Proceedings of the 2nd New England Graduate Student Water Symposium

September 11-13, 2015

University of Massachusetts, Amherst

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CONFERENCE OVERVIEW

Friday Water, Society, and Politics Workshop

From the global to the household level, societal processes have shaped and been shaped by material flows of water resources. Humans have adjusted to hydrologic patterns of water, have intervened to change those patterns and at times have attempted to restore or undo those very changes. These dynamics are driven by the intersections of cultures, histories, institutional structures, power relations, and economics with hydrologic patterns. As such, water is an integral part of international relations, politics, economics, environmental disputes, and technological innovation. This half-day symposium examines the contributions of social sciences in unveiling the relationships between societies and water resources with an eye to how the social and the physical can be co-examined and integrated to improve understandings and inform practice.

The workshop featured three speakers, Dr. Chris Sneddon, from Dartmouth College ("Transforming the Mekong: Scientific Knowledge and Geopolitical Change, 1955 to 2015"), Dr. Kelli Larson, from Arizona State University ("Risk Perceptions and Policy Attitudes: Implications for Collaborative Water Governance"), and Dr. Rebecca Lave, from Indiana University Bloomington ("Marketing environmental science and management: Stream mitigation banking in the U.S."), plus time for discussion and questions. The workshop was followed by a dinner celebrating the 50th anniversary of the Massachusetts Water Resources Research Center.

Saturday & Sunday New England Graduate Student Water Symposium

National conferences provide valuable presentation experience and networking opportunities. Unfortunately, the cost of travel, lodging, and registration presents substantial obstacles for most graduate students. To address this problem, the New England Graduate Student Water Symposium was created in 2014 and ran for its second year in 2015. Conference costs were kept low, and this year, thanks to the support of conference sponsors, registration was free for students and two nights of hotel accommodations were provided to presenters and student coauthors for a small $20 fee.

All presentations were given by undergraduate and graduate students, but post docs, alumni, faculty, and industry representatives were invited to attend. Presentation topics ranged from water and wastewater treatment process, through water quality issues, to hydrology and water resources. A special session, mirroring the Friday workshop, saw presentations in the area of environmental studies, environmental conservation, and politics.

Saturday's events included a poster contest, dedicated networking time, and a keynote presentation by USGS research hydrologist, Dennis LeBlanc ("Managing wastewater disposal on Cape Cod to improve water quality and maintain the hydrologic balance.")

TECHNICAL SESSIONS

* indicates presenting author, if not first author

Water and Wastewater Treatment I

Moderator: William Pennok

Chromate sorption on iron oxides using spectroscopy and surface complexation modeling

Nefeli Maria Bompoti, Maria Chrysochoou
University of Connecticut, Storrs, CT

Water treatment is strongly affected by the reactions on solid/solution interface. More specifically, fate and transport of contaminants in groundwater is linked to sorption reactions. Chromate is a common contaminant in groundwater and its mobility and reactivity is associated with sorption on iron oxides. To elucidate the sorption mechanisms on ferrihydrite and hematite under various environmental conditions, in situ attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy was applied in conjunction with inflow/outflow calculations resulting in complexation mechanisms and surface coverage estimation. The results indicated that chromate forms inner-sphere monodentate and bidentate complexes as a function of pH, with predominant complexes the monodentate on ferrihydrite and the bidentate on hematite. By establishing the formed complexes and the flow breakthrough curves, the prediction of sorption can be achieved using surface complexation models (SCM). Unlike empirical distribution models, SCMs provide a more robust description of sorption reactions on mineral surfaces based on equilibrium approach and can predict sorption as a function of pH, concentration and competing ions. This study presents a new 1-pK triple layer SCM for chromate sorption on ferrihydrite and hematite based on the Charge-Distribution Multisite Complexation (CD MUSIC) modelling framework (Hiemstra 2013). Based on this framework, only singly-coordinated oxygens form inner-sphere complexes with chromate. The results showed an improved fit between model and experimental data compared to the existing models. The modeling of sorption on ferrihydrite is more complicated as the aging affects the surface area while hematite is not volatile with time.

UV-LED based advanced oxidation process degradation capabilities for emerging contaminants in Nova Scotia source water.

Sean MacIsaac, Graham Gagnon
Dalhousie University, Halifax, NS

Advanced oxidation processes (AOP) are an emerging technology that has the potential to aid in the treatment of organic compounds of emerging concern. While AOP have the potential to degrade a variety of these compounds, the energy and economic tolls are often too steep for proper implementation. Mercury-halogen bulbs that are energy inefficient and are an environmental hazard when they reach the end of their useful life drive traditional UV-AOP processes. UV-LED address both of these issues as they

operate at much lower wattages and temperatures compared to traditional technologies. In addition, UV-LED bulbs can be designed to emit UV light at any desired wavelength. This allows for more specific tailoring of UV treatments for water matrices. UV-LED treatment processes provide a niche in the energy-water nexus that has the potential to save utilities money while achieving acceptable treatment benchmarks. The objective of this study was to examine the viability of UV-LED technologies when treating emerging contaminants in a water matrix. A bench-scale UV-LED reactor was used in a set of AOP experiments examining natural organic matter in a synthetic and real water matrix (plant water). Plant water was collected at JD Kline Water Treatment Plant in Halifax, Nova Scotia. Samples are analyzed primarily using size-exclusion chromatography and fluorescence emission excitation matrices.

The Effect of Water Quality Parameters on Disinfection and Validation of Rapid Testing Method for Microbiological Testing of Wastewater Following UV Disinfection

Brian Middleton, Graham Gagnon
Dalhousie University, Halifax, NS

A significant cost the wastewater treatment industry is electrical consumption. One approach to mitigating this is to modulate the energy output based on the time of year, such as the condition targeted by Halifax Water. In other words, turning the system off for part of the year and practicing seasonal disinfection to save money and reduce greenhouse gas emissions. With either approach the question surrounding microbiological integrity is raised. The research is based on validating a new technique for rapid microbiological quantification using Adenosine triphosphate (ATP) technology that could help wastewater operators make decisions regarding UV operations.

A challenge with ATP monitoring is that an ultraviolet dose sufficient to cause a significant reduction in culturability yields little to no reduction in ATP. Our lab has recently development a new method that can overcome the false lack of reduction. The objective was to assess our microbiological method on actual wastewater treatment sites to determine its application to the industry. These data are compared to traditional microbiological tests (e.g., heterotrophic plate counts) and are also benchmarked against the general treatment quality of the plant (e.g., CBOD5, TSS etc). It was found that the ratio between effluent biomass to influent biomass remained close to unity with traditional testing but the new method showed that it is closer to 0.7.

In addition three water quality parameters were synthetically altered to evaluate their effect on disinfection of Escherichia coli. Tryptophan, humic acid, and kaolin were used to imitate amino acids, organic matter, and turbidity respectively. Experiments are ongoing at present.

Effects of Surface Treatments for Granular Activated Carbon on the Bioavailability of Sorbed Ionizable Substrates

Hankai Zhu, Derick G. Brown, John T. Fox, and Adam Redding
Lehigh University, Bethlehem, PA

During bacterial adhesion, the local pH between the bacterial and adhering surfaces can change due to the charge-regulation effect. The pH can both increase and decrease from that of the bulk solution, depending on the acid/base functional groups present on the two surfaces. Our research has demonstrated that this effect can impact both bacterial activity (via changes in cellular bioenergetics, which is dependent on a pH gradient across the cell membrane) and bioavailability of sorbed, ionizable growth substrates (via changes in the substrate ionization).

We demonstrate the latter effect for the bioavailability of ionizable growth substrates on surface-modified granular activated carbon (GAC). We examined three different growth substrates – benzoic acid, ethylbenzene, and benzylamine – which exhibit acid, neutral, and basic functionalities, respectively. Using these growth substrates, we examined their sorption and bioavailabiliy with three GACs, including a baseline carbon, a weak-base-treated carbon, and a quaternary amine (strong-base) treated carbon. Zeta potential analysis demonstrated that the baseline carbon surface was acidic in nature while the treated carbons contained basic functional groups. Substrate sorption on the GACs was a strong function of pH (e.g., figure 1 for benzoic acid) and this directly affected the bioavailability of the different growth substrates on the three different GACs (e.g., figure 2 for benzoic acid). We will demonstrate through experimental and numerical results how the charge-regulation effect induces changes in local pH, which in turn alters the bioavailability of sorbed ionizable growth substrates. In addition, we will show results demonstrating that positively-charged functional groups present antimicrobial properties, in agreement with our working hypothesis for charge-regulated surfaces. Overall, these findings have implications for the bioavailability of ionizable substrates at surfaces, whether sorbed or in solid form, and understanding of this effect can lead to more effective selection and design of absorbents for specific application.

Flat Microliter Membrane-based Microbial Fuel Cell as "On-Line Sticker Sensor" for Self-supported In Situ Monitoring of Wastewater Shocks

Zhiheng Xu, Baikun Li
University of Connecticut, Storrs, CT

Novel flat membrane-based microbial fuel cell (MMFC) sensors were developed by compacting two filter membranes coated with carbon ink. High micro-porosity and hydrophilicity of membranes offered the distinct advantages of short acclimation period (couple hours), simple compact configuration with microliter size, and high sensitivity and stability. MMFC sensors were examined at two toxic shocks (chromium and nickel) in a batch-mode test chamber, and rapidly responded to shock types and concentrations. The variation of voltage output was correlated with open circuit potential (OCP). Filter membranes facilitated bacterial attachment and shortened acclimation. The MMFC sensors showed good reusability and recovered several days after toxic shocks. The

robustness of MMFC sensors was validated through 1-month tests. The stability of sensor signals was examined with coefficient of variance (CV) statistical analysis. The flat microliter MMFC has a great potential as "on-line sticker sensor" for real time in situ monitoring of wastewater quality.

Water and Wastewater Treatment II (Biofilters)

Moderator: Lei Zheng

Biologically Active Filters: An Advanced Treatment Process for PPCPs

Shuangyi Zhang, Stephen Gitungo, Lisa Axe, John E. Dyksen, Robert F. Raczko
New Jersey Institute of Technology, Newark, NJ

With the increasing concern of pharmaceuticals and personal care products (PPCPs) in source water, we are testing the hypothesis that existing filters and adsorbents in water treatment plants can be advanced to as biologically active filters (BAFs) to treat these compounds. We are also examining the effectiveness of pre-ozonation in breaking down the more recalcitrant compounds to optimize removal through the BAFs. The media in our study include granular activated carbon (GAC) and anthracite/sand dual media, which were collected from two treatment plants. In a bench-scale study with duplicate columns, the affect of pre-ozonation, empty bed contact time (EBCT) (18 and 10 min), and media substrate are being evaluated. A number of parameters are being analyzed throughout the study: pH, temperature, turbidity, dissolved organic carbon (DOC), total organic carbon, UV254, dissolved oxygen, nutrient concentrations, and adenosine triphosphate (ATP) concentration. The GAC and dual media BAFs generally showed up to 15% DOC removal with and without pre-ozonation, with pre-ozonation improving removal by 2.5%. For the GAC BAFs, the data reveal greater oxygen consumption, increased pH drop, and greater DOC removal per mg of ATP suggesting increased microbial activity as compared to dual media BAFs. ATP concentrations observed in the upper portions (37.5 cm from the bottom) of the BAFs ranged from approximately 325 to 800 ng ATP/cm3 and were as much as four times greater than the middle and lower portions. Ongoing studies involve evaluating PPCP removal as a function of EBCT and pre-ozonation. The microbial community in filter influent, effluent, and media are being assessed using 454-sequencing. Opportunistic pathogens will be examined in filter effluents while the microbial community in filter media will be studied as a function of EBCT.

Antifouling mechanisms of bismuth nanoparticle-coated membrane in wastewater membrane bioreactors

Mengfei Li, Jason Bradley, Raju Badireddy, Huijie Lu
University of Vermont, Burlington, VT

Membrane bioreactors (MBRs) combine membrane filtration with conventional activated sludge processes, providing better effluent quality and lower sludge production for wastewater treatment. Biofouling refers to the deposition, growth and metabolism of bacteria cells on the membranes, and is a significant concern to the operation of MBRs. Biofouling is highly related to membrane surface features, including pore size, porosity, biocide property, material composition, and hydrophobicity. Traditional antifouling

methods involve chemical (by adding hypochlorite or week acids) or physical cleaning (by air scouring or backwashing) of the membrane surface. In recent years, chemical membrane modification has been developed as a novel approach to reduce biofouling. Bismuth dimercaptopropanol nanoparticles (BisBAL-NP) has been proved to be effective in killing pathogenic microorganisms by contact. Additionally, BisBAL-NPs are non-carcinogenic, less bioaccumulative and cytotoxic than many other heavy metal NPs. All these properties make BisBAL-NP a potential coating regent to reduce or prevent membrane biofouling in wastewater MBRs. In this study, biofouling on regular polysulfone (PSF) membranes and those coated with BisBAL-NP were compared by conducting 1-, 3- and 5-day cross-flow filtration tests in a lab-scale nitrification MBR. It was demonstrated that BisBAL-modified membranes led to less flux decline, lower biofilm thickness and cell volume. Moreover, the total extracellular polymeric substances (EPS) accumulated on BisBAL-coated membranes were significantly less than those on regular ones, indicating an antifouling behavior involving suppression of EPS secretion as well. The fouling-layer microbial communities will be further analyzed by high-throughput sequencing to unravel more antifouling mechanisms from a microbial ecology perspective. Results from this study could potentially lead to broader applications of BisBAL-NP coating in biofouling control for wastewater MBRs.

Water Treatment Residuals-Coated Mulches for Mitigation of Urban Stormwater Pollutants - Batch and Column Studies

Hanieh Soleimanifar, Yang Deng
Montclair State University, Montclair, NJ

Water Treatment Residuals (WTRs) are the coagulation byproducts produced from traditional water treatment facilities. These materials with abundant active adsorption sites have been applied for land application due to the reduction of nutrients and metals in water. However, the direct application of WTRs as filter media for stormwater contaminants is challenging because their hydraulic conductivity is fairly poor. In this study, new filter media were prepared by coating recycled WTRs on mulch and subsequently tested for mitigation of toxic metals and phosphorus in urban stormwater runoff. Two WTRs (iron and aluminum based WTRs) and two mulches (wood and rubber mulches) were employed to synthesize four different WTRs-coated mulches. SEM images clearly showed that WTRs were tightly attached on the mulch surface. Batch tests were first performed with synthetic urban stormwater to determine the key kinetic data on immobilization of three metals (i.e., Pb, Cu, and Zn) and phosphorous by the modified mulches. Generally, WTRs-coated wood mulches showed a higher sorption capacity for all target pollutants than WTR-s coated rubber mulches that could release Cu and Zn. Results showed that the coated wood mulches removed 50%, 80%, 90% and 95% of Cu, Zn, Pb and P within 120 min at pH 7, individually. Column tests were then carried out to test the performance of these WTRs-coated mulches under a continuous flow condition. Among the different modified mulches, Al-WTRs coated wood mulch exhibited the highest removal capacity and a long breakthrough time. Finally, the results of Synthetic Precipitation Leaching Procedure (SPLP) and Toxicity Characteristic Leaching Procedure (TCLP) tests suggested that the release of undesired chemicals from used WTRs-coated mulches under different conditions was not a concern. Our results demonstrate that Al-

WTRs coated wood mulch is a promising filter media for the control of urban stormwater pollution.

Block Copolymer Functionalized Thin-Film Composite Membranes for Anti-fouling and Anti-microbial Properties
Gang Ye, Jongho Lee*, Francois Perreault, Menachem Elimelech
Yale University, New Haven, CT

Fouling control is critical in membrane-based water treatment processes due to its detrimental effects on system performance and overall energy efficiency. In the present study, we propose a novel method to simultaneously impart anti-fouling and anti-microbial properties to polyamide reverse osmosis (RO) membranes. We used Atom Transfer Radical Polymerization (ATRP) chemistry to produce a di-block copolymer film composed of zwitterionic (anti-fouling) and quaternary ammonium (anti-microbial) blocks. Successful modification of the membranes was verified by various characterization techniques, including electron microscopy, contact angle measurement, surface zeta potential, and FTIR spectra. RO experiments with the modified membranes showed that the water permeability and salt rejection were not compromised by the modification due to the thin di-block copolymer layers. Anti-fouling functionality was successfully proven by low adsorption of BSA on the modified membranes, low adhesion forces measured by atomic force microscopy, and reduced number of Escherichia coli (E.coli) attached on the modified membranes. Finally, the viability of E.coli on the modified membranes was significantly lower than the pristine membrane, showing the excellent anti-microbial property of the di-block copolymer functionalized membrane. This novel and simple method to generate bi-functional di-block copolymer has a high potential for fouling prevention in membrane-based water treatment technologies.

Water and Wastewater Treatment III (Biological P and N Removal)

Moderator: Nick Tooker

Bench-scale Testing of Novel Denitratation/Anammox SCT Process
Anthony Niemiec
Manhattan College, Bronx, NY

An Anammox BNR process has been developed and has become apparent that one of the most significant challenges in operating an effective Anammox process is both the retention of the slow growing Anammox biomass and the suppression of Nitrite Oxidizing Bacteria (NOB) to maintain the required nitrite levels in the system.

The research work plan includes the use of a simple biological nitrogen removal system with alternating aerobic (nitrification), anoxic (denitrification) and anaerobic (Anammox) cycles with glycerol addition for Glycerol Acclimated Biomass (GAB). Anammox/GAB biomass and Centrate are obtained from the 26th Ward Wastewater Treatment Plant. The objective is to cut cost on aeration and supplemental carbon.

The bench scale testing is conducted in a sequencing batch reactor system. This will be shown by finding the optimal ammonia and glycerol loading rates for specific Hydraulic retention time (HRT) values. The ammonia loading rate for a 24 hour cycle is determined based upon each process HRT. The glycerol loading rate is determined based upon a ratio of 1-2 for COD :TN(influent).

This study will show the optimal aerobic length and ratio of carbon to influent nitrogen needed for maximized removal. This will indicate whether or not this alternative Anammox process can help NYC DEP cost effectively meet their long-term nitrogen removal obligations.

Seasonal and daily variation of Greenhouse Gas emissions from Biological Nutrient Removal tanks at Field's Point wastewater treatment plant
Elizabeth Brannon, Serena Moseman-Valtierra, James McCaughey
University of Rhode Island, Kingston, RI

Biological nitrogen removal (BNR) from wastewater is necessary to maintain the health of the water bodies receiving effluent discharge. However, BNR can result in the release of potent greenhouse gases that contribute to climate change, including carbon dioxide, methane, and nitrous oxide. Due to high spatial-temporal variability, net emissions of these gases are poorly understood but may notably impact overall climate impacts from wastewater treatment plants (WWTP). The Narragansett Bay Commission's Field's Point WWTP, in Providence, RI, recently upgraded 10 treatment tanks to use integrated fixed film activated sludge (IFAS) as part of BNR that consists of four zones: pre-anoxic, aerated IFAS, post-anoxic, and re-aeration. This research represents the first known investigation of carbon dioxide, methane, and nitrous oxide emissions simultaneously over a seasonal cycle from all 4 zones in one of the IFAS BNR tanks at the Field's Point facility. Carbon dioxide, methane, and nitrous oxide emissions were measured from each zone twice a month from June 2014 to June 2015 by connecting a floating gas chamber to a cavity ring down spectrometer (Picarro G2508) that measures the three gases in real time. Additionally, to examine diurnal variation, on selected days emissions were measured every 1.5 hour from 9:30 am to 3:30 pm from the re-aeration zone. Preliminary analyses show that methane and nitrous oxide gas emissions vary throughout the year by three orders of magnitude and carbon dioxide gas emissions by two orders of magnitude. Future efforts should include examination of potential mechanisms driving the emissions in order to minimize impacts on climate change while maximizing nitrogen removal from wastewater.

Nitrogen removal with microbial fuel cells
Yan Li, Baikun Li
University of Connecticut, Storrs, CT

An integrated short-cut nitrification and autotrophic denitrification MFC was developed to treat nitrogen and produce power simultaneously. Ammonium was reduced mostly in the form of nitrite instead of nitrate (ratio was as high as 3) in short-cut nitrification MFC

cathode at low DO concentration (1mg L-1, 2 mg L-1, 3.5 mg L-1) to save aeration in the nitrification process and electron donors in the denitrification as nitrite consumed less electron donors than nitrate. Autotrophic denitrification was adopted in the denitrification MFC to use electrons produced from anode chamber without further adding carbon source into the denitrification cathode to save carbon consumption. The total removal rate was 0.0036 kg-N m-3 d-1 and removal efficiency of nitrogen was as high as 99.9%. The power generation in short-cut nitrification MFC was as high as 294.9 mW m-2 with the highest current density of 0.158 mA cm-2 and the accumulated coulombs of the whole process were as high as 87.17C at DO 3.5 mg L-1.

Modeling high rate P-removal in a vertical flow constructed wetlands using alum sludge cakes as a substrate

Lordwin Girish Kumar Jeyakumar, Yaqian Zhao
Atlantic Cool Climate Crop Research Centre, St. John's, NL

A system dynamics (SD) process based simulation model is developed using an object-oriented environment to simulate phosphorus (P) transformations in a 4-stage pilot scale dewatered alum sludge cake (DASC) based constructed wetlands (CWs). STELLA v9.1.4 (Structural Thinking Experiential Learning Laboratory and Animation) conceived on the principles of SD is used for the development of process based P model by constructing stock-flow diagrams and carrying out computer simulations using difference equations to integrate stocks and flows. The hydrology sub-model has a state variable of water volume which balances direct precipitation, ET (Evapo-transpiration), influent and effluent flowing from the VFCW (vertical flow constructed wetland). From the model simulation it was found that the major pathways leading to permanent removal of P in a VFCW system in descending order are adsorption, plant and microbial uptake. Moreover the developed model can have the ability to simulate the effluent P concentration. Model equations are presented and can be employed in numerical simulation to study optimum design strategies for a specific location with defined environmental conditions. Thus the P process based model developed in this study could be used to explain the pilot scale P removal processes and also be used to simulate the fate of P in the high strength animal farm wastewater treated in the VFCW.

Water and Wastewater Treatment IV (Process)

Moderator: Camilla Kuo-Dahab

Performance model and experimental apparatus applicable to hydraulic flocculators

William Pennock, Felice Chan, Monroe Weber-Shirk, Leonard Lion
Cornell University, Ithaca, NY

To meet the objective of minimizing operation and maintenance costs, the baffled hydraulic flocculator is an excellent choice as a reactor for drinking water treatment. Current guidance on construction of these flocculators is based on successful existing reactors and computational fluid dynamics (CFD). In order to improve the design of these flocculators, and thus to facilitate their scaling and adoption, it is beneficial to base their

design on the physical principles that directly control their performance. The aim of this work is to compare a fundamentally-based, posited model with experimental data. The model is agent-based, or Lagrangian, and predicts flocculator performance as measured by effluent turbidity as a function of influent turbidity and hydraulic characteristics of the flocculator. This line of investigation has been successfully completed for the laminar flow regime, but remains to be completed for the turbulent regime, in which all real flocculators operate. This presentation will describe the background of the project as it relates to the water treatment systems designed by Cornell University's AguaClara Program that have been implemented in Honduras. A overview will be provided of previous research on the project and of the model. Narrative of the design of the plug flow, turbulent flocculation apparatus will be given, as well as a discussion of preliminary results from the work.

