse effects such as oxidative stress, genotoxicity, cytotoxicity to name some. The main objective was to demonstrate the toxic potential of a NSAID manufacturing industry effluent. FETAX assay was carried out, for which 20 Xenopus laevis frog oocytes were exposed in medium blastula stage for each exposure group at concentrations of 0, 0.1, 0.2, 0.4, 0.8, 1.5, 3%, it was carried out in triplicate, the oocytes were kept at a constant temperature 21±2°C.
during 96 h, until they reached stage 46 or larval stage, CL50, CE50 for malformations as well as the determination of the MCIG were obtained as well as the evaluation of the abnormalities. Several malformations were observed, highlighting: cardiac and facial edema, microcephaly and axial malformations, in addition to a remarkable growth inhibition at a concentration of 0.1% and a teratogenic index of 2.60, which indicates that this effluent is a mixture with teratogenic potential for Xenopus laevis and probably can generate adverse effects in other aquatic organisms.

**RP216 Non-target dung fauna population model to evaluate environmental impacts following use of an active pharmaceutical ingredient (API) in cattle**

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Regulatory approval of veterinary medicinal products requires an effects assessment of the use of these products on the environment. Dung fauna are one group of organisms potentially affected by drug residues excreted into the environment from treated cattle. Adverse effects to the dung fauna community could have direct negative consequences for ecosystem function and services such as dung degradation, and be indicative of effects to other non-target organisms. We developed a matrix population model of the widespread yellow dung fly (Scathophaga stercoraria) to evaluate population-level effects of API residual levels in dung pats following treatment of cattle. The objective was to evaluate whether effects on the yellow dung fly population could be mitigated by a treatment regime which creates “dung refugia” by leaving a portion of a herd untreated. The novel feature of this matrix model was that it evaluated the extended period during which relevant insecticidal concentrations would be excreted after treatment. The model incorporated both the changing concentration of API in dung over a summer grazing season, as well as temperature-dependent life-history parameters of yellow dung fly populations. Model simulations evaluated the potential for long-term population maintenance of yellow dung fly when treating different percentages of the cattle herd while also incorporating variability in life-history parameters. Key population predictions and parameters derived from the population model in the absence of API inputs were verified with independent population data from the literature. The model accurately estimated the adult survival probability compared to survival rates derived from stage-class data. The model was also able to replicate population data across two growing seasons based on initial conditions. The presence of dung refugia consistently supported populations of the yellow dung fly within a single growing season as well as supported long-term maintenance of yellow dung fly populations. The ability of the model to capture observed population dynamics and simulate the efficacy of dung refugia supports using this approach to evaluate non-target effects. The results from this type of modeling can be used to support veterinary medicinal product submissions to allow for regulatory decisions regarding appropriate management strategies for their use in the practice.

**Environmental Radiation Sciences**

**RP217 Uranium Concentrations In Soil And Vegetation Near A Uranium Processing Facility**

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Accuracy of any environmental risk assessment is highly dependent on the quality of the data used in mathematical models designed to predict contaminant behaviour in various environmental compartments. Canadian Nuclear Safety Commission (CNSC) has raised concerns regarding the validity of some generic (not site-specific) parameters used for modeling the long-term behaviour of uranium in soil and its transfer from soil to vegetation near a uranium process ion facility. To address the CNSC concerns, a soil characterization study was carried out near the facility in areas associated with the highest expected air concentrations of uranium and uranium deposition rates and available to the public. The measured uranium concentrations in soil and vegetation and the location-specific soil model parameters were used to estimate future long-term uranium soil concentrations to confirm that uranium would not accumulate to levels that may be a concern for human health or the environment.

**RP218 Quantifying historical releases and ambient levels of metals and radionuclides near decommissioned uranium mine sites**

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Assessing recovery of aquatic ecosystems affected by mining operations requires knowledge of ambient levels of radionuclides and metals before initiation of activities. However, such ambient levels of pre-existing conditions are often not available for many mining operations initiated decades ago. The objective of this study was to quantify historical releases of radionuclides and metals and derive their ambient pre-operation levels. For this purpose, we obtained two sedimentary profiles in a harbour downstream of an impacted river and collected water and surface sediment samples every 2.5 km over 120 km along an impacted river and 220 km along an adjacent, non-impacted river. Using a gamma pulse from atomic bomb fallout in 1963, our sedimentary core profiles accurately reflected releases from the uranium mining operation from its onset in 1955 to its closure in 1993. Using sedimentary core profiles and comparisons of 48 water and sediment samples collected within an impacted river to 89 water and sediment samples collected in an un-impacted river, we derived ambient levels of metals and radionuclides in water and sediment of lakes and rivers. Ambient water concentrations in lakes and rivers were similar at pH of 6.78, 10 mBq 226Ra/L, and 2.5 µg U/L. We measured ambient levels in lake sediments at 107 mBq 210Po/g, 0.3 mBq 210Pb/g, 116 mBq 226Ra/g, 126 mBq 228Th/g, 97 mBq 230Th/g, and 122 mBq 232Th/g, as well as 67 µg Cu/g, 56 µg Ni/g, 65 µg Pb/g, 11 µg U/g and 1 µg Zn/g. River sediment levels were consistently lower than lake sediments. Our study provides a framework to reconstruct historical releases and obtain ambient levels of contaminant helpful in identifying contaminant of potential concern and to assess recovery of aquatic ecosystems.

**RP219 Radiation Dose Assessment for Fossil Groundwaters in the Nubian Aquifer, Egypt**

M.J. Sherif, N. Sturchio, University of Delaware / Earth Sciences

The Nubian Sandstone Aquifer System (NSAS) in hyperarid Northeast Africa and the Middle East is a huge water resource of inestimable value to the population for agricultural and domestic use. However, natural radioactivity affects Nubian aquifer groundwater quality throughout the region, posing a threat to the health of millions of people. Long-lived radium isotopes (226Ra and 228Ra) were measured by HPGe gamma spectrometry in 64 groundwater samples from deep NSAS wells in oasis areas of the Western Desert of Egypt. More than 80% of these samples had total Ra activities (226Ra + 228Ra) in excess of the maximum contaminant level (MCL) of the US Environmental Protection Agency (EPA), the European Union (EU), and the World Health Organization (WHO) for Ra in drinking water. Activities up to 2500% of the MCL for total Ra were measured in some locations. The highest Ra activities occur where groundwaters are anoxic and have the longest residence times. The annual radiation doses to humans from Ra via daily ingestion of Nubian aquifer water were calculated for different ages and compared to the Individual Dose Criterion (IDC) of the World Health Organization (WHO). The annual dose for an infant ingesting 0.5 L/day could be up to 14 mSv/year, and for an adult (2 L/day) it could be up to 1.43 mSv/year. These results indicate that groundwater from the NSAS in the Western Desert of Egypt should be used with caution, and Ra removal may be necessary in some locations before water is used for human consumption. Effects on the food chain of Ra accumulation in soils irrigated by Nubian aquifer water should be examined further for its additional exposure potential.
**RP220 Level of Environmental Perturbation and its Health Impact in Imiringi community, Bayelsa State, Nigeria**

_U. Anekwe, Federal University Otuoke_

Environmental perturbation level and its Health Impact have been analyzed in Imiringi community in Ogbia local government area. An in situ measurement approach of background ionizing radiation (BIR) was adopted. The mean exposure rate ranged from 14 to 32μR/h with an average value of μ23Rh-1 showing that the environment has been degraded. Dose rate and equivalent dose rate ranged from 121.8 to 278.4nGyh-1 and 0.45 mSvy-1 respectively. The mean value of the indoor annual effective dose equivalent (AED), outdoor AED, and excess lifetime cancer risk (ELCR) were computed to be 0.936 mSvy-1, 0.312 mSvy-1 and 0.810 x 10-3 respectively. Analysis of dose to human organs; testes and ovaries, showed that they received 0.66 and 0.45 mSvy-1 respectively and this condition suggested that elevated background radiation may not contribute to problem of infertility in this particular area. The indoor and outdoor AED were within the permissible value of 1.0 mSvy-1 for general public and below the limit of 20 mSvy-1 for radiological workers as recommended by ICRP whereas exposure rate, dose rate and ELCR exceeded the recommended values. The perturbation recorded in this environment may be attributed to the oil and gas activities such as hydrocarbon drilling, gas flaring, presence of turbines, flow stations, crude oil pipelines and incidents of crude oil spills. It is therefore advisable that the operators of the existing facilities should take proactive measures to forestall sudden elevation of ionizing radiation that may result to health challenge amongst native dwellers.

**RP221 Impact of 17-α ethinylestradiol and phosphorus-32 on Arabidopsis thaliana seed development**

_L. Manglass, Clemson University / Environmental Engineering and Earth Science; C. Vogel, P. Zhou, C. Eimen, Clemson University; N. Martinez, Clemson University / Environmental Engineering and Earth Sciences_

Synthetic estrogens such as 17-α ethinylestradiol (EE2) and short-lived radionuclides are found in wastewater effluent from sewage treatment as they are not efficiently removed during the treatment process. While the toxicological mechanisms and impact of estrogen on the environment are not entirely defined, estrogen contamination in wastewater has demonstrated impacts on growth and development of ecosystem biota. Furthermore, EE2 is more persistent in the environment than natural estrogen. Radionuclides used in nuclear medicine for the treatment and diagnosis of diseases are also released to the environment via waste-water treatment effluent because, like EE2, they are primarily excreted through urine. While radionuclides used for nuclear medicine have short half-lives such that they should only remain the environment after release for a short duration (a few weeks or less), the increased popularity of nuclear medicine procedures may result in a consistent release of radionuclides to environmental systems near effluent release points. Generally, the existing literature on multiple stressor studies between radiological and non-radiological contaminants is sparse, and studies specifically comparing estrogen and ionizing radiation are focused on human health, not environmental impact. In this study, root length assays on *Arabidopsis thaliana* seeds were conducted for 10 days on agar plates to examine the impact of EE2 and ionizing radiation both individually and in combination. Environmentally relevant concentrations of EE2 in the range of 0.5-40 ng/L were used with phosphorus-32 at dose rates in the range 10 mGy/day with both contaminants incorporated directly into the growth media. Endpoints assessed include root length, rosette development, and germination rate. The results of this study suggest that the introduction of EE2 into growth media induces early germination and faster root growth in *A. thaliana* seeds, where the addition of phosphorus-32 may have a synergistic effect that amplifies the impact on root length.

**RP222 Effects of Ionizing Radiation on Heart Rate, Instar Development, and Swimming Behavior in Daphnia pulex**

_S. Ladney, California State Polytechnic University, Pomona / Biological Sciences_

Anthropogenic activities in the manufacturing and nuclear industries are responsible for the exposure of aquatic organisms to toxic chemicals. In aquatic ecosystems, the microcrustacean Daphnia is essential to sustaining larger organisms within the aquatic food web. It is also an ideal model organism in ecotoxicology, ecology, and evolutionary biology due to its short generation time, asexual reproductions and phenotypic plasticity. Mutagenic agents, such as ionizing radiation, are comprised of ionized radioactive particles that are emitted in electromagnetic waves. These electromagnetic waves can elicit a cascade of negative effects that impact the survivability and individual fitness of Daphnia by disrupting critical cellular processes. To better understand how these contaminants affect aquatic systems, this study is designed to explore the behavior and development of *D. pulex* in the presence of low-dose ionizing gamma radiation across two generations. Four groups containing 30 female Daphnia from the parent generation will be exposed to 0, 10, 100, 1000 mGy of acute gamma radiation. Recent studies provided strong evidence that there are transgenerational effects within irradiated daphnids. Exposure to such contaminants have been found to cause physiological stress and compromised fertility, and even increased mortality. We hypothesize higher irradiation levels can negatively affect the cardiac output and fertility of the parent generation, which could affect the fecundity and performance of the subsequent generation. Once the parent generation has given birth, the heart rate, antennae growth, and instar development of the offspring will be monitored via live imaging analysis. Our results will test how radioactive toxicants influence the health and behavior of aquatic model organisms. Such knowledge will provide a better understanding of how these organisms are affected and how they respond when exposed to such environmental pollutants.

**RP223 Addressing Sustainability Needs with Isothiazolinone Chemistry: The favorable environmental profile of DCOIT**

_C. Britton, D.M. Laganella, I. Watt, DuPont / Microbial Control_

In critical end-uses such as wood preservation and antifouling paints, pesticides are required to meet highly stringent product stewardship and regulatory assessment standards. Ideally, sustainable preservatives should be highly efficacious to control a broad spectrum of target organisms while posing minimal risk to non-target organisms and the environment. Where environmental exposure can be predicted either during manufacturing or service life, subsequent leaching and ultimate environmental fate are key factors that must be considered if a chemical is to be truly considered sustainable. The organic, non-metal-based active ingredient 4,5-Dichloro-2-octylisothiazol-3(2H)-one (DCOIT), currently used in many environmentally-sensitive preservation applications globally, meets all of these requirements. By examining key aspects of DCOIT’s environmental toxicology, fate (e.g., biodegradation, soil mobility) and ultimate impact (i.e., risk) in various practical applications, we demonstrate the important role that DCOIT can play to deliver environmentally sustainable solutions.
RP224 Comparing relative efficacies of granulated activated carbon and biochar to reduce the loading and toxicity of pesticides in vegetated ditch systems

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Vegetated treatment systems significantly reduce pesticide loads in agricultural runoff. Previous studies have shown that the addition of granulated activated carbon (GAC) as a final filtration treatment can further reduce pesticide loading. Laboratory studies suggest biochar is an equally effective carbon material and a potentially more cost-effective and convenient alternative to GAC. This study evaluated the efficacy of a grass-lined ditch with carbon installations of GAC or biochar to reduce toxicity and concentrations of imidacloprid and permethrin in simulated irrigation runoff. A 180-meter section of ditch grown with red fescue was evaluated. The V-shaped ditch was five meters wide and one meter deep. Biochar or GAC was placed at the bottom of the ditch in one-meter long geotextile mesh sleeves. Simulated irrigation water was introduced to the ditch at a rate of 4.75 L/s. Toxicity and chemical concentrations were measured at the input, before the carbon filtration, and at the output. Toxicity was evaluated using water column exposures with the amphipod Hyalella azteca, and the midge Chironomus dilutus. Although toxicity to C. dilutus was reduced or removed more often than toxicity to H. azteca, results indicate that both carbon types were equally effective. Preliminary results show chemical concentrations were reduced by an average of >90%. This study further demonstrates the utility of using GAC in field-based treatment systems, as well as the potential for biochar as an equally effective substitute.

RP225 Sources, characteristics and opportunities for pesticide use and usage information applied to listed species risk assessment

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The challenges inherent in national-level pesticide endangered species risk assessments are many, varied and have been the topic of meetings, workshops, presentations and publications for many years. One challenge is the identification and incorporation of pesticide usage information in the risk assessment process. Pesticide “usage” differs from pesticide “use,” where “use” is defined by registered labels and describes limits on how the pesticide may be applied (i.e., maximum rates and number of applications), while “usage” describes documented applications with specific information on each individual event. Incorporating usage information into the risk characterization during the Biological Evaluation and Biological Opinion development process is an area of renewed interest. This poster will describe several sources of pesticide usage information (e.g., USDA Agricultural Chemical Use Program, CA DPR Pesticide Use Reporting), and how relevant field-level pesticide application information can be extracted. Examples will be given showing how these data can be utilized to refine our understanding of specific active ingredients and their associated spatial and temporal variation across use areas, and how this can inform the exposure analysis within each Step of the ESA consultation process.

Different Knowledge Systems, One Vision: Stories of Braiding Indigenous Knowledge and Western Science in Environmental Assessment and Management

RP226 Relationships 101: How understanding local protocols can help shape research and relationships

E. Hayward, Trent University / Environmental and Life Sciences

Moving towards research and environmental problem solving that involves Indigenous peoples requires a thorough understanding of colonial histories and legalities of the lands your research is taking place on. These shared histories have a large influence on the success of partnerships with Indigenous Peoples and communities, but often there is limited opportunity for researchers wanting to become involved in this type of work to become educated in this field. Within Canada, Indigenous peoples and our traditional territories continue to be governed by our own official governments and governing systems which hold the Law of Nature at the core of all decision-making processes. This has significant influence on environmental decision making and values within our communities. This presentation will give a brief introduction to two local Indigenous governing systems (Haudenosaunee and Anishinabek), as well as how the Indian Act has limited the way local Indigenous peoples may continue our responsibility as caretakers of the land. Many Indigenous peoples are registered as Aboriginal people under the ‘Indian Act’ of Canada and are limited by its wide-ranging control of everyday life. Understanding the way this act impacts our respective Nations and continued systems of governance, and our ability to uphold the Law of Nature, is fundamental to becoming aware of local community protocols for the development of relationships and the sharing of knowledge.

RP227 Towards effective First Nations’ source water protection: A technical and Indigenous Knowledge collaboration

R. Marshall, University of Guelph; M. Desjardine, Chippewas of Nawash Unceded First Nation; J. Levison, S. Gharaabaghi, University of Guelph

First Nations in Ontario face complex water management issues that put them at high risk for source water contamination. Current source water protection options for First Nations include either joining the provincial source water protection process, an option only available to the 27 of 133 First Nations in Ontario that fall within a designated source water protection area, or to conduct an on-reserve source water protection plan. However, neither option meets most First Nations’ needs for a variety of technical, cultural, and jurisdictional reasons, and few communities have adopted these processes. Particularly for First Nations situated above sensitive fractured rock aquifers, the lack of effective options for source water protection leaves communities vulnerable. Through a partnership with the Chippewas of Nawash Unceded First Nation - a community situated above fractured sedimentary rock - this research aimed to develop an effective First Nations’ source water protection framework informed by 1) hydrogeological studies and 2) interviews with First Nation community members and key informants from industry, academia, government, non-governmental organizations, and Conservation Authorities. Hydrogeological data collection activities included pumping and slug tests; down-hole geophysical data collection; sampling for waste derived contaminants; and conducting two tracer experiments to examine transport times from a septic bed to groundwater. Results indicated that groundwater is being contaminated by septic systems on reserve, and current source water protection options fail to provide adequate protection for First Nations situated above fractured sedimentary aquifers. The interviews conducted as the second component of this research examined community priorities, member-identified risks to water sources, and source water protection approaches that are built on Indigenous Knowledge and better suited to Indigenous land management practices. As a result of these studies, a source water protection framework was developed in partnership with the Nawash Water Protection Committee that is informed by Indigenous
Knowledge, best practices from several sectors, and groundwater research. Recommendations and lessons learned are provided for practitioners from First Nations, industry, government, and academia aiming to support First Nations in protecting their source waters.

