Session 1 Monitoring, Sampling and Characterization

Data for temporal and spatial variability of emerging contaminants: The case of DBPs in drinking water

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Abstract:

Disinfection by-products (DBPs) in drinking water are formed when disinfectants react with organic and inorganic precursors present in natural waters. The levels of DBPs are impacted by the amount of precursors, the type of disinfection, the disinfectant dose, water temperature, pH and residence time of water in treatment plants and municipal distribution systems. Past studies have demonstrated that regulated disinfection by-products (DBPs), such as trihalomethanes and haloacetic acids vary considerably both seasonally and spatially within municipal water distribution systems. However, very little information has been reported about the changes in concentration of emerging DBPs. Such DBPs are associated with various disinfection techniques such as chlorination (gaseous or liquid), ozonation and chloramination. In the past eight years, we have carried out intensive sampling and laboratory programs in many municipal drinking water systems supplied by surface waters to monitor and evaluate the levels of various DBPs of emerging interest. Monitoring has been conducted 1) at various moments of the year to take into account seasonal water quality and temperature pattern changes, and 2) at various locations within the treatment plant and the distribution extremities to take into account the residence time of water within the municipal network. We have focused on the following compounds found at very low concentration levels in drinking water (fron ng/L to few ug/L): Iodinated THMs and HAAs, haloacetonitriles, halonitromethanes, haloketones, aldehydes, N-nitrosamines, chlorite, chlorate, bromate. The results show that despite the very low concentrations of these compounds, their levels change considerably according to the residence time of water and the period of the year. It was observed that the patterns for spatial and temporal variations are not comparable between the different species of DBPs. The research demonstrate the relevance of generating robust spatio-temporal databases to adequately assess population exposure to DBPs in water. The implications of these results on the monitoring strategies for emerging DBPs are also discussed.

Session 1 Monitoring, Sampling and Characterization

Direct on-line mass spectrometric analysis of naphthenic acids and polycyclic aromatic hydrocarbons in aqueous samples impacted by simulated oil spills

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Abstract:

A number of trace-level persistent organic pollutants derived from petroleum hydrocarbons, such as naphthenic acids (NAs) and polycyclic aromatic hydrocarbons (PAHs), are toxic in the aquatic environment and are generally present in complex mixtures. Conventional analytical chemistry techniques require extensive sample 'clean-up' and chromatographic separation, which can be time-consuming and expensive. We describe the use of on-line membrane extraction coupled to direct mass spectrometry techniques using a capillary hollow fibre polydimethylsiloxane membrane immersed directly in the sample with detection limits in the low parts-per-billion range. A solvent passing through the membrane lumen continuously transports permeating analytes to an ion source of a mass spectrometer. We will introduce the technique and describe its application for the rapid screening of NAs and PAHs in a series of water samples equilibrated with conventional crude oil or diluted bitumen over a range of pH and salinity. We observe both qualitative and quantitative trends in the NA and PAH contents of water samples using on-line membrane introduction mass spectrometry. For example, we observe decreasing NA content with decreasing pH and increasing salinity. We discuss applications including rapid screening for environmental assessments, and in situ reaction/process monitoring for optimizing remediation strategies. The technique provides near real-time information and may be used to support decision-making and inform policy.

Session 1 Monitoring, Sampling and Characterization

The path of water quality data: From its generation to decision-making

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Abstract:

From pollution monitoring to decision making, water quality data plays a key role in research and water management. Data is linked to metadata, which includes qualitative and quantitative information and characterizes the final data from its generation to the production of reports, models, etc. As a result, data quality is at least as important as water quality itself. Modern technologies allow the acquisition of huge quantities of data. However, it is frequently observed that its generation, management and storage is not adequate, hindering an optimal exploitation. As a consequence, the extracted information is unproportionally weak to available data and often not robust enough to induce decision making. Another important flaw is the lack of a holistic and common approach among stakeholders to plan, manage and optimize data acquisition processes. In fact, the multiplicity of data sources leads to duplicated data, or data that is not comparable, nor compatible because of the divergent acquisition and storage methods.

The objective of this presentation is to describe the progressive development of a database allowing to document every necessary information to contextualize water quality data from the watershed to the citizen's tap. More specifically, the criteria as well as the short and long term objectives for such a holistic database will be discussed. Then, we will illustrate how specific case studies contributed to identify all the necessary elements needed in order to develop a holistic data management system for all types of water stakeholders. Since the system was developed through the agile method, most of the features have been implemented, tested and the database is now used by a wide variety of water stakeholders in Canada and France. Finally, the presentation will focus on future perspectives of optimized data, such as early warning systems, risk analysis for surface waters, drinking water, etc.

Session 1 Monitoring, Sampling and Characterization

Development of an Analytical Centre of Excellence in Chemical Characterization of Oil and Oil Spills in the Environment

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Abstract:

Oil is a mixture of many complex chemical compositions that differ from oil to oil, from oil to refined products at the different stages of its weathering and degradation process. Due to this complexity, chemical characterization of oil and oil products are essential to understand their behaviour, fate and toxicity in the environment in the event of an oil spill in the environment, and to assess the effectiveness of oil spill response techniques.

As part of the Multi-Partner Oil Spill Research Initiative (MPRI) under the Government of Canada's Oceans Protection Plan, efforts are being undertaken to develop an analytical centre of excellence in chemical characterization of oil and oil spills in the environment at the Centre for Earth Observation Science (CEOS) of the University of Manitoba, Winnipeg, Canada. Taking advantage of CEOS' existing state-of-the art analytical instruments such as GC/FID, GC/MS, GC/MS/MS, GCxGC-TOF-MS, HPLC-Ion Mobility Separation (IMS)-MS and ICP-MS, the development of the Centre is entailed for major capacity building in the areas of extractions and pretreatment of versatile sample types, methodological developments, interlaboratory calibrations, and training of the highly qualified personnel (HQP). The objectives are to 1) develop analytical methods to study chemical composition (both identification and quantification) of oil and oil products and their changes during spill incidents in the environment; 2) provide analytical services with both existing and new analytical methods to support related research; 3) transfer analytical techniques and capacity to related laboratories; and 4) train new generation of HQP in state-of-the-art analytical techniques and data interpretation for such studies.

The analytical centre at the University of Manitoba is playing an important role by providing analytical support to all the MPRI research groups. We have already developed analytical methods for chemical characterization of residues from in-situ burning of oil. In this presentation, we will highlight the recent developments at the Centre and collaborative opportunities for research and HQP training for the PEOPLE Network. .

Session 1 Monitoring, Sampling and Characterization

Improved analysis of metformin and guanylurea in liquid samples by gas chromatography-mass spectrometry (GC-MS)

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Abstract:

Metformin is widely used as one of the most effective first-line oral drugs for type 2 diabetes. It is difficult to be metabolized by the human body thus commonly exists in both urine and faces samples. Guanylurea is metformin's main biotransformation product with increased concentrations in the aquatic environments. Liquid chromatography-tandem mass spectrometry (LC-MS) based methods used for measuring the two compounds have been well developed, but extremely limited studies have tracked gas chromatography-mass spectrometry (GC-MS) based analysis. To help better track the occurrence of the two non-volatile biguanide compounds in liquid samples, the improvement of existing GC-MS based methods for reliable metformin and guanylurea analysis is desired. Derivatization of metformin and guanylurea is the key pre-treatment procedure before the associated analysis by GC-MS. Four selected factors affecting the derivatization pre-treatment were evaluated in this study, including temperature (90 ºC), reacting time (90 minutes), solvent (1,4-dioxane), and ratio (1.5:1) of reagent to target component. Buformin and N-methyl-bis(trifluoroacetamide) (MBTFA) were used as the internal standard and the derivatization reagent, respectively. Calibration curve of metformin was made based on the optimal conditions of derivatization. The calibration range is 200 ng - 1000 ng. Limit of detection (LOD) and limit of quantification (LOQ) are 48 ng and 200 ng, respectively. The linearity is 99.4 %. The relative standard deviation (RSD%) based on 7 times repeatability is 7.78 %. The optimal conditions for enhancing the sensitization of metformin and guanylurea derivatization performance were obtained. The improved GC-MS analysis method were eventually applied for metformin and guanylurea analysis in real water samples.

Session 2 Monitoring, Sampling and Characterization

Persistent, emerging, and oil pollution in cold marine environments: insights and lessons from 50 years of study on mercury in the Arctic Ocean

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Abstract:

The NSERC PEOPLE CREATE network provides a timely opportunity to train the next generation of highly qualified personnel to address the pressing environmental, health, policy and socio-economic issues caused by persistent, emerging, and oil pollutants in cold marine environments. Here I will provide a synopsis of 50 years of mercury research in the Arctic Ocean in the hope that it might offer some insights and lessons for the PEOPLE CREATE network. Following the observations of elevated mercury concentrations in Arctic marine mammals in the 1970s, major efforts have been undertaken in the past decades to understand the sources and processes responsible for mercury contamination in the Arctic Ocean. This has led to the realization that mercury contamination in the Arctic marine ecosystems no longer follows the general trend in global or regional mercury emissions; instead, it is increasingly driven by climate change-induced changes in biogeochemical and ecological processes that control the production and biological uptake of methylmercury. This has major implications for how the marine ecosystems will recover now that anthropogenic mercury emissions are being controlled under the Minamata Convention on Mercury, and how local communities and policy makers should develop and adopt remediation and adaptation strategies. While major progress has been made in understanding and addressing the mercury issue in the Arctic Ocean, many lessons are learnt along the way, which hopefully will help the PEOPLE CREATE network to better design and deliver its research and training program.

