The 20th Annual Environmental Chemistry and Microbiology Student Symposium

April 21st -22nd, 2017

The Pennsylvania State University

University Park, PA

The 20th Annual Environmental Chemistry and Microbiology Student Symposium (ECMSS) at the Pennsylvania State University is proudly presented by the Student Association of Environmental Science and Engineering (SAESE), and is supported by the Penn State Institutes of Energy and the Environment (PSIEE), the University Park Allocation Committee (UPAC), Environment and Natural Resources Institute (ENRI), the Engineering Energy and Environment Institute (E^3I), the Graduate and Professional Student Association (GPSA), and Materials Research Institute (MRI), Department of Civil and Environmental Engineering, Department of Plant Science, Department of Geosciences, and the Department of Chemistry.

Cover Photo: The other side of Niagara Fall, Canada

Xiong Lei, First Place Photo Contest Winner

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Welcome

The organizing committee of the 2017 Environmental Chemistry and Microbiology Student Symposium (ECMSS) welcomes you to Penn State's main campus in University Park, PA. ECMSS, now in its 20th year, is a long standing tradition at Penn State that brings together graduate and undergraduate students, post-doctoral researchers, and faculty members engaged in environmentally relevant research. The Student Association of Environmental Science and Engineering (SAESE) organizes ECMSS, with an interdisciplinary graduate student committee whose members have worked to provide a unique, enriching opportunity to the environmental science and engineering community at and around Penn State.

This year, the ECMSS organizing committee is honored to host three keynote speakers, including Dr. Margaret Torn (Lawrence Berkley National Lab), Dr. Monroe Weber-Shirk (Cornell University), and Dr. Arup SenGupta (Lehigh University). Additionally, we are proudly hosting nearly 40 student presenters from Penn State as well as several regional universities. Our Penn State participants include students from the Departments of Ecosystem Science and Management, Plant Pathology and Environmental Microbiology, Plant Science, and Agricultural and Biological Engineering in the College of Agricultural Sciences; the Geoscience department in the College of Earth and Mineral Sciences; the Departments of Civil and Environmental Engineering and Chemical Engineering in the College of Engineering; the Departments of Chemistry, Biochemistry and Molecular Biology, and Biology in the Eberly College of Science. We are also pleased to welcome students from Cornell University, Lock Haven University, Lehigh University, Benedict College and Allegheny College.

The ECMSS organizing committee has spent months preparing for this year's event, which would not be possible without the generous support of our sponsors. We would like to recognize and thank the Penn State Institutes of Energy and the Environment (PSIEE), the University Park Allocation Committee (UPAC), the Engineering Energy and Environmental Institute (E^3I), the Environment and Natural Resources Institute (ENRI), the Graduate and Professional Student Association (GPSA), and the Materials Research Institute. We would also like to thank the Departments of Civil and Environmental Engineering, Plant Science, Geosciences and Chemistry for generously donating funds for monetary awards.

We thank you for joining us for this year's ECMSS, and encourage you to enjoy the keynote addresses as well as the student poster and oral presentation sessions. Additionally, we hope you will take the opportunity to forge new connections and gain new insights into other disciplines by communicating with your fellow environmental scientists and engineers. We appreciate your participation this year, and invite you to continue to be a part of the Environmental Chemistry and Microbiology Student Symposium for years to come.

Regards,

The 2017 ECMSS Student Organizing Committee

The 20th Annual ECMSS Keynote Speakers

Dr. Margaret Torn
Ecologist and Biogeochemist, Senior Scientist
Lawrence Berkeley National Laboratory

Keynote Address: Friday 5:00 pm

Biography

Margaret S. Torn is Senior Advisor in the Climate and Ecosystem Sciences Division (CESD) and lead of the Biosphere-Atmosphere Interactions Program Domain at the Lawrence Berkeley National Laboratory. She is lead PI for three large DOE-supported projects: AmeriFlux Management Project, Belowground Carbon Cycling Scientific Focus Area, and Land-Atmosphere Interactions, and is co-PI for the Next Generation Ecosystem Experiment in the Arctic. At U.C. Berkeley, Margaret is an Adjunct Professor in the Energy and Resources, where she has taught classes on climate change impacts and adaptation, and a seminar on food systems. Margaret is an ecologist and biogeochemist who studies the natural carbon cycle and human impacts on the carbon cycle through land use, energy use, and climate change. Her research uses field experiments, isotopic tracers (14C, 13C), laboratory analysis, and mathematical models. She has published more than 100 peer-reviewed articles on topics ranging from the basic mechanisms of soil carbon cycling and ecosystem-climate feedbacks, to ecological aspects of bioenergy production, to strategies for climate-change mitigation. She is an internationally recognized expert in soil carbon cycling, seeking to understand the potential for positive feedbacks that amplify climate change on the one hand, and the potential for soils to act as a large carbon sink on the other.

Three Perspectives on the Global Carbon Cycle: Soil, Atmosphere, and Energy

Dr. Monroe Weber-Shirk
TCi Faculty Fellow, ACSF Faculty Fellow,
Department of Civil and Environmental Engineering
Cornell University

Keynote Address: Saturday 1:00 pm

Biography

Dr. Monroe Weber-Shirk received his Ph.D. in Environmental Engineering from Cornell University in 1992. His experiences working in Salvadoran refugee camps in Honduras led him to found the AguaClara program in 2005 to invent sustainable water treatment technologies. He has guided the AguaClara team to invent a series of technologies that together make it possible to produce safe drinking water without using any electricity. He organized the AguaClara program to engage students to conduct research and create a free online water treatment plant design tool. He works to empower partner organizations that in turn empower communities to build, operate, and sustain their AguaClara water treatment plants. *His research* team is investigating methods to improve performance and reduce the cost of drinking water and wastewater treatment.

Creating Community-scale, People and Planet Friendly, Water Treatment Technologies

Dr. Arup SenGupta
P.C. Rossin Professor, Department of Civil and Environmental Engineering, Department of Chemical Engineering
Lehigh University

Keynote Address: Saturday 3:45 pm

Biography

Dr. SenGupta's research interests include preparation, characterization and innovative use of novel adsorbents; ion exchangers; reactive polymers; specialty membranes in environmental separation and development of sustainable environmental processes. He is a leader in environmental technology research and education, and has guided dozens of graduate students to successful careers in engineering practice and research. He has expanded the field of ion exchange science and technology in solving critical environmental problems, and has led to the development of new classes of hybrid ion exchangers that have been incorporated into water and wastewater treatment processes globally. He heads an international, interdisciplinary effort to develop and promote a sustainable treatment system that provides drinking water free of arsenic to thousands of people all over the world. He developed and helped to commercialize the first polymer-based absorbent for arsenic in the U.S., a product that provides arsenic-safe water to well over one million people in both the developing and the developed world.

Nanotechnology (HIX-Nano): Mitigating Fluoride and Arsenic Crisis in Water

Symposium Itinerary

Friday, April 21st

2:00 – 3:30 PM Registration, Presentation Upload, and Poster Setup

3:30 – 4:50 PM Oral Presentations, Session I

Time slot	Presenter	Title
3:30 – 3:50	Wei Zhi	Metal transport enhanced by Dissolved Organic Carbon (DOC) at the watershed scale
3:50 – 4:10	Michael Schmidt	A Combined In Situ ATR-FTIR/XPS Study of the DNA-Goethite Interface
4:10 – 4:30	Angela Possinger	Soil organic matter stabilization via mineral interactions in forest soils with varying saturation frequency
4:30 – 4:50	Sarah Cronk	The importance of iron oxide and organic carbon associations during aerobic biodegradation of peatland soils

4:50 – 5:00 PM Break

5:00 – 6:00 PM Keynote Address: **Dr. Margaret Torn**

"Three Perspectives on the Global Carbon Cycle: Soil, Atmosphere, and Energy"

6:00 – 7:00 PM Catered Dinner & Networking

Saturday, April 22nd

8:00 – 9:00 AM Catered Breakfast and Late Registration

9:00 – 9:10 AM Opening Remarks

9:10 – 10:30 AM Oral Presentations, Session II

Time slot	Presenter	Title
9:10 – 9:30	Madhu Singh	Characterizing soot from vehicle emissions
9:30 – 9:50	Zhang Cai	Impact of mineral spatial distribution patterns on the reactive transport of Marcellus shale waters in natural aquifers
9:50 – 10:10	Moses Ajemigbitse	Reducing the environmental impact of the petroluem industry by waste to resource recovery
10:10 – 10:30	Uyen Nguyen	The influence of pressure on hydrocarbon biodegradation in shallow and deep Gulf of Mexico sediments

10:30 – 10:40 AM Break

10:40 – 12:00 PM Oral Presentations, Session III

Time slot	Presenter	Title
10:40 – 11:00	Sydney Stewart	Explaining the reaction rates between iron oxide-associated ferrous iron and nitrobenzene
11:00 – 11:20	C.M. Ndoun	Charazterizaton and evaluation of carbonaceous materials via the hydrothermal carbonization of unwanted waste pharmaceuticals
11:20 – 11:40	Maliheh Safari	Evolution of a partitivirus in peppers and its effect on aphid behvaior
11:40 – 12:00	Emma Clement	Does a clean bed filtration theory properly predict removal of model microbes in a moringa-coated sand filter?