Development and Evaluation of a Magnesium-Based Coagulant for the Treatment Performance Enhancement of Gravel Roughing Filtration

Brianna Wentworth, M.R. Collins
University of New Hampshire, Durham, NH

A pretreatment filtration stage is advantageous for reducing turbidity loads and particularly surges in the influent source water for subsequent treatment processes. Gravel roughing filtration has been successfully employed for pretreatment to reduce particulate loadings especially in developing countries. However, course media roughing filters achieve limited removals of organic precursors and smaller-sized particles. The need exists for improving the treatment performance of these pretreatment roughing filters.

Chemical coagulants, typically metal-based coagulants, have been employed in conventional water treatment and have been used prior to gravel roughing filters. However, metal accumulation and toxicity, filter cleaning requirements and disposal of filter residual can result in higher operational and maintenance costs as well as potential health and environmental risks. The development and use of more biologically friendly and innovative, natural-based coagulants could enhance the performance of these low-maintenance roughing filters.

As part of an overall study to explore the performance enhancement of biologically-based gravel roughing filtration systems, including mineral- and algal-based options, this presentation focuses on the potential of using magnesium as a more biologically friendly coagulant to facilitate enhanced removals, by reducing turbidity, bacterial counts (E. coli) and possibly organic precursors. Magnesium speciation was conducted to distinguish between dissolved and particulate forms, in order to optimize the water chemistry of the coagulation process and in turn differentiate between charge neutralization and other effective coagulation mechanisms. This research provides a strong basis for future evaluation of pilot-scale, coagulant-enhanced gravel roughing filters.

Particle formation during ferrate(VI) application for wastewater reclamation
Lei Zheng, Yang Deng
Montclair State University, Montclair, NJ

Ferrate(VI) has been recognized as a "green" and emerging treatment reagent for treatment of municipal secondary effluent for the purpose of water reuse, and has a potential to inactivate pathogens and remove emerging contaminants as well as phosphorus. However, the knowledge on ferrate(VI)-induced coagulation in a treated wastewater matrix is limited. The objective of this study was to investigate particle formation and characterize these iron hydroxide particles during ferrate(VI) treatment of municipal secondary effluent. Jar tests were first performed to monitor ferrate(VI) decay and particle formation, and then the produced particles were characterized in the following settling. Results showed that ferrate(VI) (3.0 mg/L Fe(VI)) almost completely decayed at pH 7.5 within 60 min, during which ferrate(VI)-induced particles gradually grew to ~1,000 nm at 30 rpm. Under identical conditions, the particle sizes were increased over 5,000 nm as the mixing speed was increased to 150 rpm. In the following settling tests, the initial turbidity in 5 mg/L Fe(VI)-treated secondary effluent were 16.7 NTU, greater than 4.70 NTU observed in the control group (5 mg/L Fe(III)), though very similar suspended particulate iron concentrations were found in the Fe(VI) and Fe(III) treated secondary effluents. After 2 hr settling, the turbidity and suspended particulate iron in the Fe(VI) and Fe(III) -induced secondary effluent decreased by 22% and 5%, and, 81% and 100%, respectively. As the settling time was extended to 72 hours, a significant reduction in turbidity or suspended iron particles was not observed in the ferrate treated samples. These findings suggest that most of iron after ferrate(VI) reduction existed in the forms of small iron hydroxide particles, which suspended in water and significantly contributed to cloudiness. And the traditionally believed in-situ Fe(VI) induced coagulation did not truly occur. Further investigation is needed to study the methods for removal of these unwanted particulates produced from ferrate(VI) reduction.

Impacts of Natural Organic Matters (NOMs) on Ferrate Decay and the Subsequent Formation of Iron Hydroxide Particles during Potable Water Treatment
Chanil Jung, Dongyu Lyu, Yang Deng
Montclair State University, Montclair, NJ

Ferrate(VI) as a green water treatment chemical has recently recaptured interests in the application for potable water treatment. However, the chemistry of ferrate(VI), different from many mature treatment reagents, remains largely undeveloped. The objective of this study was to comprehend the role of natural organic matter (NOM), a major water matric component in raw water, on ferrate(VI) decay and the subsequent formation of iron hydroxide particles (the ferrate(VI) reduction products) during ferrate(VI) application (fixed dose as 3 mg/L Fe) for potable water treatment. Bench scale kinetics tests were performed with simulated natural water spiked with Suwannee River NOM. Results showed that ferrate(VI) decay followed a mixed first- and second-order reaction pattern at either of pH 6.5 and 7.5, in agreement with a previous study that the mixed order kinetics of ferrate(VI) decay occurred in a heterogeneous ferrate system. Increased NOM

concentrations (0.0-10.0 mg/L DOC) clearly enhanced the ferrate(VI) decomposition at the both pH due to the reactions between Fe(VI) and NOM. For example, the half-life of ferrate(VI) was reduced from 122 to 80 second and from 234 to 126 second with the increasing NOM level from 0.0 to 10.0 mg/L DOC at pH 6.5 and 7.5, respectively. Different NOM fractions accelerated the ferrate(VI) decay based on the following orders: humic acid (HA) > fulvic acid (FA) > hydrophilic fraction (HPI) HA > FA > HPI at pH 6.5 and FA > HA > HPI at pH 7.5. Fluorescence excitation-emission (EEM) analysis was also applied to evaluate distinguished impacts of different NOM fractions and pH on the ferrate(VI) decay. Accompanied with ferrate(VI) decay, iron hydroxide nanoparticles were produced. Smaller particles (68-141 nm) were observed during slower ferrate decay at pH 7.5 with 30 min. As NOM was present, the particle sizes were reduced, thereby suggesting that NOM retarded the self-aggregation of these nanoparticles likely due to the adsorption of NOM onto the active sites of iron hydroxide particles.

Optimizing Dissolved Air Flotation at a Full-Sscale Plant
Sandra Vanessa Chau Li, Graham Gagnon
Dalhousie University, Halifax, NS

Louisburg water treatment plant, located in the north part of Nova Scotia, is using Dissolved air flotation (DAF) as a technology to treat Kelly lake water source in order to supply the Louisburg and fortress of Louisburg area with drinking water. Kelly Lake water is low in turbidity, alkalinity and hardness, but is high in colour and organics. The WTP is constituted by a dual DAF with 3 post filters, having a capacity of 650 000 gallons per day. During the past months the WTP has been struggling with the DAF performance on removing turbidity. This flaw is causing an increase in the operations costs of the utility due to higher numbers of back washings and shorter time life of the 3 post filters. This study is focused on optimizing the WTP by finding the best cost-effective solution to remove the greatest percentage of turbidity using DAF. The study is being performed in a bench scale DAF jar tester. First, pretreatment parameters such as Polyaluminum Chloride (PACl) dosages (10, 20, 30 mg/L), pH values (5.5 and 6.3), different buffers (caustic soda and soda ash) have been evaluated to achieve a well coagulation and flocculation process. Second, the recycle rate, a float tank parameter, is analyzed to observe if a change from 20% to 10% recycle rate is an option for reducing operational costs as well. All in all, the aim of this project is to contribute to the efficiency of the WTP, not only by increasing the performance on DAF but also the profitability of the utility.

Comparing the effect of two different organic materials on the material properties of ceramic pot filters.
Luke Scannell, James Jensen
University at Buffalo, State University of New York, Buffalo, NY

Ceramic pot filters are used throughout the world to improve drinking water from contaminated sources. Filters are made from local materials, including an organic material, such as rice husks or saw dust, and clay. The mixture of these components is measured as either a percent volume or a percent weight, with variations in local

materials controlled for by discarding filters with flow rates outside of a predetermined range. Different organic materials do not have the same properties, and this study proposes that a more accurate comparison can be done by analyzing ceramic filters' material properties based on the amount of mass removed during firing. Mass removed includes the percent of the sacrificial organic material that burns off, the percent of naturally occurring organics in the clay that burns off, and any bound water. This study will look at how the material strength, porosity, filter flow rate, and biological removal efficiency depend on the mass removed for both rice husks and sawdust. Material strength testing will be conducted using the notched bar impact test and three point flexural strength tests following ASTM standards. Microbial removal tests are conducted using vacuum filtration and agar plate total coliform counting methods to determine the effluent concentration. Filters need to achieve at least three log removal while achieving a flow rate equivalent to 2 L/hr in full scale pots. Initial results indicate a strong relationship between flow rate and mass removed for seven different percentages in both sawdust and rice husks. Material strength and biological removal tests are in progress currently. Results from approximately 80 flow tests indicate a strong correlation between flow rate and mass removed. This provides an accurate method to predict filter function and biological removal efficiency for a variety of organic materials.

Water and Wastewater Treatment V (Ion Exchange)

Moderator: Ryan Wicks

Sustainable Ion Exchange Brackish Water Desalination as an Alternate to RO

Hang Dong
Lehigh University, Bethlehem, PA

Currently, the most common used brackish water desalination technology is Reverse Osmosis (RO). Semipermeable membranes are applied to separate salt from water under specific pressure. RO has been the dominant technology used in USA by far because of its relatively lower energy cost and higher capacity compared with existing other technologies such as distillation and electrodialysis reversal. However, there are still challenges for RO desalination plants such as disposal of waste brine. One way to reduce the concentrate volume is to increase the RO recovery rate. If we can increase the recovery rate from 80% to 90%, concentrate volume could reduce half. Nonetheless, energy requirement will exponentially increase to get higher recovery rate when beyond 80%.

This proposal is trying to propose a new desalination technology using ion exchange resin as an alternative to RO. The process is to use cation exchange resin to convert cation like sodium to hydrogen ion, while use bicarbonate loaded anion exchange resin to convert anion like chloride to bicarbonate. So the TDS in brackish water will become carbon dioxide and being separate from water. The primary data shows that with up to 3000 microsiemens feed water, ion exchange column could produce around 50 to 60 bed volumes low TDS (<500 ppm) water without much energy requirement or any concentrate disposal issue. And regeneration of these resin could be done within 10 BV of regenerate and rinse water. That’s more than 80% recovery and it could be increased

further with lower TDS feed and higher regeneration efficiency. This technology could reach higher recovery rate beyond 80% with much lower cost than RO. And cheap regenerate to produce high concentration bicarbonate solution like magnesium oxide and carbon dioxide are available. In addition, it is tunable on operation size and operation capacity. The column operation system could be more size efficient than RO, and could adjust operation capacity with various resin amount.

Tunable anion exchange to treat Marcellus flowback wastewater and recover barium using impaired acid mine drainage (AMD)

Jinze Li
Lehigh University, Bethlehem, PA

In recent years, the availability of abundant natural gas in Marcellus shale in the northeast of the USA and the possibility of its extraction through horizontal drilling have shown promise for an economic energy source. However, the co-production of flowback wastewater containing objectionable electrolytes laced with radioactivity has emerged as major obstacles against fullest utilization of its potential. The flowback wastewater from hydrofracking has unusually high total dissolved solids (TDS) in the tune of 150,000 mg/l. It is, however, the presence of high concentration of barium and strontium (over 5000 mg/l) that makes the disposal of flowback through deep well injection both expensive and environmentally sensitive. The same geographic region also has severe acid mine drainage (AMD) problem. AMD is a natural biogeochemically formed water stream from abandoned mines that is acidic and contains significant amount of sulfate. Ongoing research at Lehigh University demonstrates that by appropriately selecting anion exchange resin(s) with desirable sulfate/chloride selectivity, it is possible to:

i) Transform AMD into fresh water for hydrofracturing; and

ii) Treat flowback wastewater concurrently for removal and recovery of barium.

Silver Recovery from Wastewater

Tabish Nawaz, Sukalyan Sengupta
University of Massachusetts, Dartmouth, MA

Silver, as nano-particles, is a known anti-microbial agent. Its application in a wide variety of consumer products shows an increasing trend. Its discharge and subsequent accumulation in water and soil system is potentially harmful for various aquatic life forms and soil productivity. Its presence in waste water also affects the biological treatment in WWTPs. Its recovery has high commercial value and can greatly reduce the waste water treatment cost. In this study, silver has been recovered from synthetic grey water sample using a thiol-based ion exchange resin in a packed bed mode. The ion-exchanger displayed high selectivity for silver; while all other cations broke through within the first 10 bed volumes (BV), silver broke through after 21,000 BV. The column is fully regenerated using 0.1M Thiourea and 0.1M H2SO4. Silver is precipitated from the regenerated solution using 2ml of 10N NaOH as a dark brown precipitate. EDX shows presence of silver in the precipitate with 80-85% purity. AAS on the regenerated

solution pre and post precipitation shows ˜100% silver recovery. The spent regenerant is 96-97% thiourea, and can be reused, but its efficiency drops to 60-70% compared to the fresh regenerant. Silver uptake capacity of the resin is calculated to be 3meq/gram, and is accurately captured by Langmuir isotherm. Uptake in second cycle for fully regenerated resin is 60-70% of first cycle equilibrium capacity. This presentation will discuss the role of co-contaminants, the speciation of silver-thiourea complexes after regeneration, and silver uptake and release kinetics. The process employed recovers a precious resource from waste water (silver), recycles the regenerant (thiourea), and creates no waste products. Thus, it can be a sustainable and economic treatment process.

Using Hybrid Ion Exchanger with Nanoscale Zirconium Oxide Particles (HIX-NanoZr) to Mitigate Fluoride Crisis in Africa and Asia
Michael German, Jinze Li, Arup K. SenGupta
Lehigh University, Bethlehem, PA

Millions of people face the risk of groundwater with natural fluoride contamination across East Africa and Asia. Many locations also face concurrent unsafe levels of TDS. Current fluoride technologies are not robust enough and suitable for people facing health threats and unable to access safe water. A suitable fluoride sorbent has been designed that is a hybrid anion exchange resin impregnated with nanoparticles of zirconium oxide (HIX-NanoZr). HIX-NanoZr is a synergy of zirconium oxide nanoparticles that have high capacity for fluoride with a structurally resilient anion exchanger support. Anion exchangers increase the intraparticle diffusion of trace anions to the zirconium sorbents through the Donnan Membrane Effect and allow use of nanoparticle sorbents without high pressure losses. HIX-NanoZr has high capacity (3000 BVs) and selectivity for fluoride from real groundwater influent at pH 8.3. Over multiple cycles of exhaustion-regeneration, HIX-NanoZr has high efficiency of regeneration (>95%). HIX-NanoZr systems can also reduce influent alkalinity and TDS (up to 2000 ppm) to drinking water standards (<500 ppm). In both lab-scale settings in the USA and pilot-scale settings in India, HIX-NanoZr has been locally produced in a safe and reproducible manner. Several field trials have occurred in Kenya and India. Today in India, communities are drinking fluoride-safe water (<1.5 ppm F) in Raipur, Odisha and Jabhua, Madhya Pradesh from initial HIX-NanoZr test systems. Efforts are underway to generate a sustainable business model around HIX-NanoZr.

Water, Society, and Politics

Moderator: Luke Detwiler

Improving Small Community Flood Resiliency: Strategies of Watershed Partnerships
Nicole Gillett
University of Massachusetts, Amherst, MA

In the mountainous rural communities of New England, recent damaging river floods, together with rising concerns over climate change and the prospect of more frequent strong storm events, have been changing the way in which rivers are understood and

managed. People, governments and communities are finding new and innovative of ways to adjust to the new challenges presented by this increasing concern. Some of the best of these represent a move toward what can be called community flood resilience. There are many ways that people, governments and communities are moving toward flood resilience from use new scientific approaches, to new or modified governance, institutional and policy approaches. Yet in many cases there remains a gap between scientific knowledge of experts, on the one hand, and the application of flood hazard prevention and remediation programs by government programs, on the other; and between improved programs, on one hand, and their use by and usefulness for people and communities in rural Massachusetts, on the other (preliminary findings). Filling these gaps must be a priority if we wish to help New England communities achieve flood resilience. This thesis examines two very different watershed groups in New England who are both working towards flood resiliency in their communities. I then highlight a range of approaches to institutions, policies and applications of fluvial-geomorphic science which may assist communities and policy-makers in furthering flood resiliency.

Decision support system for monitoring strategies for surface water quality based on a participative approach

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Integrated watershed management (IWM) is increasingly used to achieve targets for preventing and managing water pollution. Two of the main challenges posed by IWM are (1) getting a reliable assessment of water quality (WQ) through water quality monitoring programs (WQMPs) and (2) involving stakeholders in the process of IWM and implementation of WQMPs so that they can be part of the decision-making, understanding the stakes and integrating this knowledge in decisions and actions designed to protect the resource. However, planning and optimizing WQMPs is a very complex process due to the large number of factors that need to be considered: selection of monitoring objectives, sampling sites, WQ parameters, sampling frequencies and human, financial and technical resources. Indeed, there is no generally accepted practical holistic strategy to support all phases of planning and optimizing WQMPs.

In order to support watershed managers in the process of planning and optimizing WQMPs in a holistic and participative way we propose the development of the conceptual model of a user-friendly, intelligent decision support system (IDSS) for planning and optimizing WQMPs. The conceptual model is being designed based on information and issues related to WQMPs obtained through an extensive literature review and expert interviews. Universal Modeling Language is being used to depict the model in order to facilitate communication between domain experts, system design and software programmers for its implementation.

Since the IDSS will be designed to be driven by clear monitoring objectives and the challenge is to develop means to involve all stakeholders within a watershed, the second objective consists of the elaboration of a participative approach destined for organized stakeholders and for the general public of a watershed, in order to elicit knowledge about

needs for WQ, acquire information on WQ issues and to obtain an appreciation of existing WQ assessment.

Estimating the Ecological Economic Impact of Stormwater Runoff in Rochester, New York
Kelly Miller, Dan Lass, Jeff Wagner, Karl Korfmacher, Brid Gleeson Hanna
University of Massachusetts, Amherst, MA

Stormwater runoff generated by increased landscape imperviousness can result in flooding and degradation of natural aquatic systems in urban watersheds. We propose an ecological-economic model of stormwater runoff control that suggests the optimal volume of runoff in a watershed is given by equating the marginal damage to the marginal abatement cost of runoff. We then focus on obtaining an estimate for the marginal damage of runoff using data from the Allen Creek Watershed located in Rochester, NY. The northwestern part of this watershed is densely developed and considering whether to develop an additional 87 acres of green space that currently acts as a sink for runoff. We develop an empirical model to estimate the cost of additional runoff to the community downstream from this potential development site. Our empirical model utilizes the Long-Term Hydrologic Impact Analysis (L-THIA) model to determine the volume of runoff that potentially accumulates on each property moving downstream. Using these volumes, we estimate a hedonic property value model to determine the impact of an additional cubic foot of runoff on property values. We translate this estimate to damages to derive the marginal damage of an additional cubic foot of runoff to the downstream community. We find an additional cubic foot of runoff results in $6.47 of damages downstream. These results can be compared with abatement cost estimates from other studies to suggest next policy steps in stormwater control for the area.

Event-based hydrology on a large extensive green roof in Syracuse, NY
Mallory Squier, Cliff Davidson
Syracuse University, Syracuse, NY

Green roofs are being rapidly adopted across the United States as a modern urban stormwater management tool, yet detailed quantification of hydrologic performance is not yet fully developed. The need exists for a better understanding of the physical mechanisms that govern hydrology on a green roof in order to enhance future green roof design. Multiple factors influence the hydrology of a green roof, including precipitation properties and initial conditions. Studies have shown that water retention capacity and total runoff reduction are both inversely proportional to precipitation intensity. This work presents an event-based analysis of green hydrology on a large extensive green roof in Syracuse NY.

Our study site, the Nicholas J. Pirro Convention Center roof, located in Syracuse NY, is a 60,000 sq. ft. extensive green roof completed as a retrofit to the existing building in Fall 2011. The roof profile from bottom to top includes: (1) existing metal deck, (2) ½" existing gypsum board, (3) 3" existing insulation, (4) ½" new Densdeck gypsum board, (5) water detection mesh screen, (6) roof membrane, (7) drainage mat, (8) 3" growth

medium, and (9) vegetation. The roof was equipped during installation with Campbell Scientific (CS) 109 sensors for measuring the temperature within multiple layers throughout the roof, as well as a Belfort weighing rain gauge, CS 616 soil moisture sensors, a CS SI-111 infrared radiometer, and standard meteorological station. Additional equipment includes 3 Badger M-2000 magnetic flowmeters to measure runoff, and our experimental weighing lysimeters for direct ET measurement.

Quantifying outdoor residential water use in the Ipswich River watershed: what influences residents' behavior

Emily E. Argo, Allison H. Roy, Robert L. Ryan
University of Massachusetts, Amherst, MA

Outdoor water use accounts for the largest proportion of residential water use. Previous studies have found correlations between greater lawn size and higher total water use; however, these studies do not look at other outdoor uses of water and additional factors that may influence water use. This research seeks to quantify the amount of residential water used for different outdoor purposes and understand factors influencing residents' water use behavior. The study will take place in the Ipswich River watershed (Massachusetts, USA). The Ipswich River has been impacted by extreme low flow events following decades of unsustainable potable water use and exportation of wastewater from the watershed. To quantify water use, water meters were placed on outdoor spigots at selected residences in the watershed from August to October 2014. Study participants were recruited through multiple methods (e.g., residential surveys, flyering) and residents (n=22) recorded the date, time, and amount of water used for outdoor water use events. Outdoor water uses included filling the pool, filling the bird bath, pet care, and cleaning (lawn mowers, cars, etc.). Lawn watering had the greatest average water use (297 gallons per watering event); however the range (27-1010 gallons per watering event) was high suggesting that lawn watering is difficult to predict. Additional participants will be recruited in 2015 (target ~50 households) and meters will be placed from May to October 2015. We will survey participants to learn more about residents' responses to water use restrictions and motivations to implement water conservation strategies on their property. Information about water use and residents' motivations will be used to identify outreach approaches to encourage outdoor water conservation.

"Soundwalking": A Methodology For Drawing Attention To Aspects Of NY Waterways And Its Stewardship

Andrea Williams
Rensselaer Polytechnic Institute, Troy, NY

Citizens and tourists in New York State enjoy the beauty of its fresh water resources, but when these bodies of water become less pristine through pollution, these areas become less desirable, and therefore it is important to consider ways to increase perceptions of ownership and stewardship to protect these precious natural resources. My research focuses on one methodology termed "soundwalking", a walk based on listening to different features of a specific environment. Soundwalks that will be used in this research

will be based on listening techniques, exercises, and methods of musical composition that were developed through the study of acoustic ecology. Acoustic ecology is the study of the relationship between living beings and their sonic environment. During a soundwalk, one starts to focus on listening instead of seeing and getting oneself from Point A to Point B, and we begin to sense more of what is directly around us. We even feel our other senses engage more intensely, such as touch and smell, and it becomes easier to embody another being or a certain area. When we embody a certain area of the environment, we begin to understand its needs more. We become better caretakers of our environment.