Session 2 Monitoring, Sampling and Characterization

Fate and behavior of contaminants of emerging concern in sources and drinking water: A case study in Quebec, Canada

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Abstract:

This study aimed to provide comprehensive data on the occurrence of anthropogenic contaminants of emerging concern (CEC) in source waters (SW) and drinking waters (DW) of the Québec City region, Canada. The study also investigated the removal efficiency of CEC by five drinking water treatment plants (DWTPs). The study was based on 28 sampling campaigns conducted from June 2016 to July 2017. SW and DW of the five DWTPs were analyzed using SPE-UPLC-MS/MS (solid-phase extraction-ultra pressure liquid chromatography-mass spectrometry) for seven CEC, including acetaminophen, salicylic acid, caffeine, carbamazepine, ibuprofen, sulfamethoxazole and drospirenone. All CEC were found in both SW and DW samples, except drospirenone, which was spotted below the limit of detection only during June and July 2016 in one DWTP. Caffeine showed the highest median concentration range (12.3-91.0 ng/L), followed by acetaminophen (7.9-85.0 ng/L) and salicylic acid (21.6-39.0 ng/L) in SW samples. In DW, salicylic acid showed the highest median concentration range (20.6-50.0 ng/L), followed by caffeine (5.2-21.8 ng/L) and acetaminophen (5.0-7.7 ng/L) in DW. These differences in concentrations of CEC in SW and DW are due to the differences in the removal efficiency, which in turn depends on the type and concentration of CEC in SW. Salicylic acid was found in higher concentrations in most DW samples of all DWTPs compared to SW. Carbamazepine, ibuprofen, sulfamethoxazole and drospirenone were typically detected in the range between the limit of detection and limit of quantification in SW. Concerning DW, these CEC were found below the limit of detection. Overall, DWTPs can remove CEC occurring in SW to a certain level depending on the characteristics of the contaminant. However, the current treatment processes of DWTPs are not capable of removing CEC to not detectable levels. In this conference, we will also present the spatio-temporal occurrence of these CEC in water and discuss the implications of results for monitoring purposes.

Session 2 Monitoring, Sampling and Characterization

Occurrence and Detection of Microplastics and Biocides in the Marine Environment

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Abstract:

Microplastics and biocides are two types of widely exist emerging contaminants (ECs) in the marine environment. They may pose risks to the marine ecosystem and human health. Based on the investigation of recent publications (2016–2019), this paper contributes a thorough overview of the occurrence and detection of two representative groups of ECs, i.e., microplastics and biocides. It presents specific discussions on (1) the occurrence of ECs in seawater, sediment, and biota; (2) the analytical detection and monitoring approaches for the representative ECs. This review provides a summary of recent advances in the field and points out the remaining knowledge gaps aiming to address and assess risks of ECs to the marine environment. It could support the development of regulations and mitigation technologies for the control of ECs in the marine environment.

Session 2 Monitoring, Sampling and Characterization

Fingerprinting of chemically dispersed oils using aliphatic and aromatic biomarkers

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Abstract:

Correlation of crude oils spilled in aquatic environments with their sources and weathering processes is usually tackled using oil fingerprinting approaches such as the stability of the diagnostic ratios of biomarkers. While, the application of dispersants, changing the essential physiochemical properties of spilled oils during oil dispersion, may make these interconnections difficult. This study differentiated the weathered dispersed oil from the crude oil under different weathering scenarios through experiments associated with principal component analyses (PCA). Alaskan North Slope, a typical medium crude oil, was selected as the targeting oil. Corexit 9500A, one of the most commonly applied dispersants, was used in this study. The main factors included variations in temperature (2 and 30 ºC), the concentrations of dispersed oil (75 and 750 ppm), the applications of artificial seawater and natural seawater, salinity (5 and 35 psu), and weathering duration (30 and 60 days). Eight groups of aliphatic and aromatic biomarkers were identified and analyzed using gas chromatography-mass spectrometry. The diagnostic ratios of biomarkers were calculated as the main indicators. The stabilities and variations of the selected diagnostic ratios were evaluated and illustrated using the relative standard deviations (RSD) with PCA results. Although some biomarkers, containing some steranes, terpanes, TA-, and MA-steranes had a higher resistance to weathering, specific biomarkers, such as diamantanes and some alkylated-PAHs, were observed to discriminate among weathered dispersed oils under different conditions. The findings have helped to improve the understanding of the weathering status of dispersed oils using biomarkers. The results are crucial to oil spill monitoring and decision making for oil spill response.

Session 2 Monitoring, Sampling and Characterization

Effect of acclimation process in nutrient removal and biomass production for *Chlorella vulgaris*

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Abstract:

Microalgae-based wastewater treatment has been identified as a sustainable technology solution to treat municipal effluents while producing biomass and produce biofuel. *Scenedesmus sp*. and *Chlorella sp*. have been isolated from wastewater environments showing their capacity to grow in these polluted environments. From the conventional wastewater treatment process, after the anaerobic sludge digestion, an effluent called centrate (CW) is produced. This concentrated wastewater stream has been shown to be an excellent growth medium because of its high nitrogen and phosphorus concentrations, which are essential nutrients for microalgal growth. The main nitrogen form in centrate is ammonia. When ammonia is present at 100 mg L^{-1} or higher, it is toxic to aquatic microorganisms, including microalgae. To be able to grow microalgae in CW, it is essential to identify the maximum concentrations that could be used, while avoiding detrimental effects on their metabolism. This study investigated a 16-week acclimation process for isolated microalgal strain *Chlorella vulgaris* to CW with 128.67 ± 11.29 mg L^{-1} ammonia and 19.75 ± 1.06 mg L^{-1} total phosphorus concentrations (24% CW). Then, acclimated strain and non-acclimated strain were cultivated in 30%, 50% and 100% CW to evaluate their growth performance and nutrient removal potential before and after the acclimation process. Statistical analyses suggested that the acclimation process was achieved 45 days after cultivation in 24% CW. With respect to biomass production, the highest yield was achieved when 50% CW was employed (675 ± 8.66 mg L^{-1}). In contrast, non-acclimated cultures resulted in 452 ± 2.78 mg L^{-1} in 30% CW as the highest biomass yield and no growth in 100% CW. The highest ammonia and total phosphorus removals were obtained when acclimated *C. Vulgaris* was cultivated in 50% CW (86% and 89%, respectively), while for non-acclimated culture, 30% CW showed highest removal values. These results reflect the influence of an acclimation process on microalgae metabolism and their ability remove nutrients and other contaminants from a wastewater stream using CW as a cultivation medium.

Session 3 Prevention and Treatment I

Affordable Water Treatment Technology for Small Communities

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Abstract:

Chlorine is used as a disinfectant in the drinking water supply systems in small communities in the province. However, chlorine reacts with the natural organic matters (NOM) present in the source water and produces compounds known as disinfection by-products (DBPs). These compounds, at elevated level in the drinking water for a long-term exposure, can be harmful to human health. Since .the traditional water treatment methods have limited capability to remove NOM, our group at Memorial University, is developing an affordable activated carbon (AC) from locally available materials to remove NOM from source water before chlorination. This presentation will give an overview of the findings on the removal of NOM from the source water with case studies covering three local communities (i.e., Sunnyside, New-Wes-Valley and Salvage). The follow-up chlorination experiments illustrate that the formation of DBPs is reduced considerably after the source water is passed through AC filter. NOM fractionation of the source water from these communities were also studied in detail and the results show that the impregnated AC has a higher tendency to remove hydrophilic NOM in comparison with the non-impregnated AC. The presentation will also highlight the progress made in modifying the activated carbon to remove arsenic from the well water in the communities on Bell Island. The future plan on pilot scale study and technology commercialization will also be outlined.

Session 3 Prevention and Treatment I

Efficiency of solid ferrates (VI) for treatment of extreme arsenic concentrations in synthetic mine effluents

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Abstract:

Arsenic (As), a non-essential nutrient and well documented carcinogen, represents a major life risk for living organisms. It naturally occurs in several minerals, either as main component (e.g. arsenopyrite) or as impurity. Weathering of As-containing sulfide minerals usually entails slow As leaching, whereas grinding of As-rich ores during refractory gold mining significantly increases its release rate into the environment. Precisely, gold extraction from low-grade refractory ores generates highly contaminated effluents (up to 1 g As/L). Efficient treatment of these effluents is challenging and requires continuous research and development of new treatment options. Among those, there are ferrates (Fe(VI)), which proved efficient in As removal from drinking and municipal/industrial wastewater. However, Fe(VI) efficiency in As removal from As-rich mine effluents was not reported yet. In this context, the present study evaluated the efficiency of solid Fe(VI) for As removal in highly contaminated (from 0.1 to 1 g/L) synthetic mine effluents. To do so, batch experiments using a jar tester were performed for 1 h of reaction time, for the evaluation of three treatment scenarios: no pH adjustment, a non-maintained acidic pH, and with a maintained acidic pH, then adjusted to neutrality, at the end. Different Fe (VI)/As molar ratios (0.5/1 to 3/1) were also tested. Results indicated that for the effluent of 0.1 g/L As and a Fe(VI)/As molar ratio of 2/1, the removal of As was higher after 1 h of reaction time at maintained acidic pH, than without pH adjustment or non-maintained pH (> 80% vs. no removal). The same treatment conditions (deemed optimal) gave consistent high As removal efficiency (> 80%) for the effluent of 1 g/L As. These findings indicate that solid Fe(VI) seems promising in As removal of extreme concentrations in mine effluents. Ongoing and upcoming studies will further assess the optimal conditions of As complete removal from synthetic and real mine effluents at ≥ 1g/L As as well as As-rich sludge stability.