12:00 – 1:30 PM Poster Presentations (with catered lunch)

1:30 – 2:30 PM Keynote Address: **Dr. Monroe Weber-Shirk**

"Creating Community-Scale, People and Planet Friendly, Water Treatment Technologies"

2:30 – 2:40 PM Break

2:40 – 4:00 PM Oral Presentations, Session IV

Time slot	Presenter	Title
2:40 – 3:00	Leah Hall	*Cryptosporidium* genotypes in a suburban river watershed in southeastern Pennsylvania
3:00 – 3:20	Blake Wadsworth, Andrew Le Clair, & Steven Elgin	Correlating phenotypic/genotypic expression of MDRO's in sewage and surface waters using an amended IDEXX enterolert DST and duplex PCR
3:20 – 3:40	Ehsan Mahdinia	Optimization of *Bacillus subtilis natto* growth parameters in glycerol-based medium for MK-7 (Vitamin K) production in biofilm reactors
3:40 – 4:00	Zena Cardman	Microbial architects of anastomosing cave wall patterns in Frasassi, Italy

4:00 – 4:15 PM Break

4:15 – 5:15 PM Keynote Address: **Dr. Arup SenGupta**

"Development and Globalization of Hybrid Ion Exchange Nanotechnology (HIX-Nano): Mitigating Fluoride and Arsenic Crisis in Water"

5:15 – 5:20 PM Break

5:20 – 5:45 PM Awards Ceremony and Concluding Remarks

5:45 – 6:00 PM Poster Removal

Overview of Poster Presentations

Poster Session I (Saturday 12:00-1:30 pm)		
Poster #	**Presenter**	**Presentation Title**
1	Emma Clement	Does a clean bed filtration theory properly predict removal of model microbes in a Moringa-coated sand filter?
2	Worlasiea Djameh	Low Cost Solar Resource Measurement Instruments using Additive Manufacturing and Microcontrollers
3	Samantha Dutton	Investigation of Bat Guano (Myotis lucifugus) from a Maternity Colony and the Associated Internal Prokaryotic Microbiome
4	Melissa Finley	A Genetics Approach to Understanding the Host-Pathogen Parasitic Relationship of Apple and Erwinia amylovora
5	Jenelle Fortunato	A Flavin-based flow battery that recharges with waste heat or CO2 emissions
6	Prachi Joshi	Using NaCl as a model system to study stable mineral recrystallization
7	Faith Kibuye	Impact of Land Use and Drinking Water Treatment Processes on the Occurrence of Pharmaceuticals and Personal Care Products (PPCPs) in the Susquehanna River Basin
8	Ehsan Mahdinia	Strain and plastic composite support (PCS) selection for Vitamin K (Menaquinone-7) production in Biofilm Reactors
9	Melissa Mattwig	Differences in quality of organic matter, microbial metabolism, and phosphorus species across a trophic gradient of lake sediments in Northwestern PA.
10	Bonnie McDevitt	A Hydrogeological Investigation of Oil and Gas Wastewater Disposal Causing Salinization of Western U.S. Rivers
11	Andrew Murtha	Abstract title given in up to two rows of text, 14-pt. bold, Times New Roman and second line
12	Briana M. Nuñez	Characterization of a Natural Vibrio fischeri Isolate
13	Mohammad Rahimi	Converting low-grade waste heat into electricity using a silver ammonia battery
14	Kara Schelb	Investigating the Microbiome of Myotus lucifugus Populations and Potential for Prokaryotic Isolates as Biocontrol Agents of White Nose Syndrome
15	Arupananda Sengupta	Flow-through capacitive deionization to treat brackish water for irrigation
16	Caroline Steingard	Abstract title given in up to two rows of text, 14-pt. bold, Times New Roman and second line
17	Jonathan Stephens	Abstract title given in up to two rows of text, 14-pt. bold, Times New Roman and second line
18	Travis Tasker	Impact of Spreading Oil & Gas Wastewater as Road Treatments on Groundwater Quality
19	Nicole Urban	Acidogenic Digestion of Duckweed Using Mixed Anaerobic Cultures to Maximize Carboxylic Acid Yields
20	Katherine Van Sice	Elevated Radium Activities in Sediments from Oil and Gas Wastewater Disposal
21	Boya Xiong	Chemical Degradation of Polyacrylamide during Hydraulic Fracturing
22	He Yuting	Observing and Simulating Spatial Variations of Forest C Fluxes and Stocks in Complex Terrain
23	Zhang Huaibin	Anion Uptake by Clays Intercalated with Poly (diallydimethyl ammonium) (PPDA) Cations

Poster Abstracts

Photo Description: Rainbow near Glacier View, Alaska following a brief rain. This scene illustrates the water cycle as the sun melts snow at the caps of the mountains in the distance; the water runs through several streams and rivers. The water is then evaporated and falls as precipitation.

Scott Tustin, Second Place Photo Contest Winner

Acidogenic Digestion of Duckweed Using Mixed Anaerobic Cultures to Maximize Carboxylic Acid Yields

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Abstract

Duckweeds are efficient aquatic plants for wastewater treatment due to their high nutrient uptake capabilities, rapid growth rates, and resilience to variable environmental conditions. In addition, their high starch and low lignin contents make them a competitive feedstock for bioethanol production. Anaerobic microorganisms may convert a broad variety of complex organics (i.e., lipids and proteins) in duckweed into carboxylic acids, which are precursors of higher-value biofuels; however, research in this area is lacking.

In this study, the optimum operating conditions (i.e., solid loading, temperature, and pH) to maximize carboxylic acid production from duckweed were determined using a series of laboratory batch experiments. A mixture of pretreated anaerobic sewage sludge, compost, silage, and rumen fluid was used as an acidogenic inoculum. Batch reactors were fed with dry duckweed with total solids concentrations of 25 g/L, and initial pH was adjusted to either 5.3 or 9.2. Reactors were operated under mesophilic (35ºC) and thermophilic (55ºC) conditions for 21 days.

The highest duckweed-to-carboxylic acid conversion of 0.262 g/g (grams acetic acid per gram total solids) was observed under mesophilic and basic conditions. This result is comparable to those reported for acidogenic digestion of other organics such as food waste. The superior performance observed under these conditions was attributed to both chemical treatment and microbial bioconversion. It is concluded that duckweed is a feasible alternative feedstock for the production of advanced biofuel precursors.

Low Cost Solar Resource Measurement Instruments using Additive Manufacturing and Microcontrollers

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Abstract:

Local solar resource measurement instruments can cost up to $2000. The data collected from these instruments can be used for a broad range of applications from determining micro-climate fingerprint of a location to nutrient uptake by the soil. Designing and building a DIY pyranometer and data logger drastically reduces the cost of the solar resource measurement device. A pyranometer is a photodiode sensor that responds the changes in light intensity. It has been designed using a silicon photodiode sensor with a 3D- printed mounting case. The response in recorded in mV. The data logger uses an SD card breakout board to store the data read from the sensor. The Pyranometer and data logger combination is built using electronic components and a micro-controller (Arduino). This optimizes the performance while reducing the cost. Data from these devices can be used to determine the feasibility of solar array farm or to model the development of crops for given the location. Making the instruments affordable and easily accessible is the goal of the project.

Investigation of Bat Guano (*Myotis lucifugus*) from a Maternity Colony and the Associated Internal Prokaryotic Microbiome

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Abstract:

The invasive fungus, *Pseudogymnoascus destructans* (*Pd*), is recognized as the causative agent of White Nose Syndrome (WNS) in bats. WNS has been noted to have caused over 6.7 million bat deaths in t North America. To date, there is a lack of understanding of the significance of the internal microbiome of *Myotis lucifugus* due to limited published research. The significance of this research will assist in a greater understanding of the prospective role that the internal microbiome has in bat survival. Four sites were established within a maternity colony located at Juniata Valley High School in Alexandria, PA. During May 2016 guano samples were collected at four different time periods from the maternity colony. Guano samples were collected on sterilized plastic sheeting positioned directly beneath the maternity colony. Serial dilutions of the bat guano were streak-plated onto Tryptic Soy Agar (TSA). The streak plates were incubated at 22°C for 24-72h. Isolates were organized and differentiated based on the location of the site where they were collected. Colony and cellular morphology was used to characterize twenty-eight (28) distinctive prokaryotic colonies. Gram-stain and significant biochemical and physiological diagnostic tests were performed on pure cultures of the twenty-eight (28) isolates. Presumptive genera was concluded based on the preliminary data collected by performing traditional diagnostics. Presumptive genera included *Pseudomonas sp., Escherichia sp., Klebsiella sp., Enterobacter sp. Rodoturula sp.,* and *Corynebacterium sp.*. Currently, molecular diagnostics are ongoing. Ribosomal DNA sequencing of each isolate are being performed using oligonucleotide universal primers 27F and 1492R. It is expected that molecular diagnostic data will be presented.