The soundwalks include audio material obtained through interviews with locals and water experts on topics relating to their connection to the waterways. Participants of the soundwalks also fill out a questionnaire on their connections to the waterways and this information is the basis of my findings. (Interviewees voluntarily sign a consent form to allow use of their audio recording and photo for public use that has been approved by the IRB.) Questionnaires include asking participants to describe their soundwalk experience. Also participants are asked if they feel more connected to the environment around them. If so, how?

Environmental Engineering I

Moderator: Noura Abualfaraj

Assessing the risk of sluicing on the biotic health of the Mill River

Marney Pratt, Mia Ndama, Molly Peek*
Smith College, Northampton, MA

The Mill River in Northampton, MA, is dammed at Smith College, which creates Paradise Pond. For a cost-efficient solution to periodic dredging of the campus landmark, Smith has proposed installing a sluice gate for flow events 200 cfs or greater to flush out fine-grained, possibly contaminated sediment. This study records the diversity and abundance of macroinvertebrates at seven sites along the river to assess stream health before and after sluicing, monitoring any effects that this new sediment management regime will have on the organisms in the river. To collect samples of macroinvertebrates, Hester-Dendy samplers and kick sampling techniques were performed. The macroinvertebrates were identified to genus and their abundances provided a biotic Water Quality Index (WQI) and a Shannon Diversity Index (SDI). Kick sampling yielded an average WQI of 72.64. Site 1 yielded the highest WQI with 86.5, and Site 6 had the greatest SDI with 2.69. Site 4 yielded low diversity with 2.11, and other sites had intermediate SDIs. Site 4 also had a significantly different (p-values <0.05) rank-abundance curve from a bootstrap two-sample Kolmogorov-Smirnov test and the lowest (14%) EPT score for the sum of indicator organisms. Initial Hester-Dendy results found different types of organisms and WQI scores than kick-sampling. The water quality of the different sites ranged from "Good" to “Excellent.” While it is currently unknown what determines the diversity and abundance of organisms found at each site, initial observations from sediment accumulation and WQI results suggest that the type of sediment is a key factor. WQI and macroinvertebrate types varied based on sediment and sampling technique. Thus, we expect that the new method of sluicing in Paradise Pond

may affect the diversity and abundance of macroinvertebrates living downstream. These effects may not be equal at all sites depending on how sediment accumulates along the river.

Evaluation of the environmental effect of Endocrine Disrupting Compound in Cape Cod

Benjamin Cohen; Yuxiang Shen*
Lafayette College, Easton, PA

A considerable amount of water bodies in Cape Cod are kettle ponds, formed by glacial movement 15,000 years ago, with exclusive influence of groundwater and precipitation. Instead of a regional wastewater treatment plant, septic systems are used to remove the contamination of domestic wastewater in Cape Cod. Due to the aging of these facilities and the geological feature of the area, that the unconfined aquifers are composed with shallow unconsolidated sand and gravel, Contaminants of Emerging Concern, including Pharmaceuticals and Personal Care Products (PPCPs) and Endocrine Disrupting Compounds (EDCs), which have been introduced by organophosphate fire retardants, many detergents as well as a host of other commercially manufactured household cleaning products, enters the nearby kettle ponds through ground water system. This study aims to quantify particularly the hormonal effects of these contaminants on the aquatic environment of the Cape Cod kettle ponds and the fish habitants. Two methods of bioassays, Yeast Estrogen System No Extraction (YESne), developed by Dr. Joseph Colosi and Dr. Arthur Kney, and MVLN reporter gene assay, are applied to establish the presence of hormonally activities in the aquatic habitats of interest. Further analysis of validation of chemicals in the water samples and study of malformation of fish reproductive organs are made to evaluate ecological impact.

Sustainable solutions for your waste: Addressing the Nitrogen cycle and Stormwater Runoff

Arthur Kney, Madhav Bista*, Campbell Weyland
Lafayette College, Easton, PA

Composting has been a main area of research for many agriculture schools in today's world. The field of agricultural science has been looking into the effects compost has with regards to nutrient uptake. Nitrogen plays a central role in the composting process and in many of the applications of compost, but despite the relevance of this topic it has not been thoroughly studied in municipal solid waste (MSW) composting. The loss of nitrogen in soil is a main concern for many pedologists during the anaerobic and aerobic processes of the maturation of compost. While this is important; many other environmental scientists see compost as a solution for preventing heavy trace metals in stormwater runoff getting into the groundwater table. These scientists are treating it as a 'bio-filter'. The purpose of our research is to combine these two ideas. The goal is to create a compost that reduces the loss of nitrogen to volatilization while also serving as a bio-filter and removing heavy trace metals that may come off the roads during storms. Through analytical methods, our research will test several different compost piles for

different characteristics that could help determine a potential solution for both of these problems.

Understanding Fecal Coliform Removal in Natural Aquatic Ecosystems
Tao Huang, Wilfred M. Wollheim, Robert J. Stewart
University of New Hampshire, Durham, NH

Aquatic ecosystems provide natural services of maintaining suitable water quality by (1) transforming nutrients and pathogens through biogeochemical processes, and (2) providing a dilution capacity. Fecal coliform (FC) is a major cause of water quality impairment in the United States. However, the integration of field-scale monitoring data and watershed-scale hydrologic models to estimate fecal coliform loads and removal in varied aquatic ecosystems is still limited. In this study we applied a biogeochemical river network model (the Framework for Aquatic Modeling in the Earth System or FrAMES) and utilized available field data in a small (51.7 km2) coastal New Hampshire (NH) watershed to quantify fecal coliform removal in natural aquatic ecosystems. The Oyster River Watershed is comprised of various land use types, and has had its water quality monitored for E. coli, dissolved oxygen, and turbidity since 2001. Water samples were also collected during storm events to understand the various response of fecal coliform concentration in watersheds. The FrAMES was updated to incorporate the dominant processes controlling fecal coliform concentrations in aquatic ecosystems: terrestrial loading, upstream input, in-stream processes, dilution, and downstream transport. We applied an empirical loading function to estimate the terrestrial loading of fecal coliform (source of loading function). Data was collected from various land use types across a range of hydrologic conditions. Primary input variables include total daily precipitation, antecedent 24-hour rainfall, air temperature, and catchment impervious surface percentage. The transport of fecal coliform is based on the Water Balance Model and Water Transport Model, which spatially simulate the vertical water balance and horizontal water transport through stream networks, respectively. The attenuation is due to bacterial “die-off” and dilution processes. Results show that fecal coliform input loads varied among different land use types. Downstream river segments have lower fecal coliform concentrations due to dilution and in-stream processing. The study provides the spatially and temporally distribution of the ecosystem service of fecal coliform removal, which can be used for water quality management.

Environmental Engineering II

Moderator: Jason Bradley

Efficiency and Fouling of Closed Circuit Reverse Osmosis and a Novel Variant
David M. Warsinger, Kishor G. Nayar, Emily W. Tow, and John H. Lienhard V
MIT, Cambridge, MA

Reverse osmosis (RO) is the dominant desalination technology for desalinating seawater and treating wastewater for reuse. A new configuration of RO, called closed-circuit reverse osmosis (CCRO) promises increased efficiency and significantly improved fouling resistance. CCRO, unlike RO, runs in a batch mode instead of steady state. This

allows the pressure to vary, matching the osmotic pressure better than RO, and thus reducing losses. Furthermore, the variable salinity nature of CCRO reduces the residence time for foulants under saturated conditions, but this has not been previously studied. A novel variant of CCRO presented here can improve on some of the energy losses of CCRO, with slight additional improvements on fouling resistance by reduced residence time. The present study compares residence time for fouling and how the efficiency varies by recovery ratio for traditional multistage RO, CCRO, and an improved CCRO variant.

Power Generation from Salinity Gradients by Pressure Retarded Osmosis: Is it Viable?

Anthony Straub, Shihong Lin, Menachem Elimelech
Yale University, New Haven, CT

Salinity gradient energy, which is released upon mixing two solutions of different concentrations, is a promising and vast source of sustainable power. However, the overall efficiency with which energy can be extracted is still uncertain. In this work, we experimentally and theoretically analyze the performance of pressure retarded osmosis (PRO), one of the most widely researched methods of harnessing energy from salinity gradients, to understand the net extractable energy and practical limitations of different solution pairings. We first model the performance of full-scale PRO modules mixing river water and seawater, a widely considered solution pairing due to the massive amount of global river discharge. Our results show that the net extractable energy in this system will be very small and may even become negative when considering the high energetic cost of pretreatment and pumping. Alternatively, higher concentration gradients offer much greater extractable energy, but are not commonly considered in literature. We explore these systems experimentally and observe promising power densities with high concentrations and pressures, but also find reduced selectivity and mass transfer under these conditions that may hinder performance in large-scale systems. We conclude that higher concentration gradients offer improved feasibility, but will likely require advances in membrane and module design to be practically implemented.

Omniphobic Membrane for Desalination of Highly Saline Wastewater by Membrane Distillation

Chanhee Boo, Jongho Lee, Menachem Elimelech
Yale University, New Haven, CT

Membrane distillation (MD) is one viable option for desalination of high-salinity wastewaters, such as brines from shale gas produced water and seawater reverse osmosis plants, which cannot be treated by conventional pressure-driven membrane processes. Conventional MD membranes are hydrophobic but oleophilic, which limits the application of MD to the treatment of relatively clean water (i.e., wastewaters free of contaminants with low surface tension). Omniphobic membranes, which can repel both water and oil, provide greater wetting resistance by low surface tension substances compared to hydrophobic membranes, thereby allowing their use in broader MD applications. In this study, we fabricate an omniphobic membrane for MD by modifying

a hydrophilic glass fiber membrane via simple liquid silanization. The omniphobicity of the fabricated MD membrane was evaluated by static contact angle and sliding angle using ethylene glycol and mineral oil to represent low surface tension contaminants. We also evaluated the MD performance of the fabricated omniphobic membrane with feed solutions containing surface active species (e.g., surfactant) as well as oil contaminants (e.g., ethylene glycol and mineral oil), using a laboratory-scale direct contact membrane distillation (DCMD) unit. Our results demonstrate that the omniphobic membranes exhibit excellent wetting resistance and can sustain robust DCMD operation with feed solutions containing low surface tension contaminants. We further provide a better understanding of MD membrane wetting by different low surface tension contaminants.

Effectiveness of Muslin Fabric Filtration for Drinking Water Treatment in Developing Countries

Robert Swick, James N. Jensen
University at Buffalo, Buffalo, NY

About one billion people in developing countries lack effective and inexpensive ways to filter their water supply. Some people filter water through the fabric of their clothing (called fabric filtration). Little work has been done to apply the scientific method to optimize fabric filtration. In this work, laboratory experiments were conducted to quantify the extent to which different types of fabric removed turbidity from different water sources. These experiments involved testing several types of muslin fabric and measuring the influent turbidity, effluent turbidity, water flow rate, and hydraulic conductivity of the fabric. Independent variables included the numbers of layers (1 to 8), fabric type (bleached and non-bleached), initial water turbidity, and fabric thread count. As expected, the most effective filtration was achieved with the highest number of layers of high-thread-count fabric. Unbleached fabrics typically showed better performance than bleached fabrics. The percent turbidity remaining after filtration decreased exponentially with the number of fabric layers, in accordance to filtration theory through granular media. Unexpectedly, it was observed that the turbidity removal increased with increasing influent volume. This could be due to “filter ripening”. A sequential filtration experiment was performed in which 8 layers were used with one test involving a low-thread-count fabric and another with a high-thread-count fabric. The high-thread-count fabric removed the turbidity more efficiently than the low-thread-count fabric. The sequential filtration experiment also showed how unbleached fabric was more effective in filtration than the bleached fabric. It was observed that sequential filtration had a higher turbidity removal than filtering the water just once through 8 layers of the fabric. The data obtained can be used to empower people in developing countries in providing safe drinking water for themselves.

Hydrology

Moderator: Mallory Sqyer

Experimental Study of Head Loss through Woody Debris Jams

Brandon Teetsel, Ian Knack, Daniel Nelson, Ronald Boxx Jr., Dylan Davis
Clarkson University, Potsdam, NY

The presence of woody debris has important effects on the riparian systems within and surrounding natural channels. Large amounts of woody debris can cause jams, which can lead to flooding and damage in and near these rivers and streams. Woody debris jams can also have drastic effects on channel morphology. These effects include bank erosion, sediment scour and deposition, channel migration, and flow conditions in the channel. In addition to affecting the hydraulics and morphology of the stream channel, the presence of woody debris can greatly influence aquatic ecology by affecting fish habitats and nutrient levels. Although the influence of woody debris on channel morphology and aquatic ecology has been well recognized, the understanding of the hydromechanics behind woody debris jams is very limited. One major impact of woody debris jams is the drastic change in water depth along the length and upstream and downstream of the jam, due to the jam's high flow resistance and blockage effects. The flow resistance is composed of three different components: the channel bed roughness, the seepage head loss through the jam, and the jam surface roughness. Performing flume experiments using poplar dowels of various sizes allowed for the creation of jams of different sizes and porosities. Vertical velocity profiles were measured in different locations along the length of the jam and used to calculate the amount of head loss from each component. In this presentation, different ways to calculate the overall head loss from the jam will be discussed, along with observations about the reliability of the various methods, and what this head loss can be used for moving forward in the study of woody debris jams.

Erosion Rate Coefficient of Cohesive Sediments

K. Chamil R. Perera
Clarkson University, Potsdam, NY

Natural water bodies, such as rivers, lakes, reservoirs and estuaries, extensively contain fine grained sediments such as clay and silt. These sediments demonstrate cohesive properties in their behavior due to the impact of physical, geochemical and biological processes upon their sediment dynamics which makes the process of erosion complex to understand. Even though several empirical formulas were introduced to predict erosion rate of cohesive sediment in literature, there still exists a substantial research gap in identifying erosion mechanics of cohesive sediments.

In this study, two formulas were considered to investigate the relationship between important cohesive sediment erosional properties. The empirical formulas of interest are the linear functions of dimensional and dimensionless excess shear stress. Thirteen experimental data sets from literature were used to identify the relationship between the erodibility coefficient and critical shear stress in both formulas. Then, factors affecting the erodibility coefficient were studied and an existing empirical formula in literature was

validated to predict the erodibility coefficient when the clay percentage and dry specific weight of soil are given.

Assessing the accuracy of different techniques for predicting the runoff hydrograph and flood flows in forested Northeastern catchments

Gordon E. Clark, Richard N. Palmer
University of Massachusetts, Amherst, MA

While different methods exist for estimating runoff hydrographs in ungauged basins, the degree to which these methods can be accurately employed to determine the average recurrence interval of flood flows in the Northeast US is relatively unknown. Furthermore, process-based methods for predicting runoff hydrographs are increasingly common and serve as important tools in determining the changing climates influence on streamflow conditions. However, the need for accurate scaling of model output to ungaged catchments locations remains one of the most challenging aspects of this process and proper techniques towards this end have not been fully assessed for this region, specifically as it pertains to estimating flood flows.

This study will aim to quantify the degree of certainty to which runoff hydrographs and flood flows can be estimated for ungauged basins in the Northeast. The Upper Delaware and East Branch of the Delaware River (HUC8 codes 02040101 and 02040102 respectively) will serve as the study basins for this experiment. These basins were chosen based on the relative abundance of “reference” streamflow gauges based on spatial information from the USGS GAGES-II dataset and only streamflow gages classified as “reference” gages are used throughout the study. “Base stations” will serve as the known gauged reference for streamflow data and “project stations” will represent pseudo-ungauged catchments for which the runoff hydrograph will be estimated. Climate and catchment data will be assessed for each of the gauge locations in the study. Two techniques for scaling runoff hydrograph data will be assessed: (1) a statistical index method, coined the “drainage area ratio,” will be utilized to scale the base station to the respective project stations and; (2) the output from an HSPF model calibrated to the base locations will be scaled to estimate the runoff at project locations. The accuracy of these two methods will be verified based on NSE and R2 values based on the historic streamflow record at the project locations. In addition, the average recurrence interval of flood flows will be estimated using both of these methods and will be compared to the historical record to determine how accurately flood flows of certain recurrence intervals can be modeled when the streamflow data for a particular site is assumed to be unknown. This study will attempt to elucidate influential catchment characteristics with respect to accurate estimation of flood flows.

The characteristic hydrometeorology and land surface conditions leading flooding over different basin sizes

Xiuyuan Li, Tara J. Troy
Lehigh University, Bethlehem, PA

Flooding is a costly natural hazard globally. To improve the quality of flood predictions, it is necessary to understand the flood mechanisms across a range of drainage basin size, accounting for precipitation patterns, antecedent soil moisture, and snow. In this study, 276 sub-basins are chosen from the Ohio River basin with 60 years of precipitation, soil moisture, snow, and streamflow data, using a combination of observations and land surface model results. We find that large basins sizes usually have more positive correlation with longer precipitation duration than shorter precipitation duration, and vice versa. Soil moisture plays a significant role in determining flooding, but snowmelt also influences the flood generation. Finally, we identify if characteristic precipitation and antecedent moisture conditions lead to floods over different basins sizes. Much of the prior work has focused on small catchments, flood frequency analysis or understanding single events. This work fills the knowledge gap about the physical mechanisms leading to flooding across a range of basin scales. Furthermore, when it comes to flood projections under climate change, these results will better inform our understanding of how flooding might change.

Effect of urbanization on low flows

Javad Shafiei Shiva, David G. Chandler
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During the past years, the extent global urbanization has grown rapidly. The global urban population has increased from 14 % to 50 % of humanity from 1900 to 2010, and it is predicted that in 2050 more than 70 % of people will live in cities. The associated urban growth is attended by industrialization, climate change, global warming and growth in water usage per capita, all of which put pressure on the hydrology of cities and neighboring watersheds. Although the increase in peak flows and floods is well documented for cities, the effect of urbanization on low flows is not well understood. Low flows are important for both humans and the environment. Although it is commonly assumed that urbanization will result in depressed ground water level and associated decreased baseflow, due to an increase in impervious area, studies have found little evidence of a direct relation between urbanization and low flows. There are a couple of triggers that complicate the relationship between urban baseflow and infrastructure. For example, the integrity of water distribution network and water conveyance pipelines can contribute water directly to the subsurface, while sewer systems can decrease water tables through drainage. This presentation is an exploration of the important role that leaking pipes can play in urban hydrology with an emphasis on effect on the low flows.

Documenting the Removal of Millie Turner Dam on Stream Morphology
Denise Burchsted, Andy Marion*
Keene State University, Keene, NH

This study is being conducted on the Millie Turner Dam located on the Nissitissit River in Pepperell, MA. This dam, which was built around the year 1750, is now classified as "High" hazard potential and in "Unsafe" condition. Because of this, the Massachusetts Division of Fisheries and Wildlife plans to breach the dam in the fall of 2015 to restore pre-dam ecological function, provide passage to fish, and reduce local upstream flooding risk. Unlike other dam removal projects in New England, where impounded sediment is considered environmentally dangerous and is secured before a dam removal, this project will allow the approximately 7,000 cubic yards of mobile, impounded sediment to move on its own; this provides a unique opportunity to observe sediment movement and the resulting impacts on river habitat.

To do this, we collected baseline data of the shape and streambed sediment size of the existing stream channel. These data show clear differences with distance from the dam. The coarsest sediment and most uniform channel structure is closest to the dam and the finest sediment, widest variation in sediment size, and most complex channel form is farthest downstream. This demonstrates the impact of a barrier to sediment transport, which causes the ecosystem immediately downstream to be starved of sediment. The lack of gravels and coarse sands degrades instream habitat for fish, mussels, and macroinvertebrates, and restricts the river processes that create the complex channel forms necessary to support a diversity of species and life stages. This documentation before the removal of Turner Dam allows assessment of the impacts of the dam on habitat, furthering our understanding of the role and appropriate management of sediment transport in river ecosystems.

Water Resources

Moderator: Nicole Gillett

Determining the Skill and Value of Incorporating Streamflow Forecasts into an Early Drought Detection System
Kathryn Booras, Richard Palmer
University of Massachusetts, Amherst, MA

This research investigates forecast skill in predicting the onset and severity of drought in the Susquehanna River Basin, which encompasses over 40% of the total area of the Chesapeake Bay Watershed. Streamflow forecasts are incorporated with other key drought indices in a composite drought index to predict and classify drought severity. Climate drought index parameters for the Susquehanna River Basin, such as the Standardized Precipitation Index (SPI), Days of Storage Remaining Index (DSR), and Palmer Drought Severity Index (PDSI), are evaluated by their ability to detect water supply droughts of record. By testing portfolios of indices in selected systems models created using the STELLA® software, key climate indicators are tailored by location for hydrologic drought detection. Drought severity is defined for each system using the DSR

index to reflect the impact of drought on the systems. The skill of drought indices constructed by combining system and climate status parameters with streamflow and precipitation predictions is demonstrated through a case study on the Baltimore Water Supply. Early warning skill improves using the composite indices, providing two advantages to the systems under study: 1) water quality will improve from the maintenance of higher reservoir elevations in the main Baltimore water supply system and 2) water demands from Conowingo Pond, the location of the Baltimore connection to the Susquehanna River, will decrease during low-flow conditions by Baltimore timing supplementary flows earlier in anticipation of drought conditions. A web-based decision support tool is under development that will provide operators of the Baltimore Water Supply and the greater Susquehanna River Basin enhanced understanding of operational alternatives and impacts. Like the US Drought Monitor, this interface brings scientific understanding to a broader audience, but unlike the US Drought Monitor, the interface is specialized specifically for the use by the Baltimore Water Supply, and other interested parties.

Changes in climate extremes in the major growing regions of US mainland
Xiao Zhu, Tara J. Troy
Lehigh University, Bethlehem, PA

The security of stable food supply is becoming increasingly important these years since the global population has been growing very fast and the changing climate is challenging our food producing system. It is therefore important to understand how extremes have changed in global major growing regions, which is a good way of looking at the vulnerability of the global food supply to climate extremes. In this analysis, we also take account the effect of gridding on estimates of extremes as well as the concurrence of different indices. To start with, we use the GHCN historical climate data (daily precipitation, maximum &minimum temperature, 1984-2013) over the US mainland to analyze the changes of some commonly used extreme indices (R5d, SDII, R10, hot days, heat waves, etc.) and the concurrence between them. We find that the differences between gridded indices and the raw station indices are quite small (mostly less than 10%), which convinced us to use the gridded indices as reasonable estimates for further study temporarily. Finally, after analyzing the change of indices and concurrence, we found that during 1984-2013, most precipitation indices vary a lot, indicating the instability of rainfall distribution, except that SDII turned out to be relatively identical among all the growing seasons. And the temperature related indices were much more stable. Furthermore, the correlation of two precipitation or temperature related indices are quite strong and reasonable, and precipitation indices seems to be most related to monthly maximum temperature, which still requires much more further study. These results could bring lots of important implications and inspiration for the analysis of climate changing mechanism in the major growing regions of US mainland, which could benefit the agricultural system planning as well as the management of water resources to face the challenge of climate change.