Session 3 Prevention and Treatment I

Development of an Integrated Intelligent Toolkit for Wastewater Influent Forecasting

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Abstract:

Municipal wastewater treatment plants (WWTPs) require reliable forecasts of flow rate and pollutant loading for the design and control of wastewater treatment processes. Variations in flow rates and pollutant concentrations occur hourly, daily, monthly and seasonally. They subject unit operations at WWTPs to fluctuations that influence their performance significantly. As a result of the complex urban hydrological processes and various uncertainties arising from aging infrastructure, generating accurate wastewater influent forecasts is very challenging. In this study, an integrated intelligent platform for wastewater influent forecasting is developed. A pattern mining module is developed to characterize the temporal fluctuations in wastewater inflow and pollution loading. Meanwhile, an influent forecasting module based on machine learning is developed for predicting various influent characteristics, such as influent flow rate, water temperature, total suspended solids, and biochemical oxygen demand. The proposed tools are tested at several WWTPs across North America. The results demonstrate that the developed integrated intelligent toolkit can produce satisfactory influent forecasts. The pattern mining and influent forecasting modules are integrated with commercial wastewater simulation software to provide direct technical support for the design and management of WWTPs.

Session 3 Prevention and Treatment I

Treatment of Rural Wastewater Containing Antibiotics in Multi-Soil-Layering Systems

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Abstract:

In the rural areas with livestock production, antibiotics are often used to prevent illness and enhance livestock productivity. The used antibiotics and their metabolic products can be gradually excreted following livestock ingestion. The inappropriate application of agricultural livestock manures and the uncontrolled discharge of such wastewater in rural areas result in the continuous release of antibiotics into the environment and pose serious risks to local ecosystem and human health. Sulfamethoxazole (SMX) is one of the important sulfonamide antibiotics which have been widely used. It is expected to achieve the simultaneous removal of organic matters, nutrients and SMX from such rural wastewater. Some land-based technologies for decentralized rural wastewater treatment have been given increasing attention. This study will use the gravity-driven multi-soil-layering (MSL) system as an economic-feasible and environment-friendly technology for the treatment of rural wastewater containing SMX. During the treatment, several processes including precipitation, filtration, adsorption and biodegradation were included. The microbial process was the main driver for the removal of organic matters and the transformation/removal of nitrogen in MSL system. Both aerobic and anaerobic zones existed in MSL system based on the unique MSL structure consisting of permeable layers (PLs) and soil mixture blocks (SMBs), which could ensure the effective pollutant removal. The performance of MSL system on removing SMX was studied using factorial design. The effects of multiple variables such as the material of PLs, concentration of SMX, and pH of influent, as well as their interactions in the treatment processes were investigated. This study can help reveal the mechanism of SMX removal in MSL systems. The results can provide a sound strategy for optimal operation of MSL systems in both laboratory and field applications.

Session 3 Prevention and Treatment I

Comparative pilot scale study of ozone-base advanced oxidation processes (AOPs) to emerging contaminants (ECs) removal

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Abstract:

Degradation and elimination of three emerging contaminants (ECs) by pilot scale advanced oxidation techniques (AOPs) have been investigated in this project.

The ECs, including sulfamethoxazole (SMX), paracetamol (PCM) and caffeine (CAF), spiked in DI water samples, were subjected to UV-C irradiation, ozone based advanced oxidation techniques (AOPs) including sole ozone. By developing an engineered multiple ozone dissolution approach, the pilot benefited higher ozone concentration in liquid film more than nominal values. In return, by adding the fixed ozone rate of 0.25 mg/L. min to the reactor, the ozone consumed completely without any off-gas monitoring in the ozone flow-cell of reactor. The effect of operational parameters such as UV dose, ozone dose, reaction time and contaminants' concentration were evaluated for rate of reaction and treatment efficiency. The target pollutants achieved deficient degradation by sole UV-C fluence, while enhanced degradation was acquired by ozone treatment and UV/O3. Furthermore, ozone based AOPs demonstrated an elevated rate and removal in compare to ozonation alone due to contribution of highly reactive OH radicals to the reactions. As a consequence, the water samples confronted to the significant abatement of TOC for all ECs. The effective rate of ozone consumption was constant during 25 minutes of reaction resulting to more than 90% of degradation for SMX and PCM. All three ECs were eliminated substantially, while SMX demonstrated the highest removal rate (Figure1). To elucidate rate of reactions, the concentration of each pollutant was analyzed individually in 5 min-time intervals. A pseudo-first order rate constant was proposed for the kinetics of UV/O3 AOP degradation process. To investigate reaction efficiency, UV-Vis spectrophotometer analysis was applied. In addition, total organic carbon (TOC) and chemical oxygen demand (COD) were used as indicator parameters for a mineralization degree and by-products accumulation. This study revealed the feasibility of AOP pilot system to remediate recalcitrant organic contaminants from water samples effectively, to fully recover the water with compliance with drinking water regulations.

Session 4 Control and Remediation

Synthesis and Evaluation of Natural-Based Solidifiers for the Containment and Recovery of Diluted Bitumen and Conventional Crude Oil Spills

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Abstract:

Improved containment and recovery measures are needed to provide more options in dealing with potential diluted bitumen (DB) and conventional crude oil (CCO) spills. Solidification is an attractive and underutilized alternative spill response measure. Solidifiers can interact with spilled oil to prevent it from spreading, slow down its weathering, and facilitate its removal from the environment. Solidifiers could help create a window of opportunity by allowing spill responders to approach the spill site sooner due to suppressed release of volatiles at the site, and could also decrease water contamination by the oil, compared to a spill response without solidifier. We have synthesized a low-molecular-weight gelator-type solidifier and a polymeric sorbent-type solidifier, and evaluated these for the containment and recovery of DB and CCO spills. The amylopectin-graft-poly (methyl acrylate) solidifier is synthesized through free-radical polymerization. This inexpensive and easy-to-make sorbent effectively solidifies DB spilled in water at 4 wt% solidifier-to-oil ratio in thirty minutes, without agitation. The isoleucine-based solidifier is synthesized at room temperature with a total yield of 92%. This gelator solidifies CCO and DB at 9 wt% and 11 wt% solidifier-to-oil ratio, respectively. The solidifiers are evaluated for the suppression of the release of volatile organic compounds and the solubilizing of hydrocarbons into water. The hydrocarbon aqueous solubility is determined for the salinity and pH conditions that yield the highest DB and CCO distributions in the water column.

Session 4 Control and Remediation

A Self-Cleaning Nanoscale Hybrid System for the Separation of Oil/Water Mixture

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Abstract:

The offshore oil-spill has become the most emerging problem in the world. In the past years the use of nano-materials, that separate oil and water have gathered enormous attention in research and industries. The current study pertains to the self-cleaning nanoscale graphene/polymer hybrid system for the separation of oil/water mixture. Using single hybrid system, we have developed a two-stage process for the selective removal of the hydrocarbons. Total petroleum hydrocarbons and separation efficiency are determined by gas chromatography – flame ionization detector (GC-FID) and for final product TPHs reduced to < 1 ppm and separation efficiency reaches ≥ 99.6 %.

Session 4 Control and Remediation

Behavior of microorganisms involved in a biofiltration process using a biobed-based biofilter for pharmaceuticals removal from water

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Abstract:

Emerging contaminants (ECs) are synthetic or naturally occurring chemicals (i.e., pesticides, pharmaceuticals, personal care products, industrial additives) or any microorganisms that are not commonly monitored in the environment; however, they potentially can enter the environment and cause adverse ecological and/or human health effects. The Ontario Ministry of the Environment (2011) reported that 27 pharmaceutical and endocrine disruptors were detected in any water resources in Ontario (Canada). Biobed systems have proved their effectiveness in the treatment of ECs such as pesticides, being the microorganisms and organic substrates (biomixture) the main factors to consider.

This research aimed to study bacteria and fungi behavior during a biofiltration process for the removal of pharmaceuticals from water (10 mg/L in water for all pharmaceuticals) using local organic substrates as biomixture in a 3 level biobed-based biofilter at laboratory scale. Temperature, pH, and moisture in the biomixture were monitored every sampling day. Results showed that bacteria grow faster than fungi. ECs presence inhibits the microbial growth retarding microorganism proliferation during the first hours (72 hours for all microorganisms). Microbial growth without ECs presence was observed at 24 hours for bacteria and 48 for fungi. A cyclic growth for bacteria and fungi (highest growth at days 3 and 8 respectively) was observed in the biofilter. Kruskal-Wallis analyses (95% confidence) showed that moisture, pH and temperature of the biomixture had a significant effect on bacteria and fungi growth ($P<0.05$); moisture content (73%) exhibited the highest effect ($K=40.01$). For fungi, moisture (68%), and temperature (20.5°C) were noted to have the greatest effect ($K=33.04$ and $K=32.93$ respectively). White root fungi (related to pesticides degradation) were observed in the system. A better understanding of the EC residuals in the biofilter will help to link the microbial growth with biodegradation of these contaminants as part of a simple eco-engineered treatment system.