A Genetics Approach to Understanding the Host-Pathogen Parasitic Relationship of Apple and *Erwinia amylovora*

Finley, Melissa[a]* and, McNellis, Tim[a]
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Abstract:

Fire blight, caused by the bacterial pathogen *Erwinia amylovora*, causes detrimental economic losses each year to the global apple and pear industries. This study seeks to further elucidate the parasitic nature of the host-pathogen trophic interaction and how specific metabolic and functional biosynthetic pathways play a role in pathogenicity. Auxotrophic mutants (mutants that are unable to synthesize a particular compound(s) that is necessary for growth) were generated via Tn*5* mutagenesis and isolated with a selective minimal media. The auxotrophs were then inoculated in immature 'Gala' apple fruits in order to monitor changes in their ability to cause fire blight disease. The Tn*5* insertion site in the genome of auxotrophic *Erwinia amylovora* mutants was located via Sanger sequencing, allowing us to determine how disabling different types of metabolic processes affects the ability of the pathogen to induce symptoms. Broadly, this work indicates not only how *Erwinia amylovora* efficiently utilizes available resources during pathogenesis but also illustrates the ways in which the pathogen causes physiological and metabolic changes within the host apple tissues during infection.

A Flavin-based flow battery that recharges with waste heat or CO_2 emissions

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Abstract:

Industrial waste heat and CO_2 emissions are two untapped sources of potential energy. A pH-gradient flow battery would be a novel approach for taking advantage of these large energy reserves. A flow battery containing redox active compounds with pH dependent reduction potentials could be used to generate a pH gradient energy and upon discharge the battery could be recharged using CO_2 emissions or industrial waste heat and ammonia. The goal of the overall study is two-fold: to identify potential redox active compounds that have a pH dependent reduction potential, then to characterize the activity of the compounds in a flow-cell to determine the maximum power production and to what extent the battery can be recharged using CO_2 or waste heat and ammonia. Work presented here focuses on the search for potential compounds. From the compound survey, several Flavin-based compounds have been identified as potential candidates due to their pH dependent reduction potentials, fast electrode kinetics, and stability in O_2. Solubility studies were also performed with each compound to characterize the extent of dissolution in buffered aqueous solutions and the degree to which Nicotinamide increases the solubility of sparingly soluble compounds.

Using NaCl as a model system to study stable mineral recrystallization

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Abstract:

Minerals in natural environments can undergo recrystallization reactions with surrounding fluids after formation in which the mineral structure is preserved but the morphology, trace element content, and isotopic composition can be altered. Understanding the occurrence and driving forces of these reactions is important for using the elemental and isotopic compositions of minerals as proxies to interpret past conditions on Earth. In many cases, minerals such as calcite, barite, and iron oxides can undergo extensive recrystallization reactions, in which atoms in the bulk structure exchange with atoms in solution. Studying these processes in the laboratory is often time intensive, as these recrystallization reactions can take place over hundreds of days. In this work, we examined the extent to which halite (NaCl) could be used a proxy to study recrystallization due to its faster dissolution and precipitation kinetics. We used ^{22}Na as an isotopic tracer to study the recrystallization of halite in saturated Na solutions, and examined the effect of surface area, impurities, surface roughness, and aging of the mineral. Results from these experiments will help us understand the driving force for mineral recrystallization, hopefully improving our understanding of recrystallization for other mineral phases.

Impact of Land Use and Drinking Water Treatment Processes on the Occurrence of Pharmaceuticals and Personal Care Products (PPCPs) in the Susquehanna River Basin

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Abstract:

Occurrence of pharmaceuticals and personal care products (PPCPs) in aquatic systems is a global concern due to PPCPs persistence in the environment and their potential impacts on human and environmental health at trace concentrations. Removal of PPCPs through conventional wastewater treatment is known to be inadequate; however, the efficiency of different drinking water treatment technologies on PPCPs has received limited investigative attention. The goal of this research project is assessing the natural (hydro-climatic) and anthropogenic (land use) controls influencing selected PPCPs occurrence in identified drinking water sources within the Susquehanna River Basin, tracking their step-by-step removal efficiency through six drinking water treatment plants (DWTPs), and assessing their potential persistence in drinking water distribution systems.

Three main sample collection phases are proposed: In Phase 1, the temporal variability of PPCPs in DWTPs source waters will be evaluated through daily and bi-monthly, post storm and post spring rainfall sampling. In Phase 2, removal efficiencies of each DWTPs treatment technologies will be assessed and Phase 3 will investigate the occurrence of PPCPs at points of use within each of the DWTP's distribution networks. The PPCPs of interest are: acetaminophen, ampicillin, caffeine, metformin, naproxen, ofloxacin, sulfamethoxazole, triclosan, and trimethoprim. Sample analysis will be performed through a Thermo Scientific Q Exactive Orbitrap Liquid Chromatography-Mass Spectrometry (LC-MS/MS) System.

Strain and plastic composite support (PCS) selection for Vitamin K (Menaquinone-7) production in Biofilm Reactors

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Abstract:

Menaquinone-7 (MK-7), a subtype of vitamin K, has received a significant attention due to its effect on improving bone and cardiovascular health. Current fermentation strategies, which involve static fermentation without aeration or agitation, are associated with low productivity and scale-up issues and hardly justify the commercial production needs of this vitamin. Previous studies indicate that static fermentation is associated with pellicle and biofilm formations, which are critical for MK-7 secretion while posing significant operational issues. Therefore, the present study is undertaken to evaluate the possibility of using a biofilm reactor as a new strategy for MK-7 fermentation. Bacillus species namely Bacillus subtilis natto, Bacillus licheniformis, and Bacillus amyloliquifaciens as well as plastic composite supports (PCS) were investigated in terms of MK-7 production and biofilm formation. Results show the possibility of using a biofilm reactor for MK-7 biosynthesis. Bacillus subtilis natto and soybean flour yeast extract PCS (SFY) in glucose medium were found as the most potent combination for production of MK-7 as high as 35.5 mg/L.

Differences in quality of organic matter, microbial metabolism, and phosphorus species across a trophic gradient of lake sediments in Northwestern PA.

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Abstract:

Understanding eutrophication is at the forefront of limnological research and results in substantial environmental degradation within lake ecosystems. While there exists current literature detailing the correlation between phosphorus (P) availability and the quality of sediment organic matter or between P availability and microbial communities that process the aforementioned P, there lacks investigation of the links between microbial metabolism and the quality of sediment organic matter. This study aimed at filling this gap by investigating this relationship across a trophic gradient. We hypothesized that 1) P_o fractions in oligotrophic lakes would be dominated by high molecular weight polymers rather than low molecular weights sugars in eutrophic lakes and 2) there would exists qualitative differences in organic matter quality across a trophic gradient that would correlate with microbial metabolism. Using Biolog Ecoplates for four days and P fractionation from the sediment, we used a principle components analysis (PCA) and found that the H_20 (P_o, Pi), CaEDTA (P_o, Pi), NaEDTA (P_o), and TCA (0ºF, P_o) fractions were significantly correlated across axis one, which showed a delineation across a trophic gradient. Regarding microbial metabolism, after 96 hours we did not find a delineation across trophic gradient, instead the eutrophic and oligotrophic lakes clustered and only began to separate at the end. The mesotrophic lakes remained more separate throughout the analysis. Although we did not support our second hypothesis, we drew attention to the ecoplate analysis methodology and recommend that future analysis using this mechanism take the analysis of every sampling period into consideration.

A Hydrogeological Investigation of Oil and Gas Wastewater Disposal Causing Salinization of Western U.S. Rivers

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Abstract:

Salinization threatens our freshwater by causing a domino effect of hydrogeological processes, such as increasing concentrations of dissolved radium, sulfates, boron, fluoride, and trace metals in our water. This study investigates increasing salinity in three tributaries to a major river basin in the western USA for impacts from permitted discharges of saline oil and gas produced water. Produced waters are discharged through national pollutant discharge elimination system permits (NPDES) and, in the arid West, beneficially used for irrigation and supply water for cattle as stipulated in permit applications. However, downstream the river is a source of drinking water to the local community causing concern that the continued discharge of saline water to the freshwater supply has limited benefit. The USEPA standard for TDS in drinking water is 500 mg/L, with a recommended safe limit of 2,000 mg/L for agricultural use, and 5,000 mg/L for livestock use; however, at a single oil operation site, TDS levels of 4,000+ mg/L were observed while this water is ultimately being used for irrigation downstream. Water samples were collected during seven sampling events from 2013 to 2015 at 26 sites along the tributaries that include both upstream and downstream of NPDES permitted discharges. Statistically significant increases were determined for sodium, sulfate, chloride, and calcium downstream from discharges. USGS stream gauge flow data in conjunction with molar ratios (e.g., Na/Cl and Ca/SO_4) were utilized to determine if the spatial and temporal increases in concentrations are explained by evaporation, dissolution of minerals, or low flow rates.

Communication Between *Vibrio fischeri* Populations within the Squid Light Organ

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Abstract:

Symbiotic microbes impact the development and physiology of animals. Many microbes carry out symbiotic functions, such as the production of bioluminescence, in a manner that depends on an intercellular communication process called quorum sensing. However, the ability of spatially segregated populations of bacteria to communicate with one another by quorum sensing is unknown. Inhibition of quorum sensing systems in human pathogens such as *Staphylococcus aureus* can disrupt pathogeny. Determining how they communicate with each other could lead to the identification of drug targets to control infections.

One model for studying quorum sensing within a host is the binary symbiosis that is established between the bacterium *Vibrio fischeri* and the squid *Euprymna scolopes*. The bacteria provide bioluminescence which the squid use for camoflauge in return for nutrients. *V. fischeri* cells specifically colonize epithelium-lined crypt spaces within the light organ of the squid, resulting in spatially segregated infections.