Options For Enhancing The Water Resources Of The Fond D'or Watershed, Saint Lucia

Frank Dale Morgan, Nasruddin A. Nazerali*, Yulia Agramakova, Burke Minsley, Rachel Zucker, Diego Concha, Cornelius Isaac, Bongani Mashele, Frederick Pearce, Alejandra Quintanilla-Terminel, Andrey Shabelansky, Mirna Slim, Ananias Verneuil, Burt Xavier
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The Fond D'Or valley of St. Lucia faces severe water scarcity due to low quantity and quality of the supply drawn from the two major rivers. This work addresses the enhancement of the supply from rivers and an investigation into potential groundwater supply. Hydrological modeling was used to predict the river flow rates and calibrated with data from intakes. Optimal locations along the rivers were identified for additional intakes. Water was sampled for quality at many locations and one particular location was recommended for further study and development. A new intake is under construction at this site as of early 2015. Direct current resistivity and induced polarization measurements revealed that the shallow subsurface layers are dominated by clay at most sites where geophysical surveys were conducted. One site shows a good combination of relatively high resistivity and low chargeability at 10 to 25 m below the surface and we recommend exploratory drilling to substantiate the geophysical investigation. Other sites exhibit the correct range of resistivity values that could be accounted for by clean groundwater reservoirs in the fractured bedrock at 40 m below the surface and deeper. Further investigation is recommended at these sites.

Comparative Effects of Climate Change and Operational Changes for the New York City Water Supply System

Leslie DeCristofaro, Richard N Palmer
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The reliability of a water supply system depends on the interactions of infrastructure, operations, and the weather and climate. As the climate changes and influences short and medium term weather, infrastructure and operations will necessarily have to adapt in order to maintain reliability. This paper utilizes climate, hydrologic, and systems modeling to demonstrate the effectiveness of operational and infrastructure adaptations on maintaining water quantity and quality for the New York City Water Supply system. The magnitude of an option's effectiveness and the range of climate projections are shown simultaneously. For reducing drought, improved forecasting is best at ensuring annual refill, while reduced demand (through reduced leaks throughout the system) is most effective at preventing drought watch, warning, and emergency now and in projected climates. For managing high turbidity, effective operation is most useful in the present climate, while infrastructure adaptations become more effective in future climates. Operations (through use of existing infrastructure) and infrastructure (improvements to the Catskill Aqueduct to more easily allow transitions between flow rates) are complimentary in reducing emergency alum use. NYCDEP is already implementing many of these adaptations. A quantified look at the effectiveness of climate adaptations into the future will hopefully encourage other water managers to act despite uncertainty.

Water Quality I

Moderator: Rassil Sayess

Diminished Wastewater Treatment: Evaluation of Septic System Performance Under a Climate Change Scenario

Jennifer Cooper, George Loomis, Dave Kalen, Tom Boving, Ivan Morales, Jose A. Amador
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The effects of climate change are expected to reduce the ability of soil-based onsite wastewater treatment systems (OWTS), to treat domestic wastewater. In the northeastern U.S., the projected increase in atmospheric temperature, elevation of water tables from rising sea levels, and heightened precipitation will reduce the volume of unsaturated soil and oxygen available for treatment. Incomplete removal of contaminants may lead to transport of pathogens, nutrients, and biochemical oxygen demand (BOD) to groundwater, increasing the risk to public health and likelihood of eutrophying aquatic ecosystems. Advanced OWTS, which include pre-treatment steps and provide unsaturated drainfields of greater volume relative to conventional OWTS, are expected to be more resilient to climate change. We used intact soil mesocosms to quantify water quality functions for two advanced shallow narrow drainfield types and a conventional drainfield under a current climate scenario and a moderate climate change scenario of 30 cm rise in water table and 5°C increase in soil temperature. While no fecal coliform bacteria (FCB) was released under the current climate scenario, up to 109 CFU FCB/mL (conventional) and up to 20 CFU FCB/mL (shallow narrow) were released under the climate change scenario. Total P removal rates dropped from 100% to 54% (conventional) and 71% (shallow narrow) under the climate change scenario. Total N removal averaged 17% under both climate scenarios in the conventional, but dropped from 5.4% to 0% in the shallow narrow under the climate change scenario, with additional leaching of N in excess of inputs indicating release of previously held N. No significant difference was observed between scenarios for BOD removal. The initial data indicate that while advanced OWTS retain more function under the climate change scenario, all drainfield types experience some diminished treatment capacity.

Statistical Analysis of Compliance Violations for Natural Gas Wells in Pennsylvania

Noura Abualfaraj, Mira S. Olson, Patrick L. Gurian, Anneclaire De Roos, Carol Ann Gross-Davis
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Regulatory inspection and violation reports may provide some insight into the impact of natural gas extraction on the surrounding environment, human health, and public safety. Inspection reports for natural gas wells in Pennsylvania were collected from the Pennsylvania DEP Compliance Report from 2000 to 2014. Analysis of 215,444 inspections records for 70,043 conventional and unconventional wells was conducted in order to compare the odds of violations occurring under different circumstances. Logistic regression models were used to estimate the probability of violations occurring for both

conventional and unconventional wells. Generally, violations at conventional wells have 52.4% [$p < 0.005$] higher odds of occurring. Unconventional wells have 73% [$p < 0.005$] higher odds for environmental violations related to water contamination. Large operators (more than 100 active wells) had 43.1% [$p < 0.005$] lower odds of having any violation than smaller operators. While larger operators seem to have potentially safer practices, a few of the largest companies had rates of violation much higher than the average for all operators with some reaching violation rates as high as 1 in 4 active wells. Violations also have 7% [$p < 0.005$] lower odds of occurring each additional year that a well is in operation.

Understanding reservoir contaminant impacts through proactive modeling efforts
Lillian Jeznach, John Tobiason, David Ahlfeld
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This study presents a framework for using hydrodynamic and water quality models to understand the fate and transport of potential contaminants in a reservoir and to develop appropriate emergency response and remedial actions. In the event of an emergency situation, prior detailed modeling efforts and scenario evaluations allow for an understanding of contaminant plume behavior that may influence treatment process decisions, including maximum concentrations that could occur at the drinking water intake and contaminant travel time to the intake. A case study assessment of the Wachusett Reservoir, a major drinking water supply for metropolitan Boston, MA USA, provides an example of an application of the framework and how hydrodynamic and water quality models can be used to quantitatively and scientifically guide management in response to a variety of contaminant scenarios. In this example, the model CE-QUAL-W2 was developed and calibrated based on data from the calendar years 2003 through 2012 and verified by temperature and specific conductivity profiles. The model was used to investigate the water quality impacts of several hypothetical contaminant scenarios, including fecal coliform input from a sewage overflow as well as accidental road and railway spills of ammonium nitrate and fuel oil. Scenarios investigated the impacts of decay rates, season, and inter-reservoir transfers on contaminant arrival times and concentrations at the drinking water intake. The modeling study highlights the importance of a rapid operational response by managers to contain a contaminant spill in order to minimize the mass of contaminant that enters the water column, based on modeled reservoir hydrodynamics. The development and use of hydrodynamic and water quality models for surface drinking water sources subject to the potential for contaminant entry can provide valuable guidance for making decisions about emergency response and remediation actions.

Poly- and Perfluoroalkyl Substances: Transport Phenomena and Implications for Water Resources

Andrea K. Weber, Larry B. Barber, Denis R. LeBlanc, Emma S. J. Schwartz, Chad Vecitis
Harvard, Cambridge, MA

Poly- and perfluoroalkyl substances (PFASs) continue to gain worldwide attention as it has become apparent that these widely used persistent organic pollutants are ubiquitous in the hydrosphere, biosphere, and atmosphere with significant concentrations found in animals from remote locations such as polar bears. Although these emerging contaminants have been in use since the 1950s in applications including non-stick coatings on pans, aqueous film-forming foam (AFFF), and lithography, their transport properties remain essentially unknown. PFASs are not regularly monitored in most drinking water sources due to both difficulty in measurement and a lack of understanding which towns are at risk, despite the fact that research on PFASs health effects has indicated that they are immunotoxins and likely carcinogenic.

To elucidate how PFASs are transported in the environment, we are studying a field site at the military base Joint Base Cape Cod (JBCC) where the use of AFFF for fire training activities from 1958 to 1985 created a point source of contamination. A high-resolution field sampling effort has been undertaken to collect more than 300 groundwater samples and 6 sediment cores at the fire training area and hydraulically downgradient from the fire training area. Sediment cores enable the calculation of in situ sediment-water distribution coefficients (Kd) to determine PFAS retardation factors. PFAS concentrations in groundwater are paired with additional water chemistry measurements, including specific conductance, pH, temperature, and concentrations of dissolved oxygen, dissolved organic carbon, major cations and anions, trace elements, and VOCs, to understand how groundwater geochemistry can impact transport. This study presents the findings from field sampling data and laboratory sorption studies, which provide a detailed understanding of PFAS transport. A comprehensive overview of transport phenomena on both small and large scales is needed to determine which groundwater sources of drinking water may be at risk.

Extreme hydrology impacts on rating-curve predictions of water quality

Mark Hagemann
University of Massachusetts, Amherst, MA

This study assessed the applicability of rating-curve regression models to the task of predicting riverine solute concentrations during extreme high-flow hydrologic events, when such events are absent from the models' calibration data. Following the differential split-sample test [Klemeš, 1986], and a large validation dataset (n = 19659 data) from sites across the US Northeast, we developed a validation framework that effectively compares model performance across disparate hydrologic regimes and constituents, yet can be used to estimate individual model performance. The results reveal a widespread, systematic, and directional deterioration of rating-curve predictive performance under increasingly extreme high-flow conditions. The effect pervaded all fractions (dissolved,

suspended, total), and nearly all constituent types (nutrients, organic matter, suspended solids). This could reflect a failure of models to recognize an increasing importance of dilution at higher flows. However, the large variance in prediction accuracy at such flows reflects an overall deterioration of model performance, including instances of underprediction despite an overall tendency to overpredict. The extent of deterioration in extreme-case goodness-of-fit is not always prohibitive, and can be improved by unbiasing the predictions. These findings will be further built upon as data access, documentation, and consistency of collection are improved. Although this analysis was conducted on the aggregated results from many models and locations, it can be used to back out model-specific goodness-of-fit statistics, giving a site- and constituent-specific estimate of model performance in predicting extreme-event concentrations.

Water Quality II

Moderator: Sylvia Yu

Impact of water residence time on the variability of DBPs in drinking water at the residential neighborhood scale

Simon Rochette, Guillaume Santerre, Marie-Ève Roy, Sabrina Simard, Manuel Rodriguez, Geneviève Pelletier
Université Laval, Québec, QC

While trihalomethanes (THM) and haloacetic acids (HAA) are the most regulated disinfection by-products (DBPs) in drinking water, research is still needed regarding their spatial and temporal variability in water distribution networks (WDN). Some studies have identified links between the concentration of DBPs observed in WDN and water residence time (WRT) but studies focusing on a smaller scale with high frequency sampling haven't been conducted. The scale of a residential neighborhood was chosen and a 2 km2 residential area inhabited by nearly 6000 citizens in the Quebec City WDN was identified. For the analysis of the spatial and temporal variability of THMs and HAAs, weekly sampling campaigns were conducted over five months for twenty specific points sampled three times over the course of each campaign day. Hydraulic modeling using population data as well as flow measurements allowed for the simulation of WRT for each sampling campaign and each point sampled. Results show that for THM and HAA concentrations, the temporal component of variability is significantly superior to the spatial component. For a small scale, high frequency sampling instead of the sampling of more points will lead to a more representative portrait of THM and HAA concentrations in order to assess population exposure. Finally, this study also revealed that WRT on the scale of a residential neighborhood has potential as an indicator of THM and HAA concentrations, given that a significant difference was found between DBP concentrations linked to the lower and higher values of simulated WRT.

Formation of disinfection by-products in point of use chlorine based treatments
Félix Légaré-Julien, Christian Bouchard, Caetano C. Dorea.
Université Laval, Québec, QC

Diarrhoeal diseases kill 2 million people each year mainly in developing countries, most of them being children under 5 years old. Since many of these cases are caused by consumption of microbiological unsafe water, the WHO and the CDC promote household water treatment and safe storage practices as means to lessen the burden of diarrhoeal diseases on these populations. Among the household treatment technologies, chlorination and coagulation/disinfection combined systems have the advantage to add free residual chlorine (FRC) to treated water, which provides protection against post-collect contamination. However, reducing acute risks of diarrhoeal disease with chlorine disinfection also comes with increased chronic risks of cancer and potential sub-chronic risks of reproductive problems due to exposure from disinfection by-products (DBP). Trihalomethanes (THM) and haloacetic acids (HAA), the most common regulated DBP, are addressed by WHO guidelines. However, the WHO underlines the importance of never compromising proper disinfection in an attempt to reduce DBP. This laboratory study investigated the HAA and THM formation of 4 chlorine based products (with different formulations and formats) intended for household point-of-use water treatment. Each of these products was tested in 3 different water sources of varying organic contents. As expected, HAA and THM concentrations obtained differed between products and between water sources. THM concentrations exceeded the WHO's guideline in 13% of the tests, compared to 40% for AHA. THM and HAA elevated concentrations obtained in this study raise questions regarding the potential chronic and sub-chronic risks for the populations who might be exposed to it.

Chlorinated DBP Formation Potential Using Varying Oxidants
Julie Bliss, Xian Ma, Jun Gao, David Reckhow, John Tobiason
University of Massachusetts, Amherst, MA

The goal of this research was to compare the ability for ozone, chlorine dioxide, and ferrate to oxidize halogenated disinfection byproduct (DBP) precursors. Halogenated DBPs are formed from the reaction of halide ions (i.e. chloride and bromide) and organic matter. Ozone, chlorine dioxide, and ferrate have proven to effectively oxidize organic matter suggesting potential for the reduction of DBP formation in a distribution system after chlorine disinfection. High and low concentrations of bromide were added to source raw water before oxidation to mimic varying source water bromide concentrations. Each raw water sample was filtered, buffered to around pH 7, dosed with respective oxidants, then chlorinated with sodium hypochlorite and stored at 20˚C for up to seven days. pH and chlorine residual using the DPD indicator titration method were monitored throughout the experiment. Chlorine was quenched and trihalomethanes (THMs) and haloacetic acids (HAAs) were measured using the pentane LLE/GC/ECD method and LLE methylation with acidic methanol GC/ECD method, respectively. Results suggest increased formation potentials of DBPs in waters with high concentrations of bromide. In the majority cases, ozone and chlorine dioxide were most successful in reducing DBP formation potentials.

Water Quality III

Moderator: Michael German

A Carbon Nanotube based resettable sensor for measuring Free Chlorine in drinking water

Leo (H.H.) Hsu, Enamul Houqe, Peter Kruse, P. Ravi Selvaganapathy
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Free chlorine from dissolved chlorine gas is widely used as a disinfectant for drinking water. The residual chlorine concentration has to be continuously monitored and accurately controlled in a certain range around 0.5 - 4 mg/L to ensure drinking water safety. However, the monitoring devices are still lacked. In this research, we developed a novel free chlorine sensor that uses oxidation of phenyl-capped aniline tetramer (PCAT) to dope single wall carbon nanotube (SWCNT) and changes its resistance. The oxidation of PCAT by chlorine switches the PCAT-SWCNT system to low resistance (p-doped) state which can be detected by probing it with a small voltage. The change in resistance is found to be proportional to the concentration of the chlorine in the sample. The p-doped PCAT-SWCNT then can be electrochemically un-doped by polarizing it cathodically. This new sensor not only shows good sensing response in the whole concentration range of free chlorine in drinking water but is also able to be electrochemically reset back multiple uses. This simple sensor is ideally suited for measuring free chlorine in drinking water continuously.

Aptamer Based E-coli Detection in Waste Waters by SWCNTs Modified Biosensor System

Nimet Yildirim, Jinyoung Lee, , Hanchul Cho, HeaYeon Lee, Ahmed Busnaina, April Z. Gu
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Waste waters are monitored worldwide to protect people from infectious diseases primarily caused by enteric pathogens. All long, E-coli is a good indicator for potential enteric pathogens in waters. Thus a rapid and simple detection method for E-coli is very important to predict the pathogen contamination. Here, we are presenting a simple and highly sensitive aptamer-based single walled carbon nanotubes (SWNTs) biosensor containing probe-DNA (complementary of E-coli aptamer) immobilized on functionalized SWNTs. In this SWCNTs based E-coli biosensor a specific E-coli aptamer, which can specifically distinguish the E-coliO157:H7 strain from other pathogens was used. Employing simple directed assembly and non-covalent functionalization process these fabricated probe DNA-based SWNTs biosensors were designed with two electrode terminals to allow continuous resistance response monitoring for the E-coli detection. The detection procedure is based on competitive mode detection. A known concentration of aptamer and E-coli were mixed and after a certain time filtered. The rest of free aptamers injected to the system. With hybridization of the free aptamers and their SWCNTs surface immobilized complementary DNA (probe-DNA), we can monitor the resistance difference which is proportional to the amount of the E-

coli. Thus, we can detect the E-coli without injecting it directly onto the sensing surface and we could protect the electrode surface from the aggregation of target bacteria or other pollutants that may come from real waste water samples. After optimization experiments, the linear detection range was determined from 1 to 105cfu/ml with higher than 0.98 R2 value. The system was regenerated successfully with 5%SDS solution over 100 times without any significant deterioration of the sensor performance. The developed system had high specificity towards E-coli (less than 20 % signal with other pathogens) and it could be applied to real waste water samples with 86 to 101 % recovery and 3 to 18 % cv values (n=3).

Impact Of Municipal Water Characteristics On Corrosion Of Steel And Copper Piping

Harsha Prasad, Jeanine Plummer, Robert Ferarri
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Corrosion of critical water and utility infrastructure in high rise urban buildings results in adverse impacts on the effective life of this infrastructure and potentially massive costs for maintenance, corrective repairs and replacement. The forms of corrosion occurring in these piping systems is variable, and somewhat different for copper and steel pipe. While there are many interrelated factors impacting the rate and type of corrosion, in many cases the most significant factor is the chemistry of the municipal water supply. This study evaluated the principal causal factors of corrosion in domestic, HVAC and cooling tower piping systems in Cambridge, MA via a case study analysis. The municipal water supply in Cambridge is unusual in that it contains significantly elevated chloride (75-150 mg/l) and sodium (80-90 mg/l), in conjunction with moderate hardness, alkalinity and sulfate. Significantly accelerated corrosion, including pipeline failures, has been found to occur in newly constructed piping systems (installed 2-3 years), as well as in comparatively “young” (<15 years installed) domestic water and wet utility piping systems. In comparison to typical corrosion rates of 1 – 2 mpy, rates as high as 25 mpy were observed in Cambridge. The effective life of piping systems has been found to be reduced from='50' years to less than 3 years in certain cases. Accelerated loss of pipe wall thickness was found in many cases, often in conjunction with massively accelerated pitting corrosion and other forms of corrosion, including microbially induced corrosion and chloride induced corrosion. Additionally, water treatment programs that have proven effective in other municipalities were shown to be largely ineffective to prevent the aggressive corrosion that is occurring. In each case study, the water chemistry was fully characterized including pH, ORP, chloride, total dissolved solids, iron, copper, and other parameters of significance. Selected pipe sections underwent an elemental analysis of corrosion products determined via scanning electron microscopy with energy dispersive spectroscopy. Contributing factors including hydraulics, construction methods and pipeline preparation, and materials of construction were also analyzed. Data from each of these analyses were evaluated and correlated to the type and geometry of corrosion defects in order to develop case specific corrective measures. Details on the water chemistry and causative factors for accelerated corrosion in Cambridge will be presented.

Contamination and management of hypochlorite solutions in small water systems
Louis Coulombe, Gabrielle Santerre, Mélanie Roy, Sabrina Simard, Christelle Legay, Anouka Bolduc, Jean Sérodes, Nathalie Dassylva, Manuel Rodriguez
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Sodium hypochlorite is widely used for disinfection of drinking water in small systems. However, this product can decompose and generate contaminants such as perchlorate, chlorate, chlorite and bromate. These contaminants may form during manufacturing, transport and storage of hypochlorite solutions and are thus likely to be found in drinking water. Small systems are known to have limited resources, thus they are subject to difficulties to apply the best practices for the routine management of hypochlorite solutions.

Although hypochlorite solutions (HS) decompose naturally over time, some factors may accelerate this process. The quality of the purchased HS, the conditions of their storage and the way they are routinely used may affect their decomposition and the formation of contaminants.

The objectives of this research were to document the management of HS in small systems of the Province of Quebec (Canada) and evaluate the presence of associated contaminants in the HS and in the drinking water.

To evaluate the presence of contaminants in HS, seasonal campaigns were conducted to sample the purchased HS and the drinking water in nine municipal small systems supplied by groundwater sources. To document the routine management of HS, field questionnaire surveys and interviews were conducted with small systems operators. This project allowed to obtain a portrait about the current practices in management of HS in small system and document the occurrence of these contaminants. It was also possible to identify the main difficulties and challenges faced by the operators and find out strategies that can help and support them in their routine tasks.

Microbiology

Moderator: Lark Washington

Establishing the Relationship between Water Temperature and Depuration Rate of Eastern Oyster in Maine
Ziwen Ye
The University of Maine, Orono, ME

The Gulf of Maine is one of the most productive aquaculture regions in the United States, with the oyster ranking as the most valuable aquaculture product by weight. However, sewage-derived pathogenic bacteria, which can accumulate in the digestive tracts of oysters, is a public health risk and can cause significant economic impacts to the industry. The primary method to mitigate pathogenic bacterial contamination of oysters is depuration, whereby shellfish are allowed to self-purge and release bacteria into clean running seawater. However, little information is available regarding pathogenic bacteria

depuration rates under cold water conditions, such as those in Maine coastal waters. This project investigates how different water temperatures and pathogenic bacteria (Vibrio anguillarum) concentrations affect the depuration rates of the eastern oyster (Crassostrea virginica). The experimental findings will be used to develop a model for estimating the depuration times needed to render the oysters safe to eat under different temperatures and initial bacteria concentrations. The results will help reduce the off-market time due to bacterial contamination and in turn, increase customers' confidence regarding oyster consumption in Maine. Furthermore, in collaboration with the Department of Marine Resource, this work can be combined with existing water monitoring programs to improve marine resource and sewage source management.

