27th Annual Environmental Engineering and Science Symposium

Mitigating the Impact of Human Activities on the Environment

April 22, 2022

Civil & Environmental Engineering Buildings, Urbana, Illinois

8:15 AM – 4:30 PM

Contents

Introduction

2022 marks the 27th Annual Environmental Engineering and Science (EES) Symposium at the University of Illinois at Urbana-Champaign (UIUC). This year's theme is "*Mitigating the Impact of Human Activities on the Environment".* This theme was chosen by the symposium organizers to underline concerns about the increasing need for measures to counter impacts of human activities on the environment. The future is likely to see more technological development, population growth, and emerging contaminants. These will require innovative management approaches and technologies to avoid pollution and ecological damage. Moreover, we will see a need to change business as usual to cope with the changing climate. This symposium brings together researchers from a wide variety of backgrounds and specialties who present their research, ideas, and visions for the future. Join us as we explore engineering solutions to pressing environmental challenges.

Organizers

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 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.

Executive Committee: Aditi Kumar; Hrutuja Chaudhari; Shaival Shah
Publicity and Hospitality Committee: Zhengmiao Jia (Kevin); Zhiqian Han; Yongjian Ma; Kaifeng Xie
Program Committee: Chunghyeon Han; Ruchitha Birawat; Alankrita Sahay; Shreshtha Bangar; Aman Kaushik
Poster Workgroup Coordinators: Linkun Li; Jingyu Li
Instructor: Sotiria Koloutsou-Vakakis

Schedule

27th Annual Environmental Engineering and Science Symposium Schedule

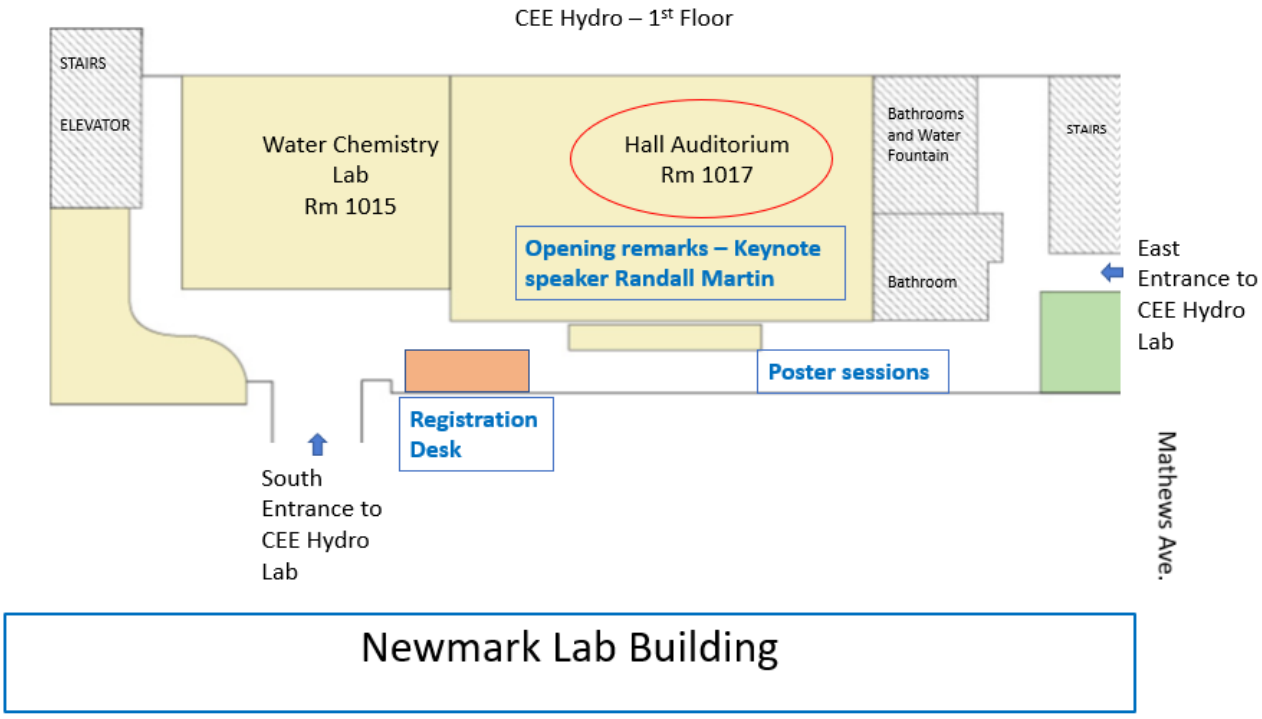
Time	Event	Location
8:15 am	Registration desk opens - Breakfast buffet available until 9:00 am	Hydro 1st floor
8:50 – 9:00 am	**Opening Remarks**: Prof. Rosa Espinosa-Marzal	Hydro 1017
9:00 – 10:00 am	**Keynote Speaker**[1]: Prof. Bruce W. Fouke (Prof. Verma introduces)	Hydro 1017
10:00 – 11:00 am	**Poster Session 1** (Moderators: Zhiqian Han, Zhengmiao Jia)	Hydro 1st floor
10:30 am – noon	**Workshop**: Yalin Li et al., The QSDsan Platform: Open-Source Tools for Quantitative Sustainable Design and Decision-Making of Sanitation and Resource Recovery Systems	Hydro 3019
11:00 am – noon 11:00 am 11:20 am 11:40 am	**Podium Session 1A** (Moderators: Chunghyeon Han, Zhiqian Han) Oh Chamteut - Plant-derived polyphenols: a sustainable alternative to inactivate enteric viruses Molitor Hannah - Intensive Mixed Community Microalgal Cultivation for Nutrient Recovery from Municipal Wastewater Yus Joaquin - Promoting natural coral growth using hydraulic lime substrates with inorganic additives	Newmark 1311
11:00 am – noon 11:00 am 11:20 am 11:40 am	**Podium Session 1B** (Moderators: Ruchitha Birawat, Yongjian Ma) Yang Xiaokai - Multi-phase chemistry surrogate modeling with elemental mass conservation using a Neural ODE Wang Shiyuan - Global disparities in PM2.5 exposure caused by consumption of goods and services Kumar Joshin - Correcting for biases in filter-based aerosol light absorption measurements at the ARM Southern Great Plains site	Newmark 2312
12:00 – 1:00 pm	**Lunch**	Bridge
1:00 – 2:00 pm	**Poster Session 2** (Moderators: Ruchitha Birawat, Aman Kaushik)	Hydro 1st floor
2:00 – 3:00 pm 2:00 pm 2:20 pm 2:40 pm	**Podium Session 2A** (Moderators: Alankrita Sahay, Kaifeng Xie) Ruffatto Ken - National inventory of phosphorus recovery potential from centralized infrastructure: a comparison of corn ethanol biorefineries and water resource recovery facilities Ye Quanhui - A magnetic nanoplatform to construct innovative bio-nano hybrid materials for sustainable resources recovery Bhagwat Sarang - Sustainable Production of Acrylic Acid via 3-Hydroxypropionic Acid from Lignocellulosic Biomass	Newmark 2311
2:00 – 3:00 pm 2:00 pm 2:20 pm 2:40 pm	**Podium Session 2B** (Moderators: Shreshtha Bangar, Zhengmiao Jia) Puthussery Joseph - Real-time measurement and source apportionment of five different endpoints of the oxidative potential of ambient particulate matter at an urban site Pavizhakattumadom Saptharishi Ganesh Subramanian - Assessing the influence of human-related activities on generation of indoor aerosols and their potential contribution to fomites Shetty Nishit - Measuring light absorption by freshly emitted organic aerosols: optical artifacts in traditional solvent-extraction-based methods	Newmark 3310
3:05 – 4:05 pm	**Keynote Speaker**[1]: Dr. Jess Brown (Prof. Snoeyink introduces)	Newmark 1310
4:10 – 4:25 pm	**Announcement of Prizes:** Symposium Student Executive Committee	Newmark 1310
4:25 – 4:30 pm	**Closing Remarks:** Dr. Sotiria Koloutsou-Vakakis	Newmark 1310