**Oil Sands Monitoring Program: Synthesis of Results and Progress Towards Cumulative Effects Monitoring**

**RP228 A cumulative effects monitoring framework for Oil Sands Monitoring**

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The Oil Sands Monitoring (OSM) program is mandated to assess cumulative effects that are attributable in whole or in part to the oil sands industry. A commitment to cumulative effects monitoring is fundamental to the OSM design but has been difficult to implement in practice. Cumulative effects assessments in the oil sands region have been conducted on a project scale in support of Environmental Impact Assessments. However, cumulative effects monitoring of oil sands development at a regional scale requires multiple stages, including spatio-temporal trajectories that can be compared to the observed environmental condition. We are also establishing conceptual models—simplified and integrated program-scale hypothesis about the influence of OS industry on cumulative effects. The conceptual model represents the structure of the monitoring program, documents our collective understanding of the system, facilitates communication among knowledge holders, and encourages consideration of the system as an integrated whole. Geospatial analyses and mechanistic models (e.g. atmospheric dispersion models) based on the relationships identified in the conceptual model establish spatio-temporal trajectories, the basis for cumulative effects assessment. These trajectories represent testable predictions that support a risk-informed approach to monitoring and inform stratification in monitoring design. In addition to the temporal predictions presented in classical cumulative effects assessment, these predictions also include spatial inferences of the accumulated state, essentially ‘filling in the blanks’ in the accumulated state assessment. Cumulative effects monitoring tests in space and time and informs revision or validation of the predictions. Changes identified through monitoring trigger an adaptive response designed to further evaluate the stressor-response pathways through focused monitoring and to initiate investigation of causative/solutions or inform the management and regulatory systems.

**RP229 A decadal synthesis of research on air emissions and atmospheric deposition in the Canadian oil sands region**


In 2019, the Oil Sands Monitoring (OSM) Program reviewed of the last 10 years of peer-reviewed literature on regional ambient environmental monitoring of air, land and water in the oil sands (OS) region of northeastern Alberta. The objectives of this review were to provide an integrated synthesis of published information and improve understanding of cumulative environmental effects of industrial development in the OS region by identifying environmental changes and, if changes are occurring, assessing evidence for a causal link to OS industrial development. The air theme accounted for more than 40% of the ~300 papers reviewed for the project. During our review, several air sub-themes emerged, including acidification and fertilization (25% of air papers), ambient air quality in local communities (22%), polycyclic aromatic compounds (PACs; 18%), metals and trace elements (14%), estimating/measuring air emissions (12%), mercury (4%), greenhouse gases (3%), and wildfire (2%). Atmospheric deposition has been studied extensively in the OS region, and was considered in many studies (e.g., transport and deposition of PACs, metals/trace elements, acidification/fertilization and mercury). In the case of PACs and metals, deposition has been investigated through several monitoring approaches (e.g. snowpack, lichens, foliation, moss, and passive monitoring). These studies exhibit a consistent spatial pattern in all examined receptors: measured deposition is highest at sites in closest proximity to central OS mining and upgrading operations, with depositional flux decreasing strongly with distance (exponential decline over 25-50 km). We will present a detailed synthesis of these and other findings, including recent results on ambient air quality assessments, source attribution, and terrestrial acid deposition monitoring in the OS region. While this presentation focuses on emissions and atmospheric deposition, the findings should be considered holistically in the context of the OS regional environment, and integration among other theme areas is required. For example, atmospheric deposition is a key pathway for airborne contaminants to enter the surrounding aquatic and terrestrial ecosystems.

**RP230 Reviewing the results of aquatic monitoring and research in the Canadian Oil Sands**


The current Oil Sands Monitoring Program (OSM) is an industry-funded, multi-stakeholder governed environmental monitoring program tasked with evaluating impacts of industrial development in the Canadian oil sands (OS). Since OSM began in 2012, many studies, organized into themes of air, water, and land have been completed, implemented and funded either directly by OSM or by other agencies. These OS studies contribute to our understanding of cumulative effects associated with both OS and non-OS associated stressors in the regional ambient environment. Initial investigation in OSM were focused on the minable region north of Fort McMurray, but have since widened to include consideration of in situ OS development also. A conceptual model framework—diagramming industry-related stressor influence on the local and regional environment including, for example, atmospheric emissions, potential seepage from tailings ponds, and land disturbance—has guided monitoring and research priorities. In 2019, as part of its state of the environment assessment, OSM undertook a review of the OS-related peer-reviewed literature published between 2009-18, a total of more than 300 papers, ~18% of which are relevant to the theme of surface water, and we report our findings here. Among studies of water, the relevant and primary effect pathways are atmospheric deposition directly into water bodies or their watersheds, hydrological alteration of those watersheds, water withdrawals, discharge of waters suitable for release (e.g. overburden drainage), and seepage of tailings waters. Secondary pathways include surface runoff of snowmelt and increased erosion from cleared land. Studies to address these effect pathways have been and are being undertaken on accumulation of polycyclic aromatic compounds (PACs) and metals in snow, lake sediments, and river sediments, changes in long-term patterns of discharge in the Athabasca, the health of aquatic organisms, and the characterization of dissolved organics present in oil sands process-affected water (OSPW). This presentation will describe in more detail the current knowledge of the ambient aquatic environment surrounding OS developments, the approaches used to identify change, and the potential sources of such changes on the chemical, physical, and biological states of lakes and rivers in the Oil Sands Region of northeastern Alberta.
Groundwater in Canada’s oil sands region is a potential conduit of oil sands process-affected water (OSPW) to the natural environment. However, this is only one of several potential stressor-response pathways identified in the literature on potential effects of OS development on groundwater and the larger ambient environment. As part of an accumulated environmental state assessment conducted within the Oil Sands Monitoring (OSM) program, we reviewed and synthesized relevant peer-reviewed literature from 2009-2018, more than 300 papers, of which ~16% were relevant to the groundwater theme. Literature highlighted the complexity of the geological setting in the region as a common theme. The marine origin of shales and evaporites produces groundwater that can be highly saline. The influence of saline groundwater is evident in increasing salt concentrations in the Athabasca River and its tributaries as they transit Cretaceous and Devonian formations. Groundwater also flows through the bitumen bearing geologic formations, picking up the water-soluble organic compounds believed to be a source of toxicity in OSPW. This, combined with the heterogeneity of local groundwater flow systems, presents significant challenges distinguishing natural groundwaters from OSPW. Conventional plume delineation suggests that OSPW is migrating through groundwater in some locations and these locations are focal points for ongoing monitoring and research. Effort has been invested in chemical profiling of groundwater and OSPW and promising approaches using ultra high-resolution mass spectrometry techniques are being developed. However, even with methodological advancements, detecting OSPW-related signals in surface waters remains extremely difficult due to high dilution factors. Researchers are also examining the origin of metals and metalloids, particularly arsenic, in groundwater. While these metals and metalloids appear to be unrelated to OS mining activity, there is some evidence of thermal mobilization of arsenic associated with steam injection at in situ OS operations. This effect is directly related to the influence of in situ activity on groundwater temperature, and appears to be transient. This presentation will characterize the natural geologic setting of groundwater in the oil sands region and discuss the added influence of oil sands extraction on groundwater quality and quantity as potential stressors for groundwater connected ecosystems.

**RP232 A decade of terrestrial biological monitoring and research in the Canadian Oil Sands**


Since 2012, a jointly run Government of Alberta and Government of Canada environmental monitoring program, governed in collaboration with local indigenous communities and funded by industry, has operated in the oil sands (OS) region of northern Alberta. This Oil Sands Monitoring (OSM) Program currently exists within the mandate to determine the extent of environmental changes due to OS operations, and assess the accumulated state of the environment in the OS region. In 2019, as part of an accumulated environmental state assessment, the Oil Sands Monitoring Program (OSM) reviewed and summarized >300 peer-reviewed papers from 2009-18. ~20% of which addressed terrestrial biological research and monitoring. We found that, despite an increasing number of publications, the breadth of topics is largely limited to a few key stressors and to a limited numbers of species of interest. Of the stressors directly considered, landscape disturbance (natural and anthropogenic) was the most prevalent, appearing in more than half the papers. Landscape disturbance has diverse effects on mammals and birds, generally with neutral or positive effects on young forest and disturbance specialists and negative effects on old growth and intact forest specialists. Linear disturbances specifically change behaviour patterns of many species, largely by facilitating movement relative to otherwise intact forests; the ecological implications of these behavioural changes are complex. The second most-often considered stressor was chemical contaminants, with literature suggesting that accumulation in plants and wildlife in the oil sands region varies in terms of both level of concern and confidence in oil sands source attribution, the latter being confounded by local geology or regional urbanisation. Assessments of wildlife contaminant burdens was largely limited to a few sentinel species, including colonial waterbirds, swallow nestlings, and small mammals, though many plant species were also used as indicators for atmospheric deposition. Caribou was the most commonly considered focal species, while mammals in general were the largest species group considered, followed by birds and plants. Caribou populations are reduced and declining, largely due to increased wolf predation resulting from increased caribou habitat overlap. This overlap is driven by a combination of larger deer populations in the region (an effect of both climate change and land disturbance) and wolf selection for linear developments (e.g. seismic lines).

**RP233 Response of Slimy sculpin in the Steepbank River, Alberta, adjacent to oil sands mining activity**

J. Bennett, Environment Canada; G. Tetreault, Environment and Climate Change Canada / Water and Science Technology Directorate / Aquatic Contaminants Research Division; T. Clark, Environment and Climate Change Canada / Water and Science Technology Directorate / Aquatic Contaminants Research Division; H. Keith, Hatfield Consultants; J. Parrott, Environment and Climate Change Canada / Aquatic Contaminants Research Division; M.E. McMaster, Environment and Climate Change Canada / Water and Science Technology Directorate / Aquatic Contaminants Research Division

Since 2009, the Canadian and Alberta governments have been developing monitoring plans for surface water quality and quantity, air quality and biodiversity of the lower Athabasca River (LAR) and its tributaries (2010-2013). The objectives of the fish monitoring program were to: 1) assess the current status of fish in the LAR, 2) identify existing differences between upstream reference and within the oil sands deposit exposure sites, and 3) identify trends/changes in fish health relative to historical studies. This study examines the fish health endpoints in Slimy sculpin (**Cottus cognatus**) in the Steepbank River, AB, in terms of growth, gonad size, condition, and hepatic 7-ethoxyresorufin-O-deethylase (EROD) activity as an indicator of exposure to oil-sands related compounds. The sampling program followed historical sampling methods (1999-2000) to provide comparable data (e.g. sculpin health) over time with an additional upstream site added as development progressed. Consistent changes were documented in sculpin collected from downstream sections of the Steepbank River within the oil sands deposit in 2010 through 2013. Sculpin demonstrated increased liver size with corresponding induction of EROD activity consistent with historical data and reductions in energy investment relative to reproductive development and gonadal steroid production capacity. There was no consistent evidence of changes in fish health metrics with increased surface mining development, particularly adjacent to the Steepbank River Mid site.
RP234 Estimation of Substance Loads from Surface Waters and Groundwater in the Lower Athabasca River - A Mass Balance Approach

Y. Yi, Alberta Environment and Parks / Environmental Science and Monitoring Division; C. Cooke, Alberta Environment and Parks / Environmental Monitoring and Science Division; N. Glozier, K. Pippy, Environment and Climate Change Canada / Water Science & Technology Directorate

Water quality and quantity monitoring in the Lower Athabasca River region are important components of the Oil Sands Monitoring (OSM) Program. The high-frequency, flow-weighted, multiple-year water quality sampling, in combination with daily stream flow monitoring, provide an opportunity to estimate and evaluate substance loads (including major ions, nutrients, and trace elements) in the Lower Athabasca River and its tributaries at various time scales. This study synthesizes concentration, river discharge and industrial water usage in the Lower Athabasca region collected during OSM, and estimates daily substance loads, including dissolved chloride, dissolved calcium and total suspended solids, at key locations along the lower Athabasca River and major tributaries. With the consideration of upstream, downstream and tributary loads, a mass balance approach is further taken to assess groundwater contribution to the surface water loading in the mainstem of the Athabasca River. The results provide reliable surface water load estimations in the region, with a fine temporal and spatial resolution. Insights into temporal and spatial patterns in the groundwater loading to the lower Athabasca River will also be shown. Substances loads in the surface water progressively increase from upstream sites to downstream sites along the Athabasca River, while the groundwater contribution shows a reach-specific pattern. The assessment of groundwater loads and possible quantification of groundwater discharge advance our understanding of complex groundwater-surface water interaction in the region.

RP235 Shifts in Invertebrate Communities in Streams within the Increasing Footprint of the Oil Sands Surface Mining Area in Comparison to Reference Areas

N. Glozier, A. Ritcey, ECCC / Water Science & Technology Directorate

In 2012, the governments of Canada and Alberta launched the Implementation Plan for Oil Sands Monitoring, which included a phased monitoring plan for aquatic ecosystem health. A key objective was to improve the understanding of benthic invertebrate community status in tributaries of the Lower Athabasca River (LAR) in relation to exposure to oil sands surface mining as well as to natural bitumen deposits. From 2012-2017, benthic invertebrate and water quality samples were collected from over 100 sites in LAR tributaries including the Steepbank, Ells, and Mackay rivers and several catchments in the Birch Mountains. Reference sites were divided into two categories (inside or outside of the natural bitumen deposit). Potentially impacted sites were grouped based on the extent of disturbance (activity) in the upstream catchment. Multivariate results indicate that over all catchments, little difference exists in community structure between the two reference categories. The PERMANOVA routine in PRIMER was used to assess community differences in reference and potentially impacted sites within tributaries. PERMANOVA results from these tributaries suggest that benthic communities shift further from reference condition as the proportion of mining activity in the catchment increases. This is more prevalent in catchments with higher activities levels. Potential environmental drivers of community change were also assessed, including water and sediment chemistry, flow characteristics, geology, and land cover.

RP236 A comprehensive study design for developing baseline data prior to the potential release of petroleum coke-treated oil sand process waters into the Athabasca River

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The oil sands industry has historically adhered to a zero discharge practice relating to the release of oil sands process affected water (OSPW) from mineable oil sands operations to the receiving environment. However, current government policy does allow for the possible release of OSPW if a treatment technology can be demonstrated, through pilot studies, to effectively treat water and thus if released would not result in adverse environmental effects. Syncrude Canada has developed a coke-slurry treatment technology for OSPW, which through small-scale studies have demonstrated to effectively decrease many toxic constituents of OSPW, and thus may allow for the safe return back into the environment. In addition, a variety of studies have been initiated to evaluate the feasibility of returning treated water during a pilot scale study. The regional oil sands monitoring program recently optimized water quality monitoring stations and turned off 3 stations in the midst of the development area (M4, M5 and M6) due to the lack of significant differences between stations M3 to M7 (a distance of 60 km); the turned off stations are in close proximity to where potential discharges of treated OSPW could occur. The main objective of this study (enhanced monitoring) was to examine the adequacy of existing baseline data and monitoring to determine potential local scale responses to a pilot discharge. The design is to evaluate whether, in the absence of a discharge, a fine scale gradient design (14 stations within 60 km) would detect differences in the plethora of endpoints in the existing regional monitoring program, including endpoints of importance to Indigenous communities. Monitoring includes water quality and sediment quality parameters, biological communities (algae, benthic invertebrates, and fish), fish health, and body burdens of contaminants across trophic levels. Overall, this baseline data collected at sites located in close proximity will provide information on the inherent variance, and ultimately the sampling intensity required to be able to detect impacts from a potential pilot release of treated OSPW, should release be allowed. The existing regional and enhanced data will be used to develop monitoring and forecast triggers that could be used in decision-making for releases within the reach of development.

RP237 Atmospheric emissions from the Fort McMurray oil sands mining operations and their impact on boreal lakes: spatial and temporal trends and climate

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Since the late 1960s, bitumen-mining activities in the Fort McMurray area have emitted a variety of compounds, including acidifying and nutrient species, which, once deposited may affect the ecological features of lake systems. Early surveys identified acid-sensitive regions in Alberta (AB) and Saskatchewan (SK) where low-conductivity lakes had little buffering capacity. With oil sands industry expansion in the late 1990s, research and monitoring programs began to investigate these concerns; this presentation highlights major findings under research monitoring. In AB, limnological surveys provide no evidence that increasing oil sands
mining and concomitant changes in acidifying and nutrifying emissions acidified lakes over 1999-2017 but there was evidence of increasing pH (alkalization) and base cations concentrations. Chlorophyll concentrations increased while nitrite-nitrate concentrations decreased and dissolved organic carbon concentrations remained unchanged. Trends often differed regionally. SK research monitoring began in 2012 with less statistical power to detect trends but sediment core studies provide no evidence of increasing acidification. Several drivers may be affecting observed trends (or their lack). First, sulfur emissions from the oil sands industry have declined in recent years with improvements in emissions technology although nitrogen (a weaker acid) emissions continue to increase. Increasing nitrogen emissions from agricultural fields to the south and globally confound detecting localized impacts of emissions from the oil sands developments. Second, while acid-sensitive lakes occur in regions such as the Stony Mountains, AB and the Athabasca Plain, SK, at distances of more than 100 km from the developments, broad-scale global factors strongly affect these lakes. Studies have shown that emission depositions (e.g., metals, PAHs) are detectable only with ca. 50-80 km of the developments because of dilution effects with increasing distance from point sources. Third, the region is experiencing a long-term warming trend with consequences such as increased permafrost melt and release of base cations from the watershed to the lakes; growing forest fire activity is an additional source of base cations to many lakes. We conclude that estimation techniques for critical loads and exceedances may need to be refined for the boreal forest region with its unique watersheds and lakes and impacts of increasing alkalization investigated.