I have two dark mutants of *V. fischeri*. When colonized by either strain separately, juvenile squid show no luminescent response. Furthermore, the bacteria cannot maintain a persistent infection. However, when juvenile animals were co-colonized with the mutants, there was a luminescent response in about 50% of the animals, and the infection is persistent within the animal. I then observed the two strains existing in spatially segregated crypts within the luminescent animals. Despite the host tissue separating the populations, the bacteria were communicating to produce bioluminescent response.

Characterization of a Natural *Vibrio fischeri* Isolate

Nuñez, Briana M.[a]***, **Andrew Cecere**[b], **Tim Miyashiro**[c]
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Abstract:

Vibrio fischeri is a bioluminescent marine bacterium that participates in a mutualistic symbiosis within the light organ of the Hawaiian bobtail squid, *Euprymna scolopes*. The bacteria camouflage the squid from predators via counterillumination in exchange for nutrients from the host. The goal of this project is to characterize a single naturally isolated strain of *V. fischeri* taken from a wild-caught adult squid and to compare it to a well-characterized type strain, ES114, to identify characteristics that may contribute to or inhibit the mutualism between the bacterium and the host. These assays aimed to determine whether the isolate is significantly different from the type strain. The natural *V.fischeri* isolate, named BMN004, was characterized through multiple assays including bioluminescence response and motility rate. From these experiments, it was concluded that BMN004 is less motile and more luminescent than the type strain. One future direction of this project include sequencing the LuxI/R region of the DNA, which is responsible for the production of the luminescence. ANother future direction includes conducting further assays involving the squid to understand how BMN004 populates the animal compared to the type strain. The completion of this project, along with the data collected from other characterized strains can give insight into bacterial-host symbiosis and what is needed for the symbiosis to be considered successful.

Converting low-grade waste heat into electricity using a silver ammonia battery

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Abstract:

A vast amount of low-grade thermal energy (temperature < 130 ºC) is available globally at industrial plants and from solar and geothermal sources. Recently, thermally regenerative ammonia batteries (TRABs) have been developed to convert low-grade heat to electricity. In a TRAB, electrical power is obtained from the formation of metal ammine complexes, which are produced by adding ammonia to the anolyte, but not to the catholyte. After the cell discharge, ammonia is separated from the anolyte using a conventional distillation with low-grade waste heat, and then added to the other electrolyte for the next discharge cycle. The previously developed TRAB based on copper electrodes and a copper electrolyte showed a relatively high power production. However, unbalanced rates of anode dissolution and deposition of copper on the cathode limited the use of copper in closed-loop cycles. To address the reversibility issue, a silver-based TRAB was explored as an alternative to the copper TRAB. Unlike a copper-TRAB, the silver-TRAB was a very reversible system that could convert low-grade waste heat into electricity through successive cycles. The successive deposition and dissolution (i.e., the electrode reversibility) was examined over a hundred cycles. The result showed a very stable power production, confirming the reversibility of the deposition and dissolution reactions. An initial economic analysis of the system showed that the cost of the materials relative to energy production was \$ 0.22 kWh^{-1}, which is 1.8 times more than the average of electricity price in the U.S. (\$ 0.12 kWh^{-1}). The silver-TRAB electricity cost could be reduced to \$0.12 kWh^{-1} if the cost of a membrane used in the system could be reduced to \$10 m^{-2}.

Investigating the Microbiome of *Myotus lucifugus* Populations and Potential for Prokaryotic Isolates as Biocontrol Agents of White Nose Syndrome

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Abstract:

Myotus lucifugus (little brown bat) populations have been declining due to infection of the bat with the White-Nose Syndrome fungus, *Pseudogymnoascus destructans*. The prokaryotic microbiome of bats from varied geographical locations was examined to reveal any trends, anomalies, and/or changes that may occur in response to White-Nose Syndrome (WNS). This was accomplished by isolating bacteria from bats from New York, Pennsylvania, Wisconsin, and Texas that experienced varied exposure levels to WNS including naïve, survivors, and deceased. Isolates from this aggregate were chosen at random and/or based on potential biocontrol capabilities as previously published by researchers in the literature. The select isolates were utilized in an inhibition study using a modified Kirby-Bauer protocol to determine if any exhibited biocontrol of *P. destructans.* Fungal conidia at varying dilutions were plated on Sabouraud Dextrose Agar. Bacterial test isolates and Clotrimazol® were inoculated onto separate sterile disks, placed on fungal lawn and plates incubated at 9°C for 14 days. Assay data showed that isolate WI624, *Arthrobacter antarcticus,* was the only isolate that inhibited *P. destructans* nearly as effectively as Clotrimazol® showing zones of inhibition of 31mm and 32mm, respectively. A second assay focused on the conidia titer per ml (3.3×10^6) of *Pd.* and results did not show the same level of inhibition. Repeat assays of the initial experiment are currently in progress including additional strains of *Arthrobacter* and other bacterial isolates, to confirm the original results, and to identify any discrepancies.

Flow-through capacitive deionization to treat brackish water for irrigation

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Abstract:

Irrigation water for agriculture is one of the major water demands in many countries, made acute by water scarcity. An emerging solution are tailored, affordable greenhouses. Their implementation has significantly reduced water use per crop cycle in Mozambique, Sierra Leone and India. Yet even a few gallons per day per greenhouse is challenging because many local groundwater sources are brackish. Capacitive deionization (CDI) is a sustainable, energy efficient, and cost effective technology for treating brackish water. It is energy efficiency and cost effective for low to moderate salinity water. Compared to technologies that remove the water such as distillation, CDI remove the salt from the water. The porous carbon electrodes for CDI are mostly made from carbon aerogels which are very expensive as compared to activated carbon powders. But the former has advantage over the latter in allowing for the more efficient flow-through operation of the CDI process. A laboratory scale prototype of a CDI cell has been manufactured for testing electrodes made from activated carbon powders in a flow-through process. Activated carbon was produced from locally sourced switchgrass using different processing conditions of pretreatment of the biomass and concurrent or sequential carbonization/activation steps in a furnace with requisite gas environment. These carbons were compared to commercially available activated carbon powders and carbon cloths studied in literature based on their CDI performance (charge efficiency, salt adsorption capacity, regeneration efficiency).

Investigation of codependent strain characteristics in polyclonal *V. fischeri* infections

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Abstract:

The light-organ symbiosis established between the marine bacterium, *Vibrio fischeri,* and the Hawaiian squid, *Euprymna scolopes*, is a model system to study how bacteria colonize a host. Juvenile squid hatch un-colonized and acquire *V. fischeri* cells from the seawater environment. The juvenile light organ houses up to six distinct *V. fischeri* populations in epithelium-lined crypt spaces, where they provide the host with bioluminescence to avoid predators. To activate light production in the light organ, *V. fischeri* uses the LuxI/LuxR quorum-signaling system. In this study, we examined the interaction of different *V. fischeri* strains on colonization of the light organ.

Two *V. fischeri* strains were isolated from wild-caught adult squid. Colonization assays with juvenile squid showed that neither strain alone is efficient at producing luminescent animals however, co-inoculation resulted in normal luminescence levels in majority of animals. Imaging of these light organs revealed that the strains colonized different crypt spaces. Together, these results suggest that the natural isolates act synergistically to produce light during host colonization.

We hypothesized that spatially segregated populations interact with each other in the light organ. To test this hypothesis, we have used a two-strain colonization model consisting of a mutant *luxI,* which does not produce quorum-signaling autoinducer, and a Δ*lux* mutant, which cannot produce light. Similar to the natural isolate model above, we found that the *luxI*/Δ*lux* strain combination only produces luminescent animals when co-inoculated and the corresponding populations occupied different crypt spaces. Together, these results support a working model in which *V. fischeri* populations communicate with one another across host tissue using quorum signaling.

Maize Nitrogen Fertilization for Dairy Production in Sardinia will Make You Feel Warm

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Abstract:

Nitrous oxide (N_2O) is a potent greenhouse gas with nearly 300 times the global warming potential of carbon dioxide (CO_2). Nitrogen (N) fertilization in agriculture is the main source of N_2O; smart management of N fertilization can prevent excessive N_2O emissions. The dairy-producing region of Arborea on the Italian island of Sardinia is a typical example of a high N input system whose N_2O footprint is unknown. Located on the coast, this region is the target of heavy regulation to prevent N pollution to groundwater.

In the summer of 2016, a group of Sardinian and American students measured N_2O emissions of an Arborean farm where N was supplied in four different forms: 1) dairy slurry, 2) mineral nitrogen, 3) separated solid fraction of dairy slurry, and 4) business as usual (BAU, as managed by the producer). Samples of soil gasses were taken for three weeks after fertilization then analyzed for N_2O and N fluxes. BAU had the largest N_2O flux followed by slurry; other treatments emitted little N_2O. Simultaneous records of CO_2 emissions indicate that BAU received more slurry than was intended. The low N_2O emission of mineral N treatment indicates that the combination of high mineral N and a source of easily decomposable carbon (slurry) explains the very high emissions from BAU and, to a lesser extent, slurry treatments. In conclusion, the regulation limiting the amount of slurry to be added to the soil may unintendedly reduce the large N_2O emissions that accompany high rates of slurry application.

