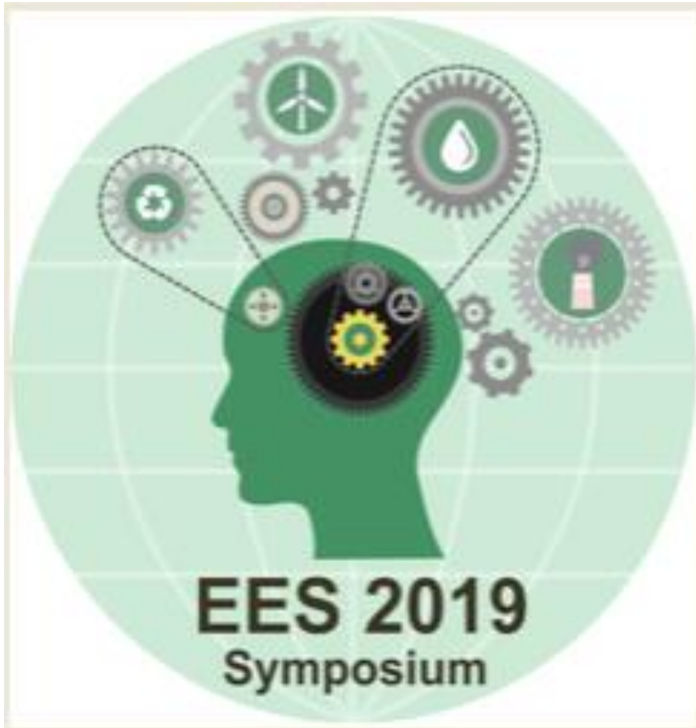


2019 AEESP Distinguished Lecture & 25th EES Symposium

April 19th, 2019

I Hotel and Conference Center

7:30 AM – 5:00 PM

CEE
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Contents

Introduction

2019 marks the 25th annual Environmental Engineering and Science (EES) Symposium at the University of Illinois at Urbana-Champaign (UIUC) as well as 2019 Association of Environmental Engineering and Science Professor (AEESP) Distinguished Lecture. This year's theme is "***Seeking Solutions to Environmental Challenges".*** This theme was chosen by the symposium organizers to bring attention to the fact that we are now becoming aware of many problems and challenges that must be addressed in order to secure a healthy environment for the future. We are seeking innovative solutions to address those environmental challenges. We hope that this symposium will bring together researchers from a wide variety of backgrounds and specialties to present their research, ideas, and visions for the future. Join us as we explore the engineering solutions to these pressing environmental challenges.

Organizers

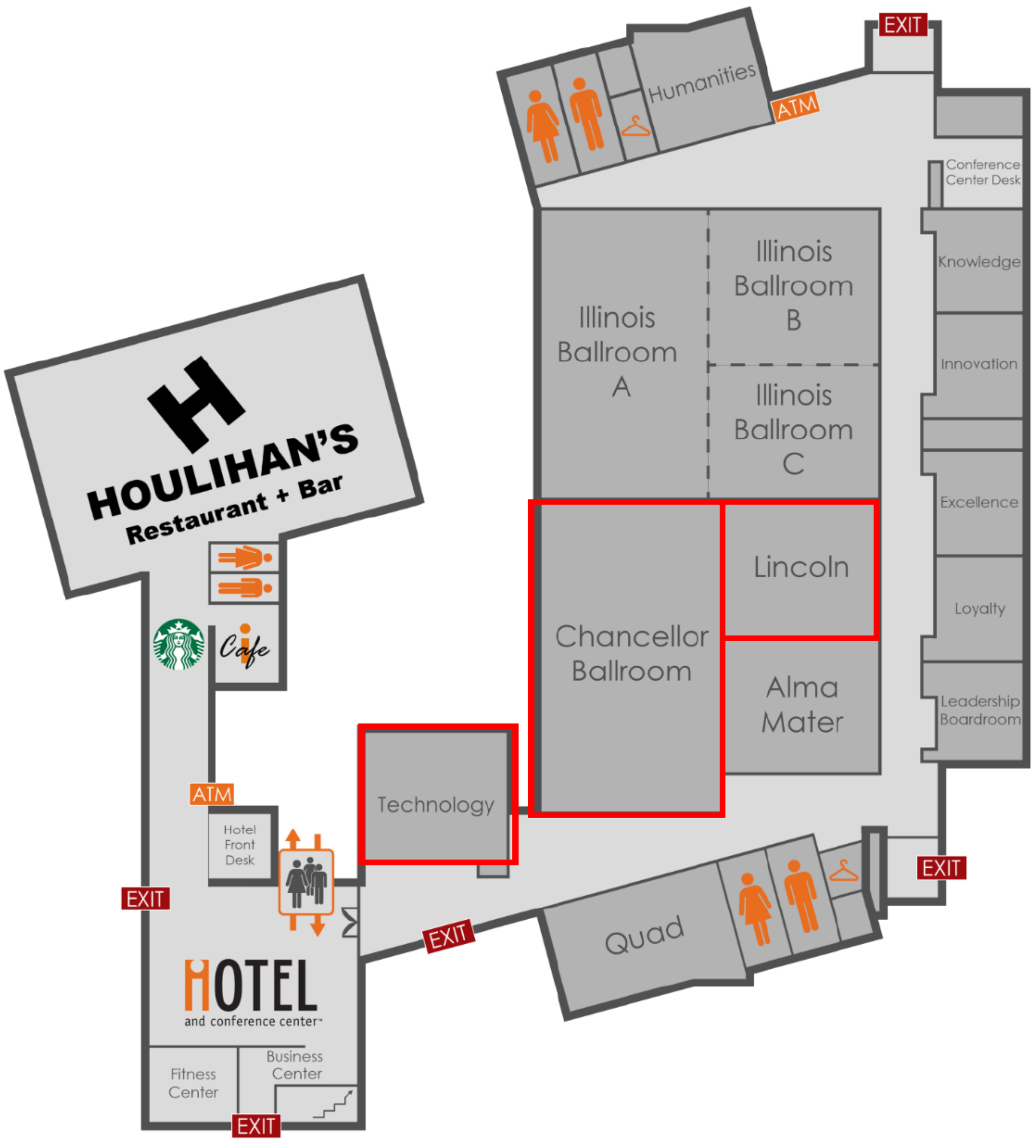
Senior graduates and students from CEE 595 G are major organizers of this event. CEE 595 G is a course taken by UIUC Civil and Environmental Engineering master's students. Students in the EES program are responsible for hosting the annual EES Symposium. This is an opportunity for us to gather together and invite the environmental engineering community to learn about our work. Each student presents either a poster or oral presentation which displays their research or a project they are working on.

Agenda

Time	Event	Location
7:30 – 8:15	**Check-in and Breakfast**	**Hallway**
8:15 – 9:15	**Poster Session 1**	**Chancellor Ballroom**
9:15 – 11:00	**Oral Session 1**	
	Oral Session 1a	**Technology**
9:15 – 9:30	**Paul Manley (Missouri S&T)** *Explosives-induced stress in plants: New methods for detecting threats*	
9:30 – 9:45	**Renee Obringer (Purdue University)** *A Resilient Water-Energy Demand Nexus Under Climate Change*	
9:45 – 10:05	**Caitlin Proctor (Purdue University)** *After the Wildfire: Responding to and Recovering from Large-Scale Infrastructure Damage in Paradise, California*	
10:05 – 10:10	**Break**	
10:10 – 10:30	**David Spelman (Bradley University)** *Modeling the Fate of Metals in Stormwater Unit Operations*	
10:30 – 10:45	**Haoran Yu (UIUC)** *A Semi-Automated Multi-Endpoint ROS Analyzer (SAMERA)*	
10:45 – 11:00	**Zhongua Zheng (UIUC)** *Machine Learning enabled coarse-grained modeling in earth system models*	
	Oral Session 1b	**Lincoln**
9:15 – 9:30	**Josue Lopez Beganza (UIUC)** *Tuning the microstructure of biomimetic hydrogels through mineralization*	
9:30 – 9:45	**Marcela Vega (University of Notre Dame)** *Use of perchlorate analog to enhance abundance of perchlorate-reducing bacteria*	
9:45 –10:00	**Ying Wu (University of Notre Dame)** *Engineering surface-display laccase biocatalyst for treating emerging organic contaminants: Kinetics and enzyme catalytic properties in acetaminophen degradation*	
10:00 – 10:10	**Break**	
10:10 – 10:25	**Baotang Zhu (University of Notre Dame)** *Biocatalytic Degradation of Parabens Mediated by Cell Surface Displayed Cutinase*	
10:25 – 10:40	**Holly Haflich (Purdue University)** *Chloramination of Polyamide-Based Reverse Osmosis Membranes in Bromide-Containing Waters*	
10:40 – 10:55	**Mackenzie Davies (Purdue University)** *Determining the effects of water temperature and ionic strength on the speciation of lead in a hot water heater*	
11:00 – 12:00	**Keynote Lecture – Dr. Issam Najm (Water Quality & Treatment Solutions Inc.)**	**Chancellor Ballroom**
12:00 – 1:00	**Lunch**	**Chancellor Ballroom**

1:00 – 2:00	**AEESP Distinguished Lecture – Dr. Lutgarde Raskin** *Converting urban organic waste streams into sustainable resources with novel anaerobic bioprocesses*	**Chancellor Ballroom**
2:00 – 3:00	**Poster Session 2**	**Chancellor Ballroom**
3:00 – 4:45	**Oral Session 2**	
	Oral Session 2a	**Technology**
3:00 – 3:15	**Aliza Funeaux (UIUC)** *Understanding phosphorus recovery feasibility at Water Resource Recovery Facilities*	
3:15 – 3:30	**Hannah Lohman (UIUC)** *Novel financing strategies to simultaneously advance development goals for sanitation and agriculture through nutrient recovery*	
3:30 – 3:50	**Zhi Zhou (Purdue University)** *Antibiotic resistance in in urban and natural environments*	
3:50 – 3:55	Break	
3:55 – 4:15	**Daeryong Park (Konkuk University)** *An evaluation of nutrient load estimation methods and the effects of monitoring frequencies in the Ohio watersheds*	
4:15 – 4:30	**Dianna Kitt (UIUC)** *Characterizing the mechanism and rate of calcium phosphate precipitation in aerobic granular sludge*	
4:30 – 4:45	**Sam Aguiar (UIUC)** Determining the Dissolution Rate of Field Grown Struvite	
	Oral Session 2b	**Lincoln**
3:00 – 3:15	**Meenu Garg (University of Notre Dame)** *A Membrane-based photobioreactor enhances algal cultivation rates*	
3:15 – 3:30	**Bumkyu Kim (University of Notre Dame)** *Predation Can Enhance Biofilm Detachment in Membrane-Aerated Biofilm Reactors (MABRs)*	
3:30 – 3:50	**Patricia Perez (University of Notre Dame)** *Unique behavior of membrane-aerated biofilm reactors (MABRs)*	
3:50 – 3:55	**Break**	
3:55 – 4:15	**John Norton (Great Lakes Water Authority)** *An Overview of GLWA Funded Research Efforts*	
4:15 – 4:30	**Jinha Kim (UIUC)** *Microbial community dynamics and performance correspondence to solid retention time during waste activated sludge fermentation*	
4:30 – 4:45	**Mariam Al-Lami (Missouri S&T)** *Aided-phytostabilization of Pb/Zn/Cu mine tailings: Enhancement of substrate functionality and ecosystem services*	
4:45 – 5:00	**Closing Remarks and Prize Distribution**	**Chancellor Ballroom**