**RP238 Spatial and temporal patterns of mercury in fish in the Athabasca and Peace River regions in relation to the oil sands operations and mercury deposition trends**

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Oil sands mining operations in the Fort McMurray area began in the late 1960s and, with improving technology, have been expanding exponentially in recent decades. Operations have been controversial given the size and extent of the open pit mines and tailings ponds, located along a ca. 75 km stretch of the Athabasca River north of Fort McMurray. Among the many environmental issues raised has been the enhanced release of mercury (Hg) into the environment from emissions, the disturbed landscape, and groundwater seepages. Early investigations reported (2009) increased concentrations of mercury in walleye inhabiting the Athabasca River although this trend was not evident in later studies (2012) using the larger data base that was available at that time; limited years of monitoring constrained the sensitivity of analyses to detect trends. With the inception of the Joint Oil Sands Monitoring Program in 2012, large-bodied fish have been sampled from an increasing number of locations along the Peace, Athabasca and Clearwater Rivers in addition to some lakes, allowing for a fuller and updated analyses of temporal and spatial trends in mercury in fish. Here we present the results of our trend analyses focusing on predatory fishery collected under JOSMP and complementary programs, placing these data into the context of findings under snow deposition and sediment core studies over this region. Overall, there is little evidence of trends of mercury increase in fish that can be related to growing oil sands operations. Fish mobility along the Peace and Athabasca River ecosystems and limitations in the frequency of monitoring affect the statistical power to detect trends.

**Invasive and Vertebrate Pest Species Control: Hazard and Risk to Non-Target Species and Innovations on the Horizon**

**RP239 Blood clotting assays to assess anticoagulant rodenticide exposure and effects in birds of prey and avian scavengers**


Birds of prey and avian scavengers are widely exposed to anticoagulant rodenticides (ARs), and in some instances individuals succumb from poisoning. Unresolved are the consequences of sublethal AR exposure (coagulopathy, anemia, altered behavior) on health and survival of non-target raptors that often encounter a multitude of stressors. In a wildlife rehabilitation setting, AR intoxication may be masked by more acute injuries related to collision with vehicles or electrocution, complicating interpretation of proximate from ultimate cause of mortality. Coagulation function (prothrombin time, Russell’s viper venom time) was assessed in 62 birds of prey and scavengers (bald eagle Haliaeetus leucocephalus, Cooper’s hawk Accipiter cooperi, red-tailed hawk Buteo jamaicensis, barred owl Strix varia, great horned owl Bubo virginianus, barn owl Tyto furcata) admitted to a wildlife rehabilitation clinic in British Columbia, Canada. Twenty-three percent of these birds exhibited prolonged clotting time or failure to form a clot altogether, a biologically significant proportion given the fortuitous and likely biased nature by which raptors are found and admitted to rehabilitation facilities. Hepatic AR concentration was determined in 10 individuals that died or were euthanized. While visual inspection of these data suggest longer clotting times in AR exposed birds, there was no relation (p>0.4) between AR residues and clotting time. Citrated blood plasma samples were also obtained from free-ranging barn owl nestlings (n=19; Lower Mainland of British Columbia, Canada) and from California condors (Gymnogyps californianus; n=29 with 8 sampled twice; Pinnacles National Park, California). In contrast to birds admitted to the rehabilitation facility, there was no evidence of prolonged clotting time in barn owl nestlings or condors, suggesting that either those individuals were not exposed to ARs through their diet or any exposure was limited or transient, and certainly below the threshold that causes coagulopathy. The utility of avian coagulation tests for diagnosing AR exposure remains promising, although there is a need to establish species specific reference values and standardize assay methodologies.

**RP240 Pharmacokinetic/pharmacodynamic analysis of first-generation anticoagulant rodenticide warfarin with Egyptian fruit bats (Rousettus aegyptiacus)**

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Anticoagulant Rodenticides (ARs) have been used to eliminate wild rodents since rodents cause various damage to both human and ecosystem. Sensitivity to rodenticide is known to be differ among species. The one factor is diversity of target molecule VKOR (vitamin K epoxide reductase), and the other is metabolism of ARs. Structural differences of VKOR are known to have effect on sensitivity to ARs. Metabolic capacity is also known to have species differences, which influence chemical sensitivity. To investigate these factors of wildlife in ARs spread area is considered to be good indicators to estimate their sensitivity. Bonin fruit bats (Pteropus pselaphon) is the only mammalian and endemic species of the Bonin (Ogasawara) islands and listed in a national treasure by the Japanese government and a critically endangered species by IUCN. Although rodenticides application is implemented in Bonin island, little is known about possible effects on fruit bats including Bonin fruit.
bats. In this study, we used fruit bats commercially available in Japan; Egyptian fruit bats (Rousettus aegyptiacus) for in vivo pharmacokinetic/dynamic study to investigate their sensitivity to rodenticide. All animal care and experimental procedures were approved by the Animal Care and Use Committee of the Faculty of Veterinary Medicine, Hokkaido University. Four Egyptian fruit bats and four SD rat were female and ten weeks old. After acclimation, 4 mg/kg (body weight) of warfarin was administered orally to rats and bats. Blood were taken from tail vein of rats or wing vein of bats at 10 minutes, and 1, 2, 4, 6, 10, 17, 24, 30, 48 and 72 hours after administration. Prothrombin time was measured with CoagCheck XS. Concentration of warfarin and hydroxywarfarin were measured by high-performance liquid chromatography coupled with electrospray ionization triplequadrupole mass spectrometry. Egyptian fruit bats showed no markedly changed prothrombin time, while rats required longer blood coagulation time after warfarin administration. Furthermore, according to Pharmacokinetics of warfarin, Egyptian fruit bats seemed to have the ability to metabolize warfarin rapidly. Pharmacokinetics of hydroxywarfarin showed the basis of rapid excretion. The majority of hydroxylwarfarin in plasma was 4′-OH warfarin. 10-OH warfarin was also detected. In conclusions, our in vivo results using Egyptian fruit bats suggest that Bonin fruit bats could have lower susceptibility to warfarin than rats.

Integrative Avian Ecotoxicology in a Changing World

RP241 Bioaccumulation and biomagnification of polybrominated diphenyl ethers in a terrestrial food chain at an urban landfill

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Biota samples from the municipal landfill located in Delta, BC, Canada, have some of the highest polybrominated diphenyl ether (PBDE) levels reported in Canada. We followed a population of European starlings (Sturnus vulgaris) breeding in a remediated area in the landfill to identify exposure routes and bioaccumulation of PBDEs in a simple terrestrial food chain. This population was compared to a reference farm site located 40 km east in Glen Valley. We analyzed samples of starling eggs, chick livers, and invertebrate species consumed by starlings for PBDE concentrations. We also collected soil samples from starling foraging areas. All samples from the landfill had higher PBDE concentrations than the Glen Valley farm and were dominated by BDE-99 and BDE-47. Stable nitrogen (δN15) and carbon (δC13) isotope analysis of starling blood samples and L. Charity, and 1 gull embryo on Bellow). Chick productivity in terns in Saginaw Bay (mean of 0.76 chicks/nest) was significantly below that of reference sites (1.21 chicks/nest). In the River Raisin AOC, productivity of gull chicks was poor in 4 of 9 years, with complete reproductive failure in 2010. In gull chicks the mean phytohemagglutinin (PHA) skin response for T-cell mediated immunity was suppressed 54-56% at both AOCs and 50% in Grand Traverse Bay. This response was suppressed 48% in terns and 39% in herons in Saginaw Bay. Mean antibody responses in gull chicks at the River Raisin AOC and in Grand Traverse Bay were two to three-fold lower than at the reference site. Ongoing immunological and reproductive impairments at these contaminated sites are consistent with the effects of persistent pollutants such as PCBs and PCDDs.

RP243 Elemental concentrations in feathers of Bonin Petrel (Pterodroma hypooleuca) on Midway Atoll

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Seabirds are often used as indicators of environmental contamination because they are long lived, feed at multiple trophic levels at varying distance from land, and their feathers can be sampled non-lethally. Bonin Petrel (Pterodroma hypooleuca) are a small gadfly petrel who breed in the Northwestern Hawaiian Islands. Bonin Petrel feed on mesopelagic prey including lanternfish (Myctopphidae), hatchetfish (Sternoptychidae), and squid. Mesopelagic fish and squid generally have greater mercury (Hg) concentrations due to methylation processes in deep water with lower amounts of oxygen, making Bonin Petrel an ideal species to monitor Hg. In addition to Hg, the sulphydryl groups in the keratin structure of the feather bind other elements while the feather is growing. This study provides a new baseline for future monitoring and compares elemental concentrations to Bonin Petrel feathers sampled approximately 15 years after the last published study on this species from Midway Atoll (Burger and Gochfeld, 2000). Bonin Petrel carcases were collected from Sand Island in Midway Atoll (28.2101° N, 177.3761° W) by U.S. Fish and Wildlife Service personnel in 2014 and 2015 and identified as hatch-year (n=42) or after hatch-year (n=42). Breast feathers and the first primary feather were taken from each bird and analyzed via inductively coupled plasma- mass spectrometer (ICP-MS) for As, Cd, Cr, Pb, and Se and for Hg via cold vapor atomic-absorption spectroscopy (CV-AAS). Of these six elements, Hg was the greatest concentration in after hatch-year birds (9.880 ± 4.710 ng/g) and the second greatest concentration in hatch-year birds (2.130 ± 0.953 ng/g). These concentrations are lower than those reported by Burger and Gochfeld (after hatch-year: 19.700 ± 1.080 ng/g,
gotten stuck and died. These petroleum seeps are both naturally occurring.

Kimberly, Westminster College / Biology
K. Kornhauser, Westminster College / Environmental Science; D. Salt Lake RP245 The Rozel Tar Seeps: Impacts to Avian Fauna at the Great Salt Lake

values with the ultimate goal of developing a mercury TRV for common loon. This effort builds upon the approach developed in both the Great Lakes Initiative (GLI 1993) and Mercury Study Report to Congress (MSRC 1997). During the development of both the GLI and the MSRC, the results of several mallard studies (Heinz 1974, 1976a, 1976b, and 1979), which demonstrated that exposure to dietary methylmercury reduced reproductive success, were determined to be the most appropriate toxicity endpoints for the derivation of an avian TRV. In the two decades since the development of the GLI and MSRC, mercury toxicity studies on a wide diversity of bird species have provided additional information about the potential toxicological effects of mercury and the relative sensitivity of birds. Like the mallard studies used in the GLI and MSRC, the common loon data demonstrate that exposure to dietary methylmercury reduces reproductive success and indicate that common loon may be more sensitive to mercury exposure than mallard. The current work through this collaboration includes analysis of published and previously unpublished data to characterize the effects of mercury and to derive toxicity values with the ultimate goal of developing a mercury TRV for common loon that reflects the current toxicity literature.

RP245 The Rozel Tar Seeps: Impacts to Avian Fauna at the Great Salt Lake
K. Kornhauser, Westminster College / Environmental Science; D. Kimberly, Westminster College / Biology

The Great Salt Lake is one of the largest migratory stops for many species of birds in North America. Along the banks of the Great Salt Lake, at Rozel Point, there are tar seeps, where some species of birds have gotten stuck and died. These petroleum seeps are both naturally occurring and human created at Rozel Point. The temperature that the seeps become sticky, the possibility of prey animals drawing predators in, and the appearance of the tar seeps are all important aspects of why birds are drawn to these seeps. Using motion sensor cameras and temperature monitoring devices, the animals that are visiting the tar seeps and the temperature variation of the seeps were monitored. One of the largest human created oil wells at Rozel Point was recapped in January of 2019. The impacts of this recapping will be monitored throughout the summer season of 2019 to determine if there are fewer birds entrapped due to the reduction of oil escaping from the ground at this well.

RP246 Effects of repeated low dose chlorpyrifos exposure to European starlings during migration
C.A. Morrissey, University of Saskatchewan / Department of Biology; M.L. Eng, University of Saskatchewan / Toxicology

Chlorpyrifos is one of the most widely used organophosphate insecticides used in over 98 countries and 50 different crops worldwide. Previous research in birds has focused on short term lethal toxicity, but there is growing evidence that chlorpyrifos can cause behavioural and neurological deficits associated with low dose longer term exposure in humans and wildlife. Here, we orally exposed 32 captive adult European starlings to control (0 µg/g bw) or low doses of chlorpyrifos (nominal conc: 0.5 and 2 µg/g bw; measured conc: 0.8 µg/g bw or 3.1 µg/g bw) that are within the range of estimated chronic exposures for avian species, and < 5% of published LD50 value for starlings. Exposure was during a fall migratory period over 15 days and birds were followed for an additional 15 days to assess recovery and latent effects. We monitored migratory orientation using Emlen funnels, daily activity, mass and plasma acetylcholinesterase (AChE) activity over time. We found predictable mass gain associated with migratory fueling but with no differences among treatments. Exposure to chlorpyrifos significantly inhibited AChE by an average of 7% (0.8 µg/g bw dose) and 33% (3.1 µg/g bw dose) relative to controls. AChE enzyme levels returned to normal within 5 days after dosing ceased. Analysis of video data will assess migratory behavior, where we hypothesize that activity will be depressed and orientation patterns will be altered in exposed birds relative to controls that could persist even after the AChE levels have returned to normal. These data suggest that repeated low level exposures during important life stages such as migration warrant consideration in avian risk assessments of chlorpyrifos.

RP247 Artificial athletic turf infill associated with systematic toxicity in an amniote vertebrate
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Artificial athletic turf containing crumb rubber (CR) from shredded tires is a growing environmental and public health concern. However, the associated health risk is unknown due to the lack of toxicity data for higher vertebrates. We evaluated the toxic effects of CR in a developing amniote vertebrate embryo. CR water leachate was administered to fertilized chicken eggs via different exposure routes, i.e., coating by dropping CR leachate on the eggshell; dipping the eggs into CR leachate; micro-injecting CR leachate into the air cell or yolk. After three or seven days of incubation, embryonic morphology, organ development, physiology, and molecular pathways were measured. The results showed that CR leachate caused mild to severe developmental malformations, reduced growth, and specifically impaired the development of the brain and cardiovascular system, which were associated with gene dysregulation in aryl hydrocarbon receptor, stress-response, and thyroid hormone pathways. The observed systematic effects were probably due to a complex mixture of toxic chemicals leaching from CR, such as metals (e.g., Zn, Cr, Pb) and amines (e.g., benzothiazole). The chicken embryo offers a valuable mammalian analogue to predict the effects of environmental toxicants such as CR.

RP248 Application of weathered MC252 crude oil to zebra finch (Taeniopygia guttata) eggs causes metabolic effects in embryos
C. Goodchild, Oklahoma State University / Integrative Biology; S. DuRant, University of Arkansas

Brooding birds externally exposed to crude oil can transfer oil from their feathers to the external surfaces of their eggs. Previous studies have documented that application of crude oil to the surface of bird eggs can cause embryotoxicity, yet the potential effects of sublethal crude oil application on avian embryo development are unknown. As has been
demonstrated in other taxa, embryonic exposure to crude oil can cause heart malformations. In this study, we used zebra finch (Taeniopygia guttata) eggs to examine the potential for cardiotoxicity in avian embryos after external application of crude oil to the eggshell. First, we conducted a pilot dosing experiment to determine a sublethal application. We then conducted a second experiment to measure embryonic heart rate and metabolic rate. We found that >2.5 µl of crude oil caused the embryo to become non-viable. Additionally, we detected a decrease in embryonic heart rate and metabolic rates in eggs exposed to 2.5 µl of crude oil. This study suggests that sublethal oiling of bird eggs may lead to post-hatch effects on cardiac function.

**RP249 Transcriptional profile in embryonic double-crested cormorants exposed in ovo to diluted bitumen**

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With oil transport intensifying in Canada, it is important to develop appropriate biomarkers of polycyclic aromatic compound (PAC) exposure if a spill occurs. Studying how genes change throughout early development can help to establish a baseline expression level prior to contamination as well as to identify developmental stages that may be more or less sensitive to contaminant exposure. Double-crested cormorants (Phalacrocorax auritus; DCCO) are colonial waterbirds that are increasingly being included in ecotoxicological studies and yet little is known about their transcriptome regulation during embryonic development. The research objectives of this study were 1) to establish the expression profiles of several key genes and 2) to assess the effects of PACs during DCCO embryonic development. 150 eggs were collected from Mohawk Island in Lake Erie, a relatively uncontaminated site. Eggs were artificially incubated from egg collection until 24 days of incubation. Five eggs were sampled every 4 days for a total of 6 time points. Targeted gene expression analyses indicated that in general, the expression levels of genes involved in xenobiotic metabolism were relatively non-existent early in development before the liver matures (day 12); whereas genes involved in oxidative stress defense continually increased throughout embryonic development. Therefore, we assessed the effects of polycyclic aromatic compound exposure in early embryonic DCCO before detoxification systems are fully formed. An additional 215 DCCO eggs were collected from relatively uncontaminated sites in Ontario and were injected with a dilution ranging from 1:10 to 1:10,000 of one of the diluted bitumens produced in Canada (Clearwater or Cold Lake Blend) prior to incubation. Vehicle only (corn oil) and non-injected controls were included in the experimental design. Embryos were sampled at day 12 when the liver is maturing and tissues were preserved for transcriptomic analysis. Preliminary results suggest that early developing embryos exposed to PACs have an upregulation of genes associated with xenobiotic metabolism and oxidative stress defense compared to controls. Overall, comparing transcriptional profiles in unexposed vs. PAC-exposed embryonic DCCO can assist in identifying molecular mechanisms of action and developing appropriate biomarkers for oil exposure in avian species.

**RP250 Comparison of Transcriptomic Responses to Ethinylestradiol in Two Life Stages of Japanese Quail**

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The use of toxicogenomic endpoints and increased reliance on early-life stage (ELS) animal exposures are two strategies that have been proposed to improve toxicity testing for regulatory risk assessment. However, it is unknown whether transcriptomic measures in ELS organisms are predictive of those measured in their adult counterparts. The present study aims to compare hepatic transcriptomic responses of ELS and adult Japanese quail (JQ) following exposure to ethinylestradiol (EE2). Exposures were conducted according to an egg injection protocol that we are proposing for standardization (for ELS) and USEPA OCSPP 850.2100 avian acute oral toxicity test guidelines (for adults). EE2 was dissolved in dimethyl sulfoxide and injected into the air cell of JQ embryos prior to incubation at 0, 3.33, and 33.3 µg/g egg. Adult JQ were fed a single dose of EE2 (dissolved in corn oil) at 0, 0.5, and 5 mg/kg body weight by gavage. The highest concentration was chosen so as not to exceed a 20% mortality rate. In embryos, the mortality rate was 14% at the high dose and embryo growth was significantly reduced. In adults, no adverse effects were observed at any of the administered doses. Liver tissue was collected from 5 JQ embryos per dose group at mid-incubation, and from 5-6 adult JQ per dose group 4 days after dosing. Transcript quantification, differential expression analysis and enrichment analysis were performed using the Kallisto workflow in Galaxy (galaxy.ecotoxplorer.ca), the EdgeR method in EcoToxXplorer (www.ecotoxplorer.ca), and the ClusterProfiler R package, respectively. ELS and adult JQ, respectively, showed 223 and 94 differentially expressed genes (DEGs), 11 of which were common. Fold change values were significantly correlated for these 11 DEGs between the two life stages. In 9 of the 11 common DEGs, ELS showed a higher magnitude of dysregulation than adult JQ. The neuroactive ligand-receptor interaction pathway was significantly enriched in both life stages. The results of this study contribute to the evaluation of toxicogenomics and ELS approaches as alternative toxicity testing methods, which are faster, cheaper, and more ethical, and to a large-scale Genome Canada-funded project (EcoToxChip; www.ecotoxchip.ca) aimed at transforming ecological risk assessment.