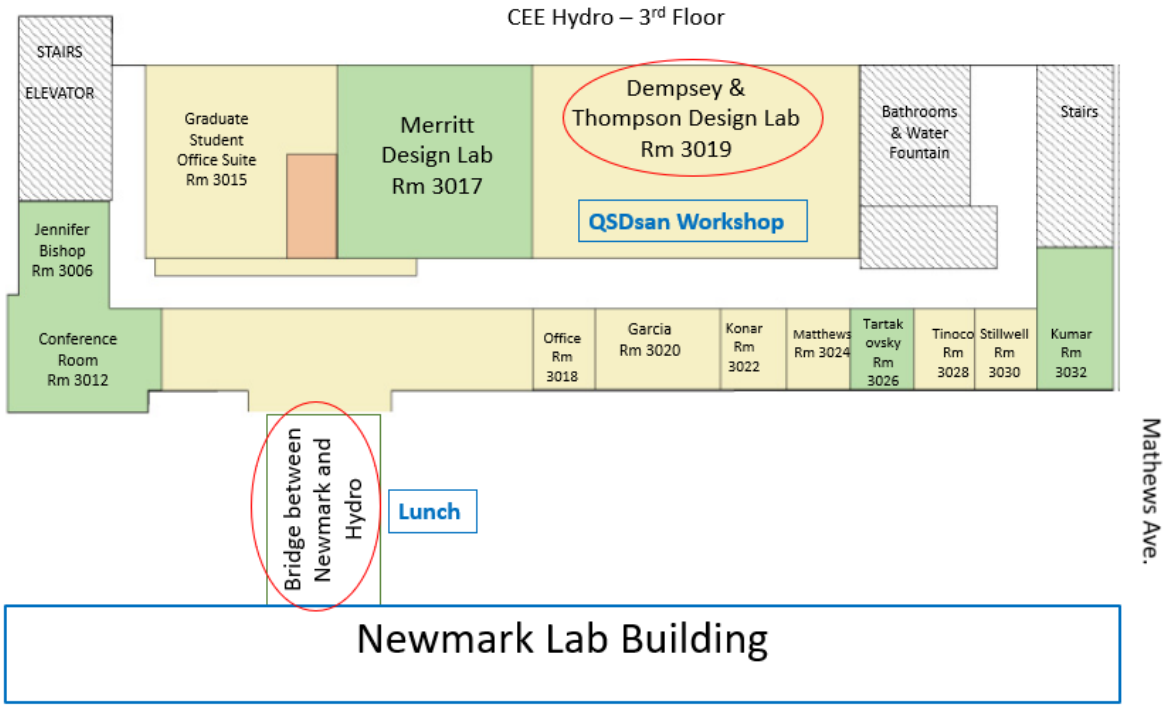
[1] Title and abstract at the Symposium website: https://publish.illinois.edu/2022-environmentalsymposium/keynote-speaker/

Poster Sessions

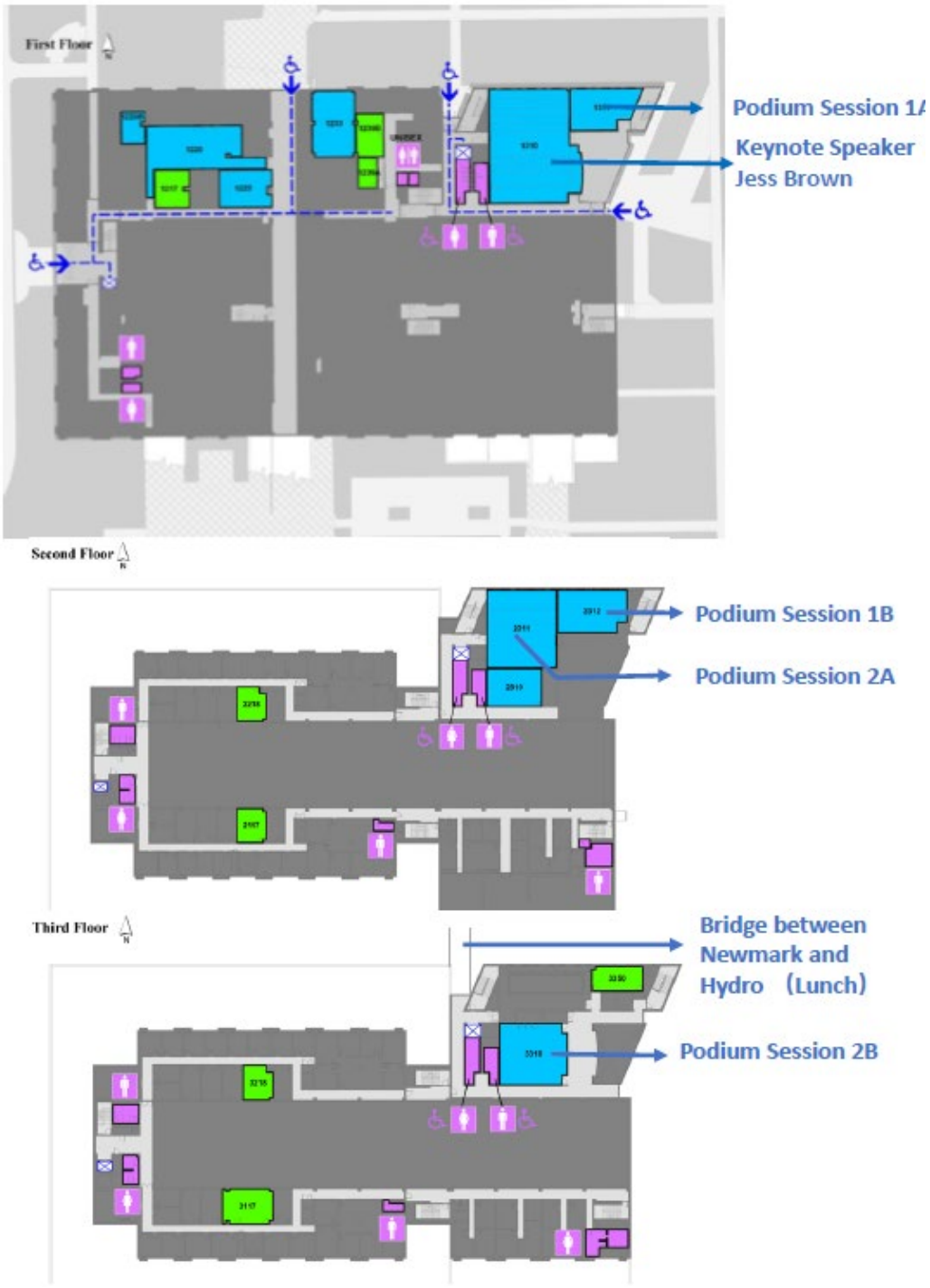
Poster Session 1 – 10:00-11:00 am Poster Presenters 1-20	Poster Session 2 – 1:00-2:00 pm Poster Presenters 21-39
1. **Liu Yicen** - The Impacts of Aerosol Mixing State on N2O5 Reaction Probability 2. **Kaushik Aman** - Comparative study on air quality status in Indian and Chinese cities before and during the COVID-19 lockdown period 3. **Li Yurui** - Enhancing electrosorption capacity and electrode longevity for selective arsenic removal through electrodeposition of ferrocene polymer coatings 4. **Clark Gemma** - Effects of point-of-use filters and stagnation on drinking water quality 5. **Jia Zhengmiao** - Evaluating the Possibility of achieving Efficient Seawater Desalination by Electrodialysis (ED) 6. **Han Zhiqian** - Several new solutions for metal pollution 7. **Yongjian Ma** - Review of chemical precipitation methods to remove heavy metal ions from industrial wastewater 8. **Han Chunghyeon** - A Review: Evaluation of Degradation of Perfluoroalkyl Substances through Plasma-based Water Treatment Process 9. **Deptula Alex** - Probing Interfacial Structural Dynamics of Glassy Gels for Engineering Porous Media 10. **Greenwood Gus** - Tuning Nanoscale Friction at the Graphene Interface Using an FET-Like Device 11. **Fu Binxin** - Nanoscale Insight into the Relation between Pressure Solution of Calcite and Interfacial Friction 12. **Zhang Xuhui** - Correlation between Nanorheological and Nanotribological Behavior of Ionic Liquids 13. **Li Linkun** - Biometric antifouling: An environmentally friendly way of conducting vessel antifouling 14. **Cong Wen** - Comparative study of Coxsackievirus and Adenovirus Inactivation by Chlorine Disinfection 15. **Mao Yuqing** - Whole-genome sequencing of Salmonella enterica to understand its transmission during a flood event in a rural area 16. **Bangar Shreshtha** - Impact of COVID-19 lockdown on ambient air quality in 9 indian mega cities 17. **Birawat Ruchitha Kamlesh** - Biodegradation of polyethylene terephtalate using microbial consortia 18. **Cortes-Pena Yoel** - Techno-Economic and Life-Cycle Implications of Integrating Cellulosic Ethanol Production and Seasonal Oilsorghum Processing at an Oilcane Biorefinery 19. **Stewart Dalton** - Incorporation of Policy Incentives and Other Location-Specific Parameters into BioSTEAM for the Techno-Economic Analysis of Biorefineries 20. **Kim Ga-Yeong** - Algae process modeling	21. **Kudli Lavanya Prashantkumar** - Techno-Economic Analysis and Life Cycle Assessment of Sustainable Azelaic Acid Production from oleic acid 22. **Kwon Jiheon** - Sustainability 23. **Shah Shaival** - Delineating groundwater recharge potential areas applying GIS techniques in Surat City (SMC), India 24. **Park Manho** - Accelerating air quality modeling with an advection surrogate model 25. **Xie Kaifeng** - Using Algal Biochar to Mitigate Greenhouse Gas Emissions in Agricultural 26. **Hunter Hope** - Aerosol composition in the Arctic 27. **Salana Sudheer** - PM2.5 induced cytotoxicity: Role of ROS and Glutathione Depletion 28. **Li Jingyu** - Developing hydrogel-based substrates to improve coral larvae settlement and coral growth 29. **To Lane** - Modeling fecal sludge pyrolysis for biochar production in an Omni Processor 30. **Sahay Alankrita** - Biochar for resource recovery 31. **Emaminejad Aryan** - Application of Bio-electrochemical Sensors for Carbon Monitoring at Water Resource Recovery Facilities: A Statistical and Microbial Analysis Approach 32. **Aguiar Samuel** - Nutrient Recovery 33. **Lohman Hannah** - Elucidating the impact of locality-specific factors on sanitation system sustainability and decision-making 34. **Zhang Xinyi** - QSDsan: An Integrated Platform for Quantitative Sustainable Design of Sanitation and Resource Recovery Systems 35. **Lee Ming Jun** - Surface Structure Modulation of Agarose-Poly(acrylamide-co-acrylic acid) Double Network Hydrogels 36. **Zheng Qianlu** - Influence of ion specificity and water uptake on the electrical double layer of graphene–ionic liquid 37. **Chaudhari Hrutuja** - Analytical modeling for design of floating treatment wetlands as a sustainable technology for wastewater purification. 38. **Kumar Aditi** - Sustainability of Ion-Exchange Water Treatment Technology 39. **Zhou Aijia** - SARS-COV-2 detection in wastewater