Map


EXIT
Humanities
ATM
Conference Center Desk
Illinois Ballroom A
Illinois Ballroom B
Illinois Ballroom C
Knowledge
Innovation
Excellence
Loyalty
Leadership Boardroom
HOULIHAN'S
Restaurant + Bar
Cafe
Lincoln
Chancellor Ballroom
Alma Mater
Technology
ATM
Hotel Front Desk
EXIT
EXIT
EXIT
Quad
HOTEL
and conference center
Fitness Center
Business Center
EXIT

Keynote Lecture

Dr. Issam Najm

(11:00 AM – 12:00 PM at Chancellor Ballroom)

"A 30-Year Career in Environmental Engineering & Science - Lessons Learned & Memorable Projects"

When I came to the U of I in 1985 as a new graduate student in Civil & Environmental Engineering, I had no clue what to expect. Over the next five years, I got to know great people and learn from wonderful teachers. Then in 1990, I set out on a journey into a career in Environmental Engineering & Science. Nearly 30 years into it, I have continued to learn so many great lessons, and have had the privilege of working on fantastic projects that combine research and advances in engineering practice. In this presentation, I will share with students and faculty some of the lessons I have learned along this journey, including those that have stayed with me from my days at the U of I. I will also highlight some of the interesting projects in which I have been involved and what they have taught me.

Bio: Dr. Issam Najm is the founder and president of Water Quality & Treatment Solutions, Inc. (WQTS), a specialty environmental engineering and science consulting company whose mission is to provide water utilities with innovative and cost-effective solutions to water quality and water treatment challenges. He provides technical leadership of the company's projects, and ensures that our clients are provided the superior service they deserve. Dr. Najm is intimately involved in a number of WQTS projects including the evaluation of water treatment plant performance, pilot-scale and bench-scale testing of water treatment technologies, regulatory and permitting support for existing and new treatment plants, development of water quality monitoring plans, and development of models for water treatment processes.

AEESP Distinguished Lecture

Dr. Lutgarde Raskin

"Converting urban organic waste streams into sustainable resources with novel anaerobic bioprocesses."

(1:00 – 2:00 PM at Chancellor Ballroom)

Anaerobic digestion based technologies have great potential for converting the enormous amounts of organic waste generated in urban environments into valuable resources. Yet few urban organic waste streams are currently treated by anaerobic bioprocesses, suggesting that new approaches are needed. This presentation will show the development of novel anaerobic bioprocesses for resource recovery from urban organic waste streams by applying knowledge of microbiomes from habitats as diverse as arctic sediments and the gastrointestinal tract of ruminant animals and sustainable technology design practices. Examples will include: (i) Biofilm-enhanced anaerobic membrane bioreactor designs to treat low-strength urban wastewater at low temperatures to achieve high quality water, reduced greenhouse gas emissions, and net positive energy production, and (ii) Dynamic anaerobic membrane bioreactor designs inspired by the physiology and microbiome of the rumen (stomach of ruminant animals) to overcome slow hydrolysis of urban organic waste streams with high lignocellulosic content to produce short-chain carboxylic acids that can be used for the production of biomethane and other bioproducts. While the role of microbiomes in developing these anaerobic bioprocesses will receive most attention, the presentation will also show how the advancement of these technologies is driven by life cycle cost and environmental assessments to enable financially viable, environmentally sustainable waste management.

Bio: Dr. Lutgarde Raskin is the Altarum/ERIM Russell O'Neal Professor of Engineering at the University of Michigan. She is a pioneer in molecular microbial ecology applied to water quality control and anaerobic bioprocesses. Her research focuses on managing the microbiome of drinking water systems and developing anaerobic bioprocesses for resource recovery from waste streams. She has published about 130 peer-reviewed journal papers and 350 conference proceedings papers and abstracts. Dr. Raskin is passionate about graduate education and has mentored approximately 15 postdocs and 90 graduate students, including 25 PhD students. She received BS and MS degrees from the KU Leuven in Belgium and a PhD degree from the University of Illinois at Urbana-Champaign. Prior to joining the faculty at the University of Michigan in 2005, she was a faculty member at the University of Illinois at Urbana-Champaign. She is an elected Fellow of the American Academy of Microbiology and the Water Environment Federation. Past honors include the American Society of Civil Engineers Walter L. Huber Civil Engineering Research Prize, the Water Research Foundation Paul L. Busch Award, U.S. National Science Foundation CAREER Award amongst others.

Poster Session1

(8:15 – 9:15 AM at Chancellor Ballroom)

1) Abhijeet Saraf (UIUC)

Latest developments in application on Microbial Fuel Cells - A Review

Microbial Fuel Cells (MFCs) comprise a novel technique of harnessing energy from wastewaters through the use of microorganisms as inoculum where the substrate in the wastewater donates electrons to a terminal acceptor and energy is tapped through an external circuit. With significant progress in the research of utility of MFCs lately, they have displayed promise in a wide spectrum of applications such as treatment of industrial and domestic wastewater, removal of persistent pollutants like PPCPs, extraction of metals from solution and production of hydrogen. Simultaneous production of electricity is coupled with the various applications mentioned above. The paper presented here provides a review of the latest research into applications of MFCs and also notes the requirements for developing MFCs into a compatible utility option in future.

2) Becca Andrus (UIUC)

Prioritizing Research and Development Pathways for Decentralized Waste Treatment

The target of the United Nations' 6th Sustainable Development Goal is to provide adequate sanitation facilities to the 2.5 billion people who currently live without them. The enormous cost associated with the installation of centralized waste treatment facilities make traditional sanitation options infeasible for the developing world. This study explores research and development pathways for decentralized treatment systems. The research is conducted on one emerging technology known as the Empower Toilet. The system has been shown to effectively meet ISO 30500 standards, but the current associated cost is too burdensome for households and small communities. A technoeconomic analysis (TEA) and life cycle assessment (LCA) was conducted to highlight the primary cost drivers and environmental impacts of the Empower Toilet. Based on the preliminary results, the way to improve global sanitation is to mass produce the system, secure low interest government loans, and operate the system where electricity costs are lowest.

3) Byung Gun Joung (Purdue University)
Predictive Maintenance on Rotating Machinery Using Artificial Neural Network Methods

Predictive maintenance (PdM) techniques are designed to helpdetermine the condition of in-service equipment in order to predictwhen maintenance should be performed. A rotating system is one of the most critical elements in a machine tool system. We want to useartificial neural network (machine learning) methods to monitor thesystem condition and predict upcoming failures.

4) Carter Strien (UIUC)
Artificial Groundwater Recharge

The San Joaquin Valley in California has struggled with water scarcity concerns that have continued to get worse in recent years. With little rainfall, the state relies on groundwater for up to 65% of total annual agricultural and urban water uses in drought years. This has led to groundwater overdraft and subsequently, aquifer depletion. A groundwater overdraft occurs when the amount of water that has been extracted from the aquifer for a given year exceeds the rate of natural replenishment. In this project, a sustainable artificial recharge system designed with the goal of increasing aquifer recharge in San Joaquin County by 5-15%. This would serve to decrease San Joaquin's overdraft from 20% to 60%. To meet this goal, two technologies are analyzed and compared: Aquifer Storage and Recovery (ASR) wells and sub-surface infiltration basins.

CEE ILLINOIS

5) Courtney Ackerman (UIUC)
Separation of phosphorus uptake and carbohydrate storage for intensive algal treatment processes

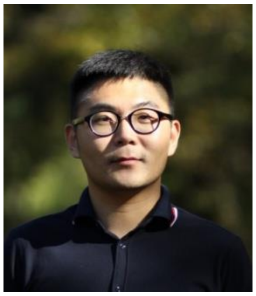
Microalgal systems have the potential to be an effective tertiary treatment step to lower effluent nitrogen (N) and phosphorus (P) levels discharged from secondary clarifiers at water resource recovery facilities (WRRFs). This work leveraged a tubular photobioreactor (PBR) system to evaluate the effect of a natural microalgal consortium on amended secondary clarifier effluent from the Urbana, IL WRRF. The PBR is critical to ensure algae dominance, but P uptake has been shown to be achieved in a dark mix tank. The objective of the work was to determine whether the system could use light time in the PBR for carbohydrate storage and still achieve the adequate nutrient removal in the dark. The system was cycled between light and dark conditions, on the timescale of hours, creating P-deplete conditions in the light, while tracking carbon storage as carbohydrates. Results of this study will inform full-scale design and operation of algal treatment processes that leverage local, naturally-occurring algae to achieve reliable phosphorus recovery.

6) Desarae Echevarria (UIUC)
Estimating the Nutrient Content of Human Bodily Excreta Using FAO Diet Data (Food Balance Sheets)

Developing communities often lack infrastructure and funds for sanitation, resulting in exposure to pathogens and environmental stressors that negatively impact health. In many of the Least Developed Countries (LDCs), these same communities rely on agriculture for employment and daily nutrition, but they lack access to fertilizers essential for high productivity. Solutions that simultaneously improve sanitation and increase access to agricultural inputs may benefit the economy and community wellness. A study showed 23 of 31 LDCs can completely offset their fertilizer use with newly installed sanitation systems.

A challenge in predicting potential nutrient recovery is that nutrient availability depends on caloric intake and protein consumption, which varies across individuals. As a starting point, country-specific food consumption data is available from a Food and Agriculture Organization (FAO) database. This poster will introduce a method to generate locality-specific datasets for nitrogen, phosphorous, and potassium excretion estimates based on country-specific caloric and protein intake.

7) Enze Jin (Purdue University)
Integrated sustainability assessment for a bioenergy system: switchgrass for cellulosic ethanol production in the U.S. Midwest



Cellulosic biofuels produced from energy crops offer significant advantages over first generation biofuels. However, due to a shortfall in cellulosic biomass and the delayed commercialization of cellulosic biofuels in the U.S., it is unlikely that the capacity to produce cellulosic biofuels will meet the 16 billion gallon target mandated by the Renewable Fuel Standard (RFS2) program by 2022. In order to understand the sustainability performance of cellulosic biofuel development, this study builds a system dynamics model for a biofuel system producing cellulosic ethanol from switchgrass under different scenarios. The model can simulate the dynamic behaviors of the cellulosic biofuel system and quantify its environmental, economic, and social impacts. The projected results indicate that cellulosic ethanol production is economically viable based on advanced bioconversion technologies and can provide significant benefits to the environment, such as greenhouse gas reductions and water use savings. The cellulosic ethanol industry also can make significant contributions to the bioeconomy and social benefits.