**RP251 Transcriptomic and Developmental Effects of Two Organophosphate Flame Retardants on Chicken Embryos**


Organophosphate flame retardants (OFRs) are used in a variety of products such as clear coats, resins, insulation, and plastic; therefore, research regarding their potential toxicological effects is warranted. In a previous in vitro screening study, two OFRs - isopropylphenyl phosphate (IPPP) and p-tert-butylphenyl diphenyl phosphate (BPDP) - were prioritized for whole animal toxicity testing based on their effects in cultured chicken hepatocytes. This study investigates the toxicity of BPDP and IPPP in chicken embryos at different developmental stages by measuring morphological and transcriptomic effects. Chicken eggs were injected with 0-250 µg/g of either OFR and then artificially incubated. Liver tissues were collected at day 11 (mid-incubation) and day 20 (1 day pre-hatch) for transcriptomic evaluation using a custom-designed PCR array. In addition, day 20 embryos were assessed for morphological endpoints and blood was collected for genetic sex determination. Neither compound decreased embryonic viability up to the highest concentration tested.
However, at 250 μg/g, gall bladder size was significantly decreased for both compounds, while IPPP exposure led to a reduction in head-bill length and tarsus length as well as an increase in liver somatic index. PCR array analysis revealed significant differences in gene expression for both compounds and time points with the most pronounced effects occurring at mid-incubation. Genes related to xenobiotic metabolism (e.g., CYP3A7 and ALDH1A1) showed the greatest upregulation (up to 100-fold). Given these changes observed in early-life stage avian embryos, further research into the long-term effects of IPPP and BPDP should be prioritized.

RP252 Genetic Diversity Comparison of Tree Swallow Populations in the Great Lakes Region using RNA-sequencing
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The Great Lakes Surveillance Program provides the opportunity to monitor toxicogenomic responses of Tachycineta bicolor populations to legacy contamination throughout the Great Lakes region. Since 2011, nestling samples are collected, DNA/RNA extracted, and chemical extractions used to produce a contaminant profile for each site. Our lab has recently finished producing both a de novo transcriptome and a reference genome for T. bicolor, which were used for DGE and population genetic analysis. Earlier variant calling using RNA-sequencing reads yielded 66,169 single nucleotide polymorphisms (SNPs) across 144 samples. Using the intersection of several variant calling pipelines (GATK, Freebayes, Varscan, VBoost, SNPiR) producing a consensus SNPs. Approximately 20,000 SNPs were used construct a linkage map for T. bicolor, allowing for further filtering of our high-quality SNP dataset. The final set high-quality SNPs were used to calculate population heterozygosity and genetic distances between areas of concern (AOC) which aid in the construction of phylogenetic trees to identify populations with increased concentrations of mutation rates. Principal component analysis and partial least squares analyzed indicate strong separation between Waukegan, Sheboygan, and the Maumee River: three of our more contaminated sites. Random forest, ad-mixture analysis, and k-means modelling were able to distinctly identify the Western Coast of Lake Michigan and the Maumee River as separate populations from the other AOCs located in the Great Lakes Regions. These results coincide with high concentrations of PCBs, PAHs, and high DNA damage profiles. Taken together, these data suggest the influence of legacy contamination upon the genetic diversity of T. bicolor nestlings.
The Fathead Minnow Reference Genome Assembly and Annotation: Overview and Utility for Sequencing-Based Technologies

PC001 An overview of the updated and annotated Fathead Minnow genome

The Fathead Minnow (FHM; Pimephales promelas) is an important and widely used organism in aquatic toxicology. Modern ‘omics methods are being employed to characterize FHM responses to toxicants, and the genetic basis of differences in stressor susceptibility. These efforts have been hampered by the lack of a reference genome sequence or a complete collection of annotated full-length gene models for FHM. Assembly of the genome has been difficult due to the highly repetitive and polymorphic nature of the genome, which in turn interfered with development of gene models. Recent advances in long-read DNA sequencing, assembly algorithms and scaffolding technologies have allowed us to generate a more complete, more contiguous genome assembly. This assembly provided the basis for identification and classification of repetitive elements across the FHM genome. We also conducted mRNA of multiple developmental stages and tissues as well as more limited small-RNA sequencing, facilitating delineation of protein coding and non-coding genes. This FHM gene collection allowed us to explore the effects of different RNA-sequencing parameters and other experimental choices on the performance of RNA-seq used for gene expression profiling. We also compared the performance of RNA-seq and microarrays for developing gene expression-based multivariate classifiers of toxicant exposure. Subsequently, we used RNA-seq to evaluate the effects of using various fish ages and durations of exposure on the sensitivity, specificity and functional interpretability of observed gene expression changes after toxicant exposure. We also compared results from mRNA sequencing with miRNA sequencing and mRNA 3′-end targeted sequencing on cost/performance trade-offs of multi-gene toxicant detection assays developed using those types of data.

PC002 De novo assembly of a highly contiguous genome reference of the fathead minnow (pimephales promelas)
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The Fathead minnow (Pimephales Promelas), found in most surface water across North America, is an important model organism widely used in both aquatic toxicology research and regulatory testing. To meet research needs for a genome reference, the first draft genome reference (NCBI accession: INCDD000000000) of the fathead minnow was made available in 2015 through a joint effort by DuPont, EPA and the University of Illinois. This first draft genome reference, assembled from short-Illumina reads, however, is incomplete (33.5% N content) and highly fragmented (contig N50 7468b), which can make it difficult if not impossible to obtain full results/conclusions of many omics-based genome-wide studies as relevant genome regions/genes could be missing or split into multiple fragments. As omics-based technologies (RNA-seq, RRBS) are increasingly used for aquatic toxicology and exposure research, it has become a pressing issue for the environmental research community. To address this issue, we carried out the de novo assembly of the fathead minnow genome using the latest genome sequencing technologies and assembling methods. We used the PacBio long reads for the initial de novo assembly, Bionano optical mapping data for hybrid assembly, and Hi-C data for the final scaffolding of the fathead minnow genome assembly. In total, we generated about 70X raw PacBio reads, 113X (effective coverage) Bionano optical mapping data, and 428 million 2x150bp read-pairs of Hi-C data for this project. Additionally, we obtained two sets of Illumina paired-end reads for genome assembly polishing and two sets of Illumina mate-pair reads for assembly scaffolding. We tested multiple different assemblers including CANU and FALCON/FALCON-Unzip, which are the top two assemblers for long PacBio reads. We then used BUSCO to evaluate different assemblers. Our evaluation showed that the FALCON assembler achieved the largest contig N50, however, the CANU assembler performed the best in terms of the complete and single gene coverage BUSCO score. Using our CANU-based assembly pipeline, we successfully assembled a highly contiguous and almost complete fathead minnow genome reference, of which the total size is 1.2Gb with scaffold N50 reaching 13.5Mb (contig N50 0.3 Mb), and the percent complete BUSCOs is 95.1% with only 3.3% duplication. This genome reference as well its complete annotation will be publicly available at NCBI and Ensembl genome databases.

PC003 Annotation of Small Non-coding RNAs From Pimephales promelas, The Fathead Minnow
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The update of the genome assembly for the fathead minnow (FHM), Pimephales promelas, presented an opportunity to predict and annotate elements of the small non-coding RNA world including transfer RNA (tRNA), ribosomal RNA (rRNA), microRNA (miRNA), piwi-interacting RNA (piRNA), small nuclear RNA (snRNA) and small nucleolar RNA (snoRNA). While the report of numbers of some of the structural and catalytic RNAs (rRNA, snRNA, snoRNA) is of interest for comparison across species as a general biological resource, data are needed on other types of small non-coding RNA (smRNA) that are becoming recognized as critical factors in gene regulation (piRNA, miRNA, tRNA), and, as such, present themselves as candidates for stressor exposure and effects indicators, either as stand-alone indicators or potentially integrated into fuller differential expression studies with mRNAs. tRNAs were detected ab initio based on primary and potential secondary structure using the newly updated genome assembly c18phphsho.fa and the program tRNAscan-SE. The Infernal program, using the new assembly and referencing Rfam (version 14.0), a database of RNA families, detected tRNAs, snRNAs, and snoRNAs as well as confirmed the tRNAs from tRNAscan-SE analysis. Two of the three types of small interfering RNAs, miRNAs and piRNAs, were detected with programs requiring both the FHM assembly and smRNAseq data. TruSeq smallRNA preps were done on brain (male and female), liver (male and female), 8 day post fertilization (4 day post hatch) fry, and unfertilized eggs, and sequenced (Hi-Seq (~ 30M reads/sample). Sequence data mapped to zebrafish (Danio rerio) miRNAs from miRbase.org (56%) and piRNAs from regulatoryRNA.org (11%). FHM piRNAs were identified using Piano, a program directed toward prediction of transposon-related piRNAs, while additional piRNAs were to be identified using piRNN, a neural-network program that can predict piRNAs more globally (e.g., non-transposon miRNA targeted) after training with FHM tRNAs, miRNAs and existing piRNAs. The state of small non-coding RNA in the FHM will be described in the context of general teleost and mammalian small mRNA resources as well as the potential for integrated study in an ecotoxicology context.
PC004 Development and Annotation of Protein Coding Gene Models for the Fathead Minnow Genome

J. Martinson, US Environmental Protection Agency / ORD; W. Huang, PC004 Development and Annotation of Protein Coding Gene Models for the Fathead Minnow Genome

The importance of the Fathead minnow in aquatic toxicology is demonstrated by the thousands of publications on the subject over the last four decades. To make the new assembly of the Fathead genome truly useful, the genomes features must be identified and annotated. Probably the most important features to annotate are the protein coding genes. Exploration of the protein coding gene space is fundamental to developing an understanding of the biological activity occurring at the molecular level within an organism in response to the environments it inhabits. A hybrid approach was employed to develop gene models for the new assembly. Two popular genome annotation pipelines, Maker2, and the Program to Assemble Spliced Alignments/Evidence Modeler (PASA/EVM) were each used to produce protein coding gene models. The ~37.2K PASA/EVM models were fed back into Maker2, primarily to update the Untranslated Regions (UTRs) of their transcript models to improve the mapping rates of RNA-seq reads to the transcript models. The Maker2 adjusted output resulted in ~25.6K gene models. PASA/EVM models that were not involved in the construction of the 25.6K Maker models and that showed no overlap with the Maker models were returned to the model set, resulting in ~36.9K gene models. The 36.9K models were then filtered based on several criteria; apparent presence of BUSCO protein coverage of ~93% (~86% single copy) and RNA-seq-to-annotation homology to reference proteins, and RNA-seq mapping rates. After filtering a final set of ~26.5K models remained, which exhibited complete BUSCO protein coverage of ~93% (~86% single copy) and RNA-seq-to-annotation mapping rates approaching 80%. The results compare favorably with the reference genome of the well-studied and closely related zebrafish, which currently is believed to have ~26K protein coding genes. Gene names and additional annotations were assigned to the models based on subsequent phylogenetic analysis (presented separately). The current set of Fathead gene models will allow detailed exploration of the effects of toxic substances on Fathead minnows and usher in the long-promised era of a deeper, omics-based, understanding of changes that occur at the molecular level due to exposure to different environments. This presentation will provide the details of the process used to develop the gene models and provide updates on the final number of gene models and their relevant statistics.

PC005 Characterizing changes in molecular toxicity pathways to predict adverse outcomes of fluoxetine in adult fathead minnows

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Fluoxetine (FLX) is the most common selective serotonin reuptake inhibitor pharmaceutical used for the treatment of psychological disorders such as depression and anxiety. Increased prescription use of FLX by human populations has led to its pseudo-persistence in effluent-receiving waterways. Despite its emerging concern as a threat to the aquatic environment, there is currently limited information on effects of FLX, including its specific mechanism of action and the associated toxicity pathways in fish. The main goal of this study is to identify and validate key molecular toxicity pathways that are predictive of apical endpoints induced by exposure to FLX using the fathead minnow (Pimephales promelas), a model species common to North American freshwater systems. Adult fathead minnows were exposed to three concentrations of FLX (7.81, 31.25, & 125 µg/L) and a control for 21 days. After 96 hours, a subset of fish were sampled and liver and brain tissue were collected to characterize molecular toxicity pathways using whole transcriptome, whole proteome and targeted metabolomic analyses. In addition, At the end of the 21-day exposure, individuals were assessed for apical outcomes of regulatory relevance including histopathology, gross morphology, fecundity, and altered secondary sex characteristics. Differential gene expression analysis revealed dysregulation of liver and brain transcripts in male fathead minnows, especially in pathways involved in protein transport processes. A parallel study conducted in our lab found a similar expression pattern in early-life stage fathead minnows. During the final seven days of the 21-day exposure, the fish treated with the highest dose showed a dramatic decrease in fecundity, indicating that chronic FLX exposure could have implications on reproductive success. Correlation analysis of physiological outcomes with early molecular response patterns is ongoing with the goal to establish molecular toxicity pathways that can be used to predict apical outcomes in addition to a better understanding of the environmental relevance of FLX. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

PC006 Assessing risks of selenomethionine toxicity in the fathead minnow using semi-quantitative modeling

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Selenium (Se) is an atomic element and essential micronutrient released to the environment from natural (ex. volcanic) and anthropogenic (ex. coal mining) activities. Once released, Se oxyanions are taken up by primary producers and biotransformed to the organic form “selenomethionine” (SeMet). Where Se concentrations are elevated, Se is bioaccumulated due to the dose-dependent substitution of SeMet for its biochemical analogue, the essential amino acid, methionine. SeMet can then be maternally transferred to the ova of oviparous animals resulting in teratogenesis and impaired recruitment, likely due to oxidative stress resultant from SeMet metabolism during embryogenesis. Current guidelines indicate whole-body, muscle, or egg/ovary Se concentrations of concern in fish; however, this approach only allows for retrospective risk assessment. The purpose of this study is therefore to use a model species (fathead minnow; Pimephales promelas) to develop a semi-quantitative model capable of predicting SeMet toxicity before it occurs. Adult fish were exposed for 28 days to control (1.18 µg Se/g; background Se), and sublethal low (3.88 µg Se/g), medium (8.75 µg Se/g), and high (29.6 µg Se/g) Se doses via diet (administered as SeMet). Fish were sampled for chemical analysis at days 4, 10, and 28 of exposure, as well as day 35 after one-week of depuration to validate a literature-derived toxico-kinetic model intended to predict tissue concentrations of concern based on oral exposures. Samples were also collected on day 4 for hepatic transcriptomic and proteomic analyses, and on day 28 for hepatic biochemical analysis, in order to derive a sensitive qualitative model of SeMet toxicity in fathead minnows under an adverse outcome pathway framework. Chemical analyses have confirmed muscle Se concentrations near or above those associated with adverse outcomes, and biochemical and transcriptomic results indicate non-significant decreases in hepatic oxidative stress and significant dysregulation of drug metabolism transcripts, respectively. Results thus far suggest this modeling approach may aid in the prospective assessment of SeMet risk posed to the fathead minnow. In future applications, these data are also intended
to help improve regulatory oversight by informing the development of the EcoToxChip (www.ecotoxchip.ca), a high throughput qPCR screening tool for assessing the effects of uncharacterized chemicals released to the aquatic environment in quantities of concern.

**PC007 Determination of an Optimal Age and Duration of Exposure of Larval Fathead Minnows for Gene Expression-based Studies**

R. Flick, D.C. Bencic, M. Kostich, A. Biales, US Environmental Protection Agency / ORD/NERL/EMMD

As genomic-based methods continue to play a greater role in the field of ecotoxicology, attention must be given to the appropriate design of studies. Exposure regimes often appear to be based on existing acute and chronic testing methods, which were designed for entirely different classes of endpoints. Very little work has been done to thoroughly evaluate the effect of exposure regime on genomic endpoints. In order to systematically study this issue, we exposed fathead minnow larvae at three different ages (48, 72 and 96 hours post fertilization) for three different durations (6, 24 and 48 h) to several compounds under static renewal conditions. Chemicals were selected to act along different MOA and have different target tissues. Using RNA-sequencing, we evaluated the global transcriptional profiles of the fish to determine the age and duration that provided the most interpretable and specific transcriptional response. The expression profiles at different ages and durations were found to be chemical-specific, with no one age-duration combination being the best. Based on our findings, we provide suggestions for the design of omics-based ecotoxicological experiments using larval fathead minnows.

**PC008 Fluoxetine-induced molecular toxicity pathways in early-life-stage fathead minnows**

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Fluoxetine (FLX) is a highly prescribed selective serotonin reuptake inhibitor (SSRI) commonly found at sub-therapeutic levels in surface waters mainly through wastewater and sewage treatment effluents. There is significant concern regarding the presence of FLX in the aquatic environment due to its ability to induce inadvertent sub-lethal effects in aquatic organisms exposed at low concentrations. However, there is limited understanding regarding the effects of FLX to aquatic organisms, particularly with regards to molecular mechanism(s) of toxicity in non-target, non-mammalian species. Advances in ‘omics technologies can improve our current understanding of FLX toxicity as these technologies offer high-throughput and cost-effective approaches to examine mechanisms of toxicity. Therefore, the objective of this study was to characterize molecular toxicity pathways associated with FLX toxicity in fish using sequence-by-synthesis whole transcriptome analysis. Early-life stage fathead minnows (Pimephales promelas) were exposed to graded concentrations of FLX (31.25, 7.81, 1.98 µg/L) and a water control immediately after fertilization. Embryos were collected four days post-hatch and differential gene expression (DGE) was evaluated. Reads were aligned against the latest FHIM genome assembly and a p< 0.05 cut-off false discovery rate was used to identify differentially expressed transcripts between FLX and control groups. Interestingly, a more pronounced and consistent across-replicate response was observed in the 7.81 µg/L treatment group compared to the 31.25 µg/L treatment group, with 78 and 8 differentially expressed transcripts, respectively. Gene set enrichment and pathway analysis using ontologies based on zebrafish in KEGG and GO Consortium showed a total of 40 perturbed pathways in the 7.81 µg/L treatment group, including those associated with growth and development, morphogenesis, regulation of tight junctions, metabolism, and cardiovascular disorder. The results of this study will be integrated with other ‘omics endpoints to identify closely regulated pathways perturbed across biological levels with the end goal of identifying molecular toxicity pathways that are indicative of adverse effects to predict apical outcomes. This study is part of the EcoToxChip project (www.ecotoxchip.ca).