Session 4 Control and Remediation

Effect of different types of demulsifiers on the stability of oil-in-water emulsion

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Abstract:

After a marine oil spill accident, stable oil-in-water emulsion (mixture of oil and water) can be formed on the sea surface. Skimming is commonly used to physically recover spilled oil including such oil-water mixtures which also present in the recovered fluid by skimmers. The mixtures reduce the efficiency of the follow-up separation process and the entire response operation. Thus, effective demulsification methods are desired to facilitate oil and water separation and any further treatment or disposal procedures. This study is to evaluate and further improve the performance of demulsifiers during oil spill response. The emulsified mixture is prepared by mixing different ratios (in volume) of oil and seawater by a homogenizer. Three representative, commercially available chemical demulsifiers, Dioctyl sulfosuccinate sodium salt, Alcopol O 60 (sodium dodecyl sulfate in alcohol solution), and Basorol® 17-R4, were selected and added into the mixture at the level of 1:2000 (in volume) to oil. The performance of demulsifiers were evaluated by emulsion breaking time, residue total petroleum hydrocarbon content (TPH) and polycyclic aromatic hydrocarbons (PAHs) in water. The residue of demulsifiers in water was also examined by measuring interfacial tension (IFT). The results showed that the demulsifier had negligible effect once free water content was over 50%. While the use of demulsifers could reduce the concentrations of TPH and PAHs in water by 51.8% when oil content was over 50%. Both Alcopol O 60 and sodium dioctyl sulfosuccinate were found in the water phase after separation. It was observed more free water content resulting in cloudier in water layer after adding demulsifiers, probably due to the wax and asphaltenes in crude oil dissolved in water. Overall, the addition of demulsifier broke the emulsion and resulted in more efficient separation of water and oil after skimming, potentially benefiting the follow-up treatment operations.

Session 4 Control and Remediation

Ionic liquid-enhanced solvent extraction for oil recovery from oily sludge

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Abstract:

Ionic liquid (IL) was investigated for its effectiveness on enhancing oil recovery from hazardous crude oil tank bottom sludge using solvent. Several factors including solvent/sludge ratio (2–8 mL/g), shaking speed (100–400 rpm), extraction duration (10–120 min), and IL/sludge ratio (0.25–1.0 mL/g) were studied. When IL was not used, the total petroleum hydrocarbon (TPH) recovery was significantly improved by the increase of solvent/sludge ratio, shaking speed, or extraction duration. However, no significant difference ($P > 0.05$) among variables (solvent/sludge ratio, shaking speed, extraction duration) were observed on TPH recovery when IL was used. The TPH recovery by IL-enhanced solvent extraction was between 88.7 ± 2.8% to 93.8 ± 2.3%, indicating that an extra recovery of 7.1–21.5% was achieved as compared to that of solvent extraction alone. The extraction condition for both solvent extraction and IL-enhanced solvent extraction was subsequently optimized using an orthogonal experimental design. The highest TPH recovery (95.49 ± 4.52%) in solvent extraction was obtained under an solvent/sludge ratio of 12:1 ml/g, a shaking speed of 500 rpm, and an extraction duration of 60 min. Compared to solvent extraction alone, IL-enhanced solvent extraction achieved a similar or higher TPH recovery (96.92 ± 4.79 %) within a much shorter duration (i.e., 10min), and a much lower solvent/sludge ratio (i.e., 4:5 ml/g) under a less energy consumption (i.e., 100 rpm) condition. Moreover, IL-enhanced solvent extraction required a remarkably low concentration of IL [Emim][BF4] (i.e., 1:10 ml/g of IL/sludge ratio). The recovered oil had similar calorific value but a higher F3 fraction compared with crude oil. The results suggested the IL enhanced solvent extraction with lower solvent consumption is an effective approach for oily sludge treatment.

Session 5 Exposure, Risk, Impact and Decision Making

Linking Climate Change to Environmental Impact and Adaptation Studies: Recent Advances and Shortcomings in Modeling of Extreme Precipitation and Temperature Processes

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Abstract:

Climate change has been recognized as having a profound impact on hydrologic (water quantity) and environmental (water quality) processes for a local site or over an urban catchment area. Hence, global/regional climate models have been extensively used in climate change impact and adaptation studies. However, due to the current limitations on detailed physical modelling and computational capability, outputs from these models are provided at resolutions that are too coarse and not suitable for these impact studies. Hence, different downscaling methods have been proposed for linking these coarse-scale climate change projections to hydrologic and environmental processes at the required relevant space and time scales. Of particular importance for environmental engineering applications are those procedures dealing with the linkage of the large-scale climate variability to the historical observations of the precipitation and temperature extreme processes at a location of interest. If this linkage could be established, then the projected change of climate conditions given by climate models could be used to predict the resulting changes of the precipitation and temperature characteristics at the given local site. Therefore, the overall objective of the present paper is to provide an overview of recent advances and shortcomings of existing downscaling approaches to modeling extreme rainfall and temperature processes in a changing climate from both theoretical and practical viewpoints. In particular, for practical application purposes, this research proposes a decision-support tool, herein referred to as SMExRain (for Statistical Modeling of Extreme Rainfalls), that can readily be used for assessing the possible impacts of climate change on the extreme rainfall processes in consideration of the uncertainty in climate change projections given by different climate models. Examples of various applications using data from different climatic conditions will be presented to illustrate the feasibility and accuracy of the proposed statistical downscaling methods.

Session 5 Exposure, Risk, Impact and Decision Making

Heavy metals risk assessment in drinking water: an integrated probabilistic-fuzzy approach

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Abstract:

Heavy metal (loids) in drinking water have long been a critical water quality concern globally. Chronic exposure to toxic heavy metal and metalloids (TMMs) through water ingestion can result in significant health risks, while the aesthetic value of water can be deteriorated by elevated concentrations of less toxic heavy metals (LTMs). Concurrent contamination of TMMs and LTMs could be a complex water quality issue that is difficult to deal with. An integrated probabilistic-fuzzy approach was developed to help water utilities assess water quality regarding heavy metal (loids) (WQHM) and make suitable water treatment decisions. In probabilistic assessments, Monte Carlo simulations were used to quantify the probabilities of exceedance of health risk guidelines due to chronic exposure to TMMs and exceedance of aesthetic objectives due to elevated LTMs concentrations. Aleatory uncertaintie due to random variations of health risk parameters can be addressed by the probabilistic assessments. A fuzzy inference system, composed of fuzzy membership functions, operators, and rules, was used to facilitate interpreting WQHM based on the results from the probabilistic assessment. Epistemic uncertainties due to vagueness and imprecision in linguistic variables used for describing health risks and aesthetic impacts can be reduced by fuzzy inferencing. The developed approach was applied to four water quality scenarios characterized by different combinations of TMMs and LTMs concentrations. Reasonable decisions were recommended for WQHM management under the four scenarios. The developed approach offers a useful tool for systematically assessing WQHM from a health risk mitigation perspective by addressing different types of uncertainties.

Session 5 Exposure, Risk, Impact and Decision Making

An Agent-based Simulation Approach for Scaling-up Design of Wastewater Treatment System and A Case Study on Chemical Surfactant Removal

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Abstract:

Pilot experiments are frequently conducted before large-scale quantitative research or industrial applications to avoid the use of time and money in under-designed projects. However, adjusting the designs of pilot-scale devices still takes large amounts of time and money. Thus, scaling-up simulation modeling can be developed to support physical tests from a numeral perspective to improve the designs and outcomes. This study developed a novel agent-based scaling-up simulation modeling with the aids of computational fluid dynamic module. The developed method simulated the chemical reactions in wastewater treatments microscopically and interactively and the multiple flows dynamically. An agent-based modeling (ABM) simulated the actions and interactions of autonomous chemicals to assess their effects on the whole treatment system. Each molecule was treated as a point-like particle that diffused in a three-dimension space under the control of fluid modules. When a pair of reactive molecules collided, a reaction occurred based on the reaction probabilities and kinetic parameters, the simulated reactants were then replaced by products. A pilot-scale study of advanced oxidation processes (AOPs) on chemical surfactant removal was applied as the case study to test the simulation modeling efficiency. The situations of AOP pilot-scale testing were fully simulated based on characteristics, properties and in-situ outcomes. More than 20 basic reactions in AOPs system were considered. The preliminary results showed approximate trends in the comparison with the experimental result curves. The simulated results will further support the pilot-scale study to optimize the designs under multiple scenarios.

Session 5 Exposure, Risk, Impact and Decision Making

Application of Drone Technology and Big Data Analytics for Monitoring and Modeling Climate and Environmental Changes

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Abstract:

As a high-latitude and maritime nation, Canada is particularly vulnerable to climate change. A higher rate of warming in high-latitude regions increases the risk of extreme weather events such as heat waves, heavy rainfalls and related flooding. Meanwhile, many regions of Canada are also affected by changing ocean environments, including changes in average and extreme sea level, wave regimes, salinity, ice conditions, and ocean pollution. Development of effective mitigation and adaptation strategies and management tools relies on an in-depth understanding of the spatiotemporal dynamics and variations of climate and environmental changes. This presentation will provide an overview of the state-of-the-art technologies (e.g., drone technology and big data analytics) and showcase some real-world applications to demonstrate how these advanced technologies can be used to help monitor, model, and understand various climate and environmental changes.

Session 5 Exposure, Risk, Impact and Decision Making

Fate and Transport of Metformin in Saturated Zone: A Flow Cell Experiment and its Simulation Using Visual Modflow

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Abstract:

As an endocrine disruptive emerging pollutant, metformin started to raise many concerns in academic circles recently. Its wide existences in different compartments such as WWTP effluents, surface water, potable water, activated sludge and soil have been confirmed by multiple studies. Currently, studies focused on metformin's fate and transport processes in groundwater system are few. To investigate metformin's transport pattern in groundwater system, as well as evaluate the impact of the emerging contaminant in groundwater system, a 2D flow cell experiment focused on metformin's transport in the saturated zone was conducted, and a corresponding numerical model of the domain was subsequently built using Visual Modflow for simulating subsurface flow and contaminants transportation. After model calibration and sensitivity analysis, significant parameters were identified. A robust and efficient approach to describe the fate and transport processes of metformin in the saturated zone was developed in this study.