8) George Kontos (UIUC)
Wastewater Management of Biorefineries

Wastewater management incurs high costs originating from numerous sources such as equipment, construction, operation, maintenance and especially energy which consumed an estimated 3% of electricity demand in the United States alone. These high costs are a growing concern as next-generation biorefineries become operational, making a thorough understanding of the source of these costs critical to assessing the feasibility of future biorefinery projects. The means of gaining this understanding is through a technoeconomic analysis (TEA) which combines engineering design, process modeling, and economic analysis into a framework that can assess the technical and economic performance of a process, in this case, wastewater management of biorefineries. Attempts have previously been made by organizations, such as the National Renewable Energy Laboratory (NREL) to conduct a TEA of the wastewater management process and it is the objective of this work to recognize any common themes among the various TEAs and then identify what information or knowledge gaps remain. This will be accomplished through thorough research of the existing TEAs on wastewater management of biorefineries, analysis, and comparison of the assumptions made, methods and conclusions and then identification of how these TEAs could become more comprehensive and improved overall. Preliminary findings based on existing TEAs indicate that wastewater management will account for about 20% of the capital costs of a biorefinery installation. Given this significant contribution to overall costs, it's imperative to have a thorough understanding of their origin and ways in which that cost can then be reduced.

9) Grant Lesak (UIUC)

Solar irradiation to inactivate pathogens

Solar irradiation is a means to inactivate pathogens in water through generation of reactive oxygen species (ROS). There are two ways the solar irradiation can inactivate the pathogens. There is endogenous inactivation where solar irradiation can directly generate radicals within the pathogens. Then there is exogenous inactivation where sunlight can hit natural organic matter in the water and form radicals that can inactivate the pathogen. This research looks to explore the radicals produced under artificial sunlight by using the chemical probe phenol and measuring its degradation using high performance liquid chromatography (HPLC). A logarithmic pattern of degradation was observed of phenol in wastewater of approximately 0.6 log reduction over 4 hours. When MS2 bacteriophage as added to the wastewater the same logarithmic pattern was observed however the log reduction of phenol was approximately 0.4 over 4 hours indicating that some ROS reacted with MS2 directly instead of phenol. These observations indicate the solar irradiation has the ability to produce ROS that can be used to inactivate pathogens.

10) Jennifer DeBellis (UIUC)

Industrial-scale Algal Wastewater Treatment Systems and the Impact of Trace Metal Contaminants on Algal Growth

Industrial-scale algal treatment systems have the potential to significantly reduce effluent nitrogen and phosphorus levels in wastewater treatment systems while offering a high value algal biomass waste stream that could be used for biofuels, bioplastics, or other materials. These systems rely heavily on consistent environmental conditions however, and can suffer an upset by an incoming spike of contaminant. Contaminants of concern include an assortment of metals like lead, copper, zinc, and iron which can become inhibitory to algal growth in trace concentrations. The goal of this study is to evaluate the effect of varied concentrations of these metals on wastewater-relevant algal communities by performing growth inhibition assays and determining the effective concentration at which growth is inhibited by 50% (IC50). This information will be used to inform design decisions in industrial-scale algal treatment systems that avoid inhibitory concentrations of these metals.

11) Jiachun Sun (Illinois Institute of Technology)

Long short-term memory neural networks model development to predict influent conditions at Calumet wastewater reclamation plant

More efficient WRP operation can be achieved when the plant can dynamically adjust the aeration based on influent conditions. Soft-sensors can be an effective tool to complement conventional hard sensors to monitor influent conditions. Ten-years historical daily data about influent conditions are acquired from Calumet WRP, including more than ten main variables. Long short-term memory neural networks (LSTMs) model could be developed using this dataset to predict real-time and future influent conditions. LSTMs model has been developed in Python and I have already got preliminary results about predicting ammonia, TKN, CBOD5, TSS and VSS. the adjusted R-squared are from 0.5 to 0.8. The next step is using genetic algorithm to optimize hyperparameters in the LSTMs model. The appropriate combination of hyperparameters will make model get high accurate predictions.

12) Junren Wang (UIUC)

A Review about the Assessment of Green Storm Infrastructure for Flood Mitigation

Stormwater runoff, also known as the rainwater runoff, is ground surface-running rainfall which cannot seep into the soil due to the presence of impervious pavement and buildings. As the increasing of the urbanization, there is more and more impervious area in the city, therefore, an increasing amount of stormwater runoff are appeared, which not only induce to the flood and groundwater shortage risk but also become a growing serious source of water pollution. Several methods were applied to diminish the impact of the stormwater runoff. Green stormwater infrastructures such as Green roofs, green gardens, retention pond and so on are introduced as possible tools to remit the rainwater runoff problem, while it is still hard for us to evaluate the impact of GI for stormwater management. Several scenarios are simulated to see the change of runoff volume, peak and water pollution.

CEE
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

13) Majid Bagheri (Missouri S&T)
Plant Uptake and Translocation of Emerging and Fugitive compounds Using Artificial Intelligence

Understanding uptake and translocation of emerging and fugitive contaminants in plants is important because human are at the risk of exposure to environmental contaminants through consumption of crops. Transpiration stream concentration factor (TSCF) is a term to describe the uptake of contaminants from the groundwater through root exposure. The mechanistic modeling of uptake and translocation is the common approach, which has been used in a number of studies. While these models have improved our understanding to some measure they present unreliable results in some cases. We used intelligent techniques and statistical analysis to improve the understanding of plant uptake and translocation of emerging contaminants. Neural network (NN) and fuzzy logic were used to develop a reliable predictive model for TSCF using physicochemical properties of the chemicals and also examining the simultaneous impact of properties on TSCF. Using statistical techniques (stepwise and forward regression), significant and effective compound properties were determined. The NN predicted the uptake values with higher accuracy compared to mechanistic models. The relationship between molecular weight and log Kow with TSCF were found to be both bell-shape and sigmoidal according to fuzzy logic. The statistical analysis indicated that log Kow, molecular weight, hydrogen bond donor, and rotatable bonds are the most important properties.

14) Matthew Triebe (Purdue University)
Exploring the link between mass and energy in machine tools

Manufacturing is an indispensable part of the global economy but it also has a large environmental burden. With an increasing awareness of environmental impact, the idea of sustainable manufacturing is receiving much attention. There has been much work in the manufacturing field to reduce energy consumption and environmental impact. This work focuses on the design of the machine tool in order to reduce energy consumption and its environmental impact. One area of interest is how mass of the machine tool relates to its energy consumption. This poster will explore the link between mass and energy consumption, and the potential of light weight machine tools.

15) Skanda S Bharadwaj (UIUC)
Virtual flow of water in agriculture

With the continuous population growth and related developments, water resources have become increasingly scarce in a growing number of countries and regions in the world. As the largest water user, accounting for over 80% of the global total water withdrawal, food production is directly constrained by water scarcity. To compensate for the domestic water deficit and meet the food demand, many countries have opted for importing food from other countries. This is termed as "virtual water". Trade of real water between water-rich and water-poor regions is generally impossible due to the large distances and associated costs, but trade in water-intensive products is realistic. Virtual water trade between nations and even continents could thus ideally be used as an instrument to improve global water use efficiency, to achieve water security in water-poor regions of the world and to alleviate the constraints on environment by using best suited production sites

16) Stephanie Schramm (UIUC)
Advancing Algae Modeling Platforms for Wastewater Treatment through Universal Stoichiometric Yield Coefficients

Nitrogen and phosphorus effluent concentrations at water resource recovery facilities (WRRFs) are becoming increasingly more stringent. Algae water treatment technologies have the ability to remove additional nitrogen (N) and phosphorus (P) from wastewater, allowing WRRFs to improve effluent quality and meet increasingly strict N and P regulations. Although algae technologies are promising, a challenge for the widespread adoption of algae processes at WRRFs is the lack of robust modeling platforms. Developing generalizable model parameters for algae such as universal stoichiometric yield coefficients, similar to stoichiometric parameters used in the International Water Association's (IWA's) Activated Sludge Models (ASMs), is needed to increase the implementation of algae technologies at WRRFs. This work introduces universal stoichiometric coefficients for algae derived from 11 genome-scale models for seven algae species. Generalizable stoichiometric parameters will bolster model accuracy and increase the use of algae technologies by wastewater design engineers and utilities in order to improve effluent quality at water resource recovery facilities.

17) Valeria Colon Melendez (UIUC)
An Evaluation of Photocatalytic Degradation using Titanium Dioxide (TiO2) in Water Treatment

The water treatment industry has been constantly searching for innovative disinfection techniques that can remove or destroy certain pollutants in order to comply with the U.S. Environmental Protection Agency's regulations and improve water quality. In recent years, researchers have studied a process that involves the usage of a photocatalyst and ultraviolet (UV) light called photocatalytic degradation. One photocatalyst that has played an important role in this process is Titanium Dioxide (TiO2). Some favorable characteristics of TiO2 are its photoactivity efficiency, stability, non-toxicity, low production cost, low energy consumption, and can be incorporated in existing processes to minimize the formation of disinfection by-products (DBP). This review will focus on discussing fundamental principles of photocatalytic degradation, TiO2 integration in water treatment and overall effectiveness.

18) Wo Jae Lee (Purdue University)
Toward Reliable and Sustainable Manufacturing Operation: Condition based Maintenance Strategy using Deep Learning and Acceleration Time-Frequency Images

In a highly automated manufacturing plant, the enhanced reliability of manufacturing equipment becomes more critical than ever before for the highly reliable and sustainable manufacturing operation. A sudden machine breakdown can bring unexpected downtime, shorter lifespan of equipment, and lower operational safety. To improve machine reliability, a machinery maintenance method has been evolved from run-to-failure maintenance to condition-driven maintenance (predictive maintenance) with the emergence of new technologies (e.g., smart sensor, IIoT, and AI). The most crucial factor for a successful maintenance strategy and practice is how to monitor in-service equipment and how to extract meaningful information from a huge amount of data available from manufacturing equipment. With this in mind, a deep learning enabled real-time condition monitoring method is proposed to identify motor condition using the acceleration time-frequency images. To collect and store acceleration data under different motor conditions, a lab-scale motor test-bed has been set up, and several sets of the experiment have been conducted to demonstrate the recognition power of the proposed monitoring method. In the study, tri-axial acceleration data rather than single axis acceleration data are used because the most influencing axis varies as a motor condition changes. Also, the combinations of different failure event rather than only one single failure event are considered together. Three deep learning architecture (GoogLeNet, Alex Nets, and ResNet50), which are known to be the most powerful to data, are tested and their performance are compered. Tri-axial acceleration data are converted into 2D images (time-frequency), and the application of the time-frequency images to the deep learning algorithms highlights that the method can efficiently handle the huge amount of data and effectively monitor the motor condition.

19) Xuehao Wang (UIUC)
MATLAB in electrochemistry

MATLAB (MATrixLABoratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces and interfacing with programs written in other languages, including C, C++, Java, Fortran and Python.Electrochemistry is a branch of chemistry that studies the relationship between electricity, as a measurable and quantitative phenomenon, and identifiable chemical change, with either electricity considered an outcome of a particular chemical change or vice versa. MATLAB has obtained a wide range of applications in different fields of science and electrochemists are also using it for solving their problems which can help them to obtain more quantitative and qualitative information about systems under their studies. In this review, we are going to cast a look on different applications of MATLAB in electrochemistry and for each section, a number of selected articles published in the literature will be discussed and finally, the results will be summarized and concluded.