Polyhydroxyalkanoate Recovery From Waste and Property Testing
Huijie Lu, Patrick Lee, Austin Grant*
University of Vermont, Burlington, VT

Polyhydroxyalkanoates (PHA) is a family of short-chain length polysters that are produced by microorganisms for intracellular energy storage. They are the precursors for biodegradable plastic, and are seen as a strong alternative to petro-chemical based plastics do to their properties and renewable production from otherwise unutilized resources. In this study, the production potential of PHA is being explored using volatile fatty acid (VFA) profiles of three wastestreams from the greater Burlington, VT area: manure, wastewater sludge and compost. A 3L sequencing batch reactor was inoculated with the typical PHA-accumulating aerobe, Pseudomonas Putida, and was operated at 37 degree C with a solids retention time of 3 days and a feast-famine cycle of 12 hours. Synthetic mixtures of VFAs were created based on fermentation results of the three waste streams and fed to the SBR during the feast phase within each cycle. Cellular PHA content, PHA monomer structure, and its rheological properties were investigated for the three synthetic VFA mixtures. By further comparing the properties to other commercial PHA polymers, the potential applications in manufacturing and biomedical industries can be determined.

Classification and Phylogenetic Identification of Heterotrophic Specialists in Activated Sludge
Bing Guo, Dominic Frigon
McGill University, Montreal, QC

Microbial communities in biological wastewater treatment systems have complex composition and functions. In this study, RNA level and the presence of polyhydroxyalkanoate (PHA) were used as classification biomarkers for heterotrophic groups specialized in consuming either readily degradable substrate (RDS) or slowly degradable substrate (SDS). A positive correlation was observed between the RNA and PHA levels, implying that high RNA level and PHA accumulation are two features of the RDS specialist group. The heterotrophic specialists were separated from activated sludge mixed cultures using flow cytometry cell sorting. Four groups of cells were collected: high-RNA-high-PHA (potential RDS specialist), low-RNA-high-PHA, high-RNA-low-PHA, and-low-RNA-low-PHA (potential SDS specialist). Phylogenetic identification of

all samples was determined using 16S rRNA gene pyrosequencing. At the phylum level, the composition was similar among different groups. Proteobacteria and Chloroflexi were the highest abundant phyla in all samples except for the low-RNA-low-PHA-group, where they followed TM7. At the genus level, all samples were filtered with taxon reads greater than 13 (1% of the total reads in the lowest group). 45 abundant heterotrophic genera were identified. Similarity analysis showed that microbial composition of the high-RNA-high-PHA and low-RNA-low-PHA groups had significant difference. Comparison between the two groups obtained different unique genera, which were significantly more enriched in one group than the other. The unique genera are possible representatives of the heterotrophic specialists. This study demonstrates that RNA and PHA are two biomarkers for classification of heterotrophic specialists in activated sludge systems, and pyrosequencing is a powerful tool for phylogenetic identification of microbial communities.

Evaluating the Robustness of Anode-Respiring Biofilms: Understanding the Dynamics of Interactions between Anode-Respiring and Denitrifying Bacteria

Varun Srinivasan, Caitlyn Butler
University of Massachusetts, Amherst, MA

Microbial fuel cells (MFCs) have emerged as a potential energy-efficient wastewater treatment strategy. MFCs can oxidize organic wastes in the anode compartment and reduce oxidized contaminants, such as nitrate, in the cathode compartment while generating electricity and producing minimal biomass. A poorly understood phenomenon is the role of competition between microbial communities that can transfer the electrons to an anode and microorganisms that use other electron acceptors. Nitrogen species are a major constituent of wastewater and nitrate can act as a competing electron acceptor in the anode causing loss in coulombic efficiency and power production. Long-term fluxes of such constituents could lead to permanent loss in exoelectrogenic activity of the biofilm. Environmentally relevant nitrate concentrations at different C to N ratios, 1.84, 3.68 and 7.36 mg-C/mg-N, were introduced to the anode compartment of operating mixed-culture flow-through microbial fuel cells (MFCs) to induce competition. Methanogenesis was inhibited as an experimental control. Electrochemical measurements performed over the course of the experiment suggested that the maximum power density and anode potential changes depended on the C to N ratio. Anode potential and power density decreased with time in the reactors with C/N ratio of 3.68 and 1.84 mg-C/mg-N while they did not change in the control and the reactor with C/N ratio of 7.38. Time-dependent changes in denitrifier concentrations and expressional changes were examined using quantitative Polymerase Chain Reaction (qPCR). Changes in relative nirK and nirS (nitrite reductases) copy numbers suggested that the presence of nitrate could induce detachment of denitrifying bacteria into suspension. When the nitrate flux was removed after 43 days, the anode potential and power densities returned back to their original values indicating the biofilm was robust to long-term nitrate fluxes.

Examination of Inactivation and Regrowth Potential of Chlorinated Biomass Cultured from Nova Scotia Drinking Water

Kyle Rauch, Graham Gagnon
Dalhousie University, Halifax, NS

Growth of biofilms in municipal distributions presents potential for infrastructure degradation, water quality reduction, and increased consumer health concerns. Therefore, proper secondary disinfection protocols are necessary to ensure a high microbial water quality at the tap. In Halifax Nova Scotia, Canada regulations are set to maintain a minimum free chlorine concentration and maximum heterotrophic plate counts (HPC) throughout the distribution system at 0.2 mgL-1 and <500 CFUmL-1, respectively. With that said, results from the HPC method have poor temporal resolution and may not accurately describe the microbial population (Rand et al., 2014). ATP assays have grown in popularity as the results are real time and better describe the microbial population. This study plans to examine the optimal free chlorine residual needed to prevent biofilm regrowth in distribution systems using an ATP assay in place of traditional culture methods. The research project first developed a regrowth method to increase the sensitivity of the assay. The new regrowth method has evaluated two mediums on an intra-assay regrowth method; and two mediums, a low and high incubation time and temperature for a pre-assay regrowth method. Based on these regrowth methods, an ATP-Chlorine response curve has been developed for the ATP based assays. The research has utilized CDC Biofilm Reactors to allow for in situ biofilm analysis as well as inactivation of suspended biomass. Along with ATP concentrations, HPC will be collected to correlate the two parameters to determine the surrogate ATP concentration to comply with local water quality regulations. Early Chick-Watson models show specific lethality coefficients ranging from -0.0551 to -0.0991 amongst the various regrowth methods. Ultimately, this study aims to provide an effective real time measurement tool to monitor the microbial water quality and prevent regrowth in municipal distribution systems

Biogas Production from Anaerobic Co-digestion of Microalgae and Septic Tank Sludge

Dingnan Lu
University of Massachusetts, Lowell, MA

Microalgae have been well recognized as one of the clean and renewable biomass energy resources. Although biogas can be generated via anaerobic digestion of microalgae; low biogas yield has been reported. Co-digestion using different co-substrates has been shown to increase the anaerobic digestibility of algae and increase the biogas yield and methane content. This study investigated the effects of septage as a co-substrate on anaerobic digestion of algae. Both algae and septage were collected from the Lowell Regional Wastewater Utility. Modified Bold Basal Medium was used to cultivate algae and the microscopic imaging revealed Chlorella spp.

Anaerobic co-digestion bottles with varying volume of algae and septage (100% algae, 75% algae, 50% algae, 25% algae and 0% algae) were setup in the lab and a reciprocal shaker bath was used to run the co-digestion at 25°C for 30 days. Different parameters

including, chemical oxygen demand (COD), total organic carbon (TOC), volatile solids (VS), total Kjeldahl nitrogen (TKN), biogas production, and biogas composition were measured during the experiments.

After 30-days of co-digestion, both the 25% and 50% algae sets had a similarly high cumulative biogas production, ~454 mLCH4/gVS an amount that quadrupled the gas production from the algae alone. This result corresponded to the initial carbon to nitrogen ratio (TOC/TKN or C/N) of 18:1 to 27:1 of the algae sludge and septage. Cellulase activity analysis based on glucose release rate clearly demonstrated the role played by the septage (i.e., the hydrolytic enzymes in the septage helped induce the hydrolysis of alage). The results demonstrated that anaerobic co-digestion using septage improved the digestibility and biogas production of microalgae.

Nanotechnology

Moderator: Leo Hsu

Separation and quantification of quantum dots and dissolved metal cations by size exclusion chromatography-ICP-MS

Pooya Paydary, Philip Larese-Casanova
Northeastern University, Boston, MA

The prevalence of engineered metallic nanoparticles within electronic products has evoked a need to assess their occurrence and fate within environmental systems upon potential release of these nanoparticles. Quantum dots (QDs) are mixed-metal nanocrystals with the smallest of particle sizes (2-10 nm) that readily leach heavy metal cations in water, potentially creating a co-occurrence of nanoparticulate and dissolved metal pollutants. In this study, we develop a size exclusion chromatography–inductively coupled plasma–mass spectrometry method (SEC-ICP-MS) for the rapid separation and quantification of ~5 nm-sized CdSe/ZnS QDs and dissolved Cd2+ and Zn2+ cations in water. The SEC-ICP-MS method provided a wide chromatographic separation of CdSe/ZnS QDs and dissolved Cd2+ and Zn2+ cations only when using the smallest SEC column pore size available and an eluent composition that prevented loss of metals to column polymer surfaces by using a surfactant to ensure elution of QDs (ammonium lauryl sulfate) and a complexing ligand to ensure elution of metal cations (ethylenediaminetetraacetate). Gold nanoparticles of sizes 5, 10, 20, and 50 nm were also effectively separated from dissolved Au3+ cations, illustrating the method applicability to a wide range of nanoparticle sizes and compositions. The applicability of the SEC-ICP-MS method to environmental systems was verified by measuring QDs and dissolved metals added to samples of natural waters. The method was also applied to monitoring CdSe/ZnS dissolution kinetics in an urban river water and in synthetic waters with different pHs and ligands. The SEC-ICP-MS developed here may offer improved automation for characterizing heterogeneous suspensions containing >1 µg L-1 heavy metals.

Development of a filter-based method for detecting silver nanoparticles in environmental water samples by surface enhanced Raman spectroscopy
Huiyuan Guo, Baoshan Xing, Lili He
University of Massachusetts, Amherst, MA

The prevalence of engineered metallic nanoparticles within electronic products has evoked a need to assess their occurrence and fate within environmental systems upon potential release of these nanoparticles. Quantum dots (QDs) are mixed-metal nanocrystals with the smallest of particle sizes (2-10 nm) that readily leach heavy metal cations in water, potentially creating a co-occurrence of nanoparticulate and dissolved metal pollutants. In this study, we develop a size exclusion chromatography–inductively coupled plasma–mass spectrometry method (SEC-ICP-MS) for the rapid separation and quantification of ~5 nm-sized CdSe/ZnS QDs and dissolved Cd2+ and Zn2+ cations in water. The SEC-ICP-MS method provided a wide chromatographic separation of CdSe/ZnS QDs and dissolved Cd2+ and Zn2+ cations only when using the smallest SEC column pore size available and an eluent composition that prevented loss of metals to column polymer surfaces by using a surfactant to ensure elution of QDs (ammonium lauryl sulfate) and a complexing ligand to ensure elution of metal cations (ethylenediaminetetraacetate). Gold nanoparticles of sizes 5, 10, 20, and 50 nm were also effectively separated from dissolved Au3+ cations, illustrating the method applicability to a wide range of nanoparticle sizes and compositions. The applicability of the SEC-ICP-MS method to environmental systems was verified by measuring QDs and dissolved metals added to samples of natural waters. The method was also applied to monitoring CdSe/ZnS dissolution kinetics in an urban river water and in synthetic waters with different pHs and ligands. The SEC-ICP-MS developed here may offer improved automation for characterizing heterogeneous suspensions containing >1 µg L-1 heavy metals.

Perfomance Evaluation of Biological Magnetic Powdered Activated Carbon
Kim Lompe, David Menard, Benoit Barbeau
École Polytechnique de Montréal, Montreal, QC

Combining high adsorption capacity of powdered activated carbon (PAC) with magnetic properties of iron oxide nanoparticles (NPs) leads to a promising composite material (MPAC) for drinking water treatment which can be separated from water using magnetic separators. This property makes MPAC attractive for biological hybrid membrane processes, for which a solid-liquid separation step would help to avoid membrane fouling issues resulting from colonized PAC.

During the first phase of this project, MPAC was successfully synthesized using a co-precipitation method. MPAC exhibited good magnetic and adsorption properties.
The second phase involved aging MPAC with different NP/PAC ratios in small bioreactors in order to assess the impact of NPs on biological treatment performance. Results show that NPs neither inhibit nor improve DOC and ammonia removal.

Five bioreactors were operated with 10 g PAC/L at increasing NP/PAC ratios and an HRT of 60 min. Unchlorinated tap water amended with nutrients served as influent water. DOC and ammonia removals were monitored. At the end of the assay, aged media was recovered from each bioreactor. The media was characterized using SEM. Specific activity of the bacteria was evaluated using the potential glucose respiration method. Biomass was detached from the carbon particles for metagenomic sequencing.

During the first 40 days of operation DOC removals declined from 60 % to 25 % due to the exhaustion of PAC adsorption capacity in all 5 reactors. The performance remained stable over the following 50 days when biodegradation took over. MPAC with 50, 40 and 20 wt-% NPs showed no significantly different DOC removal than reactors containing non-modified PAC. Ammonia removal started after 14 – 20 days of operation and reached 95 - 100 % after 1 month in all 5 reactors. Biomass development as well as DOC and ammonia removal performance were unaffected by NP content.

Assessment of Silver Nanotoxicity in Embryonic Zebrafish

Xiaobo Liu, Eduard Dumitrescu, Kenneth Wallace, Silvana Andreescu
Clarkson University, Potsdam, NY

The broadening and increasing use of nanomaterials has brought their potential environmental impact into focus. Aquatic environment is the primary site to receive and retain the nanomaterials discharge from domestic and industrial sites through wastewater and runoff. Therefore, nanotoxicity in aquatic species is of particular interest. In this study, embryonic zebrafish is used as a biological model to evaluate the environmental impact of silver nanoparticles (Ag NPs) in aquatic environment. Ag NPs with different sizes are used in this study to provide a relation between size and nanotoxicity. The effects of these NPs on embryonic zebrafish were assessed using several methods. Viability assay was used to evaluate the lethal effects through the 5-day embryogenesis. An electrochemical nitric oxide (NO) microsensor was used to test the alteration of the intestinal NO level. The effects of Ag NPs on the intestine and other tissue of zebrafish embryos were studied using histology assay. RNA in situ probe for inducible nitric oxide synthase (NOS2) was synthesized and used to determine the elevated expression of NOS2. Using the released silver ions concentrations quantified by flow injection analysis (FIA), the toxicity of dissolved Ag+ from Ag NPs was also discussed. In summary, no severe toxic effects are observed on zebrafish due to Ag NPs exposure. These results might relate to the transformation of Ag NPs in the testing environment.

POSTER CONTEST

On Saturday, conference sponsors and faculty had the opportunity to choose their top 5 posters across all topics. A wide range of excellent posters were on display on Saturday afternoon, and contest winners were announced at dinner that evening.

2015 Winners:

20. A Study of Dissolved De-icers Rates of Infiltration and Percolation: An Experimental Approach
Mikaela Rice, Rudolph Hon, Barry Shaudt, Constantin Andronache
Boston College, Chestnut Hill, MA

52. Management of Sediment in Paradise Pond, Northampton, Massachusetts
Maya Domeshek, Miatta Ndama, Robert Newton, Molly Peek, Marney Pratt, Marcia Rojas, Lizzie Sturtevant, Lyn Watts*
Smith College, Northampton, MA

2015 Honorable Mentions:

7. UMass Lowell Stream Team
Michaela Fitzgerald, Stephanie Collins
University of Massachusetts, Lowell, MA

14. Metal and phosphorus behavior during ice and non-ice covered periods in Missisquoi Bay, VT
Meagan Leduc, DongJoo Joung, Andrew Schroth
Lyndon State College, Lyndonville, VT

22. Manganese Removal and Transformation During Ceramic Microfiltration and Its Role In Fouling Development
Alyson Packhem
University of New Hampshire, Durham, NH

27. Modeling of Precipitation, Inhibition, and Dissolution Characteristics of Struvite and Vivianite in Wastewater Systems
Conor Brennan, Juliana Behrens, Adanfa He, Richard Carbonaro, Hossain Azam
Manhattan College, Bronx, NY

30. Determination of Turbidity and Particle Removal by Using Alum in a Water Treatment Pilot Plant
Huanlin Yu
Pennsylvania State University-Harrisburg, Middletown, PA

31. Removal of Aluminium From Filter Backwash Water Using Adsorbents and Geotextiles
Iffat Jahan, Graham Gagnon, Craig Lake
Dalhousie University, Halifax, NS

32. Kinetics study of 17α-ethinylestradiol (EE2) Photodegradation in fresh and saline water
Yuegang Zuo, Si Zhou*
University of Massachusetts, Dartmouth, MA

42. Hydrolyzed Poly(acrylonitrile) Electrospun Ion Exchange Fibers
Manisha Jassal, Sankha Bhowmick, Sukalyan Sengupta
University of Massachusetts, Dartmouth, MA

48. An Investigation Of Microbially Induced Calcite Precipitation For Reducing Fracture Permeability Of Rocks
Nicholas Bucci, Huijie Lu, Ehsan Ghazanfari
University of Vermont, Burlington, VT

50. How Bacteria Stay Wet In Dry Soil - The Sticky Truth
Brian C. Cruz, Leslie M. Shor
University of Connecticut, Storrs, CT

POSTERS

Water Resources, Hydrology, and Climate Change

1. Enhanced Transport of Bacteria Through Unsaturated Porous Media in the Presence of Surfactants
Derick G. Brown, Gerard P. Lennon, Jialan Zhu*
Lehigh University, Bethlehem, PA

Pathogenic organisms in on-site wastewater treatment system effluent can be retained as they pass through soil, and it is often assumed that live organisms do not reach drinking water wells. The role of surfactants, present in many consumer products, can enhance the transport of bacteria, thus increasing the persistence in groundwater. Experimental and numerical simulations demonstrate enhanced bacteria transport through unsaturated porous media because surfactants alter two important processes. First, surfactants enhance the effluent bacterial concentration by reduced attachment at the interface resulting in higher bacteria concentrations. Second, the apparent velocity of the bacteria increases significantly through enhanced size-exclusion effect. Our experimental results demonstrate that this latter effect may ultimately prove to be the greatest driver in surfactant-enhanced bacterial transport in unsaturated porous media. The HYDRUS-1D finite-element simulations of our laboratory experiments show the lower bacterial attachment to the interfaces does result in significantly higher concentrations, and that the

size-exclusion effect results in higher velocities. We then predict the fate and transport of bacteria for field conditions not determined experimentally including unsteady (pulsing) flow. The combination of experimental and numerical simulations helps to improve understanding of role of surfactants in enhancing transport of bacteria moving through the unsaturated zone.

2. Detailed analysis of Climate trends from the Northern Tier of Vermont from 2000-2014.

Nasser Abdel-Fatah, Tania Bacchus
Johnson State College, Johnson, VT

Various Intergovernmental Panel on Climate Change (IPCC) reports have focused on large scale global climate change developments. However, the public is more concerned by local and regional changes that may develop within the larger global context. Microclimate analyses allow for an evaluation of what is happening on a regional scale as it relates to the larger question of global climate changes. In the summer of 2015, weather data for the St. Johnsbury (STJ) area, from 2000 to 2014, was processed into monthly, seasonal, and yearly spreadsheets and graphs from hourly data provided by the National Oceanic and Atmospheric Administration (NOAA). All data was compiled using Microsoft Excel. Once this individual station evaluation was complete, the results were compared to other stations in the northern tier of Vermont which include: Johnson (JSC), Burlington (BTV), and Morrisville (MVL). Observations made from the decadal data showed that the winter season had a trend of increasing total precipitation and an increase in the average temperatures. Other observations in the decadal data showed that in the summer seasons there was an increase in precipitation, and a decrease in temperature. These two seasonal trends support the findings of the IPCC had made in their 5th assessment.

3. Spatial and temporal variations in freshwater export from the Eastern US: Climate change or El Nino/Southern Oscillation (ENSO) variability?

Dongmei Feng, Edward Beighley, Randall Hughes, David Kimbro
Northeastern University, Boston, MA

Freshwater input to the coastal region is a significant factor affecting the coastal ecosystem. The seasonal and inter-annual variability in freshwater input can affect phytoplankton production, landings, catches, abundance and distribution of some benthic invertebrates and fish species by altering material loading, physical conditions and the hydrodynamic environment in estuaries. Freshwater inputs can be impacted by climate and/or land use change. El Nino/Southern Oscillation (ENSO), originating in the sea surface temperature anomalies (warm or cold) in the eastern tropical Pacific Ocean, is a notable and prominent signal in inter-annual climatic variations. Recent studies shows that the probability of strong El Nino events may increase in the future. In this study, we will: (a) quantify the spatial and temporal variation of freshwater inputs along the US eastern coastal zone for the period 2000-2014 using the available streamflow measurements; and (b) develop relationships between the spatial distribution of freshwater inputs to the US eastern coastal zone and ENSO conditions. Two non-parametric statistical methods, Kendall's Tau and Spearman rank coefficients, will be

used to analyze trend and correlation with El Niño / Southern Oscillation (ENSO) index from both temporal and spatial perspectives in annual precipitation (P), evapotranspiration (ET) and streamflow (Q) from all watersheds east of the Mississippi River draining to the Atlantic Ocean. The analyzing effort will utilize precipitation data from Tropical Rainfall Measuring Mission (TRMM 3B42v7), monthly ET data from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Aqua and Terra satellites (MOD16A2), and monthly and annual streamflow data from U.S. Geological Survey gauges. The Oceanic Niño Index (ONI) in the Niño 3.4 region was used to represent ENSO conditions. Land cover data from Multi-Resolution Land Characteristics Consortium (MRLC) will be merged to estimate annual land cover characteristics for each sub-catchment within the study region.

4. Large Precipitation Events in Northern Vermont Compared to Global Temperature Anomalies and Carbon Dioxide Concentrations

Melissa Segall, Tania Bacchus
Lyndon State College, Lyndonville, VT

Large precipitation events are a likely outcome of climate change as stated in the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report. The goal of our study was to develop a large precipitation database for Northern Vermont. In a collaborative examination of northern tier weather data that included the stations in Burlington (1864-2014), Johnson (2000-2014), Morrisville (1962-2014), and St. Johnsbury (1894-2014), we analyzed data trends and correlations within the context of larger scale climate change. Large precipitation events, per calendar day, were classified by a baseline of 0.8 inches of precipitation or greater. The number of events per month, year, decade, and the entire dataset were recorded, averaged, and normalized. Positive correlations between global temperature anomalies and the number of events at St. Johnsbury for the years 1894-2014 (0.34), 1900-1949 (0.25), 1950-2014 (0.39) 1984-2014 (0.48) were calculated. Decadal frequencies of event numbering ≥ 1 more than average (1894-2014) reveal twofold increases from 1900-1909 to 2000-2009, indicating a positive trend. Large precipitation events at St. Johnsbury were compared to mean concentrations of atmospheric carbon dioxide (CO2). A correlation of 0.51 between CO2 concentrations and event number from 2000-2010 indicated a close relationship between anthropogenic warming and large precipitation events. Our results suggest that a more in depth analysis of the other Vermont stations is needed to corroborate these findings and confirm trends.