Session 6 Ecotoxicological and Ecological Effect

Sedimentation of spilled oil via marine snow

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Abstract:

During the active 87-day Deepwater Horizon spill in the northern Gulf of Mexico in 2010, a significant fraction of the spilled Macondo oil was transported to the seafloor via the sedimentation of marine snow. Here we present the chemical characterization of oil that arrived together with marine snow at a 1400 m deep sediment trap and introduce a 1-D model that simulates the transport of total petroleum hydrocarbons (TPH) to depth via diatom aggregates. Understanding the details of this oil transport mechanism, and predicting its potential magnitude, is important for the management and mitigation of future oil spills.

The trap data give insight into the nature and evolution of the sedimentation of marine snow and oil, the latter of which remained as droplets in the water column after the spill ended. Four pulses of oil flux were recognized; three of which were associated with sedimentation events associate with diatom blooms. Chemical analysis (TPH, alkylated PAH, and petroleum biomarker fingerprints) reveal the sinking oil's lack of evaporation and photo-oxidation, which indicated it was not derived from the sea surface but had "lingered" within the water column after the spill. Measurable amounts of the increasingly weathered (biodegraded and water-washed) Macondo oil was collected in the trap for ~1 year after the active spill ended, over which time the oil flux decreased overall.

The model simulates a) a diatom bloom and the resulting formation of aggregates via coagulation of cells, b) the scavenging of dispersed oil compounds by these aggregates as they sink through the water column, c) the degradation of diatom carbon and oil carbon during transit, and d) the ultimate deposition of aggregates and oil compounds to the seafloor. The model simulations compare well with measurements and suggest that around 10 - 15% of the oil dispersed in the water were transported to depths during the sedimentation of one bloom.

Session 6 Ecotoxicological and Ecological Effect

Exploring the interactions between diesel and microbial communities using large volume mesocosms

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Abstract:

Diesel is one of the most common fuels used for smaller vessels, thus has a high probability of being spilled into the marine environment. As it is a light weight fuel, the usual course of action in response to a diesel spill is to leave it to natural dispersion and attenuation, rather than try to recover or clean it up. To characterize the impact of season and mixing energy on the interactions between diesel, the water column and microbial populations, a series of mesocosm experiments were carried out. Surface spills of diesel were simulated in spring, summer and autumn, with a second spring experiment in which there were different levels of mixing energy. A range of tools were applied to measure hydrocarbons in the water column and the abundance and diversity of the microbes including viruses, prokaryotes, phytoplankton and microzooplankton over time. Season and mixing played a significant role in the amount and type of diesel compounds entering the water column, although interannual differences were also observed. Microbial responses also varied with season and mixing energy. In some instances, microbes responded positively to the addition of diesel, while other groups decreased in abundance and diversity. From these experiments, some general patterns were observed that can help in predicting the fate and behaviour of diesel as well as the microbial responses following a spill in coastal waters.

Session 6 Ecotoxicological and Ecological Effect

Insights into the joint toxicity of P25-TiO_2, nano-ZnO, and triclosan on green alga

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Abstract:

The study explored the impacts of a mixture of P25-TiO2, Nano-ZnO and triclosan under varied illuminations on green alga *Asterococcus superbus* culturing in Lake Erie water. Using multiple endpoints assays, we evaluated the toxicity of various combination of pollutants through a full factorial experimental design (2×2×2×3). Multivariate analyses were conducted to reveal the inter-correlations among those multiple endpoints. The results showed different interactive combinations cause various effects on algae. Chlorophyll pigment in triclosan-involved groups were inhibited in visible light. Photosynthesis activities were significantly affected under two- and three-order interactions especially in visible light. The disturbance in mitochondria function in interactions was almost attributed to triclosan. Stimulation in lipids and proteins occurred in P25-included groups. Oxidative stress were induced when exposed individually or interactively. Synergetic toxicity was present in oxidative stress specifically for interactions of P25 * Nano-ZnO * triclosan and P25 * Nano-ZnO. ROS is significantly high in the presence of P25. Illumination was the most significant factor to affect the toxicity. It was the first time to perform a systematic evaluation of the interactive impacts of multiple nanoparticles and personal care

Session 6 Ecotoxicological and Ecological Effect

Developing an experimental pipe rig to grow multi-species biofilms to examine antimicrobial resistance (AMR) in municipal drinking water distribution systems

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Abstract:

Antimicrobial resistance (AMR) in source waters and, increasingly, in drinking water systems is a growing global concern. Previous research suggests that biofilm on pipe wall and filtration units are important environmental compartments that promote gene transfer and the development of antibiotic resistance in drinking water system. The aim of the paper is to report on the development of a new pipe rig to grow multi-species biofilms for use in planned experiments that will examine the development of antimicrobial resistance in municipal drinking water.

The new pipe rig will be constructed as a semi- continuous, coiled- loop system with PVC and HDPE premise plumbing pipe. The rig will be equipped with removable pipe coupons to harvest mature biofilms. The coupons will be transferrable between the pipe rig of this paper and the test rigs used for AMR research. The new rig will be operated at a temperature-controlled environment of 20ºC to ensure reasonable biofilm growth rates. Flow regime (wall shear stress), nutrient levels, and disinfection levels will be controlled to exactly mimic the conditions of the AMR test rigs.

Session 6 Ecotoxicological and Ecological Effect

Identification of synthetic musks' by-products produced by chlorine oxidation and their potential toxic risk predicted by 3D-QSAR models

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Abstract:

Synthetic musks (SMs) are superior fragrance additives used in pharmaceuticals and personal care products (PPCPs). The use of SMs has led to widespread existence of SMs in various wastewater streams, resulting in a serious environmental risk because of their harmful effects and a rising public concern. Advanced oxidation by sodium hypochlorite is a popular wastewater treatment technology, however, its interaction with SMs could generate harmful SM by-products. The identification of those by-products and associated toxicity analysis are with extremely limited reports thus need to be tackled. In this study, a wastewater stream containing SMs were treated using chlorine oxidation. Afterwards, SMs by-products were identified using gas chromatography–mass spectrometry (GC-MS). Two types of methods, comparative molecular field analysis (CoMFA) and comparative molecular similarity indices analysis (CoMSIA), were applied to establish 3D-QSAR models to predict toxicity of those by-products based on lethal concentration (LC50) of mysid for SMs, The Sybyl software was adopted to predict toxicity of SM congeners using LC50 as the dependent variable. The whole data set (16 SM compounds) consists of a training set (12 SM compounds) for model generation and a testing set (4 SM compounds) for model validation. As a result, the cross-validation correlation coefficient (q^2) was obtained by the CoMSIA models as 0.566 (>0.5). The non-cross-validation correlation coefficients (r^2) is 0.998 (>0.9). The external prediction set interaction test ingress coefficient (r^2_{pred}) is 0.905(>0.6) and the SEP (standard error of prediction) of test set is 0.299. Results indicated that the models are robust and functional. The developed CoMSIA model was further used to predict the toxicity (i.e., LC50 values) of SM disinfection by-products. Results revealed that the toxicity of some by-products is higher than that of the original SMs.

Session 7 Impact Evaluation for Seafood Safety, Human Health, and Coastal Communities

Persistent and Emerging Organic Pollutants in Marine Ecosystem and Human Health Risks: Perspectives, Challenges and Future Research Opportunities

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Abstract:

Persistent and Emerging Organic Pollutants in marine ecosystem is threat to human health. Humans are exposed to such pollutants by eating contaminated sea foods. Industrial effluents, surface runoffs, and trans-atmospheric transport are the major sources for PEOPs pollution. The pollutants are known for affecting endocrine systems and some are known carcinogens. Fetuses and new borne infants are exposed to pollutants via placenta and breast milk. The coastal ecosystem of the province of Newfoundland and Labrador is particularly vulnerable due to transportation of pollutants by St. Lawrence river, and arctic current. Since, majority of the the population live near coast and eat local marine foods, people can be exposed to numerous PEOPs. However, there are very few studies to evaluate human health impacts due to exposure. It is important to conduct community-based study to evaluate the mode of exposure, pathways, body burden of the pollutants and adverse health conditions.

Session 7 Impact Evaluation for Seafood Safety, Human Health, and Coastal Communities

A community-based survey in rural Newfoundland (Canada) to explore any association between endocrine disrupting chemicals (EDCs) and thyroid hormones

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3 Eastern Health

Abstract:

Background: Exposure to EDCs can lead to disruption of thyroid hormone function. Seafood is a dominant source of EDC exposure in humans. Local seafood consumption in Newfoundland and Labrador is frequent, however, serum EDC concentrations in rural communities in the province have not yet been explored, nor have the corresponding impacts on thyroid hormones.

Aim: To explore exposure to EDCs in two rural populations of the island of Newfoundland, and test for associations between their presence and profiles of thyroid hormones.

Methods: Eighty residents from New-Wes-Valley (NWV) on the north-east coast and Burin on the south coast had serum samples tested by gas chromatography mass spectrometry for polybrominated diphenyls ethers (PBDEs), polychlorinated diphenyls (PCBs), polybrominated biphenyls (PBBs) and dichlorodiphenyldichloroethylene (DDE). Thyroid stimulating hormone (TSH), free thyroxine (FT4) and free triiodothyronine (FT3) levels were also measured. Means, 95% confidence intervals (CI) and associations between EDCs and thyroid hormone concentrations were tested in SPSS.

Results: Nineteen EDCs were detected in the serum samples, and all participants had at least 11 of the EDCs detected in their serum samples. Mean concentrations of EDCs were PBB-153=0.15 mmol/g (95% CI, <LOD-0.63), total PBDEs=4.78 mmol/g (95% CI, 0.32-18.42), total PCBs=10.87mmol/g (95% CI, 0.25-35.32) and DDE=14.09 mmol/g (95% CI, 0.89-46.42). Participants from Burin had higher PBB and PBDE concentrations than NWV, while participants from NWV had higher concentrations of PCBs and DDE. TSH and FT4 were higher in NWV than in Burin, but there were no difference in FT3 concentrations between communities. PCB-128 and PBDE-28 were positively correlated with FT3 concentrations, while PBDE-153 and total PBDEs were positively correlated with TSH and FT4 concentrations.