Conference Spaces





Newmark Civil Engineering Laboratory



Keynote Speaker – Bruce W. Fouke

Universal Biomineralization: Life-Water-Mineral Interactions through Geological Time

The survival of all forms of Life through geological time has depended on successful adaptation to, and eventual control of, mineral growth. This process of *biomineralization* has been an essential, unavoidable, and ubiquitously distributed force of nature that offers strategic benefits (access to hostile planetary environments) and profound practical problems (catastrophic mineral burial) for the heat-loving microbes inhabiting thermal spring environments in Yellowstone and beyond. This presentation will explore the scientific renaissance being driven by the study of microbe biomineralization in Yellowstone, and its impact on reframing our basic approaches to understanding the origin and evolution of life, energy extraction, water management, human medicine, and the search for life throughout the cosmos.

Bruce W. Fouke

Professor in the Department of Geology, the Carl R. Woese Institute for Genomic Biology, and the Department of Evolution, Ecology, and Behavior at the University of Illinois Urbana-Champaign.

April 22, 2022
9:00 am, CEE Bldg. (Hydro) 1017

Keynote Speaker – Jess Brown

Dr. Jess Brown

R & D Practice Director
Senior Vice President of
Carollo Engineers

Industry leader in planning, testing, design, and operation of biofiltration facilities.

April 22, 2022
3:00 pm, Newmark 1310

What I've Learned So Far

20 years ago, I graduated from the UIUC CEE program and launched my career as a professional engineer. In many ways, the water industry has changed dramatically since then; in some ways it hasn't changed at all. For this presentation, in lieu of the deep dive into how XBAT with bicarbonate resin regeneration edges out traditional RBAT and CBAT, I'll wax more philosophical, covering a few of my own observations and lessons learned from the last two decades as an engineering consultant in the water industry.

QSDsan Platform Workshop

10.30 am- noon
Location: Hydro 3019

The QSDsan Platform: Open-Source Tools for Quantitative Sustainable Design and Decision-Making of Sanitation and Resource Recovery Systems

Yalin Li[1,2], Xinyi Zhang[3], Victoria Morgan[1], Hannah Lohman[3], Ro Cusick[3], Jeremy Guest[1,2,3]

[1]Institute for Sustainability, Energy, and Environment, University of Illinois at Urbana-Champaign (UIUC), [2]DOE Center for Advanced Bioenergy and Bioproducts Innovation, UIUC, [3]Department of Civil and Environmental Engineering, UIUC

Abstract:

The increasing pace of technology development and growing complexity of sustainability challenges necessitate robust and agile tools to quickly identify critical barriers, prioritize research opportunities, and navigate multi-dimensional tradeoffs in research, development, and deployment (RD&D) of sanitation and resource recovery technologies. However, current modeling tools (e.g., GPS-XTM) are generally developed for conventional, centralized treatment technologies with limited capacities toward modeling non-sewered technologies and considering contextual factors outside the treatment plant. Moreover, the current approach of segregating system design, simulation, sustainability characterization (e.g., techno-economic analysis, TEA; life cycle assessment, LCA), and uncertainty and sensitivity analyses into multiple tools creates challenges in execution and maintaining transparency, motivating the development of new tools to streamline this workflow.

In this workshop, we will introduce the QSDsan platform, which is built around the core package QSDsan – an open-source tool in Python for quantitative sustainable design (QSD) of sanitation and resource recovery systems. With QSDsan executing system design, simulation, and sustainability characterization under uncertainty, another package – DMsan – can be leveraged to navigate decision-making among multiple dimensions of sustainability considering location-specific contextual parameters.

To create an interactive experience, we will use a case study to walk through the QSD methodology and multi-criteria decision analysis. The case study will compare the implementation of a conventional pit latrine and a urine-diverting dry toilet. The workshop attendees can access QSDsan through its website and adjust the design and process parameters (e.g., organic matter decay rate, nutrient leaching fraction) of these two units. Additionally, the attendees can access the contextual parameter (e.g., diet, electricity mix) database in DMsan to set values based on the region of interest. The web application can run the QSDsan platform to visualize results and understand how input parameters can impact the sustainability of these two units, and ultimately affect stakeholder decisions.

Poster Presentation Session 1

(Posters #1-20)
10:00 AM to 11:00 AM
CEE Hydro 1st floor

Poster #1 – Liu Yicen

The Impacts of Aerosol Mixing State on N2O5 Reaction Probability

Dinitrogen pentoxide (N2O5) is an important nighttime reservoir for NOx. The heterogeneous hydrolysis on aerosol particles is considered as the main loss pathway for N2O5, removing NOx from the atmosphere. To better understand the role of mixing state in calculating the N2O5 reaction probability (γ), we used a stochastic particle-resolved model PartMC-MOSAIC to generate 4,900 populations with different compositions and mixing states. For each population, the reaction probability γ_ref was first calculated using the particle-resolved composition data, we then calculated the composition-averaged reaction probability γ_comp, assuming that the population was internally mixed. We compared γ_comp to γ_ref for all populations and found that for 33% of the populations the error in the reaction probability was larger than +/- 20%. A detailed process analysis was provided to explain the reasons for this over/under-estimation, and to show the impacts on the predictions of ozone and nitrogen containing species concentrations.

Poster #2 – Kaushik Aman

Comparative study on air quality status in Indian and Chinese cities before and during the COVID-19 lockdown period

Amidst COVID-19 pandemic, extreme steps have been taken by countries globally. Lockdown enforcement has emerged as one of the mitigating measures to reduce the community spread of the virus. With a reduction in major anthropogenic activities, a visible improvement in air quality has been recorded in urban centres. Hazardous air quality in countries like India and China leads to high mortality rates from cardiovascular diseases. The present article deals with 6 megacities in India and 6 cities in Hubei province, China, where strict lockdown measures were imposed. The real-time concentration of PM2.5 and NO2 were recorded at different monitoring stations in the cities for 3 months, i.e. January, February, and March for China and February, March, and April for India. The concentration data is converted into AQI according to US EPA parameters and the monthly and weekly averages are calculated for all the cities. Cities in China and India after 1 week of lockdown recorded an average drop in AQIPM2.5 and AQINO2 of 11.32% and 48.61% and 20.21% and 59.26%, respectively. The results indicate that the drop in AQINO2 was instantaneous as compared with the gradual drop in AQIPM2.5. The lockdown in China and India led to a final drop in AQIPM2.5 of 45.25% and 64.65% and in AQINO2 of 37.42% and 65.80%, respectively. This study will assist the policymakers in devising a pathway to curb down air pollutant concentration in various urban cities by utilising the benchmark levels of air pollution.