20) Yi Jin (Purdue University)
Sustainability of Commercially Available Anti-icing and De-icing Chemicals

Conventional chloride-based anti-icing and de-icing chemicals may pose negative environmental impacts, deteriorate cement paste, corrode steel rebars, and reduce durability of concrete, asphalt pavement and bridges. Previous studies have showed that chloride-based chemicals deteriorated soils, increased chlorine contamination in groundwater and surface water, injured vegetation, and shrunken wildlife habitats. About 50% of corrosion on vehicles is caused by road salts. Alternative anti-icing and de-icing chemicals, such as acetate-based chemicals or beet juice, may cause less impacts on the environment, reduce long term maintenance costs of road infrastructure and vehicles, but increase their application rates to achieve similar de-icing performance. However, limited studies have been done to evaluate environmental impacts of commercially available anti-icing and de-icing chemicals. The objective of this study was to analyze environmental impacts of commercially available anti-icing and de-icing products chemicals using life cycle assessment (LCA). Life cycle assessment was used to quantify environmental impacts on global warming, acidification, eutrophication, and ecotoxicity over the entire product's life cycle. Two conventional deicers (NaCl and CaCl2) and four alternative products (KAc, CMA, beet juice and glycerin) were analyzed to determine which product has the least environmental impact during winter maintenance. In addition, five commercially available anti-icing and de-icing products (Beet Heet, liquid calcium chloride, road salt, road salt treated, and salt brine) were evaluated in terms of short-term cost (purchasing price) and long-term cost resulting from environmental deterioration relative to road salt. The results showed that salt brine is most cost-effective for ice melting in the short term, while in the long term, liquid calcium chloride will reduce environmental impact and Beet Heet will increase environmental impact compared with road salt. This analysis showed that LCA can help winter operation operators comprehensively and quantitatively evaluate sustainability of current anti-icing and de-icing chemicals.

21) Gemma Clark (UIUC)

Evaluation of POU filters at schools in Illinois for the removal of microbial and chemical contaminants

Maintaining water quality through drinking water distribution systems is a challenge. Distribution systems often involve deteriorating metal pipes and the biofilms that form within them. As a result, metals are released into the water and waterborne disease has an opportunity to spread. The State of Illinois has passed legislation mandating that elementary schools test for and control levels of lead in drinking water. Lead level control can be achieved by installing point-of-use (POU) filters. How these filters might affect the microbial quality of the drinking water is unknown. In this study, water samples will be taken from taps in elementary schools with and without POU filters. Six parameters will then be measured for each sample: free chlorine (a residual from disinfection that should be removed by POU filters) concentration; cell counts (using flow cytometry); bacterial community analysis (using PCR); lead concentration; pH and temperature.

Oral Session 1

(9:15 AM – 11:00 AM)

Session 1a

1) Paul Manley (Missouri S&T)
(9:15 AM – 9:30 AM)

Explosives-induced stress in plants: New methods for detecting threats

Remnant landmines pose a global threat to military personnel and civilians, alike. Their prevalence causes the death or injury of 15,000 to 25,000 people annually, with a fifth of those being children. Current detection methods are timely and expensive. A novel technique using hyperspectral images of vegetation is proposed. Maize and sorghum plants were exposed to drought conditions (60% Field Capacity, FC) and 250 mg kg-1 RDX (Royal Demolition Explosive) and imaged weekly using a Headwall Nano-Hyperspec hyperspectral imager. Average reflectance index values were calculated from each group and compared via Multiple Analysis of Variance (MANOVA) and Principle Components Analysis (PCA). Results show some significant differences between control and drought groups and clear significance between control-RDX and drought-RDX groups. Future work will involve targeting specific wavelengths that respond best to drought and explosive environments for custom reflectance index development.

2) Renee Obringer (Purdue University)
(9:30 AM – 9:45 AM)
A Resilient Water-Energy Demand Nexus Under Climate Change

Urban areas are growing at unprecedented rates, putting pressure on urban infrastructure systems, especially water and electricity. Additionally, the expected impacts of climate change will further exacerbate stress. In order to effectively prepare for a future that is increasingly more urban and also facing intense climate change, researchers need to focus on improving our predictive modeling approaches to urban infrastructure systems. Here I will present a study in which a novel framework for predicting the residential water and electricity use in urban areas is expanded to make future projections based on climate change. The results show a systematic shift in the water and electricity use by the end of the century. Specifically, under the RCP8.5 scenario, our model projects a relative increase in electricity use and a relative decrease in water use in six Midwestern cities due to the changing climate.

3) Caitlin Proctor (Purdue University)
(9:45 AM – 10:05 AM)

After the Wildfire: Responding to and Recovering from Large-Scale Infrastructure Damage in Paradise, California

Co-authors: Andrew Whelton (Purdue EEE and CE), Amisha Shah (Purdue EEE and CE), David Yu (Purdue CE and Political Science), and Junesook Lee (College of Manhattan)

On November 8, 2018 the Camp Fire in Northern California caused unprecedented wildfire devastation. As the Town of Paradise began to rebuild, they discovered a secondary hazard, with heavy chemical contamination in the drinking water system. Concerning maximum concentrations of benzene (2,217 ppb), naphthalene (698 ppb), styrene (378 ppb), and toluene (676 ppb) were measured in drinking water as of late February 2019. The fire was already the most destructive and deadliest California wildfire in history, burning over 153,336 acres (240 square miles) and damaging more than 10,000 buildings. Resolving this subsequent chemical contamination issue, which is believed to stem from damaged plastic components in the system, will significantly increase recovery time. In February 2019, several experts from Purdue and Manhattan College visited Paradise to provide technical assistance to the water utility. In this talk, I will share our observations, assessment, experiences as well as insights into the support we continue to provide to the community.

4) David Spelman (Bradley University)
(10:10 AM – 10:30 AM)
Modeling the Fate of Metals in Stormwater Unit Operations

Stormwater unit operations (UO) have the potential to physically separate particulate matter (PM) and the PM-bound metals from rainfall-runoff. UO separation response for PM and metals can be impacted by variable granulometric, metal partitioning and distribution across the particle size distribution (PSD), and hydrologic loadings influenced by geographic location and climate. This study illustrates a methodology to examine the portability of UO separation response for PM and metals utilizing a normalized set of UO separation behavior through a computational fluid dynamics (CFD) model. CFD is compared with a surface overflow rate (SOR) model. PM, Cd, Cu, Pb, and Zn are modeled based on measured results from seven storm events for a screened hydrodynamic separator (SHS). CFD and SOR results demonstrate variability in predicting measured UO separation on an event load basis with a bias towards under-prediction of metals separation for all events. SOR tended to over-predict separation relative to CFD and measured results. The variable distribution of metal mass across the PSD has a significant influence on model prediction. The geographic variability in metals separation for a rectangular clarifier (RC) is quantified with three storms using PSDs and PM-bound metal mass distribution from seven locations. Depending on the storm, geographic location, and metal, a wide range of metal separation of 4-82% was found for the RC based on variations in influent PSD and metal mass distribution across the PSD. This study demonstrates that a methodology for predicting PM and metal separation by a UO to any influent loading conditions using CFD or SOR is viable and represents a tool to potentially simplify UO design, analysis, and regulation through portability of UO behavior. Future study of metal mass distribution over PSD in runoff is recommended in this effort. A balanced approach between measurement cost and UO performance prediction is provided based on results of this study.

5) Haoran Yu (UIUC)
(10:30 AM – 10:45 AM)

A Semi-Automated Multi-Endpoint ROS Analyzer (SAMERA)

The oxidative potential (OP) of ambient particulate matter (PM), i.e. the ability to generate reactive oxygen species (ROS) in the presence of a biological reductant, has been investigated for a long period of time. Both dithiothreitol (DTT) and surrogate lung fluid (SLF) are widely adopted as the probes to determine OP. A semi-automated system was built based on these two antioxidant probes. Five endpoints out from the two probes, including the consumption of DTT, ascorbic acid (AA) and glutathione (GSH), as well as the generation of hydroxyl radical (•OH) in DTT and SLF, were used as OP indicators. An automated Kloehn control pump system with sample injection valve was used to automate the protocol. A liquid wavelength capillary cell (LWCC) and a Horiba spectrofluorometer were used for the measurement of five endpoints. The system was calibrated with pure substances (i.e. Cu, Fe, phenanthraquinone and 5-hydroxy-1,4-naphthoquinone) as the positive controls, and was then tested for its performance with the real ambient PM samples collected from an urban site. The detection limit and precision of the system were evaluated. We anticipate that system can be coupled to a PM sampling device to monitor the oxidative potential of ambient PM in real-time.

6) Zhongua Zheng (UIUC)
(10:45 – 11:00 AM)

Machine Learning enabled coarse-grained modeling in Earth System Models

Atmospheric aerosols vary in their chemical composition, resulting in different "aerosol mixing state", which we define as the distribution of aerosol chemical species among particles in a population, and the way these species are arranged within the particles. A realistic representation of the aerosol mixing state can be achieved in principle with a Particle-resolved Monte Carlo (PartMC) numerical model but at a computational cost that is prohibitive for further implementation in Earth System Models (ESMs). The objective of this research is to harness the capabilities of machine learning as an integrating tool between detailed process modeling and large-scale ESMs. We propose a data-driven workflow, leveraging machine learning algorithms to emulate detailed PartMC simulations, and applying the emulators to large-scale ESMs. A case study of aerosol mixing state metrics representation will be demonstrated in detail. This workflow will enable key insights into the importance of machine learning to atmospheric research.

CEE
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Session 1b

1) Josue Lopez Beganza (UIUC)
(9:15 AM – 9:30 AM)

Tuning the microstructure of biomimetic hydrogels through mineralization

Marine organisms are known to fine-tune the physical and chemical properties of gel-like environments within their bodies to guide the precipitation of calcium carbonate and synthesize mineralized tissues with sophisticated microstructures. While the three-dimensional polymer network provides sites for nucleation, the pore solution regulates mass transport to the growing mineral phase and contains soluble additives that can further influence the expressed crystalline morphology. Hydrogels serve as versatile biomimetic models to help shed light on the mechanisms exploited by living organisms to direct biomineralization in such gel-like environments. Despite poor mechanical properties, hydrogels remain a subject of intense research due to their potential for tissue engineering applications. In this work, we showcase several mineralization pathways to customize the microstructures of the mineralized hydrogel. The formation of amorphous calcium carbonate (ACC) as a precursor to the final crystallization step is shown to play an important role regulating the growth of the crystals and their spatial distribution within the network. The resulting mineralized networks show improved strength and resilience of the composite. Through this work we share insights into the mechanisms that control the formation of minerals in hydrogels and how they can open new avenues for designing bioinspired mineralized tissues for tissue engineering applications.