5. Investigating scaling effect on surface runoff in the Ohio River Basin

Yuanhao Zhao, Edward Beighley
Northeastern University, Boston, MA

Challenge of scaling in hydrology has been investigated for decades. Here we present a space-time method which enables surface runoff routing processes to be upscaled to coarser model scales while maintaining event hydrograph peak discharge and timing characteristics. A case study in the Ohio River Basin (1.3 M sqkm) is presented using a synthetic 1 cm 24-hr runoff experiment. The method combines statistical and physically-based Hillslope River Routing (HRR) modeling techniques. Cumulative Probability

Distributions (CDFs) for surface flowpath travel times based on 90-m topographic data and conceptualized model units representing individual catchments in the (HRR) model are equated by adjusting surface roughness along HRR hillslopes. Based on the 90-m digital elevation model (DEM) data, The CDF travel time for individual catchments are approximated by the beta distribution to reduce processing time for large watersheds. Nine model scales are investigated: 1, 3.2, 10, 32, 100, 320, 1000, 3200 and 10000 sqkm, where model scale represents the threshold areas used to define the underlying river network and catchment boundaries. In this study, the reference scale is set to 1 km2. A correction coefficient is applied to the whole basin to overcome limitations associated with catchment shape and discretization assumptions in the HRR model. Simulated hydrographs at the outlet of the Ohio River Basin for the eight coarser model scales have peak discharge and time-to-peak discharge values that are nearly identical to the reference scale model. To match hydrograph characteristics from model scales ranging by four orders of magnitude, surface roughness values along the hillslope flowpaths were adjusted on average -85% to +94%, where the positive values are for the 3.2 sqkm scale and the largest reductions are for the 10,000 sqkm scale.

6. Differences in stream flow estimations from precipitation data products with different spatial and temporal resolution in Puerto Rico

Harshi Weerasinghe, Edward Beighley, Akram Alshawabkeh
Notheastern University, Boston, MA

Changes in demographic structure, land-use practices, land cover, and climate, influence on the quantitative and qualitative availability of fresh water resources suitable for human consumption. Presence of more than 200 contaminated sites in Puerto Rico including 16 active superfund sites indicates the intense exposure of fresh water resources to chemical contaminants. Mobile karst aquifers are the primary groundwater source in the island and unlined landfills located above the aquifers slowly release contaminants to the water below. According to historical records, north coast has been contaminating for past 40 years. Major contaminants are septic waste and sewage. The septic absorption fields are limited throughout the country, whereas sewage lagoons are mainly observed in the low-lying coastal regions. Recent observations in the precipitation patterns show an increased storm surges and improper storm water management, which resulted in frequent flooding events. This affects negatively on the quality of surface fresh water resources. Extensive erosion in humid montane watersheds in eastern Puerto Rico results in reducing river capacity in downstream regions. To quantify and characterize Puerto Rico's surface waters, we use hydrologic modeling, satellite and radar remote sensing and field measurements. Streamflow measurements are available from 27 U.S. Geological Survey (USGS) gauging stations with drainage areas ranging from 2 to 510 km2. Hillslope River Routing (HRR) model is used to simulate hourly streamflow from watersheds larger than 1 km2 that discharge to ocean. HRR model simulates vertical water balance, lateral surface and subsurface runoff and river discharge. The model consists of 4418 sub-catchments with a mean model unit area (i.e., sub-catchment) of 1.8 km2. Using gauged streamflow measurements for validation, we first assess model results for simulated discharge using three precipitation products: TRMM-3B42 (3 hour temporal resolution, 0.25 degree spatial resolution); NWS stage-III radar rainfall (~ 5 min temporal resolution and 4 km spatial resolution); and gauge measurements from 37 rainfall stations for the

period 2001-2011. We then explore methods for combining each product to improve overall model performance. Effects of varied spatial and temporal rainfall resolutions on simulated discharge are also investigated.

Water Quality

7. UMass Lowell Stream Team
Michaela Fitzgerald, Stephanie Collins
University of Massachusetts, Lowell, MA

Beginning in 2013, over thirty (30) students from the University of Massachusetts Lowell American Society of Civil Engineers (ASCE) student chapter have been working with the Town of Lexington's Department of Public Works (DPW) Engineering division to conduct water quality assessment at selected Shawsheen River stormwater outfalls. The students are divided into field sampling teams and a data analysis team. Field sampling teams record various conditions at the time of sampling (e.g. temperature, precipitation), perform several field tests using a YSI meter and colorimeter, and collect water samples for laboratory testing. Field tests are used to measure the amount of dissolved oxygen, specific conductivity, and chlorine in the outfalls. Laboratory testing is used to determine the presence and/or quantities of Escherichia coli (E.coli), surfactants, and ammonia. Elevated concentrations of these parameters are used as indicators to determine the source of contamination into the stormwater system. In addition, this program is supplementing the laboratory testing for ammonia concentration with field test kits recommended by Region 1 of the Environmental Protection Agency (EPA). The ammonia concentration from the laboratory results will be compared with those from the field test kits in order to determine the effectiveness of the test kits in this application. The data analysis team has started to work with the Town of Lexington Engineers to find patterns in the data to identify potential pollution sources. The collaboration between the UMass Lowell ASCE Student Chapter and the Town of Lexington provides the Town of Lexington with additional testing and analysis support to meet an unfunded mandate relating to stormwater run-off from the EPA while at the same time providing real world experience to the students. It is hoped this program can serve as a model for other municipalities seeking to meet the EPA unfunded stormwater mandate.

8. Analysis of Trace Metals in Stormwater Runoff from Building Roofs
Alexander Johnson, Cliff I. Davidson
Syracuse University, Syracuse, NY

Atmospheric aerosols deposit onto urban surfaces such as streets and building roofs. A fraction of these deposited aerosols are mobilized during rainstorms and may contaminate stormwater runoff. However, little is known about the origins of the chemical constituents in the runoff. Besides washoff of dry deposited aerosol, other possible sources of contaminants include chemicals in fresh precipitation (wet deposition), washoff of debris from the surface, erosion of surface coatings, and erosion of the surface material itself. In these experiments, we investigated the trace metal content of stormwater runoff from two adjacent rooftops: a 1.5 acre green roof on the Onondaga County Convention Center and a similarly sized traditional roof on the War Memorial

Sports Arena, both located in downtown Syracuse, New York. The primary objective was to compare concentrations of trace metals in runoff samples collected from both roofs to determine if the green roof acted as a filter to remove them from stormwater runoff or if it was a source of contamination. A second objective was to determine the relative contributions of wet deposition and dry deposition as well as debris and surface erosion to runoff contamination from both roofs. Fresh precipitation was collected and analyzed for the same trace metals to determine the contribution from wet deposition. For dry deposition, fluxes of trace metals onto aerodynamic surfaces during antecedent dry weather were determined. Ambient airborne concentrations were also measured. The value for this parameter provided a lower limit to the input from dry deposition onto the roof surfaces. These data were used to develop mass balance models for trace metal deposition onto the roof surfaces and removal in stormwater runoff.

Microbiology

9. Role of shear stress on Cryptosporidium parvum oocyst attachment to environmental biofilms

Xia Luo, Sabrina Jedlicka, Kristen L. Jellison
Lehigh University, Bethlehem, PA

Hydrodynamic conditions affect microbial attachment or sloughing from biofilms, and this study investigated Cryptosporidium parvum oocyst deposition on biofilms under different shear stresses. Annular rotating bioreactors were used to grow stabilized stream biofilms at shear stresses ranging from 0.038 to 0.46 Pa to study the effect of laminar and turbulent flow on biofilm formation and Cryptosporidium deposition kinetics. Smooth, dense, and stable biofilms formed at high shear stress, compared to rough, loose and fluffy biofilms at low shear stress. The steady-state biofilms developed under different shear stress were then used to assess the impact of hydrodynamic condition on Cryptosporidium attachment. Cryptosporidium deposition onto biofilms followed a pseudo second-order model under both laminar (after a lag phase) and turbulent flows. Due to the effect of hydrodynamic lift or drag forces inhibiting attachment, the total number of oocysts attached to the biofilm at steady state decreased as the hydrodynamic wall shear stress increased. The oocyst deposition rate constant increased with shear stress but dropped when the shear was too high (i.e., 0.46 Pa), suggesting that increasing wall shear stress results in faster attachment of Cryptosporidium due to higher mass transport until the wall shear exceeds a critical limit which prevents oocyst attachment.

10. Inhibition of Methanogenesis in MFC Anode Communities

Joshua Jack
University of Massachusetts, Amherst, MA

Microbial fuel cells (MFCs) are devices that use specialized bacteria to oxidize organic matter and generate electric current. In MFC anodes, it has been found that methanogens can compete with anode respiring bacteria (ARB) for electron donors as well as space on electrode surfaces. This phenomenon has been thought to contribute to significantly lower power efficiencies in MFCs. Fortunately, the introduction of nitrate into methanogenic communities has been demonstrated to inhibit methanogenic growth. If

using an MFC as part of a wastewater treatment system, nitrate produced via nitrification would be an ideal suppressor for methanogenesis. In this study, methanogens were enriched from effluent of an existing MFC anode. Since temperature is a key parameter in methanogenic growth enrichments were conducted under at room temperature (22 deg. C) as well as 37 deg. C. Additionally, enrichment bottles included samples with graphite (a conductive material), samples without graphite and samples with granite crushed stone. This was done to investigate the effect of a conductive substratum on growth. Initial studies have demonstrated that methane is produce more quickly and in greater quantities in batch experiments with graphite, implicating that the conductive surface (graphite) is enhancing methane production. This is particularly important as methanogenesis may actually be enhanced in MFC anodes compared to suspended growth conditions. Work is currently on-going to explore nitrate's role in suppressing this activity. When the enrichment is complete, the inhibitory effects of nitrate will be explored by applying two low doses of nitrate, 1 mg-N/L and 5 mg-N/L, to the microbial communities.

11. Keeping up with cyanobacteria: Explaining biogeographic patterns of Great Lakes cyanobacteria using a neutral agent-based model

Sahar Shirani, Ferdi L. Hellweger
Northeastern University, Boston, MA

What mechanisms underlie biogeographic patterns of microbes in lakes? This question can be addressed on both ecological and evolutionary levels. Environmental factors beneficial for one type of microorganism and detrimental to another, may act as constrains, determining which type may continue to survive (natural selection). On the other hand, diversification might be merely due to accumulating mutations in geographically isolated sites, resulting in increasing divergence from common ancestor as well as from each other (genetic drift).
Here, in order to quantify the role of genetic drift, we simulate individual cyanobacteria cells in the Great Lakes using an agent-based approach. The system is divided into 9 segments, each with its unique properties and a certain number of individuals. Cells grow (divide), die and migrate between segments based on flow and dispersion rates. Each cell has a 1Mbp genome that is subject to neutral mutation (i.e. the growth rate is not affected by the genome). Due to independent evolution of the populations in the lakes, their nucleotide differences start to accumulate. Periodically, a migrant may take over the population of the destination lake, causing an abrupt drop in the nucleotide differences between the lakes. The difference then increases gradually again and the pattern repeats itself. The model is verified by simulating simplified lake systems, for which theoretical analytical solutions are available (e.g. stepping-stone model with uniform population sizes and migration rates). Then, the model is used to simulate the Great Lakes system.

Politics, Policy, and Governance of Water

13. New Data and Old: Updating Rhode Island's Ocean SAMP
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Rhode Island's Ocean SAMP (Special Area Management Plan) is a prime example of Marine Spatial Planning, resulting in, among many things, the siting of the first offshore wind farm in the United States. Implemented in 2010, the plan is now undergoing its mandatory 5-year update, which seeks to reexamine the information and policies that compose the document. Currently working on the Recreation and Tourism chapter, our ongoing research is to gather new information on offshore activities that greatly impact the economy of Rhode Island, and vetting data already contained in the plan. Our methods include desktop research, GIS mapping, and interviews with industry-sector experts, as well as collaboration with the Northeast Regional Ocean Council (NROC). Our findings will enhance both the Ocean SAMP and the regional planning effort, leading to increased management and protection of Rhode Island's offshore natural resources for the users that value them the most.

Water Chemistry

14. Metal and phosphorus behavior during ice and non-ice covered periods in Missisquoi Bay, VT
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The interaction between redox sensitive iron(Fe), manganese(Mn) and phosphorus(P) in the water column and near surface sediments has been shown to P loading and related harmful algal bloom severity in shallow eutrophic lakes. However, the behavior of these constituents underneath the ice is poorly understood. Here we describe the temporal behavior of sediment profile and water column Fe, Mn and P along with other environmental parameters in a shallow eutrophic lake, Missisquoi Bay, Vermont. Our time series comprises under ice (January-March, 2015) and non-ice (April-June, 2015) periods. During winter, thermal and dissolved oxygen stratification became progressively stronger until mid-March then weaker at the onset of the spring thaw and dissipated when there was no ice in the lake. At the same time, water column Fe, Mn and P concentrations gradually increased until the thaw began. However, during the thaw and spring runoff period, water column constituents decreased in concentration, and redox sensitive phases accumulated in near surface sediments. Indeed, when sediment time series data indicates release of Fe, Mn and P to the water column profile, corresponding increases were observed in the water column, while periods of accumulation in the sediment were confirmed with water column decrease of each constituent. When coupled with the strong positive correlations between P and Fe concentrations in the water column and sediment, we conclude that water column Fe, Mn and P loading under ice is derived from reductive dissolution of Fe/Mn(oxy)hydroxides at or near the sediment water interface(SWI).

Conversely, during melting and non-ice periods, decreases of Fe, Mn and P in the water column may be resulted from re-precipitation of these phases that adsorb P in a relatively oxygenated SWI. To conclude, redox conditions at the SWI underneath the ice exhibit sediment release into the water column thus affecting nutrient pools.

15. Implications of Volatile Organic Compound Co-Contamination and Isomer Tracing for Perfluoroalkyl Acid Groundwater Transport

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Perfluoroalkyl acids (PFAAs) are organic surfactants used in paint, non-stick coatings, and fire retardants, notably aqueous film-forming foam (AFFF). AFFF use contributes significantly to high groundwater PFAA concentrations at point sources. Their environmental persistence, bioaccumulation, and chronic health effects as likely carcinogens and immunotoxins have made PFAAs emerging contaminants of concern. PFAA transport properties in groundwater, however, are still mostly unknown.

Examining PFAA interactions with other groundwater constituents is particularly important in understanding PFAA transport. Joint Base Cape Cod (JBCC), a site with known PFAA and volatile organic compound (VOC) contamination from AFFF fire training exercises, was selected as a representative field site for the study of VOC impacts on PFAA transport. Specifically, we consider the effects of methyl tert-butyl ether (MTBE), a gasoline additive, and the industrial solvents tetrachloroethylene (PCE) and trichloroethylene (TCE) and their degradation product cis-1,2-dichloroethylene (DCE). PCE, TCE, and DCE are ubiquitous and toxic groundwater contaminants that often co-occur with PFAAs at JBCC. Groundwater and aquifer sediments collected from a background location near JBCC were used to conduct batch sorption experiments. Following 120 hours equilibration, liquid and solid phases were separated by centrifugation, extracted and analyzed for PFAAs using triple quadrupole liquid chromatography-mass spectrometry (LC/MS/MS). Resulting sediment-water distribution coefficients (Kd) and isotherms were used to determine VOC influences on PFAA sorption.

In addition to laboratory co-contaminant investigations, a field study examining whether a nearby downgradient wastewater-disposal site also may be a historical PFAA source was conducted to enhance understanding of PFAA transport. Structural isomers of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) were separated by LC/MS/MS and compared in groundwater impacted by wastewater effluent and groundwater impacted by AFFF. Isomer distribution patterns, when compared to previously published isomer profiles, suggest the possibility of plume or source mixing and provide a viable method for PFAA source tracing.

16. Raman Microspectroscopy Study of the Hydrolytic Degradation of Polyanhydride Network Polymers

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Polyanhydride network polymers synthesized via thiol-ene photopolymerization undergo surface erosion in water-rich environments driven primarily by hydrolytic degradation. Despite the numerous potential applications for these materials, the details of their degradation and erosion, however, remain poorly understood. To address this shortcoming, Raman microspectroscopy is employed in this work to study the degradation of a polyanhydride network polymer synthesized from 4-pentenoic anhydride (PNA) and pentaerythritol tetrakis(3-mercaptopropionate) (PETMP) monomers. Erosion, meanwhile, is monitored through mass loss and light microscopy data. Disk-shaped polymer samples are immersed in buffer solutions over a 24h period and hydrolytic degradation is monitored spatially and temporally via kinetic Raman studies at various depths of penetration into the samples. Raman microspectroscopy is shown to be a particularly valuable tool for the study of the hydrolytic degradation of these materials. It is expected that the insights and data provided here will contribute significantly to the development of a full mechanistic understanding of the degradation and erosion of these new polyanhydride materials.

17. Effects of nitrite and nitrate on the photodegradation of phthalic acid

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Phthalic acid (PA) is the precursor of a group of compounds called Phthalate Esters (PAEs) which are widely applied in industry as plasticizers. It was also a common degradation intermediate of phthalate based plasticizers. PAEs are hydrophobic compounds with low melting point and high boiling point. Most PAEs have very low acute oral toxicity, but many chronic harmful effects, such as reproductive and developmental toxicity, carcinogenicity, and chronic organ toxicity. The decomposition of phthalic acid is the ultimate stage in the degradation pathway of PAEs. Study of the photodegradation of phthalic acid and the effects of nitrate and nitrite on this process have great significances in elucidating the ultimate degradation mechanisms and the fate of PAEs in aqueous environment. This study reported that the photodegradation of phthalic acid obeyed the first order kinetics. The degradation rate was much faster in acidic conditions than in neutral conditions. The presence of nitrate and nitrite accelerated the photodegradation and the effects of nitrite is much more significant than that of nitrate.

18. Biomagnification of Methylmercury in a Sub-Arctic Estuarine Food Web

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Lake Melville is a large estuarine fjord in Labrador, Canada that provides abundant fish and marine mammals for indigenous Inuit in the region. Future increases in methylmercury(MeHg), a potent neurotoxin, are likely in this ecosystem due to flooding

of the main freshwater tributary for hydroelectric power development in 2017. To understand how increase in seawater MeHg is likely to affect the marine food web, we investigated the factors influencing MeHg biomagnification in this ecosystem including trophic structure and diet composition. Our study includes data for five pelagic and four benthic fish species from three locations across Lake Melville and measured fish length, weight, and age (determined by scales or otoliths). Fish diet, habitat, and trophic position were characterized based on prior literature, stomach content analysis and the use of total mercury, δ13C, and δ15N analysis. We observed a wide δ13C range, -14.12 ‰ to -30.23 ‰, which is reflective of the diverse ecosystem compromised of freshwater and marine food sources. For pelagic and benthic species, THg ranged from 0.02 to 0.50 µg g-1 (wet weight, ww) and 0.02 to 0.36 µg g-1 (ww), respectively. The mercury concentrations of pelagic fish positively correlate with their δ15N, signifying biomagnication through the pelagic food web. The calculated trophic magnification factor (TMF), or an indicator of biomagnifying potential, of 1.39 agrees well with published values from a meta-analysis of TMF's globally. We found little evidence of biomagnification of MeHg in the benthic food web, including a wide δ15N range, but no correlating increase in THg. Stomach content analysis confirmed the different benthic prey consumed, but no obvious food chain within the selected species. This study will help understand how to protect this vulnerable ecosystem with a susceptible Inuit population from future increases in MeHg exposure.

19. Stoichiometry for Oxidation of Dissolved Manganese Mn(II) with Ferrate Fe(VI)

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Known for its oxidation and disinfection ability, ferrate has the potential to become a viable alternative to other technologies in drinking water treatment. It can oxidize some inorganic and organic contaminants, and disinfects pathogens. Ferrate may be more competitive with other more popular treatment choices such as chlorine or ozone because of cost, and lack of formation of unwanted disinfection byproducts. However, the impacts ferrate has on drinking water treatment systems are still vastly unknown. The objective of this project is to explore effectiveness of ferrate for oxidation of naturally occurring dissolved manganese in water.
A bench scale analysis was conducted using a laboratory water matrix. Deionized water was buffered with 1 mM HCO3 - and dosed with a desired concentration of manganese (II) sulfate monohydrate. A desired amount of potassium ferrate salt was added to deionized water to create a ferrate stock solution. An aliquot ferrate solution was added to the manganese solution under rapid mixing and then slow mixing. The pH of the solutions was adjusted with 1M HCl or 1M NaOH during the rapid mixing period. The resultant water was then fractionated using 0.2 mm, GFF and ultra filters. Total and manganese and manganese after fractionation were measured colorimetrically. The oxidation of Mn(II) with Fe(VI) was found to follow a stoichiometric ratio of 3 moles Mn(II) : 2 moles Fe(VI). This stoichiometry was true for multiple initial Mn(II) concentrations, and pH values. Dosing Fe(VI) at above the required stoichiometry resulted in the formation of permanganate, Mn(VII), causing a pink color.

20. A Study of Dissolved De-icers Rates of Infiltration and Percolation: An Experimental Approach

Mikaela Rice, Rudolph Hon, Barry Shaudt, Constantin Andronache
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Deicer pathways from the point of application to the point of discharge require a better understanding of infiltration and percolation rates through the subsurface. Bench top experiments are carried out in small transparent 21x12x12 cm tanks filled with either (1) a poorly sorted earth material or (2) one of three sorted size fractions (fine, medium, or coarse sand). The second variable parameter is a sequence of pre-selected NaCl solutions tinted with blue dye (CAS# 3844-45-9). The range of NaCl solutions (0.05-5% NaCl) in distilled water are selected to correlate with NaCl solutions in equilibrium with ice or snow in the temperature range between 25 and 31 degrees Fahrenheit. In each experiment, a 3mm deep scarp along the longer wall of the tank is filled with 20mL of the selected solution. The progress of the experiment is monitored by high-resolution time-lapse photography using the Canon Rebel T2i camera (18 mega pixels). The exposure interval is set between 20 seconds and 5 minutes depending on the solution concentration. The total time for the experiments varies between 2 and 5 days, resulting in a sequence of 800 to 2500 frames. At the end of the experiments, all frames were converted into 20 frame per second videos lasting 30 seconds up to 2 minutes. The time compression allows for clear visualization of the infiltration and percolation processes. The parameters of interest are the style of percolation and the change of the concentration as the percolation proceeds. The experiments show that the percolation style through the freshwater column follows two different mechanisms—general advancing front and narrow finger-like convective cells. The density of the blue coloration as the experiment proceeds indicates mixing between fresh and salt water and a simultaneous slowing down of the advancing front. Selected videos will be shown with the poster presentation.