Poster #3 – Li Yurui

Enhancing electrosorption capacity and electrode longevity for selective arsenic removal through electrodeposition of ferrocene polymer coatings

Arsenic contamination is a threat to public health and difficult to remove in micromolar concentrations. Reversible adsorption with polyvinyl ferrocene (PVF) coated electrodes is a promising approach for selective uptake of arsenic oxyanions, but its low adsorption capacity and longevity remain a challenge. In this study, we demonstrate how tailored electrode fabrication strategies with a functionalized ferrocene-based redox-polymer can be used to enhance both arsenic adsorption capacity and electrode longevity. By electrodepositing the redox polymer, poly(3-ferrocenylpropyl meth acrylamide) (PFPMAm) onto a carbon substrate, electrosorption of arsenic nearly doubled compared to PVF (219 mg As/g vs. 136 mg As/g), with uptake retained after 15,000 charge-discharge cycles. In comparison, the adsorption capacity of dip-coated electrodes with both PFPMAm and PVF faded completely after long-term cycling. From a fabrication strategy perspective, the improved performance of the electro-deposited film can likely be attributed to a more robust electrode microstructure that resist fracturing during the dopping-dedopping processes associated with redox cycling. From a polymer chemistry point of view, the higher chain flexibility and lower hydrophobicity of PFPMAm led to more uniform coating of the carbon substrate, likely increasing the number of accessible electroactive ferrocene sites within the polymer coating. The high capacity and stability of electrodeposited PFPMAm illustrate how tuning the chemical structure of the redox polymer and coating method can be used to improve arsenic uptake and prevent degradation of anion adsorbing electrodes in capacitive deionization systems.

Poster #4 – Clark Gemma

Effects of Point-of-use Filters and Stagnation on Drinking Water Quality

Point-of-use (POU) filters have become an increasingly popular, simple solution to address elevated lead (Pb) levels in drinking water. We examined the effects of these filters during flowing water and immediately following stagnation periods on Pb, chlorine, and bacterial concentrations in a preschool and the laboratory. No unfiltered samples exceeded state limits of 5 µg/L for Pb in preschools. However, following stagnation periods as short as overnight, over half of post-stagnation filtered samples exceeded 5 µg/L. Laboratory testing showed no significant increases in Pb with stagnation, suggesting that the preschool may have had Pb-bearing plumbing downstream of the filters which released Pb into the filtered drinking water. Filters removed free chlorine (99% decrease) but increased bacterial concentrations. A 5-minute flush significantly decreased concentrations of Pb and bacteria in filtered samples. Replacing Pb-bearing plumbing components downstream of a POU filter may also be needed to combat Pb levels in drinking water.

Poster #5 – Jia Zhengmiao

Evaluating the Possibility of achieving Efficient Seawater Desalination by Electrodialysis (ED)

Electrodialysis is a technology that using electrochemistry to separate ions inside feed water. Alternating CEMs (cation exchange membranes, negatively charged) and AEMs (anion exchange membranes, positively charged) are placed between 2 electrodes. Cations like Na+ could only pass through CEM but will be blocked by AEM, and anions like Cl- will only move through AEM and are retained by CEM. Electrical potential gradient eventually drives ion separations, leading to a "dilute" zone with fewer salt ions and a "concentrated" zone with majority of salt ions. Electrodialysis is a great way to achieve seawater desalination since the process does not involve chemical reactions, combustions, and phase changes. In the poster, advantages and limitations of electrodialysis will be examined in order to determine the most optimal usage of this relatively new desalination technique.

Poster #6 – Han Zhiqian

Several New Solutions for Metal Pollution

Heavy metal pollution is a serious environmental problem. Heavy metals can be ingested by people through the food chain, increase the carcinogenic risk of people and affect the development of children. Therefore, removing heavy metals from wastewater or soil is very important, and much research has been done in this field. Compared with conventional ways, graphene oxide and biosorption are two new ways that have their characteristics and advantages. Graphene oxide is a new nanomaterial with a large specific surface area and functional groups that can react with heavy metals to form bindings. Due properties graphene oxide has a relatively high removal efficiency and capacity. Biosorption is a technology that is using bacteria to remove heavy metals. Biosorption can have high removal efficiency with a relatively low cost. Biosorption can combine with other technologies to get better treatment results.

Poster #7 – Ma Yongjian

Review of chemical precipitation methods to remove heavy metal ions from industrial wastewater

The growing industrialization and urbanization lead to the increasing number of heavy metals in industrial wastewater. Many heavy metal ions are known to be toxic or carcinogenic. Thus, the presence of these metals in water by improper amounts could result in critical health issues to living organisms. Heavy metals are not biodegradable and tend to accumulate in living organisms. So, it needs extra treatment process other than traditional biodegradation. To reduce the toxicity of heavy metals, scientists come up with several methods and chemical precipitation is one of the most effective and mature methods. It changes the form of dissolved metal ions into solid particles to facilitate their sedimentation. Though that, the sediments can be easily removed. This project will discuss the difference between several precipitation methods and make an assumption of suitable situations for dealing with different kinds of heavy metal.

Poster #8 – Han Chunghyeon

A Review: Evaluation of Degradation of Perfluoroalkyl Substances through Plasma-based Water Treatment Process

Per- and polyfluoroalkyl substances (PFAS) are emerging contaminants that are used in a wide range of industrial and commercial fields. These chemicals are currently considered as forever chemical due to their strong persistence toward conventional treatment methods and capability of permanent bioaccumulation in the human body. While current conventional treatment methods were able to successfully capture PFAS in the water, these methods cannot degrade PFAS after collection. For handling the collected PFAS, Plasma-based water treatment (PWT) can take a big role since a recent study has shown significant removal of PFAS. The experimental results of the study will be analyzed and discussed to evaluate the efficiency of PWT with other conventional water treatment methods for PFAS degradation. Possible byproducts of PFAS after degradation will be also provided and discussed.

Poster #9 – Deptula Alex

Probing Interfacial Structural Dynamics of Glassy Gels for Engineering Porous Media

Colloidal gel systems are a focus of research for solid phase incorporation of particulates useful in tissue engineering, drug delivery, bacterial sanitation, and filtration. Current understandings of structural dynamics of these systems are limited to long-term effects, and as such there have been recent investigations using simulation-based arguments for addressing the various structure-property relationships. Due to complications with in-situ probing of complex fluid materials from solvent phase interference and accurate tracking of particle motion, experimental support for proposed mechanisms is largely lacking. Here, we investigate the surface structure and response of a poly(methacrylamide-co-methacrylic acid) gel, which exhibits a glassy colloidal structure, to various stimuli including pH, temperature, electrostatic potential, and salt concentration, using a variety of in-situ¬ Atomic Force Microscopy techniques complemented by ex-situ¬ rheology, ATR-FTIR, contact angle measurements, and X-Ray Scattering. Further, we demonstrate the applicability of this type of system as a semi-reversible responsive tribological interface.

Poster #10 – Greenwood Gus

Tuning Nanoscale Friction at the Graphene Interface Using an FET-Like Device

Vast amounts of energy production are lost to friction and corresponding wear, with estimates placing total energy lost due to overcoming friction at 23% globally. New materials can reduce these losses directly while providing other benefits. Graphene and other 2D materials are a young class of materials poised to serve as non-toxic lubricants with intrinsically low friction and tunable surface properties. However, the current state of the art is such that altering their interfacial properties in situ is difficult, and direct effects on their frictional properties are not well documented. This work investigates the tunability of graphene supported by a SiO2 substrate using a field effect transistor (FET) inspired setup. An electric field indirectly tunes the insulator-supported graphene while nanoscale friction is measured using atomic force microscopy (AFM). The results show that friction is dynamically tunable allowing creation of systems with finely tailored properties that can be modified in situ.

Poster #11 – Fu Binxin

Nanoscale Insight into the Relation between Pressure Solution of Calcite and Interfacial Friction

Although earthquake mechanisms have been intensively investigated at both macro-, micro- and nano-scale, a gap still exists to bridge the effects observed at different scales. Here, microscale and nanoscale friction measurements are performed by Surface Force Apparatus (SFA) and Atomic Force Microscopy (AFM) to explore the influence of roughness, sliding velocity, fluid medium (aqueous vs. dry environment) and temperature. The velocity-dependent friction data is fit with the Rate and State Friction (RSF) Law in order to connect the nanoscale changes to the macroscale friction response to sliding. Both logarithmic-dependent friction weakening and strengthening regimes were observed in dry N2 environment, while the weakening trend evolves to a linear relationship as the water being introduced into the system. Images of surface topography support the contact aging as a result of atomic attrition for the weakening regime in dry condition, and the aging effect becomes less significant with the roughening surface. The evidence of contact aging is not found in aqueous solution at all investigated roughness and the pressure solution is believed to be dominant at sufficiently low velocity eliminating the effect of aging. The friction measurements with temperature surprisingly indicate a second weakening regime at high sliding velocity when the temperature exceeds a critical point, pointing an alternative mechanism altering the friction behavior at high temperature. By understanding these results, we extend our understanding of mechanisms underlying RSF laws and fault stability in multiple conditions.