2) Marcela Vega (University of Notre Dame)
(9:30 AM – 9:45 AM)

Use of perchlorate analog to enhance abundance of perchlorate-reducing bacteria

Microbial degradation of perchlorate is a promising strategy to remediate perchlorate. Perchlorate is typically found in the µg/L range, and exerts a weak selective pressure for perchlorate-reducing bacteria (PRB). Chlorate, an intermediate in the perchlorate reduction pathway, could select PRB. We tested this hypothesis with two membrane biofilm reactors (MBfRs) in three phases. First, Reactors A (control) and B (experimental) were supplied perchlorate, nitrate, and sulfate during 25 days. Then, we added chlorate to Reactor B for 30 days, and finally we stopped chlorate addition. After 10 days, in both MBfRs nitrate was completely reduced and perchlorate was reduced by 95-100%. When sulfate removal averaged 10% in both H2-MBfRS, perchlorate reduction decreased to 77-95%. During chlorate addition, sulfate reduction decreased to below 5% and perchlorate reduction increased to >95%. Once we removed chlorate, Reactor B resumed with high sulfate reduction and lower perchlorate removals. Our results suggest that chlorate addition enhances selection for PRB and inhibits sulfate reducing bacteria.

3) Ying Wu (University of Notre Dame)
(9:45 AM – 10:00 AM)

Engineering surface-display laccase biocatalyst for treating emerging organic contaminants: kinetics and enzyme catalytic properties in acetaminophen degradation

The presented work harnessed the high activity and versatility of fungal laccases and developed a novel enzyme biocatalyst for treating persistent organic contaminants in water. Enzyme biocatalysis has high catalytic efficiency under ambient conditions of temperature and pressure. However, using enzymes in solution as additives for water treatment is not suitable and economical due to short enzyme lifetimes, non-reusability or renewability, and high cost of single use. Our study overcomes these challenges by immobilizing the laccase from white-rot fungi on the outer surface of biological cells using synthetic biology methods, resulting in a new class of renewable biocatalyst (referred to as surface display laccase (SDL)). This study investigated a critical fundamental question relevant to using SDL for contaminant degradation: whether and how surface display would influence the reaction kinetics and reaction mechanism of contaminant degradation by laccase. A widely detected pharmaceutical contaminant acetaminophen (APAP) was used as the target contaminant. Results showed that the transformation of APAP by the SDL followed second-order reaction while APAP degradation by free laccase followed first-order reaction. The enzymatic reaction by both SDL and free laccase followed the Michaelis-Menten model with distinct Km and Vmax of 62.16 μM, 0.081 μM/min (SDL), and 337.66 μM, 1.044 μM/min (free laccase), respectively. The differences in Km and Vmax values between SDL and free laccase indicated that immobilization effects imposed by surface display had a large impact on the catalytic properties of SDL. Mass spectrum analysis of degradation products suggested that surface display of laccase did not change the mechanism of APAP degradation compared to that by free laccase. Particularly, the degradation pathway included enzymatic oxidization of APAP to highly reactive radical intermediates and the following chemical coupling of intermediates to form dimers and trimers, leading to detoxification of APAP. Furthermore, the SDL biocatalyst could effectively degrade APAP in actual secondary wastewater effluent and the reaction rate in the secondary effluent was improved compared to that in acetate buffer. Kinetic characterization suggested that there might be some electron mediating compounds in the secondary effluent to facilitate APAP degradation. Results from this study provided insights into the factors affecting the efficacy of the SDL and laid the scientific basis for developing and implementing innovative surface display enzyme biocatalysts for remediation applications.

4) Baotang Zhu (University of Notre Dame)
(10:10 – 10:25 AM)

Biocatalytic Degradation of Parabens Mediated by Cell Surface Displayed Cutinase

There is a critical need to develop innovative and eco-friendly technologies to address the challenges of treating contaminants of emerging concern. This study aimed to develop a renewable biocatalyst that harnesses the cutinase, a versatile fungal hydrolase, for enzymatic degradation of parabens, a class of emerging environmental contaminants with known endocrine-disrupting effects, in water reclamation and reuse. A novel biocatalyst (named as SDFsC) was constructed by expressing the enzyme Fusariumsolanipisicutinase (FsC) on the cell surface of Baker’s yeast Sacchromycese cerevisiae and demonstrated successful enzyme-mediated removal of parabens for the first time. Parabens with different side chain structures had different degradation rates by the SDFsC. The SDFsC preferentially degraded the parabens with relatively long alkyl or aromatic side chains. The structure-dependent degradability was in a good agreement with the binding energy between the active site of FsC and different parabens. In real wastewater effluent solution, the SDFsC effectively degraded 800 µg/L of propylparaben, butylparaben, and benzylparaben, either as a single compound or as a mixture, within 48 hours. The estrogenic activity of parabens was considerably reduced as the parent parabens were degraded into 4-hydroxybenzoic acid via hydrolysis pathway by the SDFsC. The SDFsC showed superior reusability and maintained 93% of its initial catalytic activity after six rounds of paraben degradation reaction. With the proof-of-concept demonstration of using SDFsC as a novel biocatalyst for degradation of parabens, similar biocatalytic treatment processes for a broader array of other contaminants could be developed in future work, opening up new opportunities of using enzyme biocatalysis as a green chemistry alternative to address more environmental challenges.

5) Holly Haflich (Purdue University)
(10:25 AM – 10:40 AM)

Chloramination of Polyamide-Based Reverse Osmosis Membranes in Bromide-Containing Waters

Chloramination can be used to control biofouling of polyamide (PA)-based reverse osmosis (RO) and nanofiltration (NF) membranes. However, waters that are treated by RO and NF contain halides (e.g. bromide in seawater). One component of chloraminating halide-impaired waters is understanding how monochloramine (NH2Cl) behaves in the presence of halides and how the secondary species react with the PA layer. Benzanilide (BA) can be used to model the behavior of the PA layer. Batch experiments were performed to evaluate how BA reacts with NH2Cl under varying pH and bromide concentrations. BA decay and by-product formation were evaluated by HPLC-UV from pH 4 to 7. Results exhibited that at pH 4, BA decay followed a pseudo-first order loss when 0.84 mM of bromide was added, which yielded a kobs of 8.97x10-2 min-1. Ortho and para-brominated-benzanilide by-products were formed at pH 4. GC/MS experiments are required to understand BA loss at neutral pH.

6) Mackenzie Davies (Purdue University)
(10:40 AM – 10:55 AM)

Determining the effects of water temperature and ionic strength on the speciation of lead in a hot water heater

Lead contamination of drinking water poses a serious health risk, specifically targeting the human nervous system. While lead in distribution systems has been extensively studied, the effect(s) of residential hot water heaters and ion-exchange water softeners on lead present in distribution systems or premise plumbing remains relatively unknown. The aim of this project is to determine if changing temperature or ionic strength influence the speciation of lead in residential potable water. Initial enthalpy models based on tabulated values (MINEQL+) at STP conditions were developed to determine how lead (II) and (IV) could change with these new variables. Lead (IV) solid PbO2 dissolution is monitored with an iodometric test via UV-vis spectrometry. Additionally, using an ICP-OES, lead (II) nitrate precipitation is measured over several time-series to determine the effects of temperature and ionic strength. Results prove that these methods of detection and analysis are effective ways to measure lead in each of these forms.

Poster Session 2

(2:00 PM -3:00 PM at Chancellor Ballroom)

1) Alexander Bruchhauser (UIUC)
Mobile Monitoring of Trace Gas and Particulate Concentrations in Champaign County

Extended or repeated incidence of trace gas, PM10, or PM2.5 exposure is shown to have both acute and long-term health impacts. Environmental Protection Agency (EPA) stationary pollutant monitoring sites provide adequate evidence of temporal variation between CO, NO, NO2, O3, PM10, and PM2.5 along with other pollutants. However, these sites cannot capture the spatial variation of pollutants between stations. Mobile pollution monitoring is one technique that captures primary and secondary production of these compounds with high temporal and spatial resolution. Our mobile monitoring method consists of using a bicycle in the Urbana-Champaign area equipped with an ARISense electrochemical instrument to map the diurnal variation of pollutants. Samples taken in 5 second intervals along with GPS tracking are used to map the concentration fluctuations under various exposures provide us with key implications for understanding the effects of exposure on human health.

2) Amber Volmer (UIUC)
Modeling the Performance of a Fixed-Bed Reactor Utilizing Immobilized Biocatalysts to Treat Perchlorate in Drinking Water

Perchlorate, an emerging contaminant, is found in public water supplies at concentrations three orders of magnitude below co-contaminants. Because low concentrations of perchlorate adversely affect mental development in children and fetuses, the US EPA is currently developing national regulations. Existing treatment technologies are energy-intensive and limited by the low ratio of perchlorate to co-contaminants. Biocatalytic treatment, an emerging technology, offers targeted degradation, using biological enzymes with high specificity toward perchlorate. Prior research suggests that biocatalyst reuse is necessary for the technology to be feasible. This study utilizes experimental results to model a fixed-bed reactor containing immobilized enzymes that target perchlorate. The model will integrate techno-economic analysis (TEA) and life cycle assessment (LCA) to understand the impact of design parameters on removal efficiency and economic and environmental sustainability. Preliminary research has examined the impacts of hydraulic loading rate and bead size on performance, cost, and global warming potential of the reactor.

3) Anisa Hardin (UIUC)
Disinfection Kinetics of Coxsackievirus B5 with Free Chlorine

The World Health Organization's "Guidelines for Drinking-water Quality" has identified safe drinking water as essential to health and a human right. Disinfection by chlorination is commonly used for drinking water purification in the United States, but the chlorine dose required to inactivate certain viruses remains unknown. One such virus is coxsackievirus. Coxsackievirus, along with other enteroviruses, causes a significant number of infections in the United States. These infections can prove fatal to those with weaker immune systems (children, the elderly, women in pregnancy, etc.). This research seeks to determine the free chlorine dosage required to effectively inactivate coxsackievirus B5 in drinking water under varying conditions and to compare those values with the corresponding US Environmental Protection Agency regulations. The goal of this research is to facilitate the improvement of water regulations and disinfection methods, thus pushing the advancement of drinking water safety.

4) Anqi Li (UIUC)
Review: The role of water in fault lubrication

The poster shows a review of The Role of Water in Fault Lubrication which was published on Nature Communications by YijueDiao and Rosa Espinosa-Marzal (Civil and Environmental Engineering, University of Illinois at Urbana-Champaign) in 2018. The authors tried to scrutinize the role of brines on fault behavior by conducting three pathways of energy dissipation as functions of contacting stresses: viscous shear of a lubricious solution film at low normal stresses; shear-promoted thermally activated slip; and pressure-solution facilitated slip at sufficiently high stresses and slow sliding velocities. They also argue that pressure solution provides a weakening mechanism of the fault strength at the level of single-asperity contacts. Whole procedure of the research was determined under nano-scale. Results together with analysis and discussions will be listed on the poster.

5) Bessie Fu (UIUC)
ACC-Mediated Calcium Phosphate Formation in Hydrogel Templates

The pathway of calcium carbonate assisted formation of calcium phosphate in organic environments has been reported to yield skeletal structures in nature. Amorphous calcium carbonate (ACC) is a soluble precursor of calcium carbonate and in this work, it is shown to control the growth of hydroxyapatite within biomimetic hydrogels. Time-dependent IR spectroscopy and electron microscopy are used to investigate the crystallization of ACC-mediated calcium phosphate. A solid-state transformation is proposed to be major mechanism in the transformation between ACC and calcium phosphate. The concentration of the solutions, as well as the presence of ACC, are determined to influence the morphology, the distribution and the microstructure of the precipitated mineral.