**Plastic Pollution Research and Solutions**

**PC009 Identification of Microplastics in Surface Water and Australian Freshwater Shrimp in Victoria, Australia**

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Compared to marine microplastics studies, there is little research into biomonitoring of microplastics in inland waters. It is also important to understand the microplastics’ uptake and their potential risks on freshwater species. The Australian glass shrimp *Paratya australiensis* (Family: Atyidae) are commonly found in freshwater waterbodies in the eastern part of Australia, a sensitive to anthropogenic stressors but have a wide tolerance range to the natural environmental conditions. This study monitored microplastics across 10 non-industrial sites in water samples and in the shrimp *P. australiensis* in Victoria, try to understand the microplastics’ occurrence, types and biomonitoring’s efficiency. In total, 30 water samples and 100 shrimp individuals were analysed, and shrimp body weights, sizes and gender were determined. Microplastics were picked, photographed and identified using FT-IR microscopy. In water samples, items were randomly selected to identify; all microplastics found in shrimp samples were identified. Results showed water samples had microplastics’ occurrence in each site, with an average abundance of 0.40±0.27 items/L. Shrimp had an average of 0.52±0.55 items/ind (23.73±30.77 items/ind, 35.9% of them displayed microplastics. Fibers were the most common shape and blue was the most frequent colour in both water and shrimp samples. The dominant plastic type in water samples was polyester, and in shrimp samples was rayon. Even though this study shows a relatively low concentration of microplastics in comparison with global studies, it is worth noticing microplastics in clean sites were still significantly presence in Australia. Compared with water samples, shrimp samples contained a wider variety of plastic types, suggesting they have the potential to be a passive sampler to detect microplastics’ pollution in freshwater environments.

**PC010 Microplastic in Polychaetes from the Norwegian Continental Shelf**

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Little is known about the presence and effect of microplastics on the seabed and its biological communities. More knowledge about microplastic in relation to benthic fauna is vital to gain further understanding. Polychaetes are present in most benthic environments and are often used as indicator organisms to investigate the impacts of anthropogenic activities and pollutants. Polychaetes have several roles in ecosystems, including the transport of sediments, organic matter and nutrients, between the water column and the upper layer of sediments. Studies on microplastics in polychaetes are only just emerging, but initial studies report microplastics in nearly all samples. In laboratory experiments, polychaetes were found to contribute to fragmentation of microplastics. Here we present a study of microplastics in the polychaete *Owenniida*, and their surrounding sediments, sampled from the Norwegian continental Shelf and the Barents Sea. The sampling areas include both remote areas and nearby offshore oil and gas installations, hundreds of kilometers off.
because each polymer has different chemistry, uses, disposal processes, and Polymer identification is now expected in plastic pollution studies, Research; C. King, Sharkastics J. Lynch, National Institute of Standards and Technology; W. beach plastic marine debris into the aquatic environment. polymer matrices and the release of potentially harmful polymer additives are necessary to elucidate the relationship between nanoparticles within microplastic particles significantly increased leaching of Bisphenol aqueous environment. Results have shown UV exposure and formation of these polymer additives into the environment and their ecotoxicological effects. However, few studies have investigated how the inclusion of carbon nanomaterials in polymer matrices can impact the release of associated polymer additives. Polymer additives may be released through mechanisms of pH-mediated polymer hydrolysis, oxidation, UV degradation, mechanical abrasion, and thermal degradation, among other mechanisms. The release of these additives from microplastic composites into the aquatic environment are of concern due to the known endocrine-disrupting activity of additives such as Bisphenol A and nonylphenol. In this study, a 5 day leaching experiments of cryomilled epoxy containing varying loadings of carbon nanotubes (0, 0.01, 0.05, 0.1%) was completed. The polymer additives that were studied were Bisphenol A (BPA), Bisphenol A diglycidyl ether (BADGE), 4-tert-butylphenol (TBP), 4-tert-butylphenol glycidyl ether (TGBE) and Nonylphenol. The epoxy was incubated in water under dark conditions, and at temperature of 65 °C. This experiment was repeated with epoxy and epoxy microcomposites exposed to 14 days of 750 Watt UV exposure. Daily measurements of polymer additive concentrations in water were made using LC-MS/MS methods to investigate the influence of epoxy surface area, carbon nanotube loading, and UV exposure increase the release of these polymer additives into an aqueous environment. Results have shown UV exposure and formation of microplastic particles significantly increased leaching of Bisphenol A from epoxy microcomposites. However, CNT loading significantly decreased BPA leaching from epoxy microcomposites. Further studies are necessary to elucidate the relationship between nanoparticles within polymer matrices and the release of potentially harmful polymer additives into the aquatic environment.

PC011 The influence of ultraviolet light on release of polymer additives from epoxy-CNT nanocomposite microplastics into the aquatic environment

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Engineered nanomaterials and nanoparticles are increasingly used in consumer products due to their properties and ability to be incorporated into performance composites. Nanoparticles such as carbon nanotubes are placed into polymer matrices to improve tensile strength, UV inhibition, flame resistance, electrical and thermal conductivity and reduce gas permeability. Many studies have investigated the impact of release of these nanoparticles into the environment and their ecotoxicological effects. However, few studies have investigated how the inclusion of carbon nanomaterials in polymer matrices can impact the release of associated polymer additives. Polymer additives may be released through mechanisms of pH-mediated polymer hydrolysis, oxidation, UV degradation, mechanical abrasion, and thermal degradation, among other mechanisms. The release of these additives from microplastic composites into the aquatic environment are of concern due to the known endocrine-disrupting activity of additives such as Bisphenol A and nonylphenol. In this study, a 5 day leaching experiments of cryomilled epoxy containing varying loadings of carbon nanotubes (0, 0.01, 0.05, 0.1%) was completed. The polymer additives that were studied were Bisphenol A (BPA), Bisphenol A diglycidyl ether (BADGE), 4-tert-butylphenol (TBP), 4-tert-butylphenol glycidyl ether (TGBE) and Nonylphenol. The epoxy was incubated in water under dark conditions, and at temperature of 65 °C. This experiment was repeated with epoxy and epoxy microcomposites exposed to 14 days of 750 Watt UV exposure. Daily measurements of polymer additive concentrations in water were made using LC-MS/MS methods to investigate the influence of epoxy surface area, carbon nanotube loading, and UV exposure increase the release of these polymer additives into an aqueous environment. Results have shown UV exposure and formation of microplastic particles significantly increased leaching of Bisphenol A from epoxy microcomposites. However, CNT loading significantly decreased BPA leaching from epoxy microcomposites. Further studies are necessary to elucidate the relationship between nanoparticles within polymer matrices and the release of potentially harmful polymer additives into the aquatic environment.

PC013 With growing plastic production, how do we identify sources of pre-production pellets and hold parties responsible for spills and releases?

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Plastics are essential in our society. They serve many purposes while improving safety and reducing costs. Because of these benefits, their production is growing by >12 million tons annually across the globe. Production in North America grew an average of 0.75 million tons between 2000 and 2016 (48 to 60 million tons) but jumped 4.4 million tons in 2017. This is the start of an upward trend on the continent, with many new pellet plants planned in the U.S. Texas with its ports and nearby oil and gas extraction is leading this growth, where the city of Corpus Christi anticipates opening the two largest polyethylene terephthalate plants in the world before 2024. Coastal Texas is already home to numerous plants that ship their product globally. This current production and its shipping has resulted in the ubiquitous presence of pellets in several bays as well as the entire Texas Seashore. Contamination is particularly high in the Matagorda/Lavaca Bay system, which is home to a polyethylene and polypropylene manufacturer. A local citizen group is suing the manufacturer under the Clean Water Act after collecting over 2,000 samples documenting pellets and plastic powder. They are asking the Court to order changes at the plant to stop the future discharges and are asking that penalties be assessed against the company (these go to the federal government). They are awaiting the Judge’s verdict in the first phase to determine if their permit was violated. If found liable a second trial phase will occur to determine the remedy. The permit language at the heart of the lawsuit states that they shall not discharge pellets at more than “trace amounts.” 171 - 1,658 tons or 7.5 - 75 billion plastic pellets have been obtained from diverse polymer reference materials and determined that microplastics >=0.03 mg can be accurately identified. Polymer identification of marine debris is complicated and a multiple-method work flow is required for complete and accurate identifications.

PC012 A deep dive into polymer identification methods for Hawaiian beach plastic marine debris

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Polymer identification is now expected in plastic pollution studies, because each polymer has different chemistry, uses, disposal processes, environmental fates, additive chemicals, affinities for contaminants, thus potentially different impacts on marine organisms. This study further evaluated the most common tool for polymer identification of meso-sized plastic pollution, attenuated total reflectance Fourier transform infrared spectroscopy (ATR FTIR). We expect ATR FTIR will remain the primary tool, but researchers should know its limitations. In 2018, we presented that this method can miss multi-layer composites because it measures only the top 1-2 um surface. The current study assessed additional limitations and solutions. Firstly, we mistakenly listed the same absorbance bands for acrylonitrile butadiene styrene (ABS) and polystyrene (PS) in Jung et al (2018). The acrylonitrile band at 2235 cm⁻¹ was present in ABS and absent in PS standards we analyzed and is necessary to differentiate the two polymers. Also, 24 samples of Hawaiian beach plastic debris that had been tentatively identified by ATR FTIR were examined with three additional methods: total transmission FTIR of heat pressed thin films of each sample, differential scanning calorimetry (DSC), and microscopic assessment of layers from thin sliced cross sections. Multiple polymers were discovered in 15 (63%) samples, and ATR FTIR alone revealed only four (27%) of these. Sixteen samples identified as low density polyethylene (LDPE) by ATR FTIR were analyzed by DSC to definitively differentiate PE densities. Correct identification success by ATR FTIR was dependent on the extent of weathering. All four of the least weathered samples were correctly identified as LDPE by ATR FTIR, whereas all of the severely and 57% of the moderately weathered ones were actually high density (HDPE). The 1377 cm⁻¹ band in the ATR FTIR spectra is unreliable in weathered PE samples. Weathering of HDPE appears to increase branching, resulting in a band at 1377 cm⁻¹ which is typically only expected in highly branched LDPE. We provide DSC melt curves obtained from diverse polymer reference materials and determined that microplastics >=0.03 mg can be accurately identified. Polymer identification of marine debris is complicated and a multiple-method work flow is required for complete and accurate identifications.
scientific community will be called on to provide expertise in tracking the path of pre-production plastics, identifying the source of the discharges and spills and explaining the harm to the ecosystem.

**PC014 Assessing the impacts of microfibers to a sediment-dwelling benthic invertebrate**

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Microfibers (anthropogenic fibers < 5mm in size) are ubiquitous in sediment, surface water, and wildlife globally. Research shows negative effects of synthetic microfibers on organisms, including impacts to growth, feeding behaviour, and hepatosomatic index. Researchers have also documented microfiber persistence in the environment; even natural microfibers may persist for months to years. However, knowledge is lacking on the chronic effects to biota from microfiber exposure and whether these effects differ according to exposure to synthetic versus natural microfibers (i.e. polyester and cotton). Our research explores the effects to freshwater aquatic biota from exposure to polyester and cotton microfibers. A chronic life-cycle toxicity test was conducted using the midge Chironomus dilutus. Since Chironomus sp. are sediment-dwelling organisms, they are directly exposed to microplastic accumulation in sediment. We exposed C. dilutus to “clean” cotton and polyester microfibers plus each type of microfiber soaked in wastewater final effluent to examine the effect from the addition of a chemical mixture. Acute exposures (10 d) evaluated biological uptake of microfibers, with results of longer-term exposures (56 d) assessed to determine the effects of microfibers by investigating individual growth and survival, time to emergence, sex ratio, reproductive success, and survival of offspring. We hypothesize that effects on C. dilutus differ according to microfiber type and exposure to the wastewater treatment chemical mixture. Methods for preparing microfiber diets and results of these investigations will discuss techniques to expose organisms via treatment diets. Preliminary results show biological uptake of microfibers by C. dilutus, and ingestion of microfibers >1mm in length. Our study will contribute to a better understanding of organismal and population-level effects on a freshwater species exposed to microfibers and associated chemicals. Results of this work will be considered in conjunction with other ongoing work testing the same microfibers and mixtures on other aquatic species, including rainbow trout (Oncorhyncus mykiss) and fathead minnow (Pimephales promelas) to look for patterns of similarity among different taxa.

**PC015 Microplastic Consumption and Excretion by Fathead minnows (Pimephales promelas): Is it dependent on particle size and organism body shape?**

*M. Felix-Kim, T. Hoang, Loyola University, Chicago / Institute of Environment and Sustainability*

The present research characterizes the dependence of microplastic consumption and excretion on particle size by fathead minnow (Pimephales promelas) over time that has not been studied. Specifically, the study is to answer 4 important questions: 1) how long does it take for larval fathead minnow to consume microplastic particles and what particles size? 2) How long does it take for the organism to excrete microplastic particles after consumption? 3) Will fathead minnow reconsume microplastic particles after excretion? 4) Are consumption and excretion dependent on the size of particles and body shape of organisms? To answer these questions, larval fathead minnow (2-3 day old) were exposed to polyethylene microbeads (PMBs) at two different consumable size ranges of 63-75µm and 125-150µm in moderately hard water. The experiments were designed to allow fish to reconsume the particles that they excreted and not to reconsume the excreted particles by transferring fish to new water every 30 minutes. Results of this study found that fathead minnow consumed significant amount of PMBs after 1h of exposure to 25 mg/L regardless the particle size. The number of consumed PMBs at smaller size range (4.5 PMBs/fish) was up to 10 times higher than that at the larger size range (45 PMBs/fish). After consumption, fish excreted the PMBs over time. For the case of allowing reconsumption, fish started to reconsume the excreted PMBs after 3h regardless the particle size. When reconsumption is not allowed, fish completely excreted 125-150µm PMBs after 12h but it took more than 24h for fish to completely excrete the 63-75µm PMBs. The excretion rate was 3 times higher for 125-150µm PMB (0.182) than for 63-75µm PMB (0.059). Interestingly, it took longer time for bent body fish to excrete PMB than regular straight fish. These results indicate that smaller size particles remain in the fish gut for longer time and hence could have higher potential effect to fish than larger particle size. Our observation showed that excreted PMBs were likely coated with organic substances that stuck the particles together and sunk on the bottom of the exposure chambers. This result suggests that in the nature environment, consumption of plastics by fish can facilitate the movement of plastics from the water column to the sediment. Plastic particles can adsorb hydrophobic organic contaminants from the sediment and can carry them to benthic organisms when plastics are consumed.

**PC016 Gastrointestinal mediated impacts on lipid metabolism following chronic exposure to a phthalate plasticizer in zebrafish**

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Plastic pollution is an emerging global threat to humans and wildlife. Upon ingestion of plastics, leaching of chemical components can occur in the organism. Diethylhexyl phthalate (DEHP) is a plasticizer that leaches from food containers and PVC breakdown products, resulting in exposure of both humans and wildlife. Evidence suggests that DEHP and other phthalates may alter metabolic processes, particularly when exposed in conjunction with overfeeding, which may be contributing to the increasing obesity epidemic over the last forty years. These effects may be modulated by peroxisome proliferator activated receptors (PPARs), a family of nuclear receptors known to be involved in lipid metabolism and adipogenesis. Using in vitro PPARα transactivation assays, we have demonstrated that though zebrafish PPARα activation by DEHP, and its primary metabolite monoethylhexyl phthalate (MEHP), is less sensitive than humans, these fish are still susceptible to the endocrine disrupting effects of these chemicals. To determine downstream impacts of PPARα activation by DEHP we conducted a 60 day feeding study with adult zebrafish (Danio rerio) which exhibited decreased expression of PPARα in gut tissue, and increased expression of PPARγ in the liver, suggesting these receptors are sensitive to DEHP exposure, however there were no impacts on body mass in these fish. Therefore, we hypothesized that early life stage exposure may result in phenotypic responses to DEHP since PPARs are intimately involved in early adipogenesis. We chronically exposed larval zebrafish to DEHP exposure (6 months) to evaluate the potential for altered lipid metabolism, starting at 3dpf to one of four treatments: Control, Overfed, Regular Fed + DEHP (3ppm), and Overfed + DEHP (3ppm). Lipid staining was conducted at 10dpf, 12dpf, and 15dpf to monitor adipogenesis. At 24 weeks, zebrafish were euthanized, and gut, liver and fecal matter were excised. Differences in expression of PPARα, PPARβ, and PPARγ were monitored at 10dpf, 12dpf, 15dpf, 4 weeks, 12 weeks and 24 weeks. To examine whether alterations in lipid metabolism lead to alterations in body composition and physical fitness, a swim tunnel assay was utilized to assess swimming performance and maximal respiratory capacity. These results demonstrate the need to understand the effects of chemicals leaching from ingested plastics, and the role these chemicals may play in population level outcomes, such as obesity.
Endocrine Disruptors, CECs and Agriculture in Developing Countries: The Nexus Bridging Environmental and Human Health

PC017 Insecticide treated mosquito net fishing in Zambia: A case study for the importance of one health approaches to public health interventions

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Insecticide treated mosquito nets (ITNs) are considered to be a great public health success story, saving millions of lives in areas with endemic mosquito borne infectious diseases. ITNs are typically treated with pyrethroid insecticides that are effective at killing mosquitos but exhibit little toxicity to humans. While ITN distribution programs are common in areas of sub-Saharan Africa, studies have indicated that utilization of ITNs lags behind distribution, which has fueled speculation of alternative uses of the ITNs. For example, recent evidence from our team, based on qualitative interviews, found that ITNs are regularly used for seine fishing in regions of western Zambia. Participants also reported co-occurring declines in fish catch quality and quantity in areas with ITN fishing. However, little work has focused on understanding whether ITNs contribute to declines in fish population, either through the small mesh size removing vulnerable young of the year from the population, or through bioaccumulation and toxicity associated with insecticides that coat the nets. To begin to address the latter, exposure experiments were conducted with embryonic and larval fathead minnows (Pimephales promelas). Fish were exposed varying areas of ITNs (0, 1, 5, 10, and 20 cm²/ITN) in 300 ml of moderately hard water for 96 hours (embryos) and 7 days (larvae). Fish were monitored daily for any morbidity or mortality associated with exposure. At the end of the experiment fish were weighed to determine growth. Results indicated that even small areas of ITN (1 cm²) impact growth of larval while larger nets cause overt toxicity. Additional experiments are ongoing to examine leaching rates from nets and impacts on endocrine specific endpoints. Result from these studies are currently being used to demonstrate the issues associated with this practice and establish community partnerships with the local traditional hierarchical tribal leadership in hopes of curbing these practices. This study highlights the need to take a holistic, one health approach when implementing public health interventions in developing countries to ensure we protect human health without adversely impacting the environmental resources that drive economic prosperity and nutritional needs in these areas.