Poster #12 – Zhang Xuhui

Correlation between Nanorheological and Nanotribological Behavior of Ionic Liquids

The application of ionic liquids (ILs) in lubrication has gained broad interests and prospects. Compared to traditional lubricants, ILs have advantages because of their negligible volatility and well-performed stability under high-temperature and high-pressure conditions. Also, the weak interactions between the cations and anions of ILs provide great chemical tunability to tailor for specific working conditions. However, the lubrication mechanism of ILs still remains unclear. To unveil the behavior of ILs under nanoconfinement, five types of ILs were selected, and their dynamic properties were measured under dry N2 environment by a nanorheometer built from an extended surface forces apparatus (eSFA). Small amplitude oscillatory shear (SAOS) sweep measurements and friction force measurements were performed to study the nanorheology and nanotribology, respectively, when the two mica surfaces with ILs in between were brought to a specific distance. By combining storage and loss moduli, viscosity, and friction, we tried to discover the correlation between rheology and tribology of nanoconfined ILs. In addition, the experiments were also conducted in equilibrium with 35% relative humidity to study the effect of traces of water on nanorheology and nanotribology. This research provided a great perspective to delve into the nanoscale lubrication mechanism of ILs and would be beneficial in the industry to make better use of ILs as lubricants.

Poster #13 – Li Linkun

Biometric antifouling: An environmentally friendly way of conducting vessel antifouling

In shipping industry, everything below the waterline is part of the marine ecosystem. Species including barnacles and mussels attach to the bottom of boats if left with no proper protection. This can impact the environment in multiple ways: the disruption of streamlined shape will lead to increased drag and fuel consumption, accelerating global warming; species may get transported to another region across the earth and become invasive species, damaging the local ecosystems. Biofouling is such a complex problem that needs to be addressed effectively. This project contains a wide literature review of technologies that have been applied to reduce the impact of biofouling on boats. On top of that, specific studies on novel bottom coatings are also conducted. Existing bottom paint can cause serious poisoning in docks and accumulation of chemicals in food chain. New formula of high-efficiency, low-toxicity paint is going to have great positive influence on the environment.

Poster #14 – Cong Wen

Comparative study of Coxsackievirus and Adenovirus Inactivation by Chlorine Disinfection

Human Adenovirus (HAdV) and Coxsackievirus are common microbial contaminants in water that are highly persistent. They are listed in the USEPA's Contaminant Candidate List 4 for future regulation. HAdV-2 is the most resistant waterborne virus to chloramine treatment while being very sensitive to free chlorine; Coxsackievirus B5 (CVB5) is one of the most resistant viruses to free chlorine treatment. We have used molecular approaches to study the mechanisms of CVB5 and HAdV-2 inactivation by chlorine comparatively in the hope to explain their significant difference in their resistance to free and combined chlorine treatments. The key components of viral replication cycles, including viral attachment and internalization, genome integrity, transcription, and replication, were analyzed to identify the steps interrupted by chlorine treatment. Efforts were also made in improving disinfection efficiency with serial application of free and combined chlorine and achieving smart water disinfection with the development of an aptamer-based viral sensor.

Poster #15 – Mao Yuqing

Whole-genome sequencing of Salmonella enterica to understand its transmission during a flood event in a rural area

Pathogens can spread with floodwater and potentially cause infectious disease outbreaks. Salmonella is a foodborne and waterborne pathogen that caused the most cases of bacterial foodborne outbreaks in the US. In this study, we aimed to understand the antibiotic resistance profiles and the transmission routes of Salmonella enterica after a flood event. We collected water samples from 16 flooded sites and nine unflooded sites in a rural area in North Carolina after a flood event. Forty S. enterica isolates were obtained from five flooded sites and five unflooded sites. All S. enterica isolates were multidrug-resistant. Illumina whole-genome sequencing was performed for all S. enterica isolates. All 40 Salmonella enterica isolates belonged to a novel sequencing type. Multiple antibiotic resistance genes were detected. Core and accessory genomes of the S. enterica isolates were analyzed to reconstruct their phylogenetic relationship and historical horizontal gene transfer events.

Poster #16 – Bangar Shreshtha

Impact of COVID-19 lockdown on ambient air quality in 9 indian mega cities

Air pollution is a major cause for health issues across the world especially in India which is highly populated. Use of fossil fuels to run the vehicles and industrialization are primary sources of air pollution. The pandemic of COVID-19 has forced many countries of the world to implement lockdown to curb the spread of the virus. This action has resulted in significant decrease of air pollutants improving the air quality all over India. This study is undertaken to understand and investigate the impact of COVID-19 lockdown on air quality improvement. Results show that in Dwarka, a big reduction of 60% was seen in PM 10 concentration in the first two phases of the lockdown period. PM2.5 and NO showed a significant drop of 42% and 70% respectively. Moreover, NO2 and NOx decrease by 60% and 74% respectively in the first phase and then increased slightly after. For Visakhapatnam, PM10 concentration dropped by almost 16% in 2020 and PM2.5 decreased by about 40%. Also a major drop of about 40-50% can be seen in the case of SO2 in past 3 years. Aurangabad experienced gradual reduction in PM10 and PM2.5 in every phase of lockdown. SO2, CO and ozone continued to increase during entire lockdown for all the cities.

Poster #17 – Birawat Ruchitha Kamlesh

Biodegradation of polyethylene terephtalate using microbial consortia

Polyethylene terephthalate (PET) is one of the most widely used polymers for the formation of plastic products. A lot of research has been done in finding eco-friendly and cost-effective ways to degrade PET, as it persists in the environment. One of the methods used is the biodegradation of PET by a microbial consortium. Five isolates namely, Bacillus licheniformis, Bacillus sp., Pseudomonas aeruginosa, Bacillus sp., and Shigella sp., were isolated from cow dung and vermicompost samples collected across Bangalore, India. The highest weight loss percentage of 1.47% was observed while degrading the PET polymer when the consortium consisting of three microorganisms, namely, Shigella sp., Pseudomonas aeruginosa, and Bacillus sp., were incubated in a minimal salt broth with PET as the only carbon source at 27°C for 14 days. Among individual isolates, Pseudomonas aeruginosa showcased the highest degradation of 0.8%. An insight into the mechanism of degradation was obtained by performing in silico docking of the enzymes-lipase, esterase, protease, hydroxylase, peptidase, and cutinase present in the bacterial isolates against the 3D structure of PET. As a positive control, PETase derived from Ideonella sakaiensis was docked against PET. The highly negative values of interaction energy in the range of -63.86 kcal/mol to -87.28 kcal/mol versus the energy value of the control (-70.88 kcal/mol) suggested that these enzymes could be the probable reason behind the degradation ability of the bacteria.

Poster #18 – Cortes-Pena Yoel

Techno-Economic and Life-Cycle Implications of Integrating Cellulosic Ethanol Production and Seasonal Oilsorghum Processing at an Oilcane Biorefinery

Oilcane is a new oil-accumulating crop engineered from sugarcane, the most productive crop on earth, potentially providing a more sustainable source of biofuels than conventional oil-seed crops. Two biorefinery configurations producing biodiesel and ethanol were evaluated, including (i) oil extraction by mechanical expression (conventional configuration), and (ii) oil extraction after lignocellulosic hydrolysis (cellulosic configuration). For the conventional and cellulosic configurations, respectively, opting to process oilcane over sugarcane leads to an increase in maximum feedstock price of 8.35 [-2.01, 23.62] (median with 5th and 95th percentiles shown in brackets) and 11.1 [0.1, 27.2] USD·ton-1, and a reduction in life cycle cradle-to-biorefinery-gate global warming potential of 111 [238, -37] and 981 [1,763, -1] g·CO2-eq·gal-etoh-1 under economic allocation. If oil-sorghum, oil-producing sweet sorghum, is processed when oilcane is out of season, the maximum feedstock price increases by 3.98 [2.35, 5.78] and 8.82 [6.59, 11.55] USD·ton-1 for the conventional and cellulosic configurations, respectively.

Poster #19 – Stewart Dalton

Incorporation of Policy Incentives and Other Location-Specific Parameters into BioSTEAM for the Techno-Economic Analysis of Biorefineries

Biofuels are being actively pursued as part of a portfolio of solutions to address climate change, but the use of cellulosic feedstocks remains challenging. This study evaluated the influence of 8 parameters that vary across locations (income, property, sales, and producer fuel taxes; feedstock price; electricity price; location capital cost factor; and tax incentives) on the economic performance of corn, corn stover, and sugarcane biorefineries via techno-economic analysis (TEA). We conducted biorefinery simulation and TEA incorporating distributions of the location-specific parameters and incentives under uncertainty using BioSTEAM, an open-source platform for the design, simulation, and sustainability characterization of biorefineries. Results of this study revealed that the range of tax rates, material prices, and incentives across U.S. states can significantly affect a biorefinery's economic viability. Altogether, conclusions from this study can be used by researchers and policymakers to evaluate the implications of tax incentives for specific scenarios.