6) Christian Ley (Purdue University)
Shifts in Microbial Dynamics as a Building Transitions Between Rainwater and Municipal Drinking Water

Trends in water conservation have given rise to the utilization of rainwater catchment for potable applications. The study goal was to characterize the microbial dynamics at a net-zero water residence, after transitioning between municipal water and rainwater as the primary source of water in the home. Microbial water quality was evaluated using qPCR, heterotrophic plate counts (HPC), and flow cytometry (FCM) to quantify bacteria. Physicochemical measurements were also conducted, including pH, temperature, total chlorine, and total organic carbon. Mean HPC values were 2.25 x 10^3 CFU/ 100 mL at the service line, but increased to 8.86 x 10^5 CFU/ 100 mL at the distal ends. Water collected from hot water fixtures exhibited an order of magnitude greater HPC levels than cold water fixtures. Legionella and Mycobacterium spp. were detected using qPCR with mean concentrations of 3.0 x 10^3 gene copies/100ml and 7.4 x 10^3 gene copies/100ml, respectively.

7) Gabrielle Lovato (UIUC)

Novel thin-film composite nanofiltration membranes with covalent organic framework active layers

The world suffers from water scarcity and a lack of safe drinking water for reasons including record population growth, accelerated development, and climate change, making it essential to start emphasizing sustainable and efficient water treatment technologies. Pressure driven membrane systems are a promising technology that can be used effectively to recycle freshwater, seawater, municipal wastewater effluent or industrial water to potable quality. Commercial membrane products typically consist of an asymmetric thin-film composite (TFC) structure: a polymeric thin active layer supported by an ultrafiltration membrane and a thick fiber backing. While this structure allows reverse osmosis (RO) and nanofiltration (NF) membrane systems to remove a wide range of water contaminants with minimal chemical additives or no thermal input, the relatively limited polymeric surface chemistry currently available, mostly fully and semi aromatic polyamides, restricts the range of water permeability and solute selectivity achieved.

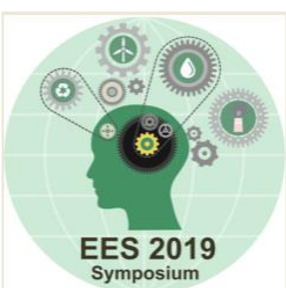
An alternative to conventional polyamide membrane materials is covalent organic frameworks (COFs). COFs have a crystalline structure created by strong covalent bonds made through synthetic reactions of organic building units. The structure provides a well-organized layer with pore size control based on chosen building units. Utilizing the up-scalable TFC structure formation of commercial membrane products, an ultrathin polyimine COF film can form on an ultrafiltration membrane support by interfacial polymerization (IP), creating a novel NF TFC membrane. This work investigates the tunable structure of three COF films, created via IP of organic building blocks (e.g., terephthalaldehyde and tris(4-aminophenyl)benzene) in non-aqueous solvents and an aqueous catalyst, on an ultrafiltration polyacrylonitrile (PAN) solvent-resistant support.

Water permeability as well as organic and salt rejection by COF membranes are assessed and compared to those of commercially available NF membranes tested under the same conditions. Current results show the large impact small changes in monomer selection have on membrane performance, with simple additions of two methyl groups on the terephthalaldehyde monomer, for example, increasing rejection of sodium chloride up to ten percent primarily through changes in the solute diffusive permeation coefficient. Additionally, physicochemical characterization of the COF membranes using techniques including scanning electron microscopy (SEM) and grazing-incidence wide-angle x-ray scattering (GI-WAXS) provide valuable insight into COF-substrate interaction and degree of crystallinity and cross-linking. Combined, the two analyses of COF membranes elucidate clear pathways forward for further studies and improvements in this field.

8) Gus Greenwood (UIUC)
Molecular Insight into the Slip of Water and Ions Along the Graphene Plane

Understanding modulation of water molecule slippage along graphene surfaces is crucial for the development of tunable graphene-enhanced nanofiltration membranes. Here, we examine shear and normal forces on supported single-layer graphene using atomic force microscopy and find that the electrolyte composition affects the molecular slippage of nanometer thick films of aqueous electrolytes along the graphene surface. In light of the shear-assisted thermally activated theory, water molecules along the graphene plane are very mobile when subjected to shear. However, upon addition of an electrolyte the cations can make water stick to graphene, depending on both the ions introduced and their concentrations. Molecular slippage also appears to be influenced by graphene's electrical double layer, which originates from graphene's substrate, indicating that modulation of the doping characteristics of graphene in liquid environments is a potential method to control the microhydrodynamics near membrane surfaces and inspiring improvements in current membrane technology.

9) Hezi Bai (UIUC)
A novel disinfectant-the peracetic acid



As the disinfection by-products of the chlorine have a latent harmful impact on human health, recently, peracetic acid, used being applied in the cleaning of agricultural products, has been proposed as a potential alternative disinfectant in the wastewater treatment. To realize the application of the peracetic acid in practice, lots of research has been devoted into this field, including the efficacy and mechanism of peracetic acid on the bacteria and viruses and optimal combination with other disinfection methods. It has been verified that the peracetic acid's disinfection ability is much greater than the hydrogen peroxide and not inferior to that of the chlorine. Meanwhile, the efficiency improves a lot when combining the peracetic acid with UV radiation due to the synergy and the high affinity of the peracetic for membranes. Though still, there remains many questions of the peracetic acid waiting for us to explore, the peracetic acid is a mighty candidate for the future wastewater treatment.

10) MekhakhemKheperu (UIUC)

Characterization and Desalination Performance Analysis of HCDI employing a redox-active material (NaMnO2)

Motivated by the growing crisis of global water scarcity, this work investigates a novel desalination method employing ion electro sorption. The goal of this research is to characterize and analyze the capacitive deionization performance of a hybrid desalination cell employing a carbon-supported, sodium exchanged MnO_2 electrode. Ultimately, a redox-active material ($NaMnO_2$), is characterized for properties such as electrochemical charge storage, ion selectivity, and cation-insertion ability. Finally, the active layer electrode is analyzed for performance in a hybrid desalination cell.

11) Mengwei Han (UIUC)

Direct dynamic measurements of Ionic liquids (ILs) under nano-confinement and their implications for energy storage systems

Ionic liquids (ILs) are a type of emerging chemicals that feature superior chemical stabilities and an ion molar ratio of 100%, which makes them perfect candidates for electrolytes in energy storage devices such as supercapacitors. For that purpose, ILs are usually coupled with nano- or meso- porous electrode materials. Therefore, it is of imperative importance to understand the structure and behavior of ILs in the confined environments, especially their dynamics that dictates the transport of ions during charging and discharging. In the present study we create a charged nano-confinement on our surface force apparatus (SFA) and directly measure the viscosity of the ILs under at charged slit pores with thickness of 2-50 nm. The results indicate that the viscosity of ILs increases when the pore size is smaller than 30 -50 nm, depending on the bulk viscosity of the IL. At pores smaller than 10 nm, ILs organize into solid-like layers, whose viscosity is determined by both the electrostatic interactions and the packing of ion layers. A universal correlation among the Debye length, film thickness, and viscosity, is discovered for various of ILs, which indicates the potential coupling of electrostatic force, steric effects and the observed viscosity. Such a correlation will enable prediction of viscosity of ILs under various confinements.

12) Peter P Sun (UIUC)

Disinfection and Sensitization of Ear Infectious Biofilms by Microplasma Jet Array

The involving development of the middle ear bacterial biofilm will cause chronic episodes of otitis. These complex media cause middle ear infection in more than 80% children. These complex structures also lead to recurrent infections and strong antibiotic-resistance. The antibiotics are usually applied for the treatment. However, besides the side-effect from the high dosage of the antibiotics, there are more than 19% of the cases reported ineffective.

Portable and replaceable microplasma jet arrays through 3D printing are designed and conceived at University of Illinois. The antibiotic resistance of Pseudomonas Aeruginosa, which was measured as the minimal inhibitory concentration (MIC50) as the antibiotic concentration that causes 50% growth inhibition, decrease 5 times after 10 mins plasma treatment and more than three orders of magnitudes after 12 mins plasma treatment. The number of living cells remaining in the biofilm before and after microplasma jet array treatment are investigated through confocal laser scanning microscopy. The microplasma jet array produced reactive species, such as OH and 1O2, are evaluated qualitatively and quantitatively through liquid chromatography. The effective disinfection parameters will be determined and provided feedback to the device optimization.

13) Sarajane Roenke (University of Notre Dame)

Expanding our Knowledge of Small Biofilms Using Similarity Analysis

In this study, we tested the hypothesis that similarity analysis could be used to develop “scaled up” biofilms with greater thicknesses but similar behavior. Similarity analysis is normally used to scale down large structures for lab studies. In order to scale up biofilms, we proposed creating synthetic biofilms with lower cell densities. These biofilms would have longer substrate profiles, facilitating microsensor analysis. We used modeling and experiments to test this hypothesis. Models using the AQUASIM and COMSOL platforms showed that that analogous profiles developed among the biofilms with different thicknesses and corresponding densities, suggesting that the approach should be effective. However, experimental O2 profiles in synthetic biofilms with different cell densities deviated from the expected results. This presentation will discuss the theory, methods, and modeling and experimental results. This research is ongoing. IfThese biofilms would have longer substrate profiles, facilitating microsensor analysis. If effective, this approach could enable a wide range of biofilm studies.

14) Shun Che (UIUC)

Promises and challenges of applying synthetic microbial consortia in biotechnology

Cooperative relationships in environmental microbial consortia enable them to perform complex metabolic tasks and efficiently cycle the nutrients, holding great promise for various engineering applications. However, challenges coexist with promises, and the potential of consortium-based technologies is far from being fully harnessed. Thorough understanding of the underlying molecular mechanisms of microbial interactions is lacking for rational design and optimization of defined consortia. These knowledge gaps could be potentially filled with the assistance of the ongoing revolution in systems biology and synthetic biology tools. With such knowledge obtained, we would expect synthetic microbial consortia to play important roles in biological and environmental engineering processes such as bioproduction of desired chemicals and fuels, as well as biodegradation of persistent contaminants.

15) Weiqi Ni (UIUC)

Study of Covalent Organic Framework Thin-Film Composite Nanofiltration Membrane with PAN Support

Two-dimensional covalent organic frameworks (COFs) were used to create the nanofiltration (NF)membrane with a COF active layer. This study used terephthalaldehyde and tris(4-aminophenyl)benzene monomers to synthesize polyimine COF via the interfacial polymerization (IP) on top of a ultrafiltration membrane support and create NF membrane. Former work with PES support demonstrates the need for alternative support materials to avoid chemical damage, so this study use polyacrylonitrile(PAN) as a new support. The flux and rejection efficiencies of the COF-NF membrane for RhodamineWT and NaCl were measured with the comparing of control PAN support without the COF film. Results indicated the good chemical resistance of PAN support as well as a significant increase of rejection after adding COF layer. Characteristic parameters like water permeation coefficient, solute permeation coefficient, and the fraction α of water flux passing through membrane imperfections was calculated using Two-film Model, then compared COF and control membrane data to evaluate the quality of model.