21. An in-depth look at New Hampshire snowpack chemistry

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Seasonal snowpacks accumulate impurities throughout the winter and can release them quickly during a melt period, thus having an impact on the surrounding environment. The timing of the melt and the amount of solutes within the snowpack have implications for how other ecosystems can manage any surge of impurities during a melt event. Previous field and laboratory studies have shown that a snowpack can lose up to 80% of its solutes in the first 20% of the runoff. In this investigation, near daily chemical profiles in the snowpack at three sites from three different winters in New Hampshire are analyzed for a pulse. Preliminary results suggest that an ion pulse is occurring when New Hampshire's snowpack melts. Black carbon (BC) also tends to flush out of the snowpack more quickly than snow water equivalent decreases during melt, but more slowly than most ionic snow solutes. Aside from the ionic pulse, an analysis of sodium and chloride ratios suggests that a large portion of these two ions may actually be derived from nearby road salt application, rather than sea salt, even at two sample sites located in New Hampshire's seacoast region. The spatial variability of snow chemistry, the movement of solutes within a snowpack throughout the winter, and how impurities lost from the melting

snowpack spread into soils and nearby streams are additional questions that we are investigating with these data sets.

Water and Wastewater Treatment

22. Manganese Removal and Transformation During Ceramic Microfiltration and Its Role In Fouling Development

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Ceramic microfiltration is used for drinking water treatment at PWN in Andijk, Netherlands. Pilot analysis shows that some transition metals such as manganese and iron are “removed/adsorbed” by the ceramic membrane. The adsorption of inorganics during ceramic microfiltration could cause hydraulically irreversible fouling requiring removal through chemical/enhanced backwashing (EBW). In practice, this is done with a low pH EBW (pH 2) in combination with hydrogen peroxide (100 ppm). The purpose of this study was to gain a better understanding of the interaction between manganese and the ceramic membrane as well as develop methods for manganese fouling control. Jar tests using synthetic manganese solutions, activated alumina (AA) powders, and nanostructured ceramic materials were used to mimic surface interactions that take place during ceramic microfiltration. Jar testing showed less manganese was desorbed from the membrane material surface when organics were present in the water. This data was used to implement changes to the ceramic membrane system at the PWN Technologies Pilot Facility in June 2015. Organics were removed from the ceramic membrane through a sodium hypochlorite EBW before the low pH/peroxide EBW to increase manganese desorption. Preliminary findings from the pilot showed that consecutive EBWs decreased the fouling in the membrane (based on filtration time and transmembrane pressure) more than non-consecutive EBWs.

23. Wastewater Effluent and CSO Disinfection

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The New York City Department of Environmental Protection (DEP) owns and operates 14 Wastewater Treatment Plants (WWTPs) located throughout New York City. Each plant is designed to treat some portion of wet weather flow with any excess flow being diverted to combined sewer overflow (CSO) detention facilities or CSO outfalls. The objective of this work is to address a number of issues related to the disinfection of both wastewater effluent and CSO discharges.

It is expected that New York State will adopt a new indicator organism criteria for all New York State WWTPs. This new criteria will replace fecal coliforms as the biological water quality indicator with Enterococcus. The switch will lead to potential challenges for WWTPs in that Enterococcus is considered more difficult to inactivate using traditional disinfection methods (chlorine) compared to fecal coliforms. Currently all NYC plants use chlorine to disinfect their wastewater prior to discharge in order to meet the biological water quality criteria. This study investigates the effectiveness and

applicability of different disinfection practices (chlorine dose and contact time versus peracetic acid (PAA) dose and contact time) for meeting the new Enterococcus standard.

Along with the pending change in indicator organism, the new permits also include standards for cyanide as well as total residual chlorine (TRC). This work is aimed to better understand the disinfectant dose and contact times required to meet the new Enterococcus criteria. It will also help to understand what impact an increased dose might have on cyanide production, effluent TRC concentrations and/or the possible need for dechlorination.

24. Gone with the Wind: Moisture Effects on Nitrogen Removal in Soil Receiving Wastewater

Faith Anderson, Jennifer Cooper, Jose Amador
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Onsite wastewater treatment systems (OWTS), also known as septic systems, release a large amount of N that can be detrimental to the environment. Once wastewater enters a septic system, it undergoes a series of treatments. The final step is dispersal onto a soil drainfield, where it percolates through the soil. Some of the N is removed from the wastewater and released to the atmosphere through denitrification. Previous studies have looked at the effect of soil moisture content on denitrification using clean water, pinpointing a minimum of 60% water-filled pore space (WFPS) for anoxic conditions to develop for denitrification to occur. Our project aims at measuring the response of denitrification to changes in WFPS when low dissolved oxygen (DO) wastewater is used instead of the O2–saturated clean water. Replicate (n=4) vials with soil of fine and coarse texture amended with clean water (8 mg DO/L) or domestic wastewater (0 - 3 mg DO/L) were used to test for N2O production under ten different WFPS. We will discuss our results in the context of the hypothesis that denitrification will take place at lower WFPS values in soil amended with wastewater than in soil receiving clean water.

25. Accuracy of Rapid Testing for Advanced Onsite Wastewater Treatment System Effluent

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Rapid testing is a desirable alternative to standard laboratory analysis for water quality testing. These tests often yield results in minutes, are cost-effective, and can be carried out on-site, eliminating transport cost and reducing sampling error. However, the accuracy of these methods has not been sufficiently investigated for analysis of advanced onsite wastewater treatment systems (OWTS). Therefore, we assess the accuracy of these rapid tests (test strips for NH4+, pH, NO3-, alkalinity, and dissolved oxygen titration) by comparing to standard analysis values. We tested final effluent from three different advanced OWTS monthly for four months within the Narragansett Bay watershed at 43 different sites. When the data were analyzed using ANOVA by ranks, statistical differences between methods were found only for nitrate and pH. Based on regression analysis, all the field methods deviated significantly from correspondence with standard

analysis. In order to eliminate sources of experimental error, a small subset of samples was selected and analyzed in the laboratory using these same rapid test methods, as well as additional rapid tests. Statistical differences from desired regression parameters were found for nitrate and pH rapid tests when analyzed with ANOVA and regression testing. Our results suggest that these methods do not give an accurate representation of true constituent concentrations for wastewater, and should not be used as such.
(Results discussed in this abstract are preliminary and have not been reviewed by NEIWPCC or NBE.)

26. Disinfection By-Product Formation in NYC Wastewater Treatment Plant Effluent

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Wastewater treatment plants in NYC are combined systems that treat the precipitation and runoff from wet weather events along with municipal wastewater flow. To protect surface water sources, the effluent is disinfected with chlorine before it is discharged into surface water. During disinfection, chlorine reacts with organic matter in the effluent, resulting in the formation of carcinogenic disinfection by-products (DBPs). If DBPs are present in the effluent, the general public can be exposed to these compounds through recreational use of the receiving waters. In this work, wastewater effluent samples were collected and batch tests were conducted under different chlorination conditions (dose and contact time). Samples were collected at different time intervals from each test and analyzed for the presence and concentration of the following DBP groups: regulated species such as trihalomethanes (THMs) and haloacetic acids (HAAs) as well as species that are not currently regulated including halogenated acetonitriles (HANs) and chlorinated solvents. The objective of this work is to determine the effect of chlorine dose and contact time on DBP formation and speciation. Preliminary results show that the dominant DBP species that form in disinfected wastewater are HAAs, which show higher concentrations at higher initial chlorine dose. However, HAA concentrations decrease with increasing chlorine contact time (>30 minutes), likely due to a reduction in residual chlorine. HANs and chlorinated solvents were also present and show similar results to HAAs at initial chlorine doses of 4 mg/L and 6 mg/L. However, at an initial chlorine dose of 8 mg/L, certain HAN and chlorinated solvent species increase with increasing chlorine contact time (>30 minutes). These results as well as the results for other DBP species and chlorine doses will be presented.

27. Modeling of Precipitation, Inhibition, and Dissolution Characteristics of Struvite and Vivianite in Wastewater Systems

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Precipitation, inhibition and dissolution of minerals [e.g. struvite ($NH_4MgPO_4 \cdot 6H_2O$), vivianite ($Fe_3(PO_4)_2 \cdot 8H_2O$)] can play important roles in the availability of important cations and anions present and the rate and extent of resource recovery in wastewater treatment systems. Struvite and vivianite have been reported widely as causing operational problems in anaerobic digestion systems. Furthermore, iron is widely used for

coagulation and for phosphorus removal purposes. The potential competing roles of struvite and vivianite require detailed investigation in the presence of different intervening compounds. Laboratory experiments and modeling studies are being undertaken that investigate three aspects of struvite/vivianite minerals: (a) formation potential and precipitation kinetics of struvite and vivianite under different environmentally relevant conditions (e.g. aerobic, anaerobic conditions) and parameters (e.g. hardness, alkalinity, pH), (b) inhibition characteristics and kinetics using chelating agents (e.g. EDTA, NTA), and (c) dissolution potential of the minerals under phosphonate based chelating agents (e.g DTPMP, EDTMP, HEDP). Batch experiments and modeling (MINEQL+) are being conducted to validate the effects of chelating agents of vivianite and struvite formation, inhibition and dissolution under varying environmental conditions. Equilibrium modeling through MINEQL+ shows that at low concentrations of Fe(II), Mg2+, NH4+, CO32-, and PO43--P reported in municipal wastewater systems, vivianite will most likely form between pH 8 and pH 9. Struvite will not be the dominant mineral to form at those lower concentrations. Modeling studies further show that there is potential of both vivianite and struvite precipitation from pH 9 and pH 10, but the dominant type between the two minerals and pH range will be determined by the presence and types of other competing ions and chelating agents. Thus, this study will provide detailed characteristics of vivianite and struvite precipitation and kinetics and will further assist in the design of future phosphorus removal, recovery and/or scale removal systems.

28. Revitalization of Abandoned Biosand Filters

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Although biosand filters (BSFs) have been implemented in over 55 countries to provide safe drinking water, the necessity of operating filters on a daily basis has raised questions about filter efficacy after a period of abandonment (e.g., due to travels away from home, or school vacations when students/faculty are not present to use institutional filters every day). An assessment of the effectiveness of revitalized BSFs is being conducted on two full-scale concrete BSFs, two 5-gallon bucket BSFs, and two 2-gallon bucket BSFs that were abandoned for two years. The filters were revitalized by rehydration (as needed), swirl-and-dump sand cleaning, tubing disinfection, and flushing. The performance of the revitalized filters is compared to that of two newly built concrete filters by measuring influent and effluent levels of Escherichia coli, Cryptosporidium parvum oocysts, and turbidity. Influent water is collected from a local creek to provide adequate nutrients to support biolayer development and to emulate field use. The influent is spiked biweekly, once with E. coli and once with C. parvum. The percent reduction of E. coli and C. parvum by each filter is calculated by testing the two subsequent effluents following each spike. In addition, flow rates of the filters as well as water quality measurements of influent and effluent water (i.e., conductivity, phosphates, ammonia, total nitrogen, total organic carbon) are evaluated weekly. Results of these analyses will also be compared with field studies of filters abandoned in Honduras and Haiti for two month and six month periods, respectively. Presently, the safe recommendation for abandoned filters is to deconstruct and rebuild, which is a cumbersome and time-consuming process that cannot easily be carried out in developing countries. Should rehydration be found an

effective method of filter revitalization, it would ensure the continued growth of efficient drinking water treatment systems in developing nations.

29. Deep UV LED Applications to Improve Water Quality

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According to the World Health Organization (WHO) 1.1 billion people lack access to any form of sanitized water. Of these, 1.6 million die every year from diarrheal diseases with 90% of the individuals being children under five. Standard Current disinfection involves costly reverse osmosis membrane systems and highly concentrated fluorine/chlorine systems. Chemical systems require efficient monitoring and the proper disposal of highly concentrated chemical wastewater. Reverse Osmosis systems result in the loss of up to 60% of the treated water and require a high-pressure pump to move the water against the gradient. Current Ultraviolet (UV) systems use low and medium pressure mercury and xenon lamps. These systems require high input power, contain hazardous materials, and require a warm-up time before providing optimal UV dosage. An economically and environmentally viable alternative is the use of narrow wavelength Deep Ultraviolet Light Emitting Diodes (DUV LEDs). DUV LEDs are compact, require lower input power, and contain no hazardous materials. Their size allows for easy adaptation to existing disinfection systems and/or molding into new and improved designs. Using narrow wavelength DUV LEDs in the UV-C range (240-290nm) the system would maximize DNA absorption of UV light and critically damaging microbial DNA while preventing the creation of dangerous by-products. Furthermore, the lifetime of DUV LEDs is significantly higher compared to mercury and xenon lamps allowing for longer usage before replacement and maintenance must be performed. Under low flow testing (100mL/minute) a 6 LOG bacterial and 4.15 LOG viral disinfection rate was achieved . Newer and more efficient system design will maximize optical power dosage and contaminated water residency time.

30. Determination of Turbidity and Particle Removal by Using Alum in a Water Treatment Pilot Plant

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This two-day troubleshooting pilot plant operation addressed design and operating issues that may happen in a full-scale water treatment plant and in order to provide empirical evidence for enhancing turbidity removal. A water treatment pilot plant, which should be operated with the same processes and in proportional dosages as a full-scale water treatment plant, is designed to reduce production and efficiency risks. A proper alum dosage was selected by jar testing, operating settings were modified with proper plant design criteria, and settled turbidities as well as particle counts of water were tracked to identify issues in the plant. By solving the issues, and with the alum dosage of 24mg/L, the settled turbidity was reduced from 10.084NTU to 3.159NTU, achieving a 68.67 percent of removal. Removal of 99.86 percent, 99.94 percent, and 99.96 percent was achieved to particle counts of 2 to 3 microns, 3 to 5 microns, and 5 to 7 microns. The settled turbidity and particle counts reduction showed that in order to achieve better

turbidity removal, larger particles as well as smaller particles need to be cohered, especially those with a size smaller than 2 microns, by using a proper but not a higher concentration of coagulant and proper flow rates. Note that a higher concentration of coagulant does not mean better performance. Although there were several limitations in this study, the main ones would be that the filtered turbidities were not accurately tracked and that parallel experiments were not conducted.

31. Removal of Aluminium From Filter Backwash Water Using Adsorbents and Geotextiles

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Aluminium present in filter backwash water (FBWW) at the J. Douglas Kline Water Treatment Plant (JDKWTP), located in Halifax, Nova Scotia, represents a challenge for environmental compliance. The aluminum (Al) concentration in the FBWW sometimes exceeds the provincial regulation of guidelines of 184 (µg/L). The utilization of alum (Al2(SO4)314H2O) coagulation during treatment operations is the predominant source of this aluminum. The aim of this study is to investigate utilizing adsorbents and geotextiles to reduce total and dissolved Al concentration and total suspended solids (TSS) in the FBWW. Three adsorbents; calcium oxide (CaO), magnesium oxide (Mg0) and ferric oxide (Fe2O3) and several combinations of these adsorbents were investigated in the study. In addition, Tencate GT500 woven dewatering textiles were chosen as filter media to remove Al as well as to minimize TSS from the adsorbent-treated FBWW. An optimal dosage of cationic polymer was also considered to assist with the acceleration of floc formation to achieve a better removal efficiency. For the testing, 1 mg/L of cationic polymer was utilized considering both pH adjustment (approx. 6.5) and without pH adjustment conditions. Adsorbent dosage was increased stepwise with an addition of 0.1~5.0 gm per liter in the FBWW resulting in recoveries of total Al between 95% to 98% using MgO and CaO and around 83~89% using ferric oxide. Reduction of TSS was also achieved in these trials. Geotextiles also used to efficiently remove TSS and total Al concentrations. Future work will focus on the optimal dosage of adsorbents to be used as well as investigating some potential removal mechanisms in the treatment process.

32. Kinetics study of 17α-ethinylestradiol (EE2) Photodegradation in fresh and saline water

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The photodegradation of 17α-ethinylestradiol (EE2), a common endocrine disrupt chemical in the aquatic environment, was investigated in deionized water and saline water under irradiation of high voltage Xe lamp (oriel). The data was well fitted by the pseudo-first-order kinetics. No significant difference was found in the rate constant (k) at different initial EE2 concentrations. The effect of pH (6 to 11) on direct photodegradation was studied in the presence of 10 mM Na2HPO4 buffer. The values of k were found to increase dramatically with the value of pH increasing from 9 to 11. The effect of salinity on photodegradation of EE2 was also evaluated. The salinity of water was adjusted by NaCl. The results showed that the presence of NaCl even at very low concentration

(0.00015 M) inhibited the photodegradation of EE2, and the inhibition increased with the increase of NaCl concentration.

33. The ecology and locational preferences of microalgae and bacteria in granular biofilms used for treating wastewater

Kristie Stauch-White, Camilla Kuo-Dahab, Chul Park, Caitlyn Butler
University of Massachusetts, Amherst, MA

Algal-sludge granules cultivated in our lab self-sustain oxygen production eliminating the need for aeration while achieving nutrient removal, saving the U.S. up to 75 billion KWh per year. These granules meet multiple treatment objectives, settle easily from the treatment stream and can be used as a bioenergy feedstock.
The goal of this project is to understand the ecology of phototrophic granules used for treating wastewater. Microscopic studies of mature granules indicate a predominance of filamentous cyanobacteria, along with planktonic and filamentous algae and heterotrophic bacteria. Measurements of chlorophyll a and quantitative polymerase chain reaction (qPCR) of 23S plastids selecting for phototrophs and the 16S gene for bacteria support these observations. Ongoing work further explores population dynamics and syntrophic relationships between phototrophs and heterotrophs both in mature granules and during granule cultivation. Isolation and subsequent pure culture studies will demonstrate selective co-cultures achieving positive granulation. Micro-profiling of granules at incremental depths reveals layers of oxic and anoxic zones. Future micro-profiling experiments will similarly show nitrogen species, and pH, thus prescribing bacteria and algae species locational preferences within granules. qPCR and RT-qPCR for functional genes will indicate nitrogen cycling, metabolic activity and pigment production.

34. Azufre River Sediments as an Inoculum for MFCs: Boon or Bane?

Cynthia J. Castro, Ignacio T. Vargas, Caitlyn S. Butler
University of Massachusetts, Amherst, MA

The extreme high Andean environment of Northern Chile has been of special interest because of its unique climate and hydrological features. The Azufre River, located in the Lluta watershed and originating at the foot of the Tacora volcano, has been exposed to mine tailings and rock deposits that produce an environment of low pH and high salinity. The river is also contaminated by minerals, such as sulfate, arsenic, and iron, and organic matter. Leiva et.al. (2014) detected chemoautotrophic and heterotrophic arsenite oxidizers at the site. Electrochemically active bacteria, bacteria that can use a solid electrode as an electron donor or acceptor, such as iron, have the potential to exist in this unique environment. I hypothesize that microorganisms from the Azufre river sediments can create a more robust anode-respiring biofilm when combined with microorganisms present in municipal wastewater (WW). Such a biofilm could be used to degrade complex organic waste streams such as human waste in extreme environmental conditions while simultaneously enhancing the power production that can be attained in a microbial fuel cell (MFC) that is inoculated with only wastewater for human waste degradation.

To assess the performance of two inoculums (Azufre sediments + WW or just WW), single-chamber air-cathode MFCs were constructed and operated in batch mode under various low pH and high conductivity conditions. Starch was used as the substrate, as it most resembles the composition of human waste. Preliminary results have shown that power production in reactors that included sediments from the Azufre River produced 0.9 +/- 0.4 mW/m2 while reactors with only wastewater inoculum produced 0.3 +/- 0.1 mW/m2 under normal conditions (pH 6.3, conductivity 5.0 mS/cm). Under stressed conditions, power production was notably higher in the mixed inoculum reactor at pH 6.3 and a conductivity of 27.0 mS/cm.

35. Differences in Methane, Carbon Dioxide and Nitrous Oxide Fluxes between IFAS BNR Tanks at Field's Point Wastewater Treatment Plant

Katherine Lynch, Elizabeth Brannon, Serena Moseman-Valtierra, James McCaughey
University of Rhode Island, Kingston, RI

In 2004, RI passed legislation that placed nitrogen removal requirements on wastewater treatment plants (WWTPs). In response to this, ten tanks at the Fields Point WWTP were upgraded by 2013 to perform integrated fixed film activated sludge (IFAS) biological nitrogen removal (BNR). However, this process may also release potent greenhouse gases including methane (CH4), carbon dioxide (CO2) and nitrous oxide (N2O) that contribute to global climate change. At Field's Point, CH4, CO2 and N2O fluxes have been measured in one of the ten IFAS BNR tanks on a bimonthly basis. The purpose of this project is to determine how representative CH4, CO2 and N2O fluxes from a single tank may be by measuring spatial variability among 3 randomly selected tanks. On three dates in June and July 2015, CH4, CO2 and N2O fluxes were measured from these three IFAS BNR tanks at Field's Point. Measurements were focused in the re-aeration zone of each tank using a floating chamber connected via tubing to the Picarro G5208, which measures CH4, CO2 and N2O simultaneously in real time. Due to the potential for large hourly variability in fluxes, tank one was measured before and after the measurements of the two additional tanks to determine if the fluxes had significantly changed over the measurement period. There was a significant difference in CH4 and CO2 fluxes, but not N2O fluxes from the three tanks. On average, tank one had the lowest CH4 and CO2 fluxes out of the three tanks. When testing for temporal variability, there was a significant difference between initial and final N2O fluxes in tank one, but CH4 and CO2 fluxes did not vary. Therefore, data that have been collected at Field's Point from tank one may represent a conservative estimate of total CH4 CO2 and N2O fluxes from all ten tanks.

36. Using stopped flow fluorometry to directly measure the permeability and selectivity limits for aquaporin-containing desalination membrane active layers

Jay Werber, David Richards, Corey Wilson, Menachem Elimelech
Yale University, New Haven, CT

Aquaporins are integral membrane proteins that can have remarkably high water permeability and complete solute rejection, even for small neutral solutes such as urea. Recently, it was suggested to incorporate aquaporin into desalination membranes to take advantage of these transport properties, and since then, much progress has been made towards this goal. However, the field still lacks clarity on what the ultimate potential is

for these membranes in terms of permeability and selectivity. In this study, the solution-based stopped flow technique with fluorescence self-quenching is being used to directly measure the water and solute permeabilities of self-assembled lipid and block copolymer vesicles, with and without aquaporin. Results have shown thus far that the technique is robust, and that water permeabilities are highest for poly(methoxazoline)-poly(dimethylsulfoxide)-poly(methoxazoline) triblock copolymer vesicles (0.22 L m-2h-1bar-1), followed by phosphocholine-based lipid vesicles (0.08 L m-2h-1bar-1), and lastly by poly(butadiene)-poly(ethylene oxide) diblock copolymer vesicles (0.015 L m-2h-1bar-1). As the selective layer of a desalination membrane would have largely the same composition as the vesicle bilayer, lessons gained from this study will set the limits for what can be achieved using aquaporin-based membranes.