Conclusions: The rural Newfoundland population is exposed to EDCs and the levels are associated with their thyroid hormone profiles. There were differences in concentrations of contaminants between two locals on different coasts, suggesting that residents around the island may experience difference sources and/or levels of exposure.

Session 7 Impact Evaluation for Seafood Safety, Human Health, and Coastal Communities

Exploring potential use of 'Very Sensitive Elemental and Structural Probe Employing Radiation from a Synchrotron (VESPERS)' for testing Persistent and Emerging Organic Pollutants (PEOPs): A study of indoor dust samples for Polybrominated Diphenyl Ethers (PBDEs)

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2 VESPERS, Canadian Light Source, University of Saskatchewan, Saskatoon, Canada.

Abstract:

Background: Presence of any PEOPs in indoor dust indicates their uses in household and offices. Majority of solid waste from households and offices are not recycled in Newfoundland and Labrador and therefore PEOPs are left in landfills. Since, the landfills are located very close to the coastlines of the province, it can be assumed that leachates and surface run offs from the landfills can contaminate marine ecosystem. However, there is no report of uses of PEOPs in household and office products in Newfoundland and Labrador. Synchrotron-based X-ray fluorescence spectroscopy (XRF) and X-ray absorption near-edge spectroscopy (XANES) are capable of providing a high level of complementary structural and analytical information. There is no study of using synchrotron-based X-ray spectroscopy techniques to analyze indoor dust for PEOPs.

Aim: To use the VESPERS beamline at the Canadian Light Source (Saskatoon, Saskatchewan, Canada) to analyze indoor dust for PBDEs using XRF and XANES spectroscopy.

Methods: Twenty indoor dust samples were collected two rural communities of Newfoundland (Burin and New-Wes-Valley). Clumps of dust samples were broken up and packed into a rectangular sample holder with dimensions of approximately 20x4x1.65 mm and sealed with Kapton tape. The samples were mounted perpendicular to the X-ray beam at an angle of 45o. Bromine Kα XRF maps were first collected using a Canberra 13 element germanium detector to determine the distribution of bromine in the dust samples. All measurements were performed using the "Pink Beam" mode, which includes all X-ray energies from 4–30 KeV (with a significant drop in flux occurring near 20 KeV). A 100 μm spot size was used for all XRF measurements. Bromine K-edge XANES spectra were collected from seven dust samples using a monochromatic X-rays were obtained using a Si(111) monochromator that provided a flux of ~1010 photons/sec and used to determine bromine speciation.

Results: The distribution of bromine in the dust samples is fairly heterogeneous. Overall, the concentration of bromine in both the Burin and New-Wes-Valley sample varied from 1-11 μg/g (average 4.5 μg/g). Most spectra collected from the dust samples exhibited a low energy feature similar to those observed in the PBDE standards, suggesting that these samples may contain PBDE's. Heterogeneity of dust samples might have influenced the test results.

Conclusions: This is the first experiment on using synchrotron-based X-ray spectroscopy techniques to analyze indoor dust for PBDEs. Indoor dust samples contain PBDEs. However, there is a possibility of presence of other bromine compounds in indoor dust. Therefore, proper protocol needed in collection and processing of dust samples. The major advantage of the technique is that X-ray absorption and X-ray fluorescence spectroscopy are able to analyze a microscopic volume in the sample and the same samples can be used for future temporal analysis. Further research needed to improve the technique.

Session 7 Impact Evaluation for Seafood Safety, Human Health, and Coastal Communities

Endocrine disrupting chemicals (EDCs) in fish and the role of seafood consumption in exposure of rural Newfoundlanders

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Abstract:

Background: Exposure to EDCs can lead to disruption of thyroid hormone function. Seafood is a dominant source of EDC exposure in humans. Local seafood consumption in Newfoundland and Labrador is frequent, however, serum EDC concentrations in rural communities in the province have not yet been explored, nor have the corresponding impacts on thyroid hormones.

Aim: To explore exposure to EDCs in two rural populations of the island of Newfoundland, and test for associations between their presence and profiles of thyroid hormones.

Methods: Eighty residents from New-Wes-Valley (NWV) on the north-east coast and Burin on the south coast had serum samples tested by gas chromatography mass spectrometry for polybrominated diphenyls ethers (PBDEs), polychlorinated diphenyls (PCBs), polybrominated biphenyls (PBBs) and dichlorodiphenyldichloroethylene (DDE). Thyroid stimulating hormone (TSH), free thyroxine (FT4) and free triiodothyronine (FT3) levels were also measured. Means, 95% confidence intervals (CI) and associations between EDCs and thyroid hormone concentrations were tested in SPSS.

Results: Nineteen EDCs were detected in the serum samples, and all participants had at least 11 of the EDCs detected in their serum samples. Mean concentrations of EDCs were PBB-153=0.15 mmol/g (95% CI, <LOD-0.63), total PBDEs=4.78 mmol/g (95% CI, 0.32-18.42), total PCBs=10.87mmol/g (95% CI, 0.25-35.32) and DDE=14.09 mmol/g (95% CI, 0.89-46.42). Participants from Burin had higher PBB and PBDE concentrations than NWV, while participants from NWV had higher concentrations of PCBs and DDE. TSH and FT4 were higher in NWV than in Burin, but there were no difference in FT3 concentrations between communities. PCB-128 and PBDE-28 were positively correlated with FT3 concentrations, while PBDE-153 and total PBDEs were positively correlated with TSH and FT4 concentrations.

Conclusions: The rural Newfoundland population is exposed to EDCs and the levels are associated with their thyroid hormone profiles. There were differences in concentrations of contaminants between two locals on different coasts, suggesting that residents around the island may experience difference sources and/or levels of exposure.

Session 8 Community Impact, Engagement and Technology Transfer

Research Mobilization as a Means for Value Creating Community Engagement

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Abstract:

According to the report: Competing in a Global Innovation Economy: The Current State of R&D in Canada by the Council of Canadian Academies (2018): "Canadians have not fully captured the economic benefits stemming from Canadian research advances." One way of capturing economic (and non-economic) value from academic research is by implementing systematic research mobilization programs. Indeed, research conducted at universities can have considerable commercial potential. However, turning those discoveries, innovations, and inventions into commercially viable products can prove extremely difficult. Based on a systematic review and narrative synthesis of the literature on translational research: the different models, its practice, and the efforts to streamline it, the author proposes a novel translational research & development framework to better link university science and engineering research to commercial outcomes, i.e., to create a more seamless transition from research to business. The author identified the best practices in translational research (as encountered mostly in biomedical research), adapted them for use in more general science and engineering research contexts, and combined them with well-established best practices in project management, new product development, new venture creation, science of team science, and intellectual property management. The result is a robust, structured framework that can help university investigators bring their ideas to market. The proposed framework is also relevant to university investigators who might not intend to turn their early-stage innovations into businesses. They can use it to advance the development of their innovations to the point where they become attractive for others (e.g., entrepreneurs, industry), to embrace the challenge of developing the innovations further for the market or for other forms of value creating community engagement.

Wave Tanks for Oil Spill Science: A Summary of 15 Years of Research at the DFO Test Facility

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Abstract:

The use of mesoscale wave tanks in the field of oil spill research has proved invaluable due to their ability to generate realistic oceanic conditions compared to smaller flask based experiments. A number of wave tanks have been constructed around the world for use in oil spill science, each with their own strengths and capabilities. This presentation will focus on the Department of Fisheries and Oceans (DFO) test tank facility located at the Bedford Institute of Oceanography (BIO) in Dartmouth, Nova Scotia. When it first opened in 2004, the facility consisted of a single wave tank 15 m in length. Over the years the capabilities of the facility have been expanded, now consisting of two 30 m tanks equipped with a flow through circulation system and the ability to do both surface and subsurface oil releases. Early research projects used the wave tank facility to evaluate the dispersion efficacy (DE) of various crude oil types treated with chemical dispersants. Alternative treatment options, such as the use of mineral fines and the impact of oil-particle aggregate formation on the fate of dispersed oil have also been evaluated. The facility has been used for the development and testing of new instrumentation for monitoring dispersed oil including fluorometers, underwater imaging and in-situ mass spectrometry. In addition, due to the use of natural seawater containing native microbial communities the tank has been used to examine the biodegradation of a wide range of oil types under different climatic conditions, and effluent from the tank has been used to conduct toxicity studies on a variety of different test species. Future research at the facility is focused on the fate and behavior of spills of refined oils and the long-term weathering of these products.

Session 8 Community Impact, Engagement and Technology Transfer

Preliminary Evaluation of A Biosurfactant-based Herding Agent for Marine Oil Spill Response

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Abstract:

The thickness of oil slick is a critical factor for in-situ burning during marine oil spill response. Traditional chemical herding agents have been widely used to thicken oil slicks to reach the ignite requirement. Biosurfactants are surface-active amphiphilic molecules produced by microorganisms. They have demonstrated capacities of serving as oil treating agents (e.g., dispersants, washing agents, emulsifiers, de-emulsifiers). Biosurfactants have the potential to be bio-herders, spreading rapidly over a water surface into a monomolecular layer and contracting oil slick. However, biosurfactant based herding agents are still in an early stage of development with extremely limited research reported. This study focused on the preliminary evaluation of the effectiveness of a biosurfactant based herding agent generated in the NRPOP lab by a marine oriented strain Rhodococcus erythropolis. Five factors including water temperature, salinity, initial oil thickness, herder dose, and spray location were considered for the performance evaluation. Results indicated that the maximum thickness change rate is 89.33% which was obtained at 20 min after adding the biosurfactant to surface of the initial oil slick on fresh water at 24 °C. The highest herding efficiency is 73.77% when biosurfactant/oil ratio was set as 1:48 (v/v %). This research helped to evaluate the potential of using biosurfactants as oil herding agents in the marine environment.