PC018 A Comparative Study of Contaminants of Emerging Concern Occurrence and Hazards in Two Major Wastewater Treatment Plants, Taipei, Taiwan

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Over the next few decades, the most populated cities will face increasing demand for sustainable water quality; however, diverse gradients of wastewater treatment capacities exist throughout Asia. This consideration is increasingly important because the majority of the world population and highest number of megacities are now located in Asia. For example, Taipei, Taiwan ranks among the most densely populated cities globally. We performed an initial study of the occurrence and associated water quality hazards of contaminants of emerging concern (CECs) in Taipei. We specifically evaluated 23 CECs in influent and effluent of two wastewater treatment plants with different treatment technology over two sampling seasons: the 2015 summer monsoon season, and the 2016 winter dry season. We also investigated whether temporal differences in CECs occurrence and hazards existed among and between the two plants. On each sampling event, analytes were extracted, separated and analyzed following previously reported methods using solid phase extraction and isotope dilution LC-MS/MS. We detected 13 of the 23 target analytes (acetaminophen, benzoylecgonine, caffeine, carbamazepine, diclofenac, diltiazem, diphenhydramine, erythromycin, fluoxetine, ketamine, sucralse, sulfamethoxazole, trimethoprim). We then used a fish plasma modeling approach to determine whether water quality hazards differed among each sampling location. We also employed probabilistic environmental hazard assessments for antibiotics to identify probabilities of exceeding the predicted no-effect concentration for promoting antibiotic resistance. Consistent with observations from previous studies, acetaminophen, caffeine and sucralse were detected at the highest levels. While the primary cocaine metabolite benzoylecgonine was occasionally detected at low ng/L levels, ketamine, another drug of abuse, was observed at elevated level in effluents (81 - 447 ng/L). Treatment efficiencies, effluent concentrations and associated water quality hazards differed between the two plants. At the more advanced Dihua plant, acetaminophen removal efficiency approached 100%, while at the Bali plant, which primarily relies on a type of chemically enhanced primary treatment technology removal efficiencies were as low as 1%. Our results indicate that different treatment technologies were more important than season and daily influences on effluent CEC levels and water quality hazards in this pilot investigation.

PC019 Chemical pressures on watersheds in Chile: Chemical, biologic and human concerns

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In the northern regions of Chile, the dominant arid environment is bisected by rivers that irrigate highly productive agricultural landscapes. Many of these rivers are multi-use in that they provide energy for hydropower, water for irrigation and drinking water for the adjacent human communities, and it is not unusual for human communities to live in close proximity to areas that are involved in intensive, industrial agriculture. While the riverine systems in this environment may contain detectable levels of pesticide contamination, the cascading relationships from chemical occurrence to validated response in aquatic species to adverse impacts on human communities are difficult to establish for a number of reasons. The first is that, in such arid environments, the release of pesticides from agricultural lands is difficult to quantify in a reliable fashion, which makes the water-borne exposure difficult to assess. The second is that the Andes Mountains present a biogeographical barrier to species dispersion, therefore many of the aquatic species of interest are endemics. This creates problems as the molecular biology of these endemic species, in many cases is not well described. Fortunately, recent work on an endemic mayfly Andesiops torrens (Insecta, Ephemeroptera) and an endemic fish species, Trichomycterus areolatus may ameliorate these problems. Finally, the jump from impact on aquatic species to adverse health impacts in humans, is difficult to make as other routes of exposure, such as direct contact by workers, or aerial exposure in adjacent communities, obfuscates the role that water plays in pesticide exposure.

PC020 Organic Contaminants of Interest in Northern Pakistan River Ecosystems

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Anthropogenic environmental contaminants can adversely impact aquatic ecosystems.Livelihood impacts resulting from decreasing fish diversity have led to a multi-disciplinary collaboration between the US and Pakistan to address these concerns. The main purpose was to identify and quantify organic contaminants in the Swat and Kabul Rivers in Northern Pakistan in order to inform implementation of new and existing policies to improve water quality, fish diversity and overall fish health. Samples
were collected along both the Swat and Kabul Rivers during low and high river flow in 2018 and 2019. Samples were screened for target and non-target contaminants using liquid chromatography tandem quadrupole time-of-flight mass spectrometry. Both rivers contained a suite of phthalates, pharmaceuticals, pesticides, and chemicals in personal care products with the Kabul River system appearing more contaminated than the Swat River system. Detailed occurrence results will be presented and implications on fish diversity, fish health and river-based livelihoods of communities in the region will be discussed.

**PC021 Estrogenicity of agricultural runoff: Rainfall simulation study of worst-case scenarios using fresh farrowing swine manure, layer and broiler litter**

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Agricultural runoff into surface water has been implicated in the feminization of fish, but field studies have failed to associate estrogens in runoff directly with effects on fish. Therefore, fresh manure from laying hens, roaster chickens, and farrowing swine, animals known to excrete high concentrations of estrogens, was tilled into plots (n = 6 for each manure type), and 24h later rainfall simulation was conducted. Runoff was collected for 30 min. Estrogenic activity (estradiol equivalents, E2Eq) was measured in vitro using E-Screen, in addition to a panel of N, P, and total organic carbon. Rainfall simulations were again conducted at 1- and 3-week post manure application. Year 1, three layer litter plots had E2Eqs that approached the No Effect Concentration of 2 ng/L 24h post-application. While one plot remained at 1.6 ng/L E2Eqs at one week, the other plots ranged from 0.1 - 0.5. In YR 2 and 3, maximum E2Eqs concentrations at 24h ranged from 2.1 to 6.6 ng/L, somewhat above the NOEC. By week 1, concentrations were < 25% of 24h concentrations. In YR 2 roaster litter gave similar results, with 24h E2Eqs of 1.3 to 5.1 ng/L, with similar reductions of E2Eqs by week 1. In YR 3, 24h swine slurry ranged from 0.4 to 4.7 ng/L. Despite plot proximity to one another, there was substantial variability among plots, yet it appears that even these worst-case scenarios failed to result in runoff E2Eqs concentrations high enough to alter biological processes in aquatic organisms.

**PC022 Chemicals of Emerging Concern in SE Asia: Countrywide differences in knowledge bases regarding ecotoxicology and human health risks**

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Rice and other important crops such as bananas, coconuts, sugar cane and oil palms are critically important crops for food and economic security throughout SE Asia. Farming these crops often occurs in monocultures that utilize multiple pesticide applications across the landscape. In the short-term, these agrochemicals provide the farmers with stable crop production, but may also lead to resistance and exposure risks to the farmers and to the biodiversity that may support ecosystem services within the agroecosystem. To understand the knowledge base regarding issues surrounding aquatic contamination and the outcomes to aquatic ecosystems across SE Asia, we conducted a literature search in Pubmed for each SE Asian country. The country names and were paired with the search terms “endocrine *disrupt*”, “aquatic toxicology”, “pesticide” and “fish”, and “wastewater” and “chemical”. Our results found that, within SE Asia, the most peer-reviewed literature is from Malaysia (45.2%) and Thailand (30.1%). There very limited literature published from Myanmar (0.2%), Laos (0.6%) and Cambodia (1.1%), and while not extensive, researchers from the Philippines, Indonesia and Vietnam are publishing regarding the impact of environmental contaminants on the aquatic environment: 4.4%, 5.8% and 12.7% of all SE Asia literature, respectively. In SE Asia, Non-Governmental Organizations and funding partners, including the United Nations Food and Agriculture Organization, have developed programs to support Integrated Pest Management and other sustainability programs such as the Closing Rice Yield Gaps in Asia, (CORIGAP), the Sustainable Rice Platform (SRP), and Land-use Intensity and Ecological Engineering--Assessment Tools for Risks and Opportunities (LEGATO). The interconnectivity of the aquatic systems across SE Asia demonstrates an increased need to understand how pesticide use affects agroecosystems and human health. Integrating alternatives to pesticides, such as the use of natural pest predators, some of which may also support food and economic security, into pest and weed control, will provide the capacity to support the One Health Paradigm in SE Asia.

**PC023 At the Nexus of Water Quality, Food Security and Economic Development: The Lower Volta River in Ghana**

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The Lower Volta River in Ghana serves as the drinking water source for the capital Accra and its over four million inhabitants. Additionally, the river is an important site of food production through high-intensity pen-aquaculture and serves as an economic resource for building materials through sand dredging. These competing interests need to be reconciled to maintain high drinking water quality while ensuring food security and economic viability. We assessed water quality and microbial communities along sixteen sampling sites between Lake Volta and the estuary of the river using solid phase extraction and LC-MS/MS analysis. Overall water quality was good but exhibited land-use related deterioration consistent with pen-based aquaculture (occurrence of antibiotics at low ng/L concentrations), agriculture (herbicide presence) and rural development (personal care products at concentrations approaching ug/L concentrations). In addition, herbicides and plasticizers were detected in river water and drinking water at low ng/L concentrations. DNA extracted from surface sediment, water, and sediment core samples and analyzed by Illumina sequencing for 16S rRNA genes broadly concurred with analytical chemistry. Quantitative PCR (qPCR) for 12 different antibiotic resistance genes and qPCR followed by Illumina sequencing for pathogens and virulence genes were also performed on these samples. Sequencing data was processed using QIME2. Based on Bray-Curtis Dissimilarity Analysis, the microbial communities in the water and sediment samples were very distinct from one another; the surface sediment samples demonstrated a clear dependence on location along the river, with those samples most heavily impacted by aquaculture facilities deviating from a simple location dependence. Taxonomic analysis also suggested an impact of two aquaculture facilities on the microbial community make-up. As developing countries advance water quality, food security and economic development, competing interests need to be reconciled. This study may serve as one example of these interests and will be expanded to develop solutions.

**Contaminant Issues in Waste Streams**

**PC024 Global distribution of Decabromodiphenyl ethane through electrical and electronic equipment trade originated in China**

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Decabromodiphenyl ethane (DBDPE) has been used as a competitor of, and is proposed as an alternative to, the commercial decabromodiphenyl ether (deca-BDE) flame-retardant in electrical and electronic equipment (EEE). However, current studies have indicated that DBDPE has potential persistent, bioaccumulative, toxic characteristics. As the biggest EEE
manufacturing and exporting country in the world, China has inescapably contributed a remarkable amount of DBDPE to international trade flows. DBDPE can be distributed worldwide with the international trade of EEE; it can also be released to the environment throughout the product lifespan (e.g., in in-use and waste stocks). Using a dynamic substance flow analysis, we estimated the time-dependent mass flows, stocks and emissions of DBDPE in China, and the global dispersal of DBDPE originating in China through the international trade of EEE and e-waste. Our analysis indicated that, between 2006 and 2016, ~230 thousand tonnes (kt) of DBDPE has been produced in China, in which ~196 kt of DBDPE were released to the environment during the production, use phase and waste disposal activities. By the end of 2016, ~152 kt of the DBDPE produced resided in in-use products across China. During the period 2000-2016, ~39 kt of DBDPE were exported from China in EEE products, most of which (>50%) ended up in North America. Based on projected trends of China’s DBDPE production, use and EEE exports, we predict that, by 2026, ~74 and ~14 kt of DBDPE originating in China would reside in in-use and waste stocks, respectively, in regions other than mainland China. The in-use and waste stocks of EEE will act as long-term emission sources of DBDPE worldwide and generate continuous risk to the environment and public health. Eventually, an increasing amount of DBDPE in EEE will enter the waste stream in the next decades; the global redistribution of DBDPE within the international waste transfer chain and the contamination in products produced from the recycled materials containing DBDPE deserve our attention in the future.

PC025 Estimation of the fate of HBCD isomers in two waste recycling facilities and their emission to the environment

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Hexabromocyclododecane (HBCD), which is used as a flame-retardant in a wide range of products, has recently been included in the Stockholm Convention on Persistent Organic Pollutants (POPs). HBCD can be emitted to the environment from waste treatment and recycling plants across China. During the period 2000-2016, ~39 kt of HBCD were exported from China in EEE products, most of which (~50%) ended up in North America. Based on projected trends of China’s HBCD production, use and EEE exports, we predict that, by 2026, ~74 and ~14 kt of HBCD originating in China would reside in in-use and waste stocks, respectively, in regions other than mainland China. The in-use and waste stocks of EEE will act as long-term emission sources of HBCD worldwide and generate continuous risk to the environment and public health. Eventually, an increasing amount of HBCD in EEE will enter the waste stream in the next decades; the global redistribution of HBCD within the international waste transfer chain and the contamination in products produced from the recycled materials containing HBCD deserve our attention in the future.

PC026 Brominated dioxins emission from e-waste recycling facility in Japan

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Brominated dioxins such as polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/DFs) should be detected for their risk assessment according to the review article by the WHO/UNEP expert panel. Since 2002, the Ministry of the Environment of Japan (MOE) has conducted a series of field studies to survey the emissions of brominated dioxins from the potential sources related with brominated flame retardants (BFRs). Past surveys clearly revealed that PBDD/DFs tended to be detected in working air and effluents from the facilities recycling the waste of electric household appliances (e-waste) at concentration in excess of the standards for chlorinated dioxins in Japan. Therefore, this study investigated the current status of brominated dioxins emission from the e-waste recycling facility in Japan. According to the Law for Recycling of Specified Kinds of Home Appliances, e-wastes such as TVs, refrigerators, air conditioner and washing machines were collected and recycled properly in the e-waste recycling facilities. Here, 10 of 47 e-waste recycling facilities were investigated, which were the same facilities as previous MOE investigation. The total amount of materials recycled in 10 facilities was 203 kt for e-waste collected in FY2016, which was about 42% of those in 47 facilities. Working environment air (n=21) in the site of manual dismantling of e-waste were collected using a high-volume air sampler. Final effluents (n=12) in operation were collected in amber glass bottles. Wastewaters (n=4) generated at the separating process before the treatment in the wastewater treatment equipment were also collected. Sampling was conducted during December 2017 to January 2018. 2,3,7,8-TCDD equivalent for extract containing brominated dioxins (TCDD-EQPBDD/DFs) and WHO-toxic equivalent for PBDD/DFs (WHO-TEQPBD/DFs) in samples collected were measured by in vitro cell-based assay and GC-HRMS, suggesting that PBDD/DFs emission at FY2017 was lower than those at FY2002 and FY2011. There was correlation between WHO-TEQPBD/DFs and decaBDE concentration, indicating source of PBDD/DFs. For water samples, but not working air, TCDD-EQPBDD/DFs and decaBDE concentration was extremely higher than WHO-TEQPBD/DFs, suggesting existence of unidentified dioxin-like compounds derived from e-waste. Obtained results also indicate that it is important for the environmentally sound management of brominated dioxins such as PBDD/DFs derived from e-waste to control dust and particulate matter in the facility.

PC027 Is e-waste a source of contamination in a tropical coastal ecosystem?

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End-of-life electrical and electronic products (e-waste) is the fastest growing stream of waste globally. As e-waste contains a wide range of
hazardous compounds, handling and recycling of e-waste is a challenge in terms of cost and logistics, and may be a source of environmental contamination. Tanzania represents a growing economy, with increasing demand and import of electronic products, along with poor regulatory guidance and facilities for recycling and disposal of these products. Only a few studies have addressed environmental contamination in Tanzania, and in general little is known regarding the occurrence and dynamics of organic contaminants in tropical food webs. Particular compounds associated with e-waste such as chlorinated paraffins and brominated flame-retardants remain insufficiently studied. Sampling of coastal marine fish from different trophic levels with different dietary niches was conducted during field campaigns in 2018 and 2019. Sample sites include two sites in Dar es Salaam and one site on Unguja Island, Zanzibar, which differ in human activity, policies regarding import of electronic goods and waste, and thus pollution pressure. Fish muscle was analysed for legacy flame-retardants (PCBs and PBDEs), mercury, organochlorine pesticides, and new flame-retardants. Stable isotopes of carbon and nitrogen were analysed to assess dietary carbon source and trophic level, respectively. A recent study from the Anthrotox project shows elevated levels of chlorinated paraffins, deca-BDEs and new brominated flame-retardants in soil, suggesting local contamination from e-waste. In fish samples, however, organochlorine pesticides dominated, and levels of PCBs and flame-retardants were very low, indicating no apparent source of contamination from e-waste. The present study investigates contaminant occurrence and food web dynamics in a region where very little data exist, even on legacy contaminants. In addition, the study highlights the need to target newer types of flame-retardants in order to assess the increasing issue of environmental contamination from e-waste.