37. Simultaneous bio-remediation of leachate and production of algae for biofuel
Kaitlyn Sniffen, Christopher M. Sales, Mira S. Olson
Drexel University, Philadelphia, PA

Currently, the growth of algal biomass for the production of biofuel is not fully economically competitive with traditional fossil fuels. Coupling algae growth with existing infrastructure or processes may help offset this cost imbalance. Waste sources such as landfill leachate, which are expensive to treat but also contain high concentrations of nutrients (N and P) and minerals (Fe, Mg), can be used as growth media for the algae while simultaneously reducing the cost of treatment for the leachate, due to the algae's removal of nutrients. The use of untreated landfill leachate as nutrient media for algae was tested over the course of 22 weeks in two 15-gallon Plexiglas tanks. These open tanks were located in an urban greenhouse with no supplemental environmental controls, and acted as a treatment system for the leachate. Tanks were operated as semi-batch reactors with a hydraulic residence time of 21 days. Over the course of 22 weeks, biomass reached a maximum density of 480mg/L, with a maximum growth rate of 25.6mg/L/day. Nitrogen consumption rates increased with increasing influent concentration, up to 80 mg NH4/L, when a maximum rate of 8.43 mgN/L/day was achieved. Above 80 mg NH4/L, rates of nitrogen consumption decreased substantially, demonstrating the potential toxic effects of high ammonia concentrations on algal activity.

Nanotechnology

38. Influence of Capping and Sulfidation on the Deposition of Silver Nanoparticles
Joseph Murphy, Yunqi Chen, Boris Lau
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The environmental fate of nanoparticles (NPs) relies heavily on the surface properties of the NPs. Recent studies have shown that most of silver (Ag) NPs at the effluent of wastewater treatment plants are sulfidized. Understanding the impact of NP surface functionalization and sulfidation can provide insight on their transport in aquatic systems. Using dynamic light scattering and quartz crystal microgravimetry (QCM), we observed the role of surface ligand type and density on the aggregation and deposition dynamics of 50 nm Ag NPs. At pH of 7 and an ionic strength of 5 mM NaNO3, QCM results show

that “transformed” polyvinylpyrrolidone (PVP)-capped AgNPs (i.e., the AgNPs that are sulfidized in the presence of natural organic matter (NOM)) deposited over times more than “pristine” PVP-capped AgNPs on NOM-coated silica substrate. On the other hand, both “pristine” and “transformed” citrate-capped AgNPs had no observable deposition under the same experimental conditions. This indicates that, both in the presence and absence of sulfidation, citrate-capped AgNPs are more difficult to be immobilized (i.e., easier to persist) than PVP-capped AgNPs. With the use of solvent cleaning and UV cleaning to partially/completely remove PVP from AgNPs, additional deposition experiments are currently underway to investigate the impact of ligand thickness/density.

39. Impact of hematite nanoparticle size and shape on functions for water treatment
Nicholas Billmyer, Amanda Lounsbury, Julie Zimmerman
Yale University, New Haven, CT

Traditional nanoparticle theory suggests that smaller particle size, and greater surface area impacts functions such as adsorption and photoreduction. Further, degrees of crystallinity have also been suggested to impact these functions. However, there has been little work towards spanning the gap between particle morphology, crystallinity, and subsequent particle reactivity. Hematite (α-Fe2O3) offers a unique approach to explore these relationships. There are numerous techniques to synthesize different size and shaped hematite nanoparticles in a controlled manner. Further, α-Fe2O3 has great potential for application in water treatment due to its thermodynamic stability, abundance as well as adsorptive and photoreductive properties.

Hematite nanoparticles were successfully synthesized by use of several traditional methods, including hydrolysis, hydrothermal, and annealing of geothite particles. The effects of pH, anions in solution, and thermal exposure have been examined. The results indicate that different shapes and sizes of hematite nanoparticles have a direct impact on adsorption and photoreactivity.

40. Design and Development of an Analytical Method for the Detection of Nanoceria Particles
Ali Othman, Gonca Bulbul, Silvana Andreescu
Clarkson University, Potsdam, NY

Nanoceria is currently used in various catalytic processes due to their unique chemical and electronic configuration. These particles are characterized by high reactivity, and catalytic properties which make them useful for implementation in many practical applications. In addition to the recently discovered therapeutic applications, nanoceria has been used as fuel additive, as a fuel-borne catalyst and as abrasives in printed circuit manufacture to decrease the emission of particulate matter from diesel engines and to lower the generation of diesel exhaust particles (DEPs), but are emitted as cerium oxide nanoparticles (CeO2) along with DEP in the diesel exhaust. Studies show that these nanoparticles may induce lung injury and co-localized in the lung tissues after combined exposure. Moreover, CeO2 induced sustained inflammation and surfactant accumulation, and altered the balance of mediators involved in tissue repair process leading to excess collagen deposit and pulmonary fibrosis. Thus, the release of these nanoparticles into the

environment may cause health concerns. Methods to determine the concentration of these nanoparticles under conditions relevant to environmental and biological systems are needed to determine the level of exposure and provide concentration limits for toxicological testing. In this presentation, we demonstrate design and development of a new method for the detection of nanoceria particles (CeO2). The method is based on the use of different organic ligands (chelating agents) such as ascorbic acid and catechol that are used to recognize and catalytically amplify signals, aiding in the detection of the nanoceria particles in the environment. The analytical capability of our approach and a potential implementation of this method for real world applications will be discussed.

41. Nano-impact Electrochemistry: A New Approach to Study the Adsorption/Desorption of Environmental Contaminants with Single Particle Resolution

Anahita Karimi, Daniel Andeescu, Silvana Andreescu
Clarkson University, Potsdam, NY

The electrochemical study of single particle impacts with an electrode is a rapidly developing field which provides extensive and unique capabilities for the detection and characterization of nanoparticles. Here, we report the applicability of single nanoparticle collision method to detect, evaluate and predict contaminates' reactivity in water-containing environment. Engineered metal oxide nanoparticles have been used for the removal of contamination from water. By this technique, the removal efficiency by nanoparticles and the interaction process can be monitored and the performance evaluated with the single particle resolution.

42. Hydrolyzed Poly(acrylonitrile) Electrospun Ion Exchange Fibers

Manisha Jassal, Sankha Bhowmick, Sukalyan Sengupta
University of Massachusetts, Dartmouth, MA

Ion-exchange materials have received widespread attention in recent years but the morphology of ion-exchangers is limited to spherical beads or membranes, creating limitations of applicability. In this study, we report a potential ion-exchange material developed from poly(acrylonitrile) fibers that was prepared by electrospinning followed by alkaline hydrolysis (to convert the nitrile group to carboxylate functional group). Characterization studies performed on this material using X- ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), Fourier-Transform infra-red spectroscopy (FTIR) and ion chromatography confirmed the presence of ion-exchange functional group (carboxylate). The hydrolysis conditions were optimized to obtain an ion-exchange capacity of 2.39 meq/g. Ion-exchange capacity for different forms of PAN polymer, i.e. powder, micron-sized fibers and electrospun sub-micron fibers was also compared. The results show that under same hydrolysis conditions, electrospun sub-micron sized fibers have the highest ion-exchange capacity compared to other polymer forms. This work demonstrated that sub-micron fibers can be synthesized with significant ion-exchange capacity that can be used as an efficient ion-exchange material.

43. Environmental toxicity of engineered nanoparticles in CMP effluents
Dinusha Karunaratne, Eduard Dumitrescu*, Kenneth Wallace, Silvana Andreescu
Clarkson University, Potsdam, NY

Chemical mechanical planarization (CMP) is a wafer polishing technique used for removing of excess deposited materials during the manufacturing of integrated circuit (IC) chips in semiconductor industry. The CMP slurry, an aqueous dispersion containing engineered nanoparticles (ENPs) as the abrasive element and other chemical additives, is the major component affecting the polishing process. The chemical additives in the slurry selectively dissolve the materials present on the wafer surface, while nanoparticles, such as silica, ceria or alumina, mechanically remove the chemically modified surface film through abrasion. However, none of these slurry components are incorporated into the semiconductor product. Instead, they are eliminated through CMP effluents along with dissolved and particulate materials removed by the polishing process. Therefore, the CMP effluents might be a threat to the acquatic environment. Here, zebrafish embryos are used as a biological model in order to determine the toxicity of original slurries and CMP effluents containing nanoparticles and common chemical additives. The lethal effects of the individual slurry components and their mixtures are studied using viability assays, where the mortality and malformation rate are assessed. Furthermore, the compositional change of a CMP slurry throughout a particular CMP process is discussed. For this purpose, the nanoparticles in the slurries are characterized before and after the CMP process. We suggest that the chemical additives may change the physiochemical properties of the nanoparticles which consequently induce lethality and developmental defects in zebrafish embryos.

44. Evaluating the potential cytotoxicity of engineered nanomaterials towards waste- and drinking water biofilms
Sanaz Alizadeh, Kim Maren Lompe, Benoit Barbeau, Yves Comeau
École Polytechnique de Montréal, Montreal, QC

Over the last decade, exponentially growing applications of engineered nanomaterials (ENPs), and their consequent release into the environment have raised concerns about their impact towards aquatic biota. The potential of engineered nanoparticles to produce toxic concentrations of reactive oxygen species (ROS) and interaction of ROS with key cellular components are proposed as the premier mechanics of toxicity of nanomaterials. Currently, there is significant paucity of knowledge regarding long-term consequences of ENP release and the mechanism of cytotoxicity in biological water and wastewater treatment plants.

In order to better understand the potential cytotoxic mechanisms of ENPs in typical waste-and drinking water biofilms, we carry out dose and material dependent fluorometric well-plate assays, using 2’7’-dicholorofluorescein–diacetate (H2DCF-DA), The aim is to quantitatively assess the intercellular ROS production rate in aquatic biofilm samples after exposure to silver (50 nm), zinc oxide (30nm) and magnetic iron oxide ENPs (10 nm). Biofilm is grown in lab-scale reactors and later exposed to low (0.1-5 ppm) and high (100 – 500 ppm) concentrations of ENPs. Transmission electron

microscopy (TEM-EDS) is used to determine spatial distribution of ENPs in the biofilm samples.

The concentration-dependent ROS production of ENPs was observed during first ROS test. Our preliminary results demonstrate significant ROS production initiated by zinc oxide and silver ENPs at low doses but no or only low effect with iron oxide ENPs. This study will contribute to a better understanding of ENPs-biofilm interaction in biological water treatment facilities.

45. Graphene Oxide nanofiltration membrane by means of Langmuir-Blodgett molecular assembly

Carlo Alberto Amadei
Harvard University, Cambridge, MA

Carbon nano-architectures are emerging as valid alternative to inorganic ceramic and polymeric membranes for nanofiltration membrane (NFM). In particular, 2D graphene oxide (GO) is capturing the interest of the scientific community for its low-cost and high throughput synthesis process from oxidation of graphene flakes (i.e. Hummers' method). In this work, we report the fabrication of GO-NFM on porous Polyvinylidene fluoride (PVDF) membrane. The fabricated membranes (GO-PVDF) are characterized by surface science techniques, such as scan electron microscope, atomic force microscope, displaying a GO film thickness of less than 50 nm. Such a low thickness was achievable thanks to the GO casting process, which is based on Langmuir Blodgett (LB) molecular assembly. This technique allows a better controlled GO casting process compared to traditional techniques (e.g. vacuum filtration, VF). Water permeability tests display a different behavior between the membranes obtained by the two techniques (LB and VF) due to the different molecular assembly of the GO layers. This work could represent the link between pristine nanometer-graphene-thin membranes obtained by bottom up approach and micrometer-GO-laminate membranes obtained by VF or SC.

Environmental Engineering

46. Bioaccumulation of Hydrophobic Organic Contaminants in Benthic Invertebrates

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In order to maintain shipping channels in NY-NJ Harbor, approximately two to four million cubic yards of bottom sediment need to be dredged each year. Approximately 70% of the dredged material is considered contaminated under current regulations. This is mainly the result of the transfer of hydrophobic organic contaminants (e.g. PAHs, PCBs, PCDD/Fs) into the sediment and subsequently to invertebrates that serve as the base of the benthic food chain. Typically this transfer of contaminant to benthic invertebrates is determined based on 28 day bioaccumulation tests. The ability to predict the bioaccumulation in benthic invertebrates is important in evaluating the suitability of dredged material for beneficial reuse and in determining effectiveness of various remediation options at contaminated sediment sites.

In order to gain a better understanding of the bioaccumulation of hydrophobic organic contaminants in benthic invertebrates, a mechanistic model has been developed in Microsoft Visual Basic for Applications. The model has been used to evaluate the effects of various factors on bioaccumulation behavior. These include: organic carbon and non-organic (black) carbon content of the sediment; partitioning behavior; bioenergetics of the organisms (as defined by organism growth, respiration, ingestion, egestion rates); gut partitioning; and effect of chemical uptake through ventilation versus diet. 28-day bioaccumulation test data are being analyzed using Biota Sediment Accumulation Factors (BSAFs), and BSAFs from the test data are being compared to model calculated values to determine model performance.

47. Per-sulfate oxidation studies for effective removal and regeneration of perfluoroalkyl contaminant compound sorbed granular activated carbon"

Nageshrao Kunte, Dinusha Siriwardena, Michelle Crimi, Thomas Holsen, Christopher Bellona
Clarkson University, Potsdam, NY

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) are characterized as contaminants of concern. Their ubiquitous presence in environmental media including groundwater has initiated awareness for the need of remediation techniques. In situ chemical oxidation of sorbed PFASs is a treatment approach to remediate contaminated groundwater which incorporates the sorption of PFASs onto granular activated carbon (GAC) in situ followed by effective contaminant treatment and regeneration of the carbon using chemical oxidation. Amongst oxidation methods, heat activated persulfate is indicated as a promising approach for effective degradation of PFASs. The purpose of this study was to evaluate the effectiveness of in situ persulfate oxidation and to establish dose standards considering by-products and varied groundwater conditions. The laboratory study focuses on more commonly detected long chain PFAS perfluorooctanoic acids (PFOA) and perfluorooctane sufonic acid (PFOS). Two different types of Filtrasorb brand of GAC manufactured by Calgon Corporation, which have shown efficient adsorption capacity according to previous experimental results, are first employed to develop adsorption isotherm and sorption kinetic data. The carbon containing sorbed PFOA and PFOS are then exposed to persulfate heat activated at 80°C. The presentation focuses on experimental results that represent the impacts of varied groundwater conditions such as persulfate loading rate, sulfate concentration, pH, and co-contaminant concentration during PFASs degradation. The prospective features of per-sulfate oxidation in ISCO application will also be described.

48. An Investigation Of Microbially Induced Calcite Precipitation For Reducing Fracture Permeability Of Rocks

Nicholas Bucci, Huijie Lu, Ehsan Ghazanfari
University of Vermont, Burlington, VT

Microbially Induced Calcite Precipitation (MICP) is a bio-geochemical process that induces calcium carbonate precipitation within a pours media matrix. MICP has been widely studied over the past decade for its potential applications as bio-cement relating

to, hydrology, and environmental remediation. Preventing contaminant migration via fracture networks in bedrock is one of the main focus points in many of the engineering applications today. For example, it is necessary to properly seal the host and cap rocks for subsurface containment of captured CO2, and it is critical to seal the access shafts while constructing nuclear waste disposal facilities. These are two of the many potential applications that MICP can prove beneficial to with regard to reductions in permeability. MICP offers an attractive alternative to traditional grouting/cementation technologies due to its low viscosity reagent and low-pressure application technique. The success of MICP implementation for rock fracture sealing and permeability reduction needs to be evaluated more comprehensively based on the distribution of CaCO3 precipitation in situ, the strength of precipitate bonding with the fractures, and the resistance of precipitates to long-term persistent changes in temperature, pressure, or groundwater flows in subsurface environments. This research is working to develop the necessary laboratory methodologies, apparatuses, and procedures that are required to generate accurate data which will support the hypotheses about MICP use in situ, in the future. Preliminary experiments conducted with sandstone suggest permeability reductions as high as 80% after being treated with MICP. These preliminary findings are extremely encouraging for the success of the research's ultimate goals: To have substantial broader impacts in education, outreach, and execution on the development of sustainable and reliable subsurface remediation and mitigation alternatives.

49. A Comparison of Cryptosporidium spp. Monitoring Systems in a Pennsylvania Watershed

Jenelle Fortunato, Kristen Jellison
Lehigh University, Bethlehem, PA

Cryptosporidium parvum is a host-specific waterborne parasite that causes gastrointestinal illness and is potentially life-threatening in immunocompromised persons. The challenges in treating Cryptosporidium spp. arise from its resistance to chlorine disinfection and the fact that it is too small to effectively filter. Characterizing Cryptosporidium spp. contamination in watersheds, through enumeration and genotyping of oocysts, provides pertinent information regarding the origins of the parasite and the associated public health risks. The current protocol for detecting Cryptosporidium spp. in municipal watersheds is detailed in EPA Method 1623. However, the cost of the filters employed in this protocol and the inability to both enumerate and genotype Cryptosporidium spp. oocysts within the same sample are two drawbacks to this method. The goals of this project are three-fold: to develop a cheaper alternative for oocyst detection using biofilms in place of filters; to identify correlations among biofilm development, oocyst detection, and various water quality parameters to determine optimum conditions (e.g., watershed locations and times of year) for utilizing the biofilm system for oocyst monitoring; and to develop a protocol that allows enumeration and genotyping of Cryptosporidium spp. oocysts within a single sample. Data collected from a watershed near Philadelphia, PA have shown that biofilms and filters have similar detection rates; in fact, among positive samples, biofilms have a higher average capture rate per sample. Several correlations among biofilm development, oocyst detection, and water quality parameters were observed at certain sites. Lastly, a protocol has been developed that allows for oocysts to be removed from a microscope slide following

enumeration and processed through DNA extraction and PCR (positive PCR samples could then be genotyped), which has shown successful detection of less than five oocysts.

50. How Bacteria Stay Wet In Dry Soil - The Sticky Truth
Brian C. Cruz, Leslie M. Shor
University of Connecticut, Storrs, CT

The retention of soil moisture between rainfall or irrigation events is imperative to the growth and productivity of agricultural crops. As global climate change progresses, widespread reduction in soil moisture due to amplified extreme weather events is predicted. As a result sustainable agriculture technologies are required to modulate extreme variations in soil moisture. Microbial produced extracellular polymeric substances (EPS) have the ability to influence soil moisture by (i) retaining water directly within their carbohydrate-rich hydrogel matrix, and (ii) promoting an aggregated soil structure. Using a microfluidic device which emulated a sandy-loam soil microstructure, increased moisture retention was observed in solutions of artificial groundwater containing EPS producing bacteria; however, biofilms of EPS producing bacteria not contained within the microstructure environment were unable to demonstrate increased moisture retention, suggesting EPS requires a microstructure environment to provide its moisture retention properties. The objective of this study was to compare moisture retention by EPS producing bacteria in microfluidic devices which emulated two soil aggregation states. The different aggregation states were defined by differences in soil micromodel pore size distributions, with “aggregated” devices containing an increased number of small (<30um) and large (>100um) pores while “non-aggregated” devices contained more medium (30-100um) pores. Two strains of EPS producing (EPS+) and non- producing (EPS-), GFP-expressing Sinorhizobium meliloti were compared within each micromodel. Devices were contained within an environmental control chamber and desiccation conditions were induced by reducing the relative humidity from 100% to 83%. Results showed EPS+ bacteria induce greater moisture retention than EPS- bacteria in both soil device geometries. Moisture retention by EPS+ bacteria was increased in aggregated soil micromodels when compared with non-aggregated devices. This work suggests a synergy between microbial EPS and soil microstructure which enables increased moisture retention, and may enable development of biotechnologies to improve moisture retention and enhance agricultural productivity.

51. Inactivation of E. coli by UV Light Emitting Diodes (LED) – A Review and Initial Steps for Implementation in Rural Communities
Carmen Carolina Ontiveros Verdugo, Sean MacIsaac, Graham Gagnon
Dalhousie University, Halifax, NS

Ultraviolet radiation can be used for the disinfection of drinking water. Short-wave ultraviolet radiation (200 to 290 nm) is the most common UV Radiation (UV) used in water treatment. In many instances, inactivation of viruses, protozoa and bacterial pathogens by UV has been demonstrated. A lot of people who live in rural areas, do not have reliable access to microbiologically safe water. Many researchers are interested in UV technology as a potential point of use (POU) disinfectant for places with difficult access to clean water, however traditional mercury based lamps require constant power

sources which can be costly or unreliable in rural areas. UV technologies with light-emitting diode (LED) emit UV-C wavelengths comparable to mercury discharge; they are free of heavy metals and have low-power consumption. Based on a literature review and preliminary experimental research this research will evaluate the appropriate application for UV LED in rural communities. The experimental approach for this work will utilize a UV LED collimated beam (AquiSense Technologies) that of emitting UV light at 255 nm, 265 nm and 285 nm. The research will utilize E. coli as a target microorganism and will compare initial disinfection with tradition UV disinfection using mercury based UV and work that has been reported in the literature. The work will describe future steps for implementing UV LED technology for ensuring safe water in rural communities.

52. Management of Sediment in Paradise Pond, Northampton, Massachusetts
Maya Domeshek, Miatta Ndama, Robert Newton, Molly Peek, Marney Pratt, Marcia Rojas, Lizzie Sturtevant, Lyn Watts*
Smith College, Northampton, MA

Paradise Pond (3.7ha) lies on the Smith College campus in Northampton, Massachusetts upstream of a small dam on the Mill River. Sediment trapped in the pond from the 140km2 upstream watershed must be removed on a regular basis. This was traditionally done on ~8-year cycle through a dry excavation method where the pond was drained and sediment removed by heavy equipment, although the 2008 dredging was done using a hydraulic dredge. A total of 43,500m3 of sediment has been removed from the pond since 1998. More recently, the idea that sediment could be released into the downstream reach without harming the ecosystem has inspired a sluicing experiment.

The Paradise Pond Sluicing Experiment will use the drainpipe at the bottom of the dam to sluice sediment from the pond downstream. This will be done during high flow events to mimic the natural transport of sediment. A series of 5 downstream reference stations has been established to monitor changes in channel morphology, bottom sediment characteristics, and a suite of biological stream health parameters. Sediment cores have been collected from Paradise Pond and Hulberts Pond, located in a partially filled downstream oxbow. Analyses of these cores show no significant differences between upstream and downstream sites.

Sediment accumulation in Paradise Pond is monitored through the creation of a series of bathymetric maps. Sediment movement in the pond during hydrologic events is measured with an Acoustic Doppler Current Profiler (ADCP) using static moving bed tests. To date, sediment movement has been detected at a number of locations in the pond, including near the dam, at discharges as low as 360cfs. It is likely, however, that coarser sediment will need to be moved closer to the dam before it can be sluiced from the pond.


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