Session 8 Community Impact, Engagement and Technology Transfer

Remediation Technology for Marine oil spill considering off-shore harsh weather conditions

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Abstract:

Due to the enormous environmental, ecological and economic impact, offshore oil spills are becoming more and more significant. This problem becomes even worse with cold and harsh weather conditions as bad weather hampers oil spill containment. After the occurrence of spill, selection of a proper remediation technology is a challenge and depends on many factors which include spill type, spill location, spill size, weather conditions and regulations. The paper explains the existing remediation technologies and their efficacy in the containment of oil spill given the offshore harsh weather conditions. This research focusses on a specific amount of spill study, its release evaluation, exposure assessment and exposure impacts. The study utilizes previous databases and records to analyze and determine the level of risk imposed using mathematical models. This research optimizes the response, techniques and resources and finally screen for the existing remediation methods. Through this research, a risk-based remediation technique is proposed by prioritizing risk through a risk matrix and identifying an appropriate remediation technology. A comparative assessment is carried out on different remediation techniques on the basis of seven evaluation criteria chosen and the techniques are therefore evaluated with particular emphasis on cold and harsh weather conditions. This decision support framework will provide a path forward and overview to enhance the oil spill response measures. It will work as a guideline for preparedness and response during emergency situations of spills and help reduce their impacts.

Session 9 Oil Spill Response

Bacteria involved in the natural attenuation of hydrocarbons in Canada's marine and freshwater environments

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Abstract:

Climate change, the opening of the northwest passage, the exploitation of offshore eastern oil reserves and oil sands and the transportation of oil products for distribution are putting Canada's oceans and freshwater resources at an elevated risk for an oil spill. As part of Canada's Oceans Protection Plan (OPP), a comprehensive program has been put in place to address marine oil spill responses and their ability to effectively respond to accidental spills. Research is also underway to assess the ultimate fate of oil spilled into freshwater environments in Canada. These two environments are different, but the question that remains as to how effective oil spill countermeasures are in any environment and how ready are we to deploy them. There are many known obligate hydrocarbon degrading bacteria in the marine environment, but little is known about their freshwater counterparts.

This research is evaluating the potential of natural attenuation as an operational oil spill countermeasure strategy in both marine and freshwater environments. In situ microcosms have been developed to examine the microbial community structure and its' oil degrading ability under natural conditions using both microbiological and genomics-based approaches. In addition to whole community characterization, individual isolates have been obtained from freshwater environments that have obligate hydrocarbon-degrading abilities similar to their marine counterparts. The results are showing that hydrocarbon degrading bacteria are ubiquitous and optimizing their degradation performance is a very promising option. In addition to improving our understanding of the factors influencing natural degradation kinetics these studies will support the development of more rapid and effective interventions.

Session 9 Oil Spill Response

Research and Development of Improved Boom Designs for Oil Recovery in Aquatic Environments

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Abstract:

This paper describes and presents results from a research project aiming to develop, assess and validate alternative boom designs that will make it possible to contain and collect oil in aquatic environments at faster speeds than current technologies allow. A secondary objective was to investigate and demonstrate the usefulness of modern computational fluid (CFD) methods and large-scale physical model experiments in advancing oil recovery technologies.

A series of two- and three-dimensional CFD simulations were performed using the OpenFOAM CFD Toolbox to investigate the performance of several high-speed oil spill containment boom concepts for relative speeds up to 4 knots. The problem was modelled as two-phase incompressible flow past a fixed boom system. Following initial testing of the capability of OpenFOAM to simulate the performance of oil containment booms by comparing simulation results to experimental data, CFD simulations were implemented to investigate the containment performance of several different boom systems for different oil types (light, medium and heavy) and relative speeds.

A series of two- and three-dimensional 1/8 scale model experiments were conducted to investigate the performance of three different boom concepts for floating oil recovery (and several variations thereof) at medium and high speeds (relative to conventional booms). The 2D testing featured water and oil flowing past fixed boom models, whereas the 3D testing featured more realistic, flexible, and floating boom models that were towed through water (and oil) in both calm water and wavy conditions.

The project showed that both CFD techniques and large-scale physical model experiments are useful methods for understanding the complex interactions between water, floating oil and recovery booms, and for advancing the design of recovery boom technologies. Moreover, several innovative and promising boom design concepts capable of delivering acceptable performance at higher speeds, and thus worthy of further R&D, were identified.

Session 9 Oil Spill Response

Ecological Risk Assessment of Oil Spills in Ice-Covered Waters: A Surface Slick Model Coupled with a Food-Web Bioaccumulation Model

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Abstract:

The limited knowledge on oil-ice interactions and on the ecological outcomes of oil spills in the Arctic represent sources of uncertainties for shipping and oil and gas activities in polar regions. The behavior of oil in ice-covered waters is not fully understood and, although models have been developed and adapted to ice conditions, gaps in knowledge still exist, limiting our capacity to predict how polar ecosystems will respond to the exposure to petroleum's toxic compounds. The presentation will introduce a methodology to define the ecological risk posed by oil spills in the Arctic by the integration of an improved surface slick model to a fugacity-based food-web bioaccumulation model for icy waters. Focus will be given on the use of the fugacity approach in the prediction of the distribution of oil's toxic components in the environment and the implications of this distribution to the Arctic ecosystem. The physical processes of natural dispersion of oil and oil entrainment in ice are taken as direct inputs to the multimedia environment and concentrations of naphthalene – taken as a surrogate for oil – are predicted in each environmental compartment considering three ranges of ice coverage (low, medium and high). The multimedia environment includes organisms in a food web representative of the Arctic ecosystem, consisting of three species' comprising three trophic levels linearly related. Based on concentrations in water and in organisms on the food web and given the ice coverages, the ecological risk is characterized using as endpoints the Risk Quotient (RQ) and the Bioconcentration Factor (BCF) representing respectively the potential for acute toxic effects and bioaccumulation of contaminant in the food chain. Opportunities for combining recent advances in oil slick modeling in ice-covered waters and environmental risk assessment will be discussed, with emphasis on the implications of such events to the unspoiled Arctic ecosystem.

Session 9 Oil Spill Response

Salt-mediated Performance of Halotolerant *Exiguobacterium* sp. N4-1P for Crude Oil Biodegradation in the Marine Environment

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Abstract:

Oil Spills occurring in the marine environment could cause severe negative impacts on the ecosystem. Special species of microorganism act as the finial degraders for these petroleum hydrocarbons, while most of them can hardly survive under the unfavorable salinity. Halotolerant bacteria are those capable of growing in an extensive range of salt concentrations and have been identified to widely exist in marine environment. Thus, it is necessary to understand response of halotolerant oil-degrading bacteria to spilled oils under various saline conditions. In this study, halotolerant Exiguobacterium sp. N4-1P, a bio-emulsifier producer isolated from marine sediment in Northern Atlantic Canada was selected as a representative species, and 0.5% (v/v) Alaska North Slope crude oil was used to simulate oil spill. Results indicated that strain Exiguobacterium sp. N4-1P could grow under a wide range of NaCl concentration (i.e., 0 - 12% NaCl), though a salinity higher than 5.0% NaCl would inhibit its growth. Biodegradation assays manifested that Exiguobacterium sp. N4-1P would like to grow in the oil phase under a relatively low NaCl concentration (i.e., less than 1.5%), along with the preferring degradation of insoluble long-chain n-alkanes and obvious bio-emulsifier production. While under a higher NaCl concentration (i.e., more than 3.5%), cells would like to grow in the aqueous phase and preferred to degrade the relative soluble naphthalene and the associated bio-emulsifier production was limited. When the salinity is 1.5% NaCl, the crude oil biodegradation achieved its highest efficiency with the association of the maximum biofilm productivity. While in the hypersaline environment, the crude oil biodegradation efficiency was low due to the antagonistic effect of the bio-degraders, with a higher cell hydrophobicity for hydrocarbon uptake but a lower hydrophobicity for salt tolerance. This research helped to reveal the fate of a halotolerant oil-degrading bacterium when facing spilled oils under an extensive range of salinity, resulting in a better understanding of widespread hydrocarbon-degraders and a confirmed potential for aiding oil spill response in the marine environment.

Session 10 Prevention and Treatment II

Performance Evaluation of Advanced Technologies for Treatment Recalcitrant Emerging Contaminants: Laboratory and Pilot-scale Investigations

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Abstract:

In the recent past, there has been significant interest towards development of advanced treatment technologies for removal of "emerging contaminants" in municipal wastewater. Technologies developed in this domain mainly focus on tertiary treatment units particularly targeting the emerging contaminants which are otherwise unaltered by conventional wastewater treatment process. In this context, the possibility of using disinfection units such as UV and ozonation units for treatment emerging contaminants was considered a viable option. Modifications of these processes such as UV/H2O2, O3/H2O2, photoassisted ozonation (UV/O3) have been studied widely for removal of numerous emerging contaminants aiming for enhanced degradation. Studies pertaining to advanced oxidation-based technologies are mostly confined to laboratory experiments conducted with very high initial concentration of the contaminants as analytical techniques for quantification of trace contaminants was uncommon. Thus, the applicability of these technologies to treat emerging contaminants which occur in very trace quantities ranging from ng/L to µg/L is unknown. This present study evaluates efficacies of wide range of treatment techniques such as UV, O3, UV/H2O2 UV/O3, peracetic acid (PAA), UV/PAA on degradation of two predominant emerging contaminants namely carbamazepine and venlafaxine. Initially the performance of treatment techniques were evaluated through laboratory experiments conducted with high initial concentration of the contaminants and the operational parameters were optimized. Further, experiments using actual secondary effluent were conducted on pilot-scale units of UV, O3 and UV/H2O2 evaluating treatment efficiencies for actual incidental levels of the contaminant. The performance of the advanced oxidation treatment methods were also compared with reverse osmosis (RO) on pilot-scale. Among the evaluated technologies, RO was found to be highly effective in removing a broad range of contaminants. Overall, the findings from this study suggests that selection of treatment technologies for emerging contaminants are influenced by many factors including targeted treatment efficiency, energy and capital requirements and formation of undesirable byproducts.