Poster #20 – Kim Ga-Yeong

Algae process modeling

Despite the potential of the algae-based wastewater treatment to efficiently remove nutrients and produce a wide range of bioproducts, the lack of a mechanistic model to predict the effluent quality and biomass production has limited the optimization of algal nutrient recovery process design. This study aims to develop a phototrophic-mixotrophic process model (PM2), which can simulate the growth of algae on light energy, stored carbohydrates or lipids, and organic substrates. In particular, the algae process model is being incorporated into QSDsan – an open-source, Python-based quantitative sustainable design and simulation platform – to enable the fast and robust simulation, techno-economic analysis (TEA), and life cycle assessment (LCA) under uncertainty. Continuous online monitoring data (pH, DO, temperature, light intensity, TSS, PO43-, NH4+, NO3-) from a full-scale CLEARAS EcoRecover microalgal treatment system are used to refine, calibrate, and validate the algae process model.

Podium Session 1

(Presenters #1-6)
11:00 AM to 12:00 PM

Podium Presenter #1

(Newmark 1311)

Oh Chamteut – 11:00 AM to 11:20 AM

Plant-derived polyphenols: a sustainable alternative to inactivate enteric viruses

Human noroviruses are major food- and waterborne pathogens, causing approximately 20% of all cases of acute gastroenteritis cases in developing and developed countries. Proper disinfection of harvested food and drinking water is critical to minimize infectious disease. Grape seed extract (GSE) is a mixture of plant-derived polyphenols used as a health supplement. Polyphenols possess anti-microbial and -fungal properties, but antiviral effects are not well-known. Here we show that GSE outperformed chemical disinfectants (e.g., free chlorine and peracetic acids) in inactivating Tulane virus, a human norovirus surrogate. Data from molecular assays and molecular docking simulations suggest that polyphenols physically associate with viral capsid proteins to aggregate viruses as a means to inhibit virus entry into the host cell. Plant-based polyphenols like GSE are an attractive alternative to chemical disinfectants to remove infectious viruses from water or food.

Podium Presenter #2

(Newmark 2312)

Yang Xiaokai – 11:00 AM to 11:20 AM

Multi-phase chemistry surrogate modeling with elemental mass conservation using a Neural ODE

Modeling atmospheric chemistry and physics is computationally expensive and limits the widespread use of air quality models. This computation cost arises mainly from solving high-dimensional systems of stiff differential equations. Previous work has demonstrated the promise of machine learning (ML) to accelerate air quality model simulations but has suffered from numerical instability during long-term simulations. Here we use a Neural ODE to create a multi-phase chemistry surrogate model which conserves the mass of all chemical elements. We couple the near-explicit gas-phase Master Chemical Mechanism (MCM) with the state-of-art Particle-resolved Monte Carlo Model for Simulation Aerosol Interactions and Chemistry (PartMC-MOSAIC) and use an autoencoder to learn a compressed representation of the chemical system to reduce memory usage and computational expense. Preliminary results of training on a small dataset are promising; we are currently working to scale up training workflow to realize the full potential of this approach.

Podium Presenter #3

(Newmark 1311)

Molitor Hannah – 11:20 AM to 11:40 AM

Intensive Mixed Community Microalgal Cultivation for Nutrient Recovery from Municipal Wastewater

Wastewater treatment facilities with pending effluent total phosphorus (TP) limits that exceed the capabilities of enhanced biological phosphorus removal typically rely on expensive and waste-generating chemical polishing. Microalgal wastewater treatment technologies can recover nutrients, capture CO2, and generate revenue from biomass, while at the same time achieving effluent TP concentrations below the current limit of technology. However, to ensure the financial viability of microalgal technologies, it is essential to optimize their design and control through better understanding of the microbial communities and unit processes. We characterized a new installation of the Advanced Biological Nutrient Recovery (ABNRTM, CLEARAS Water Recovery Inc.) system, which targets rapid phosphorus removal through high density microalgal cultivation in photobioreactors. The initial sampling period, in November 2021, identified corrective actions for improved performance. Online monitoring continues, with the goal of elucidating the mechanisms governing system performance, process variability, and resource requirements to optimize system performance and sustainability.

Podium Presenter #4

(Newmark 2312)

Wang Shiyuan – 11:20 AM to 11:40 AM

Global disparities in PM2.5 exposure caused by consumption of goods and services

Millions of people globally die each year from exposure to ambient fine particulate matter (PM2.5). Much of the emissions that lead to this exposure are caused by activities in service of economic demand for goods and services. Owing to economic globalization, to disparities in industrial and environmental regulation, as well as to atmospheric transport, economic activity is more polluting in some areas than in others. To explore these disparities, we combine economic, geophysical, and epidemiological modeling approaches to quantify the difference between the pollution that people cause by consuming goods and services, and the health impacts resulting from the pollution to which they are exposed. First, we use a multi-regional input-output model of international trade to couple economic transactions among 56 economic sectors in 43 countries to a global pollution emissions inventory. We then use the Intervention Model for Air Pollution (InMAP) to estimate global PM2.5 concentrations resulting from the emissions. Finally, we use the Global Exposure Mortality Model (GEMM) to estimate excess PM2.5 mortality rates. We find that economic consumption in China, India and the U.S. causes the most deaths globally of the countries we study. Economic consumption in most countries causes more deaths in other countries than domestically, with only Brazil, China, Japan, Mexico, Indonesia, India as exceptions. Per unit of economic demand, India, Indonesia and China cause the most deaths: with 4.1, 6.8 and 7.4 million USD spent per death, respectively, as compared to a global populated average of 20.2. Although consumption in the U.S. causes nearly 200,000 deaths per year, the number of deaths caused per unit of demand is relatively small compared with other countries. These findings shed light on the uneven effects of globalization on public health.

Podium Presenter #5

(Newmark 1311)

Yus Joaquin– 11:40 AM to 12:00 PM

Promoting natural coral growth using hydraulic lime substrates with inorganic additives

This work shows how engineered substrates can be designed with a combination of inorganic additives to aid in coral restoration. Building upon our previous work, we extended our studies to a calcium carbonate-rich material of higher durability than the previously investigated non-hydraulic lime. We investigated substrates based on natural hydraulic lime (NHL), to which we incorporated $MgCO_3$, $MgSO_4$ and $SrCO_3$ with concentrations ranging between 5% and 20% by mass.

The presence and/or controlled release of Mg, Sr and Ca ions from the substrates helps in larval settlement, and aid in post-settlement growth, mineralization, and defense of juvenile corals. How the ions' presence in the substrates affects the complex search behavior of the larvae, was investigated in three Caribbean broadcast-spawning species (Colpophyllia natans, Diploria labyrinthiformis and Orbicella faveolata). The results demonstrate significant preferences for larvae to choose specific compositions depending on the coral species.

Podium Presenter #6

(Newmark 2312)

Kumar Joshin – 11:40 AM to 12:00 PM

Correcting for biases in filter-based aerosol light absorption measurements at the ARM Southern Great Plains site

Measurement of absorption of solar radiation by aerosols is vital for assessing direct radiative forcing, which affects local and global climate. Filter-based aerosol light absorption measurements are subject to unquantifiable artifacts associated with the presence of the filter medium and the complex interactions between the filter fibers and accumulated aerosols. Various correction algorithms (Bond et al., 1999; Virkkula et al., 2005; Li et al., 2020) have been previously developed to correct the filter-based absorption but are unable to predict particle-phase absorption coefficient (Babs) with a high degree of accuracy universally. In this study, we used Machine Learning to predict particle-phase Babs and compared its accuracy against the traditional equation fitting-based correction algorithms. We have analyzed three months of high-resolution ambient data collected in parallel using a PSAP and 3-wavelength PASS; both instruments were operated at the Department of Energy's Southern Great Plains user facility in Oklahoma. We found that the Random Forest Regression (RFR) machine learning algorithm outperformed Babs predictions by both the Revised Virkkula and Virkkula (2010) algorithms. The wavelength averaged Root Mean Square Error (RMSE) values for predicting Babs using RFR, Revised Virkkula, and Virkkula (2010) algorithms were found to be 0.37, 0.67, and 3.18 Mm-1, respectively.

Poster Presentation Session 2

(Posters #21-39)
1:00 PM to 2:00 PM
CEE Hydro 1st floor

Poster #21 – Kudli Lavanya Prashantkumar

Techno-Economic Analysis and Life Cycle Assessment of Sustainable Azelaic Acid Production from oleic acid

Azelaic acid is a renewable bioproduct derived from oleic acid with industrial applications including lubricants, cosmetics, and pharmaceuticals. However, current ozone-based production methods for azelaic acid are energy intensive and pose combustion hazards. A potentially more sustainable conversion pathway is to replace ozone with hydrogen peroxide for the catalytic oxidation of oleic acid. Novel conversion technologies employing hydrogen-peroxide based methods have significant technological and market driven uncertainties, that need to be evaluated to understand their potential commercial feasibility and environmental impact. In this study, we leverage BioSTEAM—an open-source platform for design and evaluation of biorefineries— to perform techno-economic analysis and life cycle assessment of hydrogen peroxide-based methods for production of azelaic acid under uncertainty.