Impact of Spreading Oil & Gas Wastewater as Road Treatments on Groundwater Quality

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Abstract:

The development of conventional and unconventional oil and gas (O&G) in Pennsylvania poses concerns for water quality. Flowback and produced waters are typically hypersaline and contain a variety of organic, inorganic, and radioactive contaminants. In northwestern PA, conventional O&G wastewaters are spread directly on roads for both de-icing and dust suppression under existing regulations. The objective of this project is to investigate if spreading conventional O&G wastewater on Pennsylvania roads for dust suppression is impacting water resources. Working with PADEP and local municipalities, 10-12 samples of O&G wastewater currently used for road treatments were collected and characterized by measuring organic (by GC-FID), inorganic (by ICP-OES), and radioactive (by gamma spectroscopy) contaminants. The O&G wastewaters were then applied to road aggregate and subgrade material to evaluate the potential for contaminant mobilization following the Synthetic Precipitation Leaching Procedure (SPLP; EPA Method 1312). Data were used to assess the potential impacts to ground and surface water or attenuation of metals in the road bed. Results from this project will be useful for predicting the potential impacts of spreading conventional O&G wastewaters on roads.

Elevated Radium Activities in Sediments from Oil and Gas Wastewater Disposal

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Abstract:

Oil and gas (OG) production in Pennsylvania generates yearly billions of liters of produced water that has high levels of total dissolved solids, heavy metals, and naturally occurring radioactive material. When produced water is treated in centralized waste treatment facilities (CWT) and discharged to surface water it can impact water quality and cause elevated levels of radium activities in sediments. In 2011, the Pennsylvania Department of Environmental Protection requested wastewater treatment facilities to no longer accept unconventional OG wastewater. Our study aimed to (1) assess if the policy change in April of 2011, which led to decreased unconventional OG wastewater treated at CWT, also led to decreased radium activities in sediments and (2) characterize radium activities over a large transect (53km) both upstream and downstream of OG treatment facilities for evidence of watershed-scale impacts not observed in previous studies. We observed increased radium activity in sediments collected downstream of CWT facilities in both 2014 and 2016 and significantly ($p < 0.01$) higher average radium activity for 30km downstream of a CWT. The sediments with higher total radium activity also contained higher percent silt and clay composition and may indicate transport of radium with fine-grained sediment material. In order to better understand the bioavailability of radium we conducted sequential leaching experiments to determine what compounds it was associated with.

Does a clean bed filtration theory properly predict removal of model microbes in a Moringa-coated sand filter?

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Abstract:

Lack of access to clean drinking water is a serious health problem. Often, when methods for cleaning drinking water are available, they are too expensive to be practical. In our approach we adhere an antimicrobial and cationic protein from the seeds of the Moringa oleifera tree to sand to reverse the charge and provide an antimicrobial layer. Previous work shows that, when packed into a filter, this coated sand can remove 99.99% of model microbes. Here we will discuss applying various known clean bed filtration theories to this filter to predict removal of microbes and to allow scale-up. In our experiments we varied both the size of the model microbes, the ionic strength and the concentration of microbes in the influent in order to test the model. In addition we created a model to predict breakthrough of the model microbes from the filter. Armed with two theories of performance and filter lifetime, we will be able to disseminate this idea to areas of the world that need it most.

Chemical Degradation of Polyacrylamide during Hydraulic Fracturing

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Abstract:

Polyacrylamide (PAM) based friction reducers are a primary ingredient of slickwater hydraulic fracturing fluids. Little is known regarding the fate of these polymers under downhole conditions, which could have important environmental impacts including strategies for reuse or treatment of flowback water. The objective of this study was to evaluate the chemical degradation of high molecular weight PAM, including the effects of shale, oxygen, temperature, pressure, and salinity. Data were obtained with a slickwater fracturing fluid exposed to a shale outcrop at high pressures/temperatures (HPT) simulating downhole conditions. Based on size exclusion chromatography analyses, the peak molecular weight of the PAM was reduced by two orders of magnitude, from roughly 10 MDa to 200 kDa under typical HPT fracturing conditions. The rate of degradation was independent of pressure and salinity but increased significantly at high temperatures and in the presence of oxygen. Results were consistent with a free radical mechanism; the addition of a radical scavenger (tert-butanol) essentially eliminated degradation. The shale outcrop adsorbed some PAM (~25%), but importantly it catalyzed the chemical degradation of PAM, likely due to dissolution of iron at low pH. These results provide the first evidence of radical-induced degradation of PAM under HPT hydraulic fracturing conditions without additional oxidative breaker.

Observing and Simulating Spatial Variations of Forest C Fluxes and Stocks in Complex Terrain

Yuting He, Kenneth Davis, Yuning Shi, David Eissenstat, Jason Kaye, Margot Kaye, Henry Lin, Douglas Baldwin

Abstract:

Terrestrial carbon (C) cycle remains the least constrained component in the global C cycle, partly due to the difficulty to quantify C sources and sinks in complex terrain. In this study, we used observations at Shale Hills Critical Zone Observatory and a biogeochemistry model - Biome-BGC to examine the spatial distribution of C stocks and fluxes in a first-order watershed. We fed the model with observed soil moisture and soil temperature to reduce the uncertainties in simulating water and energy cycle. With only three parameters constrained by observations, the model could represent the average C pools and fluxes in the watershed. The three parameters are whole-plant mortality, N input (deposition/fixation) and maximum decomposition rates of soil and litter C pool. Whole-plant mortality rate is crucial to aboveground C pool; N input is crucial to aboveground C fluxes (e.g. NEP); and maximum decomposition rates are crucial to soil C pool. We then applied this tuned model to six sites along the topography, and the model was able to produce the general spatial patterns of C pools in the watershed, with higher biomass and soil C in the valley and lower on the ridgetop, even though the model underestimated the spatial contrast along the topography. We also examined the effects of four environmental factors on the spatial distribution of C pools. These four environmental factors are soil moisture, soil temperature, N availability and solar radiation. Among the four factors, soil water and N availability dominated the spatial distribution of aboveground biomass. Soil water was also the most important factor controlling soil C distribution. This study highlighted the importance of accurate hydrological simulations to ecosystem modellings.

Anion Uptake by Clays Intercalated with Poly (diallydimethyl ammonium) (PPDA) Cations

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Abstract:

Polymer intercalated clay nanocomposite materials were prepared using several montmorillonites and PDDA (Polydiallyldimethylammonim chloride) polymer and they were tested for the removal of nitrate, perchlorate and chromate anions from aqueous solutions. The polymer intercalated nanocomposite materials were prepared at room temperature using PDDA corresponding to 2 times the cation exchange capacity (CEC) of montmorillonite. Powder X-ray diffraction (XRD) analysis of the above polymer intercalated nanocomposite materials either showed no crystalline peaks or very broad spacing with the intercalation of PDDA polymer in the interlayers probably as a result of ~~a~~ exfoliation of the clay layers. Infrared spectroscopy revealed the presence of PDDA in all the nanocomposite materials. The adsorption/uptake of nitrate, perchlorate and chromate by polymer intercalated nanocomposite materials prepared from three different montmorillonites was investigated. The maximum adsorption capacities of nitrate, perchlorate and chromate by one of the polymer intercalated nanocomposite materials prepared from montmorillonite, Kunipea, Japan were calculated to be 0.40 $mmol/g$, 0.44 $mmol/g$ and 0.299 $mmol/g$, respectively. The other two polymer intercalated nanocomposite materials prepared from montmorillonites from Wyoming and China showed very good uptake capacities for perchlorate but somewhat lower uptake capacities for chromate and nitrate compared to the nanocomposite prepared from montmorillonite from Kunipea, Japan. The nitrate, perchlorate and chromate uptakes by the polymer intercalated nanocomposite materials could be described well using the Freundlich isotherm while their uptake kinetics fitted well to the pseudo-second order model. Nitrate, perchlorate and chromate uptake kinetics were found to be fast as equilibrium was reached within $4h$. Furthermore, the uptakes of chromate by polymer intercalated nanocomposite materials were found to be highly selective in the presence of Cl^-, $SO_4^{2-}$and CO_3^{2-}, the most abundant naturally occurring anions. Therefore, polymer intercalated nanocomposite materials could be used as highly efficient adsorbents for the separation of especially chromate from drinking water, wastewater or ground water.