PC028 Substance flows and environmental emissions of chemicals associated with industrial waste treatment in Japan

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Because a large portion of chemical substances would be eventually processed as waste, a sound management of chemicals during waste treatment processes is important for chemical risk reduction throughout their lifecycle. Quantitative data of the flows and the environmental emission of chemical substances, however, is still lacking for waste treatment processes. This study investigated the substance flows and the atmospheric emissions of chemicals associated with waste treatment in Japan, especially focusing on industrial waste incineration. Firstly, we investigated the inflows of chemicals to different waste treatment processes in Japan by different waste categories by analyzing the information obtained from the Japanese Pollutant Release and Transfer Register (PRTR). We also estimated the inflows of heavy metals to the incineration processes based on metal content analysis of incineration residue samples. The results showed that several specific waste categories were dominant in the chemical inflows. For example, the dominant sources of heavy metals for incineration processes were sludge and waste acid/alkali. To accurately estimate environmental emissions, the difference in chemical inflows by the types of waste predominantly processed at each facilities should be considered. Secondly, we estimated emission factors for incineration facilities by measuring the concentrations of heavy metals, volatile organic compounds, and aldehydes in the exhaust gas. The emission factors ranged over a few orders of magnitude, which we attributed to the differences among exhaust treatment systems. The installed technology must be considered to accurately estimate emission factors for incineration facilities. Finally, we estimated the atmospheric chemical emissions from industrial waste incineration facilities in Japan. The accuracy of the estimates were improved when the type of predominant wastes and installed technology at each incineration facility was considered. The results suggested that the emissions of heavy metals, 1,4-dioxane, and acetaldehyde from industrial waste incineration cannot be ignored when compared with those released by other emission sources. By contrast, the emissions of hexavalent chromium, most of the investigated volatile organic compounds and aldehydes were much less than those from other sources. The results indicated that chemical management during waste treatment processes would be important for some chemical substances.

PC029 PFAS in aqueous samples from landfills

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One source of concentrated poly- and perfluoroalkyl substances (PFAS) is landfills. These sources include leachates from different landfill types (municipal solid waste, municipal solid waste incineration ash, and construction and demolition), from gas condensates, storm water and groundwater within the landfill boundaries. The objective of this study was to evaluate PFAS from these aqueous landfill sources for 26 PFAS species including 11 perfluorooalkyl carboxylic acids, 7 perfluorooalkyl sulfonates, 5 fluorotelomers, and 3 perfluorooctane sulfonamides. Landfill leachate is typically disposed of off-site at a wastewater treatment facility, and landfills often pre-treat the leachate to make it more acceptable for these facilities. Landfills with leachate these pre-treatment systems (reverse osmosis, powdered activated carbon, biological aerations, and evaporation) were evaluated to determine the effectiveness of treatment systems to remove or concentrate PFAS. Results show that total PFAS concentrations were variable with groundwater and storm water measuring at detectable but low levels (generally < 600 ng/L). Gas condensates and leachates were characterized by higher levels. No statistical differences were observed between gas condensate and the different types of leachate due to the high variability of the results. The maximum total PFAS concentration observed were 54,000 ng/L for an ash leachate sample and 81,000 ng/L for a gas condensate sample. The predominant PFAS species in both of these samples were the perfluoroctane sulfonamides. Among the treatment systems reverse osmosis was the most effective with over 99% reductions in total PFAS within the permeate.

PC030 Presence and Partitioning of 13 Organophosphate Flame Retardants (OPFRs) in the Solid and Liquid Waste Streams of Five Wastewater Treatment Plants in Canada

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Organophosphate Flame Retardants (OPFRs) are esters of phosphoric acid that are increasingly used by the flame-retardant industry to replace regulated brominated diphenylethers (BDEs). In this study we investigate the occurrence and distribution of 13 Organophosphate Flame Retardants (OPFRs) in the liquid and solid waste streams of five wastewater treatment plants in Canada. While some analytes showed partition from the liquid waste stream to the solid waste stream and visa versa, all the detected analytes survived secondary wastewater treatment. Results from effluent samples collected in parallel to biosolids were used to estimate field-based solid-water partition coefficients (KD). These values were compared with octanol-water partition coefficients for significance. The values calculated in this study can be used to predict, model and understand the behavior and fate of OPFRs in the environment.
Models as a Tool for Understanding and Communicating Threats to Aquatic Ecosystem Integrity

PC031 Benefits of an Enhanced Adaptive Management Model in Stakeholder Communications

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Mercury was used in the manufacturing process at a facility in Waynesboro, Virginia between 1929 and 1950, resulting in its release and migration into South River surface water, sediments, soils, and biota. As characterization and remedial planning progressed through the RCRA process, an innovative vehicle was needed to capture baseline characteristics, remediation progress and effects, and monitoring components of this complex system that could be communicated to an equally diverse group of stakeholders. The overall goal was to develop a decision-analytic framework that would capture all key values and parameters that are deemed most relevant to the on-going, decision-making process by all stakeholders. Development of the Enhanced Adaptive Management (EAM) model for the South River underwent several phases. Throughout the development phase until the present, data generated through on-going program activities and stakeholder involvement continue to inform the overall direction of program. The initial phase involved achieving acceptance of the fundamental concept by the South River Science Team. Along with this phase came a conceptual description of what the model could and could not do. Next a framework was developed that allowed for the incorporation of parameters critical to the technical understanding of the complex system, and equally critical parameters valued by the public. Extensive interactions among team members were conducted to ensure all interests were represented accurately. Visualization was a key tool in demonstrating all interests were being included. Once the model components were established, stakeholders were asked to rank model criteria. To assess the model, a series of removal scenarios was tested to demonstrate a range of outcomes for each. Since its inception, the EAM framework has served as a program repository to track, address and incorporate additional or modified remedial options, monitoring elements and stakeholder interests. Its flexibility also permits incorporation of new evaluation and analytical tools as they become available. This case study is a clear demonstration of the benefits in using the EAM decision tool as a focal point in complex remediation programs.

PC032 Predicting fathead minnow tissue selenium concentrations from oral selenomethionine exposure using compartmental toxicokinetic modeling

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Selenium (Se) is a trace element and essential micronutrient for almost all forms of life which has a narrow threshold between beneficial and toxic doses. Though it is found in many bio and geological compartments, Se is particularly enriched in organic (i.e. fossil fuel) deposits and can be released to the aquatic environment by both natural and anthropogenic activities. When liberated to the aquatic environment in excess, aqueous Se oxyanions can be biotransformed to the organic form “selenomethionine” (SeMet), whereupon Se can bioaccumulate due to SeMet’s dose-dependent substitution for the essential amino acid and biochemical SeMet analogue, methionine. Bioaccumulated Se can subsequently pose risks consumers. Oviparous animals dependent upon aquatic environments are at particular risk, as SeMet is shunted to their developing eggs causing oxidative stress during embryogenesis that can lead to terata and/or recruitment failure. Many current protective guidelines rely on tissue threshold approaches to determine whether Se concentrations pose risks to these animals, however these risks could be mitigated further if these concentrations could be predicted before the occurrence. This research presents a compartmental model of Se toxicokinetics in a model organism, the fathead minnow (Pimephales promelas). Rate constants for Se flux across fathead minnow tissues in fish exposed to selenomethionine have been derived using literature values and SAAM II modeling software and subsequently used to inform a model coded in Python, and experimental data are currently being used to validate the model’s fitted values. It is hoped that the finalized model can be used to inform proactive risk assessment of fathead minnows orally exposed to selenomethionine, and that the model may ultimately be extrapolated to other species at risk through the development of species-specific model objects.

PC033 Coupling chemical stressors and inter-specific competition to forecast trout population dynamics: strengths and weaknesses of mechanistic models

C. Accolla, V. Forbes, University of Minnesota / Ecology, Evolution & Behavior

One of the major goals of ecological risk assessment (ERA) is to understand the impacts of chemicals on populations, communities and ecosystems. However, methods for estimating and integrating exposure and effects are often based on individual-level responses, whereas it is crucial to predict impacts of stressors at higher levels of biological organization. Mechanistic models have an essential role to ensure better predictive capacity, integrating the effects of chemicals and inter-specific relationships across multiple spatio-temporal scales. Furthermore, models can extrapolate both stressor impacts and life histories across species that cannot be tested in the lab. The aim of this research is to compare the impacts of generalized stressors affecting different metabolic pathways of two trout species: Salmo trutta (brown trout, BT) and Oncorhynchus clarki stomias (greenback cutthroat trout, GCT). GCT is threatened because of chemical exposure and competition with BT. Many hypotheses exist to explain why BT is a better competitor. For example, BT reproduces in a more favorable season and is bigger (and therefore has a higher energy intake). Furthermore, aggressive behaviors have been reported in the literature. To understand the population dynamics of these two interacting species, we developed an individual-based model. The individual description is based on Dynamic Energy Budget theory, which describes the metabolic organization of organisms. When representing the two species separately in their respective environments, we found that individual-level responses to different stressors were qualitatively comparable; however, results at the population level differed markedly. When modeling inter-specific competition, we show that BT competitive advantages do not emerge from its life-history traits. This result suggests the importance of representing competition explicitly, to reproduce natural patterns and better forecast chemical impacts on populations. Moreover, the choice of temperature profile affects simulation results, showing that we need to consider carefully the ecology of the species of interest. Our research analyzes how models that quantitatively link impacts of chemicals and other stressors on individual life-history traits to consequences for populations can be informative for ERA. We also explore model limitations and strengths when representing complicated population dynamics for management purposes.
Publicly Accessible Data Analytic Tools for Environmental Toxicology, Chemistry, and Risk Assessment

SF001 The EPA CompTox Chemicals Dashboard as a Data Integration Hub for Environmental Chemistry Data

The U.S. Environmental Protection Agency (EPA) Computational Toxicology Program integrates advances in biology, chemistry, and computer science to help prioritize chemicals for further research based on potential human health risks. This involves computational and data-driven approaches that integrate chemistry, exposure and biological data. The National Center for Computational Toxicology (NCCT) has measured, assembled and delivered an enormous quantity and diversity of data for the environmental sciences, including high-throughput in vitro screening data, in vivo and functional use data, exposure models and chemical databases with associated properties. The CompTox Chemicals Dashboard is a web-based application providing access to data associated with ~875,000 chemical substances. New data are continuously added to the database on an ongoing basis, along with registration of new and emerging chemicals. This includes data extracted from the literature, identified by our analytical labs, and otherwise of interest to support specific research projects to the agency. By adding these data, with their associated chemical identifiers (names and CAS Registry Numbers), the dashboard uses linking approaches to allow for automated searching of PubMed, Google Scholar and an array of public databases. This presentation will provide an overview of the CompTox Chemicals Dashboard, how it has developed into an integrated data hub for environmental data, and how it can be used for the analysis of emerging chemicals in terms of sourcing related chemicals of interest, and deriving read-across as well as QSAR predictions in real time. This abstract does not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

SF002 QSARINS and QSARINS-Chem standalone version: Tools for QSAR models development, validation and application
E. Papan, N. Chirico, University of Insurbia / Department of Theoretical and Applied Sciences; A. Sangion, University of Toronto, Scarborough / Department of Physical and Environmental Sciences; P. Gramatica, University of Insurbia / Department of Theoretical and Applied Sciences

Since 2012 the QSAR Research Unit in Environmental Chemistry and Ecotoxicology at University of Insurbia has been developing free tools dedicated to the development, validation and application of models based on Quantitative Structure Activity Relationships (QSARs), and suitable to support the hazard and risk assessment of existing as well as not yet synthesized chemicals. In particular, the software QSARINS (www.qsar.it) is a user-friendly platform, which assists users in the analysis of data, in the development and validation of QSAR models based on Multiple Linear Regression (MLR) following the “OECD guidelines on the Validation of (Q)SAR Models,” and in the application of these MLR-QSARs for screening purposes. This tool includes procedures for data curation (correlation analysis and data filtering), features selection based on a Genetic Algorithm (GA), and diagnostic (internal and external validations, Y-randomization, analysis of the applicability domain, etc...). Furthermore, this software incorporates a database of chemicals (including their 3D structures), which have been collected and curated from the literature and used to generate our QSARs over the last two decades. In addition, to facilitate the application of QSARINS-generated models by non-expert users, we have recently released the QSARINS-Chem standalone software. This tool provides a simplified workflow and assists general users, experienced and non-experienced modelers as well as regulators, in the application of selected MLR-QSARs (supported by the QSAR Model Reporting Format (QMRF)) for screening purposes. This presentation illustrates the functionalities of the QSARINS software and of the new QSARINS-Chem standalone version, and gives examples of how these free tools can be successfully applied to generate and validate QSARs and predictions, for multiple endpoints, according to the “OECD principles for the Validation, for Regulatory Purpose, of (Q)SAR Models.”

SF003 Screening for biological relevance of environmental chemistry data using the toxEval software package

With thousands of potential chemicals in our natural environment, and advancements in instrumentation and analytical capabilities often providing detection levels in the nanogram per liter level and below, evaluating the biological relevance of chemical occurrence remains a challenging task. The U.S. Geological Survey and the U.S. Environmental Protection Agency have collaborated to develop the open-source software package toxEval (https://github.com/USGS-R/toxEval) to simplify this type of evaluation by efficiently examining chemistry data in multiple ways. The toxEval R package was designed to provide an efficient method to evaluate potential adverse biological impacts from user defined environmental chemistry data. Measured chemistry data is compared with benchmark bioeffect concentrations (concentrations at which biological activity may exist) to screen for potential adverse effects and prioritize the potential hazard by chemicals and sites. ToxCast is used as the default benchmark concentration database due to its broad coverage of more than 9000 chemicals and more than 300 bioeffect assays. Since there are often specific, previously compiled benchmark databases (e.g. the EPA aquatic life benchmarks) that are well established, an option is available to override the default bioeffect database in favor of a custom database for screening. These techniques allow for analysis of small to large data sets including capabilities to visualize and examine results for multiple chemicals per sample, multiple samples per site, and numerous sites across a broad geographic area. This demonstration will include an introduction to bioeffect evaluation concepts included in toxEval, results of a case study using water chemistry sampling results from Great Lakes tributaries using ToxCast as the bioeffect database, and a comparison of the results from the ToxCast database to established water quality benchmarks. This approach is intended to provide information for assisting scientists and watershed managers in better understanding where the greatest likelihood of adverse biological effects exists and what types of adverse effects may be impacting resident organisms. This abstract does not necessarily reflect USEPA policy.

SF004 Using lifecycle chemical emission information for high-throughput exposure-based risk assessments
L. Li, University of Toronto, Scarborough / Department of Environmental Sciences; J.A. Arnot, ARC Arnot Research & Consulting; F. Wania, University of Toronto, Scarborough / Department of Physical and Environmental Sciences

Chemical screening and prioritization assessments are commonly based on chemical hazard indicators (i.e., persistence, bioaccumulation, and toxicity) and/or commercial tonnage (i.e., the quantity produced or on the market). However, realistic ecological and human exposures, and associated risks, are additionally dependent on chemical use and release information (e.g., How and how much of a consumer product is used/released?). Substance flow analysis is a powerful tool to mechanistically derive chemical use and release rates throughout chemical and product lifecycles. Chemical screening and prioritization assessments can therefore benefit from incorporating substance flow analysis into chemical exposure and risk models. Here, we describe a new holistic modeling framework, comprising a substance flow model (a modified version of CiP-CAFE) and chemical exposure and risk models (RAIDAR and RAIDAR-ICE), which enables efficient, defensible screening and
prioritization of chemicals based on exposure- or risk-based assessment metrics. The modeling framework requires only two basic inputs, i.e., the commercial tonnage and molecular structure, and is thus well-suited for screening-level decision-making for a myriad of data-limited commercial chemicals. As a case example, the modeling framework is applied and tested for the estimation of human exposure to 95 neutral organic chemicals released during different lifecycle stages of articles or products. The model predictions are evaluated against an independent dataset of inferred human exposures of the US population; the difference between predicted and inferred exposure rates is within two orders of magnitude for 85 chemicals, and within an order of magnitude for 66 chemicals, with a coefficient of determination (R2) of 0.52, suggesting a reasonable performance of the model system. Our modeling framework allows for a “forward” evaluation of human aggregate exposure to chemicals arising from their actual use, or a “back” calculation of the critical production/import quantities of a chemical that would not cause an unacceptable level of risk. The approach shows promise in high-throughput screening of thousands of commercial chemicals.

**SF005 Using MicrobiomeAnalyst for comprehensive analysis of microbiome data**

*J. Xia, McGill University*

The past few years have witnessed a fast growth in the number of microbiome studies to understand human and environmental health. Despite the development of several powerful pipelines for raw sequence data processing, there is a great demand for user-friendly and easily accessible tools for statistical and functional analyses of microbiome data. Here we introduce MicrobiomeAnalyst, a public cloud/web-based tool for comprehensive analysis of microbiome data. The current version contains four modules - Marker Data Profiling, Shotgun Data Profiling, Taxon Set Enrichment Analysis, and Projection to Public Data. Each module contains a wide array of well-established as well as advanced methods for statistical analysis and visual exploration. MicrobiomeAnalyst has been implemented based on Java and R programming languages. It is hosted on a high-performance Google Cloud instance. Over the past 12 months, the public server processed over 50,000 jobs submitted from over 15,000 users worldwide. MicrobiomeAnalyst is freely available at https://microbiomeanalyst.ca.

**SF006 Using MetaboAnalyst for comprehensive analysis of metabolomics data**

*J. Xia, McGill University*

MetaboAnalyst (metaboanalyst.ca) is an easy-to-use, web-based tool used by >100,000 researchers worldwide for metabolomics data analysis, functional interpretation and biomarker identification. The workshop aims to introduce participants to the key features of the most recent release of MetaboAnalyst (version 4.0), including its comprehensive statistics capacity (univariate and multivariate analysis), pathway and enrichment analysis for both targeted and untargeted metabolomics data, biomarker analysis and meta-analysis, as well as multi-omics data integration through network-based visual analytics. During the workshop, participants will be given an overview of the different modules in MetaboAnalyst and most of its main functionalities. Selected example data sets will be processed using different MetaboAnalyst features as part of a live demonstration. Workshop participants will then continue with a “hands-on” lab using their own laptops. Participants are encouraged to bring their own data and to process it with MetaboAnalyst 4.0. Alternately, they may work with our example data sets and an accompanying tutorial to explore MetaboAnalyst 4.0 on their own.
it is expected that a number of additional high-throughput sequencing experiments will provide greater coverage and more thorough characterization of the fathead minnow genome. We are hopeful that this genome browser will serve as a SETAC-driven, collaborative genome research and development project that will benefit the ecotoxicology and ecological risk assessment communities. The contents of this abstract neither constitute nor reflect USEPA policy.