Poster #22 – Kwon Jiheon

Sustainability

The skeletons of many marine organisms are composed of multifunctional mineral-organic composite structures. Here, we investigate the formation of mineral-organic composites starting with the precipitation of amorphous calcium carbonate (ACC) nanoparticles as a precursor to amorphous calcium phosphate (ACP) nanoparticles. ACP wets the network of an agarose hydrogel and transforms into platelike hydroxyapatite (HAP) strongly intertwined with the polymer. This mineralization pathway leads to a small enhancement of the mechanical properties of the agarose gel. However, we observe that successive mineralization cycles lead to a gradual increase of the mineral content in the hydrogel, and thereby, of the strength of the hydrogel, as the interaction between mineral and polymer is preserved. This method opens the possibility of improving the mechanical performance of hydrogels via mineralization. More broadly, the mechanisms revealed in this study help advance both the fields of biomineralization and tissue engineering.

Poster #23 – Shah Shaival

Delineating groundwater recharge potential areas applying GIS technique in Surat City (SMC), India

The main objective of the project is to determine the potential sites for groundwater recharge within Surat city, situated on the banks of Tapi River near the western coast of the Indian subcontinent. With rampant use of groundwater, the city is expected to run out of the indispensable resource in the coming decades. To delineate groundwater potential zones of the study region, eight hydrogeological factors such as soil, lineament, drainage, average rainfall, land use land cover, slope, geology and geomorphology were considered. SRTM DEM, soil, geology and geomorphology map of GSI, Landsat-8 and rainfall data were arranged and processed in ArcGIS, Geomatica and ENVI software as per requirements to prepare eight individual thematic layers. All the thematic maps were integrated using the Analytical Hierarchy Process (AHP) with assistance of MATLAB. The study area was divided into Poor, Moderate, Good and Very Good groundwater recharge zones which showed the potential of groundwater artificial recharge for different areas throughout the study map.

Poster #24 – Park Manho

Accelerating air quality modeling with an advection surrogate model

Chemical transport models are key tools for improving air quality by diagnosing problems and evaluating the effectiveness of abatement plans. A major bottleneck in the use of these models is computational cost. Machine-learned surrogate modeling from coarse-grained accurate solutions may replace direct high-resolution integration, which is computationally expensive. Here we evaluate the potential cost reduction by employing a learned advection operator for GEOS-Chem. We confirmed the necessity of cost reduction by preliminary simulation. A 3-month transport tracer simulation at 0.25° × 0.3125° resolution took 2,558 min while a simulation at 4° × 5° resolution took 43 min. However, the coarser model cannot recreate the patterns in the finer one. Currently, we are building a learned solver to emulate 1-D and 2-D advection operators. We will expand the learned stencil to 3-D and eventually we will apply this to the advection scheme for GEOS-Chem.

Poster #25 – Xie Kaifeng

Using Algal Biochar to Mitigate Greenhouse Gas Emissions in Agricultural

Agricultural greenhouse gas emissions account for approximately 33% of total greenhouse gas emissions. Among all the methods that can be applied to reduce GHG emissions in agriculture, use of algal biochar has a massive potential to sequestrate carbon since microalgae can be a bioremediating agent and a potential biofuel. Additionally, microalgae transfer their biomass to biochar, which has the power of changing the physical and biological properties of soil, thus improving fertilizer utilization and reducing GHG emissions. My poster will discuss the mechanisms of how algal biochar reduces GHG emissions and provide a perspective of algal biochar limitations and applications.

Poster #26 – Hunter Hope

Aerosol composition in the Arctic

Polar regions are highly susceptible to climate change. Aerosols play a role in the heating of the surface by disrupting the surface energy balance. It is believed that different aerosols have differences in their impact on regional climate change. Therefore, we are interested in investigating the aerosol composition in the Arctic and how it is affected by sea ice leads.
To analyze this, we use data from the INPOP field campaign and compare aerosol compositions of the air on days when wind is primarily coming from land to days when wind is primarily coming from the sea, as well as coupling days with similar wind speeds and direction, save a land-direction component. Additionally, sea ice lead data are used to determine if there are aerosol composition trends that correspond with exposed ocean.

Poster #27 – Li Jingyu

Developing hydrogel-based substrates to improve coral larvae settlement and coral growth

Coral reefs can protect shorelines from storm and support commercial fisheries. They form the highest biodiverse ecosystem, providing marine habitats to more than 25% of all marine life. However, recent human activities threaten corals' survival and coral reefs have declined rapidly. Developing substrates to promote coral larvae settlement is crucial. Our hypothesis is that providing these substrates with controlled release of active molecules that attract larvae and/or feed juvenile corals can further accelerate coral reef restauration. Based on the well-accepted drug delivery capability of hydrogels, we have designed three different hydrogel-based substrates including magnesium chitosan-alginate hydrogel (Mg-Chi-Alg), calcium chitosan-alginate hydrogel (Ca-Chi-Alg), and strontium chitosan-alginate hydrogel (Sr-Chi-Alg). Fourier transform infrared (FTIR), scanning electron microscope (SEM), and rheology have been used for characterization of the hydrogel substrates. Mg-Chi-Alg hydrogel shows significant cation (magnesium) release in the artificial sea water. On this basis, our team will attempt to incorporate extract molecules from crustose coralline algae (CCA) into the hydrogels and monitor substrates' ability of attracting coral larvae in the sea.

Poster #28 –Salana Sudheer

PM2.5 induced cytotoxicity: Role of ROS and Glutathione Depletion

The ability of a toxicant to induce cell death shares a very complex relationship with glutathione (GSH) depletion and the generation of reactive oxygen species (ROS). So far, very few studies have explored this relationship for ambient particulate matter (PM). Thus, the objective of this study is to evaluate this relationship using a large number of ambient PM2.5 samples collected from several distinct locations. We used A549 (human lung epithelial) cells and Crystal Violet, DCFH-DA (Dichloro-dihydro-fluorescein diacetate) and Monochlorobimane assays to study cellular responses when these cells are exposed to the water extracts of PM2.5 filters. Our results show that there is a good correlation between cell viability and ROS response ($r > 0.5$). However, the ROS response was only moderately correlated with GSH depletion ($0.32 < r < 0.40$) and cytotoxicity was weakly correlated ($0.11 < r < 0.41$) with GSH consumption. These results indicate that PM2.5 might induce glutathione depletion through other mechanisms beside ROS generation and PM2.5 induced cell death might also occur through GSH-independent pathways. Our study implies that antioxidant depletion and ROS generation should perhaps be seen as independent events rather than being viewed as synonymous to each other.

Poster #29 – To Lane

Modeling fecal sludge pyrolysis for biochar production in an Omni Processor

Pyrolysis of fecal sludge can make sanitation more affordable and accessible, while simultaneously producing biochar, a byproduct that improves carbon fixation, water retention, and nutrient delivery in soils. The Omni Processor (OP) pyrolyzes sludge to produce biochar, while leveraging the energy contained in sludge to fuel the process. Using QSDsan, an open-source Python package for quantitative sustainable design of sanitation and resource recovery systems, our group developed a computational model of the OP that evaluates the fate of carbon and nutrients from waste streams to sludge treatment byproducts and emissions. While the model produces reliable results based on fixed assumptions, it lacks responsiveness to changes in design and operation decision variables such as pyrolysis temperature, residence time, moisture content, and feedstock composition. Using literature data, we aim to elaborate carbon and nutrient mass balances in the existing model and better characterize the relationships between decision variables and resulting biochar characteristics.

Poster #30 – Sahay Alankrita

Biochar for resource recovery

Biochar is a promising agent for wastewater treatment, soil remediation, and gas storage. Although, it is made of agricultural and industrial wastes such as crop straw, litter, and dewatered sludge, it plays a substantially important role in environmental treatment, emphasizing on the concept of "treating wastes with wastes." Biochar technology finds many applications in wastewater treatment. It has been increasingly used as an adsorbent to remove toxic metals, organic pollutants, and recover nutrients (nitrogen and phosphorus) from wastewater. Compared to natural/pure biochar, engineered biochar generally has larger surface area, and stronger adsorption capacity (more abundant surface functional groups, SFGs), which can mean great prospects in various wastewater treatments, including industrial wastewater (dye, battery manufacture, and dairy wastewater), municipal wastewater, agricultural wastewater, pharmaceutical waste and storm water. With recent research, it can be concluded that biochar technology represents a cost effective, and environmentally-friendly solution for the treatment of wastewater.