Oral Presentation Abstracts

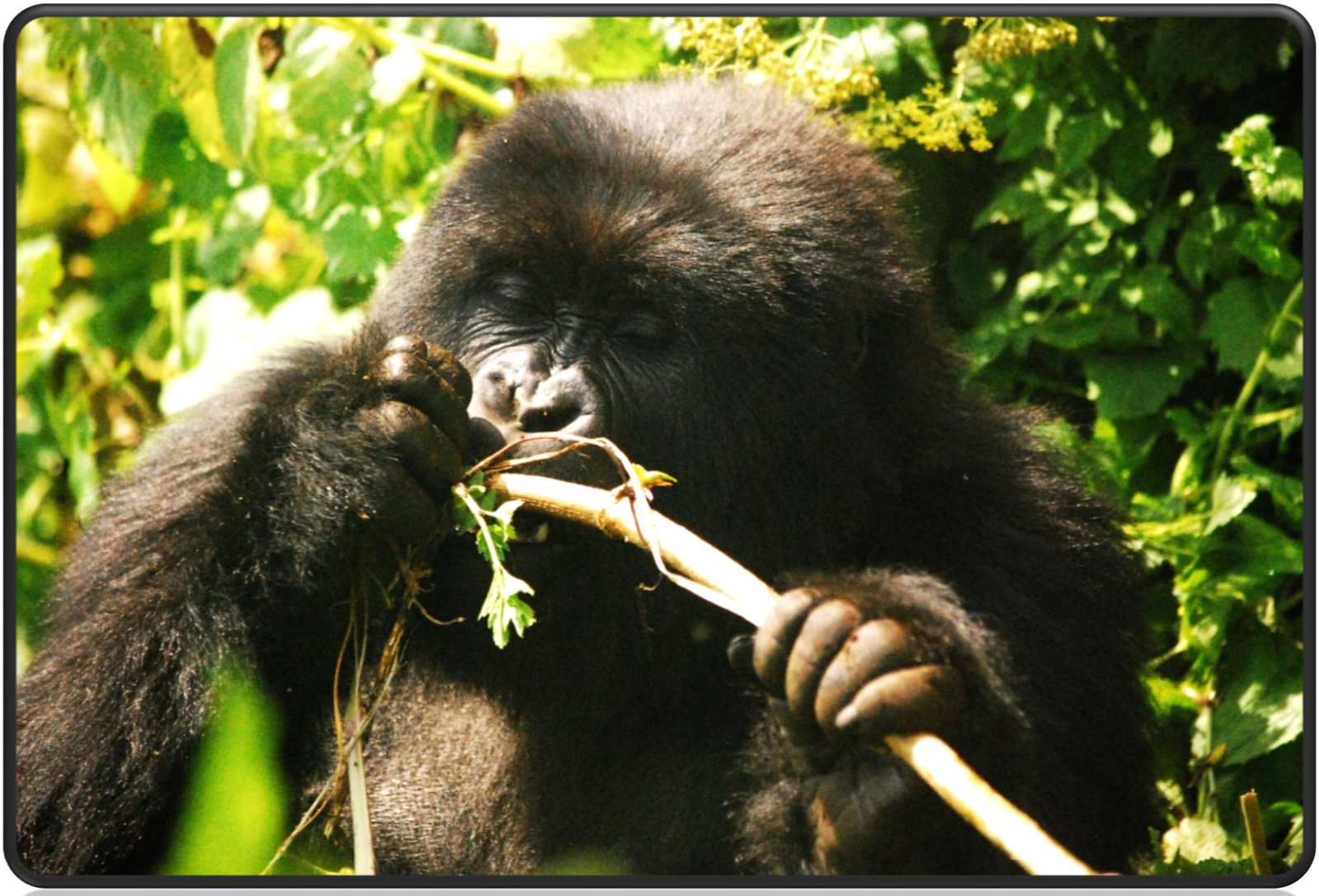

Photo Description: An endangered mountain gorilla is pictured eating the white celery plants that grow in abundance in the mountains of Rwanda, the only place this type of mountain gorilla can be found.

Emma Clement, Third Place Photo Contest Winner

Reducing the Environmental Impact of the Petroleum Industry by Waste to Resource Recovery

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Abstract:

Petroleum fossil fuels have graced the energy limelight for decades providing reliable energy and economic breakthrough for several countries, however, the environmental impacts are well documented. One area to be addressed is the waste produced due to petroleum exploration and production. My research asks the question, "Is it possible to reclaim some of the raw materials from the waste stream, i.e. the sand, clay and water, for new jobs thereby reducing the waste stream and the environmental impact?"

Sand plays a prominent role in the fracking process and hydraulic fracturing can require as much as 200,000 lbs. of sand. Clay is also an important component of the drilling process. The clay and sand are therefore valuable resources that should be of interest for conservation and management. Drilling especially hydraulic fracturing requires high volumes of water, sometimes freshwater, while producing a very high volume of wastewater that requires treatment. This wastewater returning to the surface is high in salinity, up to 5 times that of seawater, and radioactivity in the form of Radium from the formation. My research presents novel processes to reclaim raw materials from the solid waste and a treatment for radium removal.

Microbial architects of anastomosing cave wall patterns in Frasassi, Italy

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Abstract:

Vermiculations are visually striking cave wall formations, with anastomosing patterns and soft, sediment-like texture. They are found globally, and are extensive in the sulfidic Frasassi cave system (Italy). The origins of these patterns are uncertain, though biological influence has been hypothesized for decades. Our previous work revealed unexpectedly diverse Bacteria; new data highlight the likely role of Archaeal and Bacterial growth in vermiculation formation. In a decade-long experiment, vermiculations regrew in cleared patches of cave wall. Regrowth occurred as contiguous extensions of intact vermiculations, and was faster proximal to chemical energy sources (e.g. HS^- and NH_4^+ degassed from the aquifer). Near the water table, $\delta^{15}N$ and $\delta^{13}C$ in the vermiculations are isotopically depleted. Ammonium oxidizing Archaea, sulfur oxidizing Bacteria, and relatives of methanogenic Archaea dominate. Taxa enriched in the vermiculations relative to unvermiculated wall sediment include ammonium and sulfur oxidizers, iron and nitrate reducers, and motile species. The C:N ratio is ~7 at all elevations, while unvermiculated cave wall sediments have a higher ratio (14), and an order of magnitude lower organic C and N by weight. The microbial assemblages in vermiculations are similar to those in many subsurface and dark biosphere environments, offering an accessible system in which to study interconnected redox processes and self-organizational patterns in biofilms across a range of geochemical niches.

The importance of iron oxide and organic carbon associations during aerobic biodegradation of peatland soils

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Abstract:

Climate change is altering the global carbon cycle and may turn traditional, terrestrial carbon dioxide sinks into carbon dioxide sources. Peatlands, a known carbon dioxide sink, are anaerobic and mostly frozen environments found within the northern latitudes of the northern hemisphere. Thousands of years of organic carbon buildup are potentially at risk for mineralization if aerobic conditions become favorable for aerobic microbial respiration. Abundant soil minerals, such as the iron oxide ferrihydrite, are known to associate with organic carbon through sorption and coprecipitation in these peatland environments.

Our work aimed to show that these mineral-organic carbon associations could prevent the aerobic biodegradation of organic carbon, thus minimizing carbon dioxide emissions from peatlands. A 148-day incubation featuring soil dissolved organic carbon (SDOC), a mixed soil microbial community, and synthesized ferrihydrite was used to show that sorption and coprecipitation act to minimize, but not prevent, the aerobic biodegradation of organic carbon. Measurements of carbon dioxide and total dissolved organic carbon throughout the incubation indicated the success of microbial respiration. Changes to the mineral morphology and phase-changes over the incubation were observed with Transmission Electron Microscopy (TEM), Scanning Electron Transmission Electron Microscopy-Energy Dispersive X-ray Spectroscopy (STEM-EDS), and ^{57}Fe Mossbauer Spectroscopy. Further, differences in the microbial community were observed using 16S rRNA sequencing. With further examinations of redox cycling in these peatland environments, we can assess the stability of mineral-carbon associations and develop better predictions of carbon dioxide emissions from these regions.

Cryptosporidium Genotypes in a Suburban River Watershed in Southeastern Pennsylvania

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Abstract:

Cryptosporidium is a sometimes-deadly waterborne parasite that causes gastrointestinal illness. There are various host-specific species, including human infectious *C. hominis* and *C. parvum*, and various watershed sources, including agricultural runoff, wastewater treatment plants, and wildlife vectors. Tracking watershed contamination can provide valuable information about *Cryptosporidium* to utilities and healthcare/government officials.

We previously developed a cost-effective method for watershed sampling that utilizes the natural development of biofilms on submerged surfaces. The biofilm samplers provide comparable *Cryptosporidium* sp. detection to the costly EPA-approved filters. Our current project uses both biofilm samplers and filters to monitor *Cryptosporidium* sp. contamination at five locations (spanning upstream rural sites and downstream suburban/urban sites) in a major suburban river watershed.

In October 2015, we began sampling twice per month at each location. Samples are processed through immunomagnetic separation, DNA extraction, and nested PCR; PCR-positive samples are cloned and sequenced. Genetic sequencing results, paired with water quality and ancillary data analysis, allow us to look at the patterns of *Cryptosporidium* sp. detection throughout the watershed.

Genotyping results to date show that agriculture is the most likely source of *Cryptosporidium* sp. in the upper watershed, and various other sources, including both humans and wildlife, increase the variety of detected species downstream. This research is ongoing, and more specific watershed characterization will be possible as sampling and genetic sequencing continue. Understanding the sources and species of *Cryptosporidium* in drinking water source watersheds will permit more strategic watershed protection efforts and reduce the exposure of the public to this waterborne pathogen.

Optimization of *Bacillus subtilis natto* Growth Parameters in Glycerol-based Medium for MK-7 (Vitamin K) Production in Biofilm Reactors

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Abstract:

MK-7 is the key form of vitamin K used as a dietary supplement and its production revolves around *Bacillus subtilis natto*. Current fermentation strategies, which suggest static fermentations without aeration and agitation, can be problematic for large scale MK-7 production due to the design and scale-up issues. Therefore, applying biofilm reactors in this regard was proposed in this study, which utilizes both agitation and aeration without significantly interrupting MK-7 secretion. Preliminary studies for plastic composite support (PCS) and strain selections were presented in the past study. In this study, biofilm reactors were constructed using the selected PCS and *B. subtilis natto* strain for MK-7 production. Using response surface methodology (RSM), optimum growth parameters including temperature, pH, and agitation were determined in a glycerol-based medium. Results were presented in a statistical model (R^2=0.90), leading to optimum growth conditions of temperature (35°C), agitation (200 rpm) and pH (6.58). Model predicted MK-7 concentration was validated and MK-7 concentrations produced in biofilm reactors (12.09±1.72) were 58% higher compared to the suspended-cell reactors (7.67±2.15), which is a critical step towards improved industrial scale productions.