Session 10 Prevention and Treatment II

Removal of nutrients and emerging contaminants in Kingston, ON municipal wastewater by a local algal consortium during autotrophic and mixotrophic growth

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Abstract:

Owing to their rapid growth rates and tolerance to fluctuating environmental conditions, microalgae have been widely studied for their potential to remove nutrients from various kinds of wastewater, but their ability to treat emerging contaminants (pharmaceuticals, personal care products, etc.) from such wastewater requires further investigation. A consortium of local microalgae was isolated from a wastewater treatment plant in Kingston, ON and cultivated in dilute centrate wastewater. Batch bioreactors were used to assess algal growth, nutrient removal, and biomass composition, and the consortium's ability to remove ibuprofen, carbamazepine, and ciprofloxacin from wastewater was quantified and its removal mechanisms elucidated. The effect of a two-phase mixotrophic growth model using glycerol was compared to a primarily autotrophic culture environment in terms of wastewater treatment and pollutant removal rates. The benefits of using algal polycultures are discussed as results are compared to the performance of a monoculture of Chlorella sp. This project has the potential to inform the operations of and decrease the ecological risks of future phycoremediation projects.

Session 10 Prevention and Treatment II

Enhanced production of lipopeptides by Bacillus Subtilis and the associated effect on diesel biodegradation in the presence of nickel

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Abstract:

As a group of the most effective biological surface-active compounds, lipopeptides have diverse structure mostly produced by *Bacillus Subtilis*. Lipopeptides can effectively increase the solubility and mobility of organic contaminants thereby accelerate their removal from the environment. However, the low productivity limits the application of lipopeptides in the environmental industry.

Facing the abovementioned challenges, economical lipopeptide production by marine originated bacillus strain *Bacillus subtilis* N3-1P was investigated in this study. Local fish waste was selected and investigated as a low-cost comprehensive nutrient source in microbial growth medium. Immobilized robust biocatalyst was further employed to boost biosurfactant production rate. Results indicated a crude biosurfactant productivity of 1.6 g/L using fish liver peptone extract as a production medium. The critical micellar concentration of extracted and purified biosurfactant was 0.018 g L^{-1}. The production rate was boosted over ten times within 24 hours with the addition of fly ash-based biocatalyst. Fourier transform infrared (FTIR) spectroscopy and matrix assisted laser desorption/ionization time of flight (MALDI-TOF) analysis demonstrated the final biosurfactant product belonged to lipopeptides.

The effect of generated lipopeptide product on diesel biodegradability by oil degrading strain *Rhodococcus erythropolis* R25 was then investigated. Nickle was added as the most documented heavy metal in oil products/derivatives. The lipopeptide product demonstrated a positive effect on reducing the toxicity of Ni to the tested oil degrading strain. The presence of the lipopeptide product increased the solubilization of diesel oil, increased the cell permeability and cell surface hydrophobicity, thus stimulated diesel biodegradation.

Session 10 Prevention and Treatment II

Utilization of organic compounds in bioelectrochemical systems

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Abstract:

Bioelectrochemical systems (BES) are an emerging technology for energy efficient wastewater treatment. In BES, a biofilm of anaerobic exoelectrogenic bacteria (Geobacter spp., Schewanella spp.) oxidize organic matter at the bioanode and hydrogen gas is produced at the cathode. Compared to conventional treatment, BES require minimal mixing and no aeration to achieve rapid degradation of organic materials. The utilization of acetic acid by exoelectrogenic bacteria is well studied, however, acetic acid is a poor representation of more complex compounds in real domestic or industrial wastewater. In this research, methods for evaluating substrate utilization were developed and tested with a number of short-chain fatty acids. We monitored the electric current and SCFA concentration in a mixed-culture BES over a 44 hour test period and found that some SCFA were decomposed to acetic acid prior to utilization while others appeared to be directly oxidized. Electric current generation, which is an indicator of the activity of exoelectrogenic bacteria, was found to be high for some SCFA even in the absence of high concentrations of acetic acid, indicating direct utilization of SCFA. Electrochemical impedance spectroscopy (EIS) was also tested as an evaluation method for substrate availability and it was found that EIS and exchange current could be used to assess how readily organic substrates can be utilized in BES. These findings show that there is partial utilization of SCFA by exoelectrogens and present a method to evaluate the utilization of SCFA, and these methods can be applied to evaluate the biodegradation of other organics in BES.

Poster

Accumulation of Discoloured Material in a Full-Scale Drinking Water Distribution System

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Abstract:

Consumer concerns related to discoloured drinking water in urban systems is a worldwide concern. Discoloured water occurs due to inorganic material and biofilms accumulating on the pipe walls of drinking water distribution systems. This material is subsequently mobilized by sudden changes in hydraulic conditions. Using a full-scale experimental drinking water distribution system, the accumulation of material within the wallsof PVC pipe was investigated. The laboratory design consisted of two identical pipe loops, each with a length of 200m and a diameter of 108mm, located in a temperature controlled environment. The laboratory is equipped with high precision monitoring equipment. Three accumulation periods of 40, 80, and 120 days, using different conditioning flow rates in each rig, allowed for cohesive layers of material to accumulate. At the end of each experiment three successive flushing steps occurred to erode the accumulated material from the pipe walls. During each flushing step,water samples were collectedto analyze the characteristics of the mobilized material usinghigh resolution turbidity data. A turbidity vs total suspended solids (TSS) curve was created using data from the collected water samples. Material accumulation of 9.7 mg/m2, 10.7 mg/m2, and 12.5 mg/m2were measured for 40, 80, and 120 days, respectively. The average accumulation rate was 0.24 mg/m2/ day, 0.13 mg/m2/day, and 0.10 mg/m2/ day for 40, 80, and 120 days respectively. The results indicate a linear trend of material accumulation, however; occurred during the initial days. Furthermore, the strength of cohesive layers was observed to increase with increasing growth duration.

Poster

Metal Impregnated Activated Carbon for NOM Removal from Drinking Water Sources of NL

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Abstract:

High level of Natural Organic Matter (NOM) and the exceedance level of Disinfection by-products(DBPS) such as HAAs and THMs have been of high concern in about 30% of distribution systems in Newfoundland. Although Activated Carbon (AC) has been widely used for the removal of Natural Organic Matter (NOM), it is recommended as the final step in water treatment systems because of its low capacity and slow kinetics. Previous studies showed that HAAs and THMs are mostly dependent on the very hydrophobic acids (VHA) and neutral hydrophilic (NHI) types of NOM. The impregnation of AC by three valent ions of Fe and Al was investigated in this study to improve the NOM removal to decrease the precursor of disinfection by-products including HAAs and THMs. The sources of metals were Ferric Chloride, and Aluminum sulfate since their mechanism in the removal of NOM were considered in the previous study through coagulation. In the current study. The optimization of the impregnated activated carbon was applied by examining different dosages of metal: AC ratio of 0.25% to 10%. The results indicate about 10-27% improvement in the removal of NOM. The results revealed that NOM removal by the tailored AC showed improvements in comparison with the original AC. Also, the investigations illustrated that VHA removal was the dominant fraction that was removed by AC in the beginning and in the end, NHI was removed. The mechanism of NOM removal has been investigated by NOM fractionation based on hydrophobicity, and the results show that impregnated activated carbon show a higher tendency to remove hydrophilic NOM in comparison with the non-impregnated AC. Also, the kinetic studies showed the faster removal of NOM by Iron impregnated AC.

Poster

Shoreline Classification Mapping for an Oil Spill Response in the Canadian Arctic using Sentinel-2 Data

Maria Yulmetova

Memorial University of Newfoundland

Abstract:

In case of an oil spill, all the oil that is not recovered out at sea will be eventually washed onto shore. Shoreline classification is the first step that must be done to locate the most vulnerable coastal environments and choose the appropriate treatment technique which depends on substrate type. This study estimates the potential of using open-access high-resolution Sentinel-2 imagery for coastal mapping. Maximum Likelihood Estimate (MLE), Support Vector Machine (SVM) and Random Trees (RT) classification methods are tested using per-pixel and object-based classification logic. Also, we investigate whether the use of auxiliary data, such as Sentinel-1 radar imagery and Digital Elevation Model (DEM) improve the classification results. To avoid misclassification in shallow waters areas that tend to reflect spectral characteristics of the bottom, the coastline is delineated using the Normalized Difference Vegetation Index prior to applying classification in order to both avoid the potential misclassification and decrease computational expenses.

The results demonstrate that the pixel-based method overperforms the segmented, and non-parametric methods overperform the traditional methods. Low accuracy of MLE is explained by the fact that the training samples are not normally distributed along the study area, while RT and SVM do not require the normality and demonstrate better results. However, applying RT and SVM only to the optical imagery without additional layers do not produce satisfying results either. The highest accuracy of 79% is achieved by the pixel-based RT classification incorporating both DEM, radar and optical imagery. This confirms that using high dimensional data by incorporating different sources improves the classification results. The resulting shoreline classification map improves the overall preparedness to an oil spill, thus reducing its' environmental impact.