**SF009 The Adverse Outcome Pathway (AOP)-Wiki: Actionable Knowledge to Support 21st Century Toxicity Testing**
D.L. Villeneuve, US Environmental Protection Agency / Mid-Continent Ecology Division; C. Wittwehr, European Commission DG Joint Research Centre; S. Edwards, RTI International / Research Computing Division

The vision and strategy for toxicity testing in the 21st century addresses the need for data to inform chemical safety assessment by advocating the use of high throughput screening (HTS) approaches that can provide data rapidly and cost-effectively for thousands of compounds. However, data generation is just one part of the solution. For these data to be useful, decision-makers need access to the background information and interpretive context that can be used to transform the data into actionable knowledge that can inform decisions. The adverse outcome pathway (AOP) framework was developed as a systematic approach for organizing and synthesizing the biological plausibility, weight of empirical evidence, and quantitative understanding to explain and contextualize the connection between a pathway-based biological change and the apical adverse effects considered relevant to risk assessment. The AOP framework is rooted in a collaborative spirit in which subject matter experts contribute and combine their expertise to systematically describe cumulative and emergent knowledge that would otherwise be accessible to only a small fragment of the stakeholder community. Knowledge organized in this manner is captured in the AOP knowledgebase, presently represented by the AOP-Wiki (aopwiki.org). Thus, the AOP-Wiki becomes a source of actionable knowledge that supports practical application of the new data streams emerging from 21st century toxicology. This presentation introduces the conceptual and philosophical underpinnings of the AOP-Wiki and then invites the audience to explore the details of how AOP-knowledge is assembled and delivered through the current on-line platform and provide feedback on how the system could be improved for both contributors and users of AOP information. The contents of this abstract neither constitute nor reflect official policy of the USEPA.

**SF010 The USEPA Sequence Alignment to Predict Across Species Susceptibility tool for species extrapolation**
C. LaLong, US Environmental Protection Agency / Office of Research and Development; C. Finnegan, ORISE at USEPA; J. Doering, NRC / USEPA / Mid-Continent Ecology Division

For any given chemical limited toxicity test data exists and typically, if available, the data only represents that generated from a few model species. Therefore, the necessity to extrapolate existing toxicity knowledge collected from one species to others is a prominent challenge in chemical safety evaluations. This challenge is heightened in considering chemical impacts to threatened and endangered species where toxicity testing is impractical. Overall, it is critical to advance innovative methods and technologies for cross species extrapolation to inform chemical safety decisions. One such technology is the US Environmental Protection Agency Sequence Alignment to Predict Across Species Susceptibility tool (SeqAPASS; https://seqapass.epa.gov/seqapass), that capitalizes on existing and continuously expanding protein sequence and structural information to evaluate similarities and differences in chemical molecular targets across species. Based on the similarity of a known sensitive species to other species, a prediction of chemical susceptibility can be elucidated across hundreds to thousands of species. The tool relies on prior knowledge of a chemical protein target and a sensitive species and uses that information as a starting point to compare primary amino acid sequences, functional domains, and critical amino acids across species. SeqAPASS is flexible in that it allows the user to utilize all available information about the chemical protein interaction from the linear protein sequence to understanding of the tertiary structure of the protein. The results from the SeqAPASS tool can be downloaded as tables (.csv or .xlsx files) and visualized through an interactive box-plot graphic, that can also be downloaded. The newest release of SeqAPASS v4.0 will provide help menus and query guidance for the user, as well as rapidly interpretable data summary tables, with continuously improving user friendly features for streamlined navigation of the interface. Methods developed in the SeqAPASS tool aim to capture the state-of-the-science in protein comparison techniques and will continue to evolve as bioinformatic approaches improve and become more automated, particularly surrounding protein structural comparisons across species. The contents of this abstract neither constitute nor reflect official policy of the USEPA.

**SF011 EnviroTox Database: Overview and Applications**

Flexible, rapid, and predictive approaches that do not require the use of large numbers of vertebrate test animals are essential, as the chemical universe remains largely untested. Development of robust new approach methodologies (NAMs) and non-testing approaches requires the use of existing information via curated, integrated datasets. A large, diverse dataset was developed from a range of sources, with harmonization and characterization steps to ensure that the information could be effectively organized and mined. The resulting EnviroTox database (www.envirotox-database.org) contains 91,217 aquatic toxicity records representing 1,563 species, and 4,016 unique chemical CAS/®, Chemical-specific information is linked to each record and includes physical chemical information, chemical descriptors, and mode of action classifications. Toxicity data are associated with the physical chemistry data, mode of action classifications, and curated taxonomic information for the organisms tested. To make these data accessible and useful to stakeholders, the dataset was transitioned from Microsoft Excel and Access into a modern MySQL format, allowing for a format that is relational and scalable, facilitating easy access, sharing, and integration with other datasets and tools. The dataset is accessed via a web-based query system that is integrated with a predicted no effect concentration (PNEC) calculator, an ecological threshold of toxicological concern (eco-TTC) distribution tool, and a chemical toxicity distribution (CTD) tool. The novel interface allows users to explore the data, upload additional datasets, derive threshold values based on specific criteria, and explore the potential use and applications. This presentation will provide an overview of the EnviroTox Database and examples of how the database and its associated tools can be used to inform chemical evaluation and alternative method development.
The ECOTOXicology Knowledgebase (ECOTOX, https://www.epa.gov/ecotox/), is a comprehensive, curated database that summarizes toxicity data from single-chemical exposure studies to aquatic life, terrestrial plants, and wildlife. For over 30 years, ECOTOX has provided ecologically-relevant toxicity data to meet the systematic review and data transparency needs of the USEPA for risk assessments and regulatory decisions. Data are curated from relevant studies after processing through well-established protocols to exhaustively search the literature, review references for applicability and acceptability, and extract data for all study details, including species taxonomic hierarchy, chemical purity, routes of exposure, and all calculated or statistically derived endpoints provided by the authors. ECOTOX currently includes data for more than 11,000 chemicals from over 48,000 references, with additional data uploaded quarterly. To meet the increased demand for relevant empirical toxicity data and the evolution in toxicity testing, ECOTOX was recently updated with a new user interface, enhanced functionality for searching and exploring curated data, and inclusion of more mechanistic (e.g., genetic, enzymatic) and pathway-based (e.g., hormonal, cellular) data. Further, links to databases and tools were integrated, laying the foundation for future interoperability across sources of information on chemicals, species, and effects. Presented here is an overview of the ECOTOX Knowledgebase with vignettes demonstrating: 1) extent, distribution, and types of empirical toxicity data available; 2) exploration and visualization tools to identify relevant toxicity data for focused research questions and decision-making; and 3) efforts to increase interoperability for comparison to in vitro data, species comparisons/extrapolations, evaluation of field contaminants data, and development of adverse outcome pathways. This abstract does not necessarily reflect USEPA policy.

Oh, the Changes I've Seen Over the Past 30 Years

SF013 Evolution of the Science of Ecotoxicology: A 30 (Plus) Year Retrospective

G.T. Ankley, US Environmental Protection Agency / Mid-Continent Ecology Division

The contributions of Paracelsus notwithstanding, toxicology as a formal scientific discipline is a comparatively new endeavor and, within the broader field, ecotoxicology is in its relative infancy. Consequently, it is still possible for a scientist who has been engaged in the field for just a few decades (such as me) to have directly seen/participated in enormous changes in expectations and approaches relative to the assessment of chemical impacts on the environment. In this talk I will use examples from my career to illustrate the following timeline/evolution of the field of ecotoxicology. Initial concerns in the field focused largely on direct effects of chemicals or chemical mixtures on survival and, to a somewhat lesser extent, subtle effects on growth and reproduction. While these types of apical, population-relevant responses remain a cornerstone for ecological risk assessment, the techniques and actual endpoints employed to assess them have--and continue to--change substantially. Much of this transformation has been driven by (often legislated) expectations to consider possible ecological effects of an ever-greater number of chemicals (and chemical mixtures) on a wider array of endpoints in an era of steadily diminishing resources for conventional testing, including increased concern over animal use. This has accentuated the development of rapid, inexpensive, high-content tools based on early perturbation of biological pathways. However, as pathway-based approaches/tools in areas such as 'omics and high throughput testing become commonplace in ecotoxicology, the core challenge of translation of test data into responses meaningful to risk assessment increases. Basically, we are faced with the reality that more data/information--however elegantly measured--does not directly translate into increased knowledge, without a concurrent advance in understanding. Developing this understanding is one of the "big challenges" for the next generation of ecotoxicologists. The contents of this talk do not reflect USEPA policy.

SF014 From Microcosms to Mesocosms Via the Cairns' (VPI&SU) School of Ecotoxicology

S.E. Belanger, Procter & Gamble Company / Global Product Stewardship

At the formation of SETAC, Professor John Cairns, Jr. of VPI&SU (now known more commonly as Virginia Tech) was at the front of advocating the incorporation of ecology into aquatic toxicology and experimentation in the field of human-induced perturbations. The principles were formed during an extended period as a protege of Dr. Ruth Patrick at the Academy of Sciences of Philadelphia researching impacts of industrial wastes on rivers of the eastern and southern United States. Many of those principles were articulated in a report of the National Academy of Sciences committee in 1981, which Cairn’s chaired, on use of model ecosystems in environmental assessment. Those same principles shaped approximately 3 decades of research at leading private sector environmental labs including those of Procter & Gamble, Shell Chemicals and its related businesses, Unilever, NCASI, as well as important public sector sites such as USEPA Monticello Research Station, Kellogg Biological Station, the Savannah River Ecology Laboratory and a number of NSF funded sites. In this presentation, I will review the motivations for the emphasis by the Cairns lab on model ecosystems and how industry put these into play in researching effects of contaminants, chemicals and effluents, particularly in the consumer products industry. We will touch on some of the major scientific and technical advances brought about either directly or in parallel with these efforts in a pictorial guide of many facilities and how they remain relevant and still needed today and into the future.

SF015 Yesterday's Primary Consumers Become Tomorrow's Secondary Producers

C. Mancini, AECOM / Remediation Practice

Who knew that coming of age post National Environmental Policy Act would lay the foundation for such a diverse, predictably, unpredictable career! The past 50 years have seen unprecedented environmental awareness and regulation that has created an entire industry which many scientists have participated in! The National Environmental Policy Act (1970), Federal Water Pollution Control Act (1972), Resource Conservation and Recovery Act (1976), Comprehensive Environmental Response Compensation and Liability Act (1980) and guidance and further regulation that followed all necessiated consideration of ‘protection of human health and the environment’. The interest and application of principles of bentic taxonomy and ecology followed a parallel path. Understanding of bentic assemblages as indicators of habitat characteristics was mainly an academic endeavor prior to the 70’s. In conjunction with sediment chemical analyses, benthic community analyses became more important in assessing habitat health and ‘clean vs polluted’ systems; toxicity and bioassay protocols in the 1990s formed the three-pronged Sediment Quality Triad approach we now use routinely for sediment and other types of assessment. Advances in field, laboratory and communication technologies further fueled the utility of benthos as a key metric for aquatic systems. Graduating with degrees in biology in the 70s and 80s gave many passionate ‘naturalists’ a new and expanding platform to stand on that had not existed previously. This ‘case study’ exemplifies the significance of sometimes random, early career events and suggests future, random events for new scientists to consider.
The Clean Water Act (CWA) establishes the structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. With updates in 1972, the CWA gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for contaminants in surface waters. Applying water quality criteria to control the release of chemicals into water bodies was quickly identified as insufficient to manage all potentially toxic pollutants in an effluent, nor did it predict biological effects in the receiving waters. New methods to estimate chronic toxicity were developed for effluent testing and validated with interlaboratory studies and in field studies that demonstrated the connection between effluent/ambient water toxicity and effects on instream communities. Techniques to identify the cause(s) of toxicity were developed and EPA created a technology transfer center for the water-quality-based permits, technical assistance, Toxicity Identification Evaluations (TIEs), and training at EPA-Duluth. During this time, we identified many chemicals that were not covered under the chemical-specific limits included in NPDES permits or were not expected to cause toxicity at concentrations present. The sediment program followed the steps of the WET program by developing sediment toxicity methods to address the causes of toxicity and develop numerical criteria for specific sediment toxics to address the challenge of bioavailability of sediment contaminants. This presentation will provide an overview of the development of the methods, technical challenges, and scientific accomplishments, as well as link how the methods and most importantly, how these approaches were vetted through SETAC journals and public meetings, which was essential for the environmental management decisions within EPA. Disclaimer: This presentation does not necessarily reflect the views or the policies of the USEPA.

SF018 This Just In!! Everything IS an Endocrine Disruptor: Perspectives from an EDSTAC groupie!
E.M. Mihaich, ER2
Long before the phrase endocrine disruption became a household term even your mother knows, casual observations made by amateur and trained scientists around the world began to tell a story of possible adverse effects on wildlife and humans from exposure to chemicals that might be interfering with the endocrine systems of wildlife and humans.

Thousands of papers, news articles, blogs, and tweets later, along with a staggering amount of research dollars, it is time to take stock of where we have been and what lessons we have learned (or not learned) in this seemingly always “emerging” field. Terms such as weight of evidence, mode of action, adverse outcome pathways, and in silico and in vitro screens have been coming out of the mouths of ecotoxicologists at an unprecedented rate in the last 20 years because of this “emerging” field. This is all for the good and SETAC members have been central to much of the development and advancement in the science and interpretation of the data. This talk will walk the audience through those early days of casual observations and regulatory interest to where we are today with drilling down to specific definitions and hypotheses, identifying modes of action, and deciding on hazard versus risk approaches to evaluating the adverse consequences of exposure to both natural and anthropogenic chemicals. The trade-offs inherent in narrowing the focus of an assessment to target specific modes of action versus a more holistic, population-relevant approach, taking into account all adverse responses, will be discussed and the consequences of toxicologists and ecotoxicologists actually talking now and into the future will be explored.

SF019 Development and application of ecosystem services concepts: Evolution or devolution?
P.N. Booth, Ramboll Environ / Ecological Sciences; D. Pelletier, Ramboll US Corporation / E&H
William Foster Lloy first proposed the dilemma of overexploitation of resources in shared-resource systems in 1833 by postulating a hypothetical example of unregulated grazing on common land. The idea that individual users acting independently in their own self-interest will almost inevitably behave contrary to the common good by depleting or spoiling a resource, led to the ecologist Garret Hardin coining the term “tragedy of the commons” in 1968. From an economics standpoint, such a dynamic arises because external costs such as the depletion or pollution of a resource are not accounted for in the decisions made by individual users of the resource. The concept of ecosystem services, or “the benefits ecosystems provide to human wellbeing” emerged in the 1980s in a parallel fashion with concepts of sustainable development and has been increasingly applied to a wide range of environmental decision-making
as a means of internalizing environmental externalities. In theory, if
decision-makers had the ability to fully account for impacts to or depend-
dence on ecosystem services, humankind's development strategies would
be economically and ecologically efficient. This talk will summarize the
trials and tribulations in the evolution of ecosystem services thinking,
touching on major events in policy development including adoption of the
concept of payment for ecosystem services (the Costa Rica example), to
the inception and conception of the Millennium Ecosystem Assessment,
and the creation of the Intergovernmental Science-Policy Platform on
Biodiversity and Ecosystem Services, and the alphabet soup of NGO and
governmental organizations and programs that have come of age in the
last decade. Along the way, the talk will raise a series of questions about
whether and to what extent ecosystem services approaches have contrib-
uted to the sustainability of the planet's resources and poses questions
for the audience to ponder regarding the future direction of the concept
of ecosystem services in environmental decision-making. For example,
from a logistical standpoint, will approaches to classifying and measur-
ing ecosystems converge, or might it make more sense to have different
approaches for different applications?

SF020 Exposure Science in Transition - The Case for Exposure-
Informed Decisions

A. Guiseppi-Elie, US Environmental Protection Agency / OCSPP/ RAD

We are exposed daily - be it in the foods we eat, the water we drink,
the air we breathe, and personal products we use - to different physi-
cal, chemical, biological stressors that can potentially affect our health.
Exposure science, in general, develops information on “what we are
exposed to” and “how much.” Exposure assessments apply this informa-
tion to specific decision contexts, where it may be necessary to predict
and potentially mitigate adverse health outcomes, or alternately, enhance
positive health endpoints. Exposure science has broad applicability
including, for example, in food safety, public health and industrial hygiene
and, hence, the focus of exposure assessments can vary by discipline with
a key example being its use in risk assessments. It can be successfully
argued that without exposure, regardless of the hazard potential of any
stressor (chemical or otherwise), there can be no risk. This follows the
widely accepted risk paradigm that equates risk to the combined effects
of hazard and exposure. History, however, is on the side of hazard regardless
of exposure. For example, the exposure element of the “dose makes the
poison” adage was somehow lost in the centuries of toxicity testing that
followed Paracelsus’ observation. In the past, exposure has been relegated
to a secondary role in risk-based decisions. Fortunately, in the 21st cen-
tury, exposure science has evolved significantly moving the field from
discrete “external” exposures to “internal” and personal measurements.
Technological advancement in measurements (e.g., analytical techniques,
sensors) as well as high-throughput in silico methods have expanded and
diversified the exposure toolset. These advancements have revived the
critical place of exposure as requisite to hazard assessment to inform the
best decision-making in light of complex 21st century issues. This story
will focus on a few of the examples that abound, such as the evolution to
personal sensors and high-throughput exposure methods. Coupled with
a renewed energy around collaboration, practitioners are equipped now
more than ever to work together to solve real world problems.

SF021 Putting ecology and risk back into ecological risk assessment

W.R. Gala, Chevron Energy Technology Company / HES

The devaluation and distrust of science found in many sectors of the
public have taken a toll on the conduct and quality of ecological risk
assessments (ERAs). Thirty years ago, practitioners and researchers
were advancing the science and practice of ecological risk assessment
to improve the incorporation of ecological conditions into ERAs, to
obtain greater accuracy in exposure point concentrations and improve
the understanding of the toxicity of constituents of concern to an ever-
broader range of ecological receptors. The goal was to collect data and
perform studies to reduce uncertainty and conservatism to improve the
accuracy of ecological risk estimates. Rather than a continuing improve-
ment in ERA, we have seen a digression to conservative screening-level
risk assessments protecting ghost receptors from phantom exposures. As
a long-time SETAC member and Industry ecotoxicologist, I will provide
my perspective on the great promise we had for ecological risk assess-
ment in the early days and the errors we have allowed into the process
that undermine the application of high-quality science in ecological risk
assessments today. I remain hopeful that we can return to the optimism
of our youth and focus our efforts to: improve assessment and estimates
of ecologically relevant exposures by incorporating advance sampling
techniques and knowledge of how ecological receptors utilize and distrib-
ute themselves in impacted environments; develop ever more accurate
ecological benchmarks that are based on toxicologically and ecologically
significant endpoints; and improve the communication of ecological risk
by providing accurate descriptions of the likelihood and consequences of
exposures to constituents of concern.
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