Evolution of a Partitivirus in Peppers and Its Effect on Aphid Behavior

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Abstract:

Plants are very frequently infected with cytoplasmic RNA viruses that persist for many generations through nearly 100% vertical transmission without producing any obvious symptoms. Movement between plant cells and transmission through grafting has not been observed in these persistent viruses; instead they are distributed to all host cells through host cell division.

Peppers are perennial plants, and as domesticated plants human selection accelerated their evolution, so codivergent timelines should be easier to follow. Jalapeño peppers are all infected with *Pepper cryptic virus* 1 (PCV1), which belongs to the *Partitiviridae* family; its genome consists of two dsRNAs that encode the RNA-dependent RNA polymerase (RdRp) and the coat protein. To investigate the evolution of this virus, dsRNA was extracted from over one hundred different pepper cultivars/landraces/wild plant materials including different species of *Capsicum.* spp. The presence of PCV1 was tested by RT-PCR using specific primers. The nucleotide sequence of the RT-PCR products was determined and their phylogenies have been analyzed. Here we present evidence for a remarkably slow evolution rate in PCV1.

Vectors play an important role in the transmission of acute plant viruses, and aphids are the most common vectors of agriculturally important plant viruses. Several studies showed that viruses manipulate plant's volatile compounds and plant quality to attract vectors or to deter vector feeding in order to enhance their transmission to healthy plants. The roles of plant persistent viruses in the ecology of their hosts have not been studied thoroughly, but their very long-term relationships with their hosts, and their high level of vertical transmission imply beneficial interactions. Studying the aphid-virus interaction revealed the beneficial role of PCV1 for its Jalapeño host.

Characterization and Evaluation of Carbonaceous Materials via the Hydrothermal Carbonization of Unwanted Waste Pharmaceuticals

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Abstract:

Currently, the United States leads the world in pharmaceutical production accounting for 39% of the world production. As a results, hospitals and long-term care centers flush approximately 250 million pounds of unused pharmaceuticals down the drain each year. In our search for environmentally friendly biomass to yield carbonized waste for environmental and energy-related applications, it is reported for the first time in this study the use of hydrothermal carbonization of pharmaceuticals for the synthesis of carbonaceous and derivative materials. The feedstock used in this study constituted of 14 Over the counter (OVC) and 10 Prescription only medicine (POM) that were combined and crushed to reduce their surface area and heterogeneity. The microstructure and chemical composition of the raw feedstock and the resultant hydrochar were examined using the using the Scanning Electron Microscopy (SEM), Brunauer–Emmett–Teller (BET) surface area analysis, X-ray powder diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and Energy-dispersive X-ray spectroscopy (EDX).

The FTIR spectra indicated a clear shift in the spectrum when moving from the raw pharmaceuticals to the hydrochar as the intensity of the functional groups, bands and peaks have increased. There is also a loss of various functional groups due to diverse thermal decomposition upon hydrothermal carbonization at different temperatures. The XRD profiles showed patterns largely similar to calcite and some peaks corresponding to n-acetyl- dl-valine. EDX results demonstrate an increase in the carbon content from the raw pharmaceuticals to the carbonized hydrochar at 180, 230 and 275 ^{0}C for 24 hours. The results from the batch experiment showed the effectiveness of the hydrochar as adsorbent with over 90% removal of Pb^{2+} ions attained after 60 minutes.

The influence of pressure on hydrocarbon biodegradation in shallow and deep Gulf of Mexico sediments

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Abstract:

A significant portion of oil released during the Deepwater Horizon disaster reached the Gulf of Mexico (GOM) seafloor. Predicting the long-term fate of this oil is hindered by a lack of data about the combined influences of pressure, temperature, and sediment composition on microbial hydrocarbon remineralization in deep-sea sediments. To date, studies regarding the influence of high pressure on hydrocarbon biodegradation have focused on the fates of model compounds or soluble fractions of crude oil in the water column.

In this study, we investigated crude oil biodegradation by native GOM microbial communities under simulated seafloor conditions, with particular focus on the role of pressure. Oxic core-top sediments from 13 GOM sites at water depths from 60-1500 m were incubated aerobically with crude oil at temperatures (4, 10, 20 ºC) and pressures (0.1–15 MPa) that approximated *in situ* conditions. After 18 days, 45-90% of total n-alkanes and 3-60% of total polycyclic aromatic hydrocarbons were depleted. At $\leq$ 6 MPa, more than 80% of n-alkanes were lost. We observed a modest inhibitory effect of pressure. In reactors incubated at 4ºC and pressures of 6-15 MPa, total n-alkane depletion was negatively correlated with pressure (R^2 0.85), equivalent to a 4% decrease in total n-alkane biodegradation for every 1MPa increase.

These results extend the findings of Prince et al. (2016), who found that pressure had a slight inhibitory effect on crude oil biodegradation by planktonic microbes, to deep sediment communities. Although pressure alone is not a major inhibitor of biodegradation in our experimental range, the expansion of oil exploration to deeper waters (e.g., 5000m) opens the risk of spills at conditions at which pressure might have a more significant effect.

Soil organic matter stabilization via mineral interactions in forest soils with varying saturation frequency

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Abstract:

Soils store a large fraction of the global carbon (C) stock, and soil organic matter (SOM) interaction with minerals is an important, yet under-recognized, mechanism of soil C stabilization. One pathway of mineral-SOM stabilization is co-precipitation, or incorporation of SOM into minerals as they form. Co-precipitation is expected to occur in environments with frequent fluctuations in soil saturation and high input of DOM, but few observations of co-precipitation as such in natural soils exist. To better understand the relationships among hydrology, redox processes, co-precipitation, and mineral-SOM stabilization, this study compares mineral-SOM properties across a forest soil hydrological gradient with expected differences in co-precipitation processes due to varying saturation frequency. Soil samples were collected from Hubbard Brook Experimental Forest (Woodstock, NH) sites with low, medium, and high frequency of water table intrusion into surface soils. A combined approach of bulk soil characterization (e.g., basic soil properties, mineralogy, extractable metals, and SOM biological stability), density fractionation, and X-ray and NMR spectroscopy will be used to evaluate mineral-SOM stabilization processes in this system. Preliminary results indicate significant differences in C and N content, pH, metal and SOM chemistry with depth and saturation frequency, and a positive correlation between C content and oxalate-extractable Fe and Al. In particular, greater enrichment in carboxylic C with medium saturation frequency was shown with both C K-edge XANES and ^{13}C-NMR. Ongoing work will use Fe K-edge EXAFS and XANES and short-term aerobic incubations to further probe the nature of Fe-OM interactions.

A Combined In Situ ATR-FTIR/XPS Study of the DNA-Goethite Interface

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Abstract:

DNA in soil plays an important role in the cycling of genetic information in the environment. Adsorption onto mineral surfaces has great impact on this function. This study probes the kinetics, equilibrium behavior and bonding mechanisms associated with adsorption of DNA onto goethite, a common soil mineral. Surface sensitive ATR-FTIR and XPS approaches are applied to directly characterize the DNA-goethite interface. Adsorption kinetics follow a pseudo-first order model, suggesting adsorption rate is surface limited. Adsorption rate constants increase with DNA concentration, ranging from 3.29×10^{-3} to 3.55×10^{-1} min^{-1}. Equilibrium adsorption, as monitored by ATR-FTIR and XPS, follows the Langmuir model, with a high affinity of DNA for goethite observed ($K = 4.07 \times 10^5$ and 3.90×10^5 L/mg for ATR-FTIR and XPS, respectively). ATR-FTIR and XPS characterization of the structure of surface adsorbed DNA demonstrates inner-sphere coordination between backbone phosphate groups of DNA and goethite. Furthermore, adsorbed DNA retains a B-form helical structure, suggesting the DNA helix adsorbs on goethite without degradation or alteration to structure, despite binding of backbone phosphate groups. This work advances our understanding of the environmental behavior of DNA by clarifying the mechanism of adsorption onto a prominent soil mineral.

Characterizing soot from vehicle emissions

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Abstract:

Particulate matter derived from vehicle emissions or other combustion processes is detrimental to human health. Deteriorating air quality due to particulate emissions has been linked to high risk of heart and lung diseases and also contributes to climate change. Thus, to establish global air quality guidelines, it is important to measure the concentration of soot in the atmosphere. Laser induced incandescence (LII) is a diagnostic that measures soot concentration and primary particle size. It can be used in-situ and has high sensitivity, providing accurate measurements with low concentrations of soot. Interpretation of LII signals for these measures requires reference to LII models that predict soot primary particle size and concentration, each with assumptions about its physical parameters – often leading to discrepancies between simulated and experimental results. This work uses carbon black as soot surrogate and highlights some such differences by comparing experiments with model predictions. For instance, transmission electron microscopy (TEM) from this work shows significant changes in carbon black nanostructure upon laser heating, an aspect overlooked by LII models. UV-Vis spectroscopy of laser heated carbon black shows that its emissivity can be approximated by that of a black-body. This makes the analysis of the LII signal more straightforward than with presumed initial properties. Models often over- or under-predict soot primary particle size when compared to particle sizes directly measured by TEM. Concentration determination is similarly skewed. Thus, refinement of model parameters by comparison to experimental results is required to better predict these quantities – as shown by the presented results.