16) Yiquan Wu (UIUC)

Saline sewage treatment: multi-step chlorination increases disinfection efficiency and reduces DBPs formation and toxicity

Chlorination is extensively applied for disinfecting sewage effluents, but it unintentionally generates disinfection byproducts (DBPs) which are harmful to aquatic organisms. In some coastal area where fresh water is scarce, seawater has been applied for toilet flushing in many communities, which may cause the production of brominated DBPs. It is demonstrated by Yu et al. (2017) that multi-step chlorination is a convenient way to improve disinfection efficiency and reduces DBPs. Compared to one-step chlorination, two-step chlorination and three-step chlorination enhanced the disinfection efficiency by up to 0.81- or even 1.02-log for two different chlorine doses and contact times, and the DBP formation in three-step chlorination was decreased by up to 23.4%. The overall toxicity of one-step and three-step chlorination was evaluated in terms of adverse effects on the development of embryo-larva of a marine polychaete P. dumerilii. The results revealed that the primary saline sewage effluent with multi-step chlorination was less toxic than that with one-step chlorination. In practice, to fulfill the same disinfection goal, multi-step chlorination should consume less chlorine than the commonly used one-step chlorination by 16.7%. These results indicate that multi-step chlorination could reduce the potential adverse effects of disinfected sewage effluents to aquatic organisms in the receiving marine water.

17) Wyatt Sherlock (UIUC)

Field analysis of gas and particle formation in an enhanced electrostatic precipitator

There is concern about generating gaseous and particulate emissions during carbon dioxide removal from flue-gas streams generated by the combustion of hydrocarbon fuels. A leading technology for sub-micrometer particle removal, a modified electrostatic precipitator (ESP), will be tested. Testing will occur at Abbott Power Plant at the University of Illinois at Urbana-Champaign as part of the US Department of Energy's Flue-gas Aerosol Pretreatment project. This research will provide a better understanding of the gaseous and particulate composition inside the ESP with real flue-gas at actual operating conditions. The relevance of this research is to better understand potential corrosion to flue-gas ducts and particle formation from the ESP. We will determine how much the ESP will affect the concentration of nitrogen oxides, sulfur oxides and carbon monoxide. Concentration measurements will be made upstream and downstream of the ESP using Fourier Transform Infrared Spectroscopy (FTIR) and dedicated gas analyzers for nitrogen and sulfur oxides. Temperature and pressure will be measured as well to make relevant comparisons. In addition to gaseous FTIR measurements, a developed method utilizing gas stripping and particle condensation will be used to measure concentrations of gaseous and particulate nitric and sulfuric acid. The ESP will be operated at varying voltages and flowrates during several weeks. These experimental results will be compared to the Extended AIM Aerosol Thermodynamics model and a self-developed model to showcase the partitioning between the gas and particulate phases. Moving forward, this will lay the groundwork for future research in measuring the particle number concentration and size distribution of specific particulates such as nitric and sulfuric acid that are potentially produced inside the ESP.

18) Yijue Diao (UIUC)

Effect of Brines on Calcite's Strength and Implication on Injection-Induced Seismicity in Hydraulic Fracturing

The increase in the occurrence of earthquakes attributed to wastewater injection in the context of hydraulic fracturing has been the subject of recent and intense debate. While the induced earthquakes along the fault plane are known to occur from propagated fractures, little is known about how the fluid chemistry of the wastewater could alter the fault strength, and thereby the pathway of earthquake nucleation. Given the presence of carbonate rocks in conventional oil reservoirs and its reactivity with water, it is of importance to understand how the presence of infiltrated brines influence their strength. Using an atomic force microscope and an extended surface forces apparatus, we investigate the pressure solution and the frictional characteristics of calcite in aqueous environment in calcium carbonate saturated solutions and in NaCl and CaCl2 brines with a wide range of geologically relevant concentrations. Our results show that when the pressure solution of calcite is triggered at sufficiently high contact stress, the shear strength of calcite is significantly weakened, and much more prominently in CaCl2 solutions. This brine-specific effect is mainly attributed to the varying calcite reactivity in response to pH. This nanoscale study advances the knowledge of carbonate fault behavior in the presence of a reactive fluid, and calls for attention to the chemical composition of the produced water used for fluid injection in the context of hydraulic fracturing.

19) Yixiang Wang (UIUC)

Non-additive effects Contribution of the Mixture of Metals and Organic Compounds to the Cytotoxicity of Particulate Matter (PM)

The adverse health effects of particulate matter (PM), including the PM-catalyzed biological generation of reactive oxygen species (ROS), have been widely studied. Due to the complexity of PM chemical compositions, generally pure chemicals, e.g. standard organic and metals solutions are studied to assess the toxic effect of PM components. However, the applicability of these methods to understand the interactions among the PM components has not been validated. To address these questions, we selected several metals (Cu, Fe, Mn) that are related to the oxidative potential (OP) of PM and assessed their interactions with the organic compounds in inducing the toxicity. Chinese Hamster Ovary (CHO) were used for assessing the cytotoxicity of the PM. Metals constitute one of the most toxic fractions of ambient PM. Our preliminary tests showed that Fe alone only expresses low toxicity, however, nontoxic Fe drastically increases the toxicity of other organic compounds, indicating some sort of interaction of metals with the organic compounds for inducing the toxicity. Our study highlights the need to account for the interactions between organic compounds and metals, while apportioning the relative contributions of chemical components in the PM toxicity.

20) Yuehao Shi (UIUC)
Biosand

Biosand filtration is a kind of emerging point-of-use water treatment method. It was advanced by traditional slow sand filtration. As the name suggests, the biosand filtration uses biosand which is sand covered by biofilm to remove the pathogen and contaminants in water. The facility for biosand filtration is biosand filter (BSF).In a new study, Banu develops a new method which combines modified biosand filters (MBSF) and solar pasteurizers to treat drinking water and removed most of the total coliforms (up to 99.99%) in the water. In Banu's research, the water quality after this coupled system met the water standard of World Health Organization. In another study, Danley's group developed an experiment to measure the effect of changing total organic carbon (TOC) in the influent water for BSF removal efficiency. This research confirms that the water quality of influent water in BSF will affect the treatment efficiency.

Oral Session 2

(3:00 PM – 4:45 PM)

Session 2a

1) Aliza Furneaux (UIUC)
(3:00 PM – 3:15 PM)

Understanding phosphorus recovery feasibility at Water Resource Recovery Facilities

Minimizing the release of nutrients from the built environment's municipal Water Resource Recovery Facilities (WRRF) and runoff is vital to reducing nutrient pollutions in waterways. In the United States, municipal WRRF implement phosphorus (P) removal and recovery processes to limit their contribution to the natural environment through eutrophication and hypoxic zones. These systems vary in their potential for removal of P versus recovery of P, total P removal, and their cost of implementation at the WRRF. While models do exist for commonly used P removal processes, little work has been done to develop a general heuristic framework aimed at determining what type of P removal process is best fit for WRRFs of varying throughput, influent compositions, and treatment configurations.
This work develops a generalized plantwide process model used to assess the feasibility of operating various types of nutrient recovery systems at a WRRF. The model compares the potential for P removal and recovery as struvite with the associated monetary costs and environmental impacts of implementation. Full-scale WRRFs are modeled and simulated using GPS-X. The nutrient removal systems considered are traditional A2O, modified bardenpho enhanced biological phosphorus removal, chemical precipitation through ferric chloride, and side-stream struvite precipitation. Latin Hyper Cube random sampling is used to create potential treatment scenarios. These scenarios determine daily throughput and influent compositions including total P, total nitrogen, calcium, potassium, magnesium, and COD. In each case, P mass flows and struvite recovered are compared with costing data from Life Cycle Costing and environmental impact from Life Cycle Assessment to best inform decision making for picking the most suitable nutrient recovery system.

A generalized plantwide process model that considers various types of nutrient recovery schemes allows for cost-effective implementation at municipal WRRFs which have the largest impact on managing the P released by the built environment.

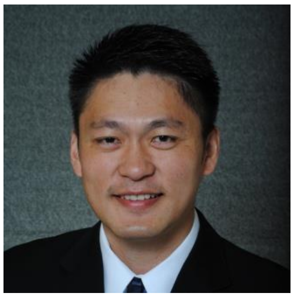
2) Hannah Lohman (UIUC)
(3:15 PM – 3:30 PM)
Novel financing strategies to simultaneously advance development goals for sanitation and agriculture through nutrient recovery

Although access to safely managed sanitation is improving, globally, over two billion people still do not have access to basic sanitation services. The sixth Sustainable Development Goal seeks to achieve universal sanitation access; however, limitations in financial resources push us to consider innovative opportunities in the built environment to meet goals. Resource recovery sanitation acts as a medium to improve access to agricultural nutrients (nitrogen, phosphorus, potassium). The objective of this work was to determine if resource recovery sanitation technologies can support profitable business through selling recovered nutrients. A techno-economic analysis framework was used to assess the economic viability of selected technologies by incorporating a discounted cash flow analysis to track life cycle costs (informed by local data collection in Uganda) and income throughout the lifetime of a urine diversion dry toilet (UDDT) and downstream recovery processes. Two resource recovery financing scenarios were selected to assess the profitability of this business model: an aid-driven scenario and an entrepreneurial scenario. The aid-driven scenario assumes that an aid agency will cover the costs to implement a conventional pit latrine, and a NGO or contractor will cover the remaining costs to upgrade the latrine to a UDDT with the opportunity to sell recovered nutrients. The second scenario assumes that an entrepreneur, NGO, or contractor covers the entire cost of a UDDT. The recovered nutrient selling price was varied from $0-$1.50 per kg nutrients to determine the break-even point of the business model and to compare to the typical market value of fertilizers in Uganda. Results show that both scenarios are profitable at a nutrient selling price at or below a fertilizer market value. Overall, this research makes the case to support recovered nutrient markets for locations with limited fertilizer access and the need for improved sanitation.

CEE
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

3) Zhi Zhou (Purdue University)
(3:30 PM – 3:50 PM)
Antibiotic resistance in in urban and natural environments



Antibiotic resistance has often been correlated with trace levels of antibiotics, but little is known on how antibiotic resistance is affected by various environmental factors. In this study, the effects of non-point source pollution and anthropogenic pressure were evaluated. The wide occurrence of ARGs without direct impact of wastewater discharge suggest that both trace levels of antibiotics and environmental factors may contribute to the wide occurrence of antibiotic resistance. ARG abundances were positively correlated with nutrients, trace level antibiotics, land use types, and residential population density. It is interesting that the abundance of selected ARGs were positively correlated with polyketide synthase (PKS) genes that are responsible for natural biosynthesis of antibiotics, suggesting that natural production of antibiotics may also contribute to the wide occurrence of selected ARGs. The wide occurrence of ARGs without direct impact of treated wastewater highlights the potential impacts from anthropogenic activities and biosynthesis of natural antibiotics.