Explaining reaction rates between iron oxide-associated ferrous iron and nitrobenzene

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Abstract:

Ferrous iron (Fe^{2+}) associated with Fe oxides has been shown to be an important reductant for many contaminants in anaerobic groundwater environments. Understanding reaction rates in these systems has been difficult, in part because of experimental limitations in obtaining thermodynamic measurements. Recent work has demonstrated that mediated potentiometry can be used to determine the reduction potential (E_H) of the Fe^{2+}-Fe oxide redox couple. Using nitrobenzene as a model contaminant, this work relates the E_H of the Fe^{2+}-Fe oxide couple to the measured nitrobenzene reduction rate. A linear free energy relationship was developed to describe the reaction rate as a function of E_H across varying solution conditions, including pH, Fe^{2+} concentration, and oxide loading. The reduction of nitrobenzene was found to be rate-limited by the first electron and first proton transfer. The surface area normalized reaction rate coefficient was correlated to the E_H of the oxide-associated Fe^{2+} through a LFER with an optimized slope of -0.91±0.04, compared to a theoretical value of -1. Reaction rates measured for goethite- and nanogoethite-associated Fe^{2+} show a kinetic dependency on oxide surface area, though it appears the thermodynamic effects were independent of particle size. Excellent agreement was found between this study and data reported in the literature for nitroaromatic reduction by Fe^{2+} associated with goethite, nanogoethite, and hematite. These results show the rate of contaminant reduction by Fe oxide-associated Fe^{2+} can be explained by thermodynamic driving force of the reaction.

Does a clean bed filtration theory properly predict removal of model microbes in a Moringa-coated sand filter?

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Abstract:

Lack of access to clean drinking water is a serious health problem. Often, when methods for cleaning drinking water are available, they are too expensive to be practical. In our approach we adhere an antimicrobial and cationic protein from the seeds of the Moringa oleifera tree to sand to reverse the charge and provide an antimicrobial layer. Previous work shows that, when packed into a filter, this coated sand can remove 99.99% of model microbes. Here we will discuss applying various known clean bed filtration theories to this filter to predict removal of microbes and to allow scale-up. In our experiments we varied both the size of the model microbes, the ionic strength and the concentration of microbes in the influent in order to test the model. In addition we created a model to predict breakthrough of the model microbes from the filter. Armed with two theories of performance and filter lifetime, we will be able to disseminate this idea to areas of the world that need it most.

Correlating Phenotypic/Genotypic Expression of MDRO's in Sewage and Surface Waters Using an Amended IDEXX Enterolert DST and Duplex PCR.

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Abstract:

The study focused on an approach geared toward the assessment of sewage and natural surface waters for MDRO's, concentrating on *Van* genes associated with *Enterococcus* spp. The multi-phase study utilized an advanced IDEXX Enterolert® DST technique along with duplex PCR. This study was directed toward the potential resistant gene-transfer between bacterial species, with a focus on Vancomycin-resistance bacteria. Water samples were collected from four (4) different established sites in the Lock Haven area. From these samples, 50 isolates were identified as *Enterococcus spp.* based on IDEXX Enterolert® and traditional diagnostic tests. Several Minimum Inhibitory Concentration (MIC) tests and Kirby-Bauer (KB) disk diffusion assays were performed on 25 randomly-selected *Enterococcus spp.* isolates. Isolates exhibited resistance to Vancomycin and Teicoplanin up to 35 µg/mL and 10 µg/mL, respectively. Experimental data was compared to published research on antibiotic resistance patterns and suggests the presence of the *VanA* gene. Additional studies utilizing the KB and MIC data on antibiotic concentrations were next applied to field studies to test the efficiency as a pre-screen of potential VRE's. Seven (7) out of 98 wells of the IDEXX Quanti-trays™ tested positive for resistance to both antibiotics, suggesting the presence of *Van* genes. These isolates were exposed to an increased concentration of Vancomycin (150 µg/mL) and exhibited 100% resistance; suggesting the presence of the *VanA* gene. Correlation studies of the phenotypic to genotypic expression of isolates will be conducted based on the *tn1546* transposon containing *VanA* utilizing Duplex PCR.

Impact of Mineral Spatial Distribution Patterns on the Reactive Transport of Marcellus Shale waters in natural aquifers

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Abstract:

Natural gas production from Marcellus Shale formation has significantly changed the energy landscape in recent years. Accidental release, including spills, leakage, and seepage, of the Marcellus Shale waters (MSW) may occur, the release of high concentration of chemical species can potentially impose significant risks on natural drinking water resources. In order to investigate how and to what extent the mineral spatial distribution pattern controls the reactive transport of chemicals from MSW in heterogeneous subsurface aquifers. Flow-through experiments were carried out with a pulse of MSW release using 2D flow cells (12 cm by 40 cm) packed with the same vermiculite and quartz mass in three patterns that differ in correlation length. The uniform flow cell contains well-mixed pattern. The 1/4 zone and 1/2 zone flow cell have vermiculite zones with one-quarter and one-half of flow cell length, respectively. Results show the 1/2 Zone flow cell with largest correlation length led to the least ion exchange reaction for Na, Ca, Mg, K and more mobility of heavy metals compared to those in 1/4 Zone and uniform flow cell. In 1/2 Zone flow cell, mineral precipitation dominated Ba decrease. While in uniform flow cell with smallest correlation length, ion exchange reaction dominated Ba decrease. However, in 1/4 Zone flow cell, both ion exchange and mineral precipitation leading to Ba decrease. Our work emphasizes that mineral spatial pattern regulates the types and to what extent of reaction occurred among aquifer solid materials and release chemicals, therefore controlling the spatial and temporal scales that MSW chemicals remain in aquifers. Insights gained here are expected to advance predictive understanding of MSW reactive transport processes in the naturally heterogeneous subsurface aquifers and provide strategy for sustainable shale gas development in the future as well.

Metal transport Enhanced by Dissolved Organic Carbon (DOC) at the watershed scale

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Abstract:

Extensive lab studies have demonstrated that DOC enhances metal mobility and metal leaching from soil columns. Understanding of the DOC-metal coupling at the watershed scale has been relatively limited. This study aims to test the hypothesis that DOC facilitates metal transport and is primarily controlled by large water events at the watershed scale. We test the hypothesis at the Coal Creek, Colorado, using paired concentration-discharge (CQ) data from a USGS station at the mouth of Coal Creek. The data exhibits contrasting CQ behaviors of geogenic species (Na, Ca, Mg) and trace metals (Fe, Al, Cu). The geogenic species shows dilution behavior where concentrations decrease as discharge increases. In contrast, trace metals that form complexes with DOC showed enrichment behaviors that are similar to those of DOC export, where concentrations increase under increasing discharges, particularly under spring snowmelt conditions. Large discharge events (avg. 6.0 m^3/s) during spring snowmelt seasons that occurred only 4.5% of time accounted for disproportionately higher fractions of 49.3%, 49.6%, 48.7%, and 50.3% for annual export of DOC, Fe, Al, and Cu, respectively. This study indicates that export of trace metals and DOC from terrestrial lands to aquatic systems are highly skewed toward hydrological "hot moments". High-elevation and snow-dominated watersheds in the remote region usually suffer from undersampling and lack of data. This study highlights the importance of understanding climate change in contaminant and nutrients export, where extreme hydrological events are expected to occur more often.

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Department of Civil and Environmental Engineering
Department of Plant Science
Department of Geosciences
Department of Chemistry

The chairs and the student organizing committee wish to thank Debra Lambert for administrative assistance – she has answered countless questions and has made the organization of this symposium immeasurably easier.

We are grateful to the many individuals that are participating in the symposium as judges. Their service adds professionalism to our efforts to provide a competitive forum to encourage excellence in environmental scientific research.

We would like to acknowledge our keynote speakers, Dr. Margaret Torn, Dr. Monroe Weber-Shirk, and Dr. Arup SenGupta, for sharing their experiences in the field of environmental research.

The diversity of research presented at ECMSS is its greatest strength, and the symposium would not be a success without the outstanding contributions of the student participants. We appreciate the participation from Penn Staters as well as the many students and faculty who have traveled from around the region to join us.

Finally, the symposium co-chairs wish to thank all of the dedicated student volunteers that have served on the organizing committee. Their dedication to this meeting has allowed for the continuation of a great tradition, and their desire to innovate has fostered its growth.

Sarah Cronk– *Treasurer*

Moses Ajemigbitse – *Abstract Book*

Paulina Piotrowski – *Judging*

Boya Xiong and Prachi Joshi – *Publicity*

Jared Carte – *Secretary*

Kyra Murrell – *T-shirt and Photo Contest*

Jenelle Fortunato – *Website*

Nick Macelko and Faith Kibuye – *Hospitality/Event Setup/Food*

Miranda Stockton – *Off-Campus Outreach*

Nicole Urban – *Undergraduate Outreach*

Sincerely,

Ben Roman and Joseph Amsili

Co-chairs, 2017 ECMSS Organizing Committee

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