4) Daeryong Park (Konkuk University)
(3:55 -4:15 PM)
An evaluation of nutrient load estimation methods and the effects of monitoring frequencies in the Ohio watersheds

Agricultural and urban lands in Ohio are among the most significant contributors of the excess pollutants, the total nitrogen and phosphorus respectively. Although many research and monitoring projects addressed the trends and variability in nutrients, the present results and explanations are still very uncertain. The proposed project will: i) Calculate nitrogen and phosphorus concentrations, and loadings in the Ohio watersheds, using the most complete long-term datasets, and ii) Compare load estimation methods with a particular emphasis on the effects of monitoring frequencies.

5) Dianna Kitt (UIUC)
(4:15 PM – 4:30 PM)
Characterizing the mechanism and rate of calcium phosphate precipitation in aerobic granular sludge

With increasingly stringent standards for wastewater treatment plant effluent, the demand for technologies that are able to increase phosphorus removal while also recovering a valuable and marketable fertilizer product is growing. Aerobic granular sludge (AGS) is a promising technology that has demonstrated the ability to increase phosphorus removal while enhancing recovery through the precipitation of calcium phosphate minerals within the granule. A rigorous understanding of precipitation mechanism and rate has been limited by simultaneous biological uptake and release of phosphate and cations. As a result, more work is needed to better understand how to control and enhance mineral precipitation within the polymeric matrix of the granule as well as how the pre-existing mineral phases within the granule influence recovery. To address this issue we performed precipitation experiments using AGS and solutions supersaturated with respect to hydroxyapatite and $CaHPO_4$. We monitored the solution characteristics (pH, [Ca], and [P]) in order to quantify the impact of calcium pre-enrichment on the extent and rate of phosphate removal with aerobic granular sludge. Initial results showed that enriching granules with calcium significantly enhances the extent and rate of phosphorus removal. Removal increased from 25% to 48% and the rate increased from 1.9 to 13 day-1 with the presence of calcium enriched granules. Additionally, a lack of fines production indicated that precipitation was promoted within the granule EPS matrix. Results have also indicated that calcium pre-enrichment increases the transition from amorphous calcium phosphate to more stable forms such as HAP. Overall, this work identifies conditions under which aerobic granules enhance mineral phosphate precipitation and suggests that calcium treated granular sludge can be used to recover phosphorus as a stable calcium phosphate mineral. Future work will identify the mineral(s) produced from this technique as well as their solubilities and value as a phosphorous product for agriculture.

CEE Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

6) Sam Aguiar (UIUC)
(4:30 PM – 4:45 PM)
Determining the Dissolution Rate of Field Grown Struvite

Managing phosphorus (P) within the built environment is essential to securing P fertilizers necessary for meeting projected food demands and preventing excess P leaching into waterways from municipal water resource recovery facilities (WRRF). Minimizing the release of P into waterways prevents eutrophication, dead zones, deadly algal blooms, and biodiversity loss which negatively impact the natural environment.

In response, WRRF's are increasingly implementing sidestream processes to reduce concentrated P streams generated from anaerobic digestion of Biological Nutrient Removal (BNR) sludge. One such process is the crystallization of struvite ($MgNH4PO4·6H2O$). Phosphorus removal and recovery through struvite precipitation at WRRF's reduces P recycling to mainline treatment while producing a P-rich fertilizer with the potential to reduce runoff. One challenge faced by the widespread introduction of struvite recovery technologies is the dissolution of P rich fines in mainline treatment after washout from crystallizer reactors. In WRRFs where struvite crystallization has been implemented, an unknown impact on downstream plant operation is present due to the lack of data characterizing the dissolution of these fines.

In this work, batch dissolution of field grown struvite, pure struvite, and pure hydroxyapatite was characterized at the lab scale using the shrinking object model. Experiments were performed at various WRRF relevant temperatures to allow for temperature-based correction factors. From these experiments, the dissolution rate constant is elucidated for future plantwide modelling studies.

This research works towards allowing for kinetics-based dissolution processes within plantwide modelling. The dissolution rate constants found here will allow for future evaluations of the chemical impacts of treatment efficacy, life cycle costing, and life cycle assessment which have yet to be performed for these types of recovery systems. These types of assessments will inform future WRRF design by providing tools to evaluate what combination of plant influent conditions and process chains would result in cost-effective P recovery.

CEE Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Session 2b

1) Meenu Garg (University of Notre Dame)
   (3:00 PM – 3:15 PM)
   A membrane-based photobioreactor enhances algal cultivation rates

In this research, a novel biofilm-based photobioreactor was proposed. The reactor incorporated gas-transferring membranes at the base of the biofilm, allowing gas transfer with the biofilm without affecting the bulk liquid. We hypothesized that CO_2 supply with these membranes could prevent carbon limitation within the biofilm, and prevent pH shifts and strip excess O_2, leading to higher growth rates in the biofilm. Both 1-D and 2-D biofilm models were developed to assess performance compared to conventional algal biofilm reactors. Experiments comparing both types of reactors were also conducted. Results suggested the proposed system would lead to higher growth algae cultivation rates, especially when high light intensity are used. This process could provide a more efficient way to grow algae for environmental and industrial purposes. It also could allow efficient capture waste CO_2 from power plant, anaerobic digesters, or other sources.

2) Bumkyu Kim (University of Notre Dame)
   (3:15 PM – 3:30 PM)
   Predation Can Enhance Biofilm Detachment in Membrane-Aerated Biofilm Reactors (MABRs)

Recent research has showed that predation can create large internal voids at the base of heterotrophic MABR biofilms, potentially promoting detachment. However, past studies only lasted a few days, included few replicates, did not include controls without predation, and only addressed hollow-fiber membranes. In the current study, the effects of predation on heterotrophic MABR membranes were carried out in triplicate, and included controls without protozoa. Biofilm and void formation was monitored over time using optical coherence tomography (OCT). The abundance of protozoa (eukaryotes) was assessed for each condition via molecular analyses. We carried out detachment tests and measured the mechanical property of biofilm via shear rheometry. Our results show that the effect of predation on internal voids is reproducible, and occurs only when protozoa are present. The internal voids weaken the biofilm, decreasing the viscous and elastic behavior and increasing biofilm sloughing. In conclusion, predation can promote detachment in MABRs.

3) Patricia Perez (University of Notre Dame)
(3:30 PM – 3:50 PM)
Unique behavior of membrane-aerated biofilm reactors (MABRs)

The membrane-aerated biofilm reactor (MABR) is an emerging wastewater treatment technology based on air-supplying hollow-fiber membranes. Membranes deliver oxygen directly to biofilms growing on the membrane surface, providing up to 100% oxygen transfer efficiency and saving up to 85% in energy. Membrane-aerated biofilms (MABs) behave differently from conventional biofilms, leading to differences in biofilm microbial community structure, response to environmental conditions, and removal fluxes. In this presentation, we discuss our research into the unique behavior of MABs. Using microsensors and advanced modeling, we systematically explored the effects of gas back-diffusion on MABs, as well as the dynamic effects of transient venting on oxygen transfer rates. We studied techniques to enhance nitrification fluxes and achieve partial nitritation, and explored the effect of a range of operating parameters on MABR performance. Finally, we explored the unique effects of protozoan predation on MABs, using real-time imaging with optical coherence tomography (OCT), DO microsensor profiles, DNA sequence analysis, and mathematical modeling. Our results suggest that MABs behave differently from conventional biofilms, and this behavior should be considered when developing MABR applications.

4) John Norton (Great Lakes Water Authority)
(3:55 PM – 4:15 PM)
An Overview of GLWA Funded Research Efforts

The purpose of this talk is to describe the research program at the Great Lakes Water Authority (GLWA). Each year the GLWA pays approximately $350,000 into the Water Research Foundation and funds around $650,000 additional research, primarily to larger regional research institutions. Current research efforts include 1) biological uptake of phosphorus, 2) smart water networks to manage pressure and flow, 3) condition assessment of large diameter water transmission mains, 4) parameters surrounding anaerobic digestion, 5) treatment of PFAS through a WWTP, and 6) water and wastewater utility innovation. I discuss our current research efforts, primary research focuses, research methods, prioritization approach, and methods of collaboration.

5) Jinha Kim (UIUC)
(4:15 PM – 4:30 PM)
Microbial community dynamics and performance correspondence to solid retention time during waste activated sludge fermentation

Anaerobic digestion is a common solid stabilization process to treat excessive sludge in wastewater treatment plants. Though methane production is a major consideration to generate energy, other strategies also exist. Digesters are modified into fermenters where the resulting products (volatile fatty acids and alcohols) could be utilized for bioproduct conversion, used as an additional carbon source for nutrient removal and potentially for industrial wastewater treatment processes, etc. However, our understanding of a strategized fermenter operation is limiting. We aim to provide insights of how to achieve high fermentation performance in terms of observing the microbial dynamics. A systematic approach is made by looking into the correspondence of microbial community structure, activity and fermentation performance to varying solid retention times in waste activated sludge fermenting batch tests. With the help of biotechnology, a mass balance model and an ordination technique, we identify active core populations having potential significant fermentation roles.

6) Mariam Al-Lami (Missouri S&T)
(4:30 PM – 4:45 PM)
Aided-phytostabilization of Pb/Zn/Cu mine tailings: Enhancement of substrate functionality and ecosystem services

Mining activities have left a legacy of disturbed sites with large quantities of mine tailings. The unfavorable characteristics of tailings generally limit natural development of soil biota and plants, thus posing threat to public health and surrounding environment through wind and water erosion. This greenhouse study aimed to investigate feasibility of rich organic amendments (biosolids, biochar, humus), and mycorrhiza fungi for aided phytostabilization of Pb/Zn/Cu tailings with biomass crops (miscanthus, poplars, willows). Untreated tailings resulted in stunted growth with severe chlorosis/necrosis due to metal phytotoxicity and lack of nutrients, while amendments and their combinations resulted in a dramatic increase in biomass production. Moreover, amendment addition highly improved tailings properties: microbial activity, organic carbon, nutrients, cation exchange capacity, and water retention. Metal phytoavailability and accumulation within plant tissue significantly reduced in amended tailings. Besides contaminant stabilization, this approach improves the provision of ecosystem services and enables the financial viability of mine reclamation.

CEE Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Acknowledgements

- CEE EES area faculty at UIUC, and Marvis Orzek (area program coordinator)
- Co-hosting universities and institutes: Perdue University, University of Notre Dame, Bradley University, Illinois Institute of Technology, Rose-Hulman Institute of Technology
- Symposium executive committee:

  Prof. Yujie Men

  Yue Xing, Yaochun Yu

- Symposium program committee:

  Abhijeet Saraf, Weiqi Ni, Xuehao Wang, Junren Wang, Ki Dongwon

- Symposium public committee:

  Siwei Zhang, Anqi Li, Yuehao Shi, Shuaiqi Wu

- Symposium hospitality committee:

  Skanda Bharadwaj, Valeria Colon Melendez, Hezi Bai, Grant Lesak, Carter Strien, Yiquan Wu, Ran Mei, Shun Che