Poster #31 – Emaminejad Aryan

Application of Bio-electrochemical Sensors for Carbon Monitoring at Water Resource Recovery Facilities: A Statistical and Microbial Analysis Approach

Carbon monitoring and management at water resource recovery facilities (WRRFs) can enhance both the treatment efficacy and energy efficiency of wastewater treatment biotechnologies. Therefore, WRRFs are increasingly relying on using sensors for automated control of unit processes and efficient decision making. Bio-electrochemical sensors (BESs), which leverage electrogenic biofilms to generate an amperometric signal of carbon metabolism, are gaining increasing attention due to their capability of monitoring changes in wastewater composition and detecting toxic shock events. This study presents a long-term field evaluation of a BES deployed in a full-scale WRRF for 247 days to quantify its sensitivity to organic load variations and assess the impact of abiotic factors on the BES response signal and biofilm composition using advanced data analysis and microbial techniques.

Poster #32 – Aguiar Samuel

Nutrient Recovery

Struvite precipitation is an effective way to remove soluble orthophosphate from P rich feedstocks. However, in practice these systems sometimes generate fine struvite particles during "upset" events and as a result suffer from typically low and highly variable P recovery rates. This work first uses the shrinking object model to elucidate the dissolution rate of struvite particles as a function of size. Then, the shrinking object model is integrated into a commercial wastewater simulation software (SUMO) to analyze the effects of low yield struvite crystallization on plantwide processes. Plant effluent quality is most negatively affected (TP increases of up to 0.8 mg-P L-1) during low yield operation and when washout particles are fine (<200 μm). This work suggests design and optimization of struvite crystallization should focus on not only conversion of soluble P to struvite, but also on particle retention to yield the best overall plant performance.

Poster #33 – Lohman Hannah

Elucidating the impact of locality-specific factors on sanitation system sustainability and decision-making

In resource limited settings, sanitation systems often fail to meet their goals – 70% of systems fail within the first two years. System failures often stem from a mismatch of solutions and implementation context. The objective of this work is to explore the influence of context-specific input parameters on system sustainability and decision-making criteria (e.g., environmental impact, daily user cost). This work is achieved through modeling the construction and operation of non-sewered sanitation and resource recovery technologies and varying context-specific input parameters. Key contextual parameters are related to energy, population demographics, and economics. Preliminary results indicate that greenhouse gas emissions across technologies are most sensitive to a country's energy mix. Demographic parameters such as dietary intake and user population impact the quantity of recoverable nutrients available for resource recovery systems. Overall, the tools and methods in this research can be used to improve the decision-making process of sanitation system selection.

Poster #34- Zhang Xinyi

QSDsan: An Integrated Platform for Quantitative Sustainable Design of Sanitation and Resource Recovery Systems

Robust and agile tools are required for the research, development, and deployment (RD&D) of emerging wastewater treatment and resource recovery technologies. We herein introduce QSDsan – an open-source Python package that leverages the quantitative sustainable design methodology for integrated process modeling, system design, simulation, and sustainability assessment of sanitation and resource recovery systems. By providing flexible, transparent, and freely accessible modules for a streamlined workflow of modeling, evaluation, statistical analyses, and visualization, QSDsan can be used to enumerate and investigate the opportunity space for a diverse portfolio of emerging technologies under uncertainty. The capacities of QSDsan are illustrated through a series of analyses: (i) benchmark simulation model no. 1 (BSM1) was simulated and compared to an implementation in MATLAB/Simulink for verification of dynamic process modeling and simulation algorithms; (ii) uncertainty and sensitivity analyses of the BSM1 incorporating uncertainty in 28 parameters; (iii) mapping of BSM1 system's performance across its decision space.

Poster #35 – Lee Ming Jun

Surface Structure Modulation of Agarose-Poly(acrylamide-co-acrylic acid) Double Network Hydrogels

Hydrogels provide a versatile platform to create biocompatible and biodegradable soft materials for applications in biomedicine, among others. For many of these applications, the sensing capability and responsive ability of the material is strongly desired, while maintaining sufficient strength to survive stressors. Charged double network hydrogels could provide a solution to this conundrum. These hydrogels possess desirable mechanical strength similar to biological tissues such as cartilage and can be designed with biologically compatible networks. Furthermore, the inclusion of charged copolymer enables dynamic response to stimuli such as salt concentration, pH and electric field, which enables charged double network hydrogels as aqueous sensors and actuators. In this project, I will explore how the surface of agarose-poly(acrylamide-co-acrylic acid) double network hydrogel changes in response to salt solution through characterization methods such as atomic force microscopy, surface zeta potential and thin gel tensile test.

Poster #36 – Zheng Qianlu

Influence of ion specificity and water uptake on the electrical double layer of graphene–ionic liquid

Supercapacitors are new-generation energy storage devices with high power density and long cycle life. Ionic liquids (ILs) are promising electrolyte candidates for supercapacitors due to low volatility and high thermal and electrochemical stability. Since a supercapacitor stores energy by forming an electrical double layer (EDL) at the electrode-electrolyte interface, it is important to understand the interfacial structure. Due to the hygroscopic nature of ionic liquids, the influence of water on the EDL is also of interests. The layering structures of five ILs on charged graphene surfaces were investigated by atomic force microscopy (AFM) in dry condition and 33% relative humidity. The electrochemical windows were determined by cyclic voltammetry. Differential capacitance was characterized by electrochemical impedance spectroscopy (EIS). The work attempts to scrutinize the subtle correlation between the differential capacitance and the nanoscale structures in the EDL. The knowledge will contribute to the optimization of IL-graphene-based supercapacitors and other electrochemical devices.

Poster #37 – Chaudhari Hrutuja

Analytical modeling for design of floating treatment wetlands as a sustainable technology for wastewater purification.

As a result of the direct discharge of sewage and leaching of fertilizers from farmlands into the water bodies, there is a rise in the concentration of nutrients, which leads to the formation of algal blooms. One of the biological treatments to combat this situation is called 'floating treatment wetland' which is a cost-effective, highly efficient, and simple technique to treat wastewater it comprises of small artificial platforms that allows the aquatic emergent plants to grow in water. The unique ecosystem that develops, creates the potential to capture nutrients and transform common pollutants that would otherwise plague and harm our lakes into harmless by-products. This paper gives the brief design of an analytical model using MS Excel for the engineering design of floating wetland, by optimizing the parameters to get higher pollutant removal efficiencies.

Poster #38 – Kumar Aditi

Sustainability of Ion-Exchange Water Treatment Technology

Ion exchange is an effective wastewater treatment technology. As the name suggests, the ion exchange process is used to replace harmful ions from a water sample with desirable ones. There are several kinds of ion exchange resins containing beads that can carry out this process and, the underlying chemistry is determined by the type of contaminants that are present in the water sample. This process can be restricted to just water softening or can be extended to the removal of toxic metals. The beads exchange cations with hydrogen ions or anions with hydroxyl ions. There are certain disadvantages associated with this method like high operating costs however the overall benefits outweigh such drawbacks. It is important area of research to ponder upon how the scope and reach of this process change in the future with lesser resources and worsening climate conditions.

Poster #39 – Zhou Aijia

SARS-COV-2 Detection in wastewater

COVID-19 pandemic is a global concern which has caused millions of cases and deaths. Wastewater-based epidemiology (WBE) can track SARS-CoV-2 infection dynamics through wastewater. Aiming to detect the existence of pre-symptomatic or asymptomatic patients in specific areas prior clinical test results, and to remind special attention for viral spreading, the SARS-CoV-2 viral concentration in wastewater was monitored from April to October 2021.Wastewater samples were collected in 9 locations in Urbana-Champaign and a rural area nearby. Our study developed a timesaving WBE method, which used MgCl2 addition and centrifugation to concentrate SARS-CoV-2 into sludge, based on the understanding that enveloped virus RNA in sludge was dozens of times higher than it in supernatant. We correlated wastewater viral concentration data with clinical tests and found Pearson's relationship showed weak to moderate positive in four of seven sampling locations.

Podium Session 2

(Presenters #7-12)
2:00 PM to 3:00 PM

Podium Presenter #7

(Newmark 2311)

Ruffatto Ken – 2:00 PM to 2:20 PM

National inventory of phosphorus recovery potential from centralized infrastructure: a comparison of corn ethanol biorefineries and water resource recovery facilities

Anthropogenic discharge of excess phosphorus (P) to water bodies and increasingly stringent discharge limits has fostered interest in quantifying opportunities for P recovery and reuse. To date, geospatial estimates of P recovery potential in the United States (US) have used human and livestock population data, which do not capture the engineering constraints of P removal from centralized infrastructure. Here, renewable P (rP) estimates from plant-wide process models were used to create a geospatial inventory of recovery potential for centralized water resource recovery facilities (WRRFs) and corn ethanol biorefineries, where a biorefinery can generate on average three orders of magnitude more rP than a WRRF and nearly double the total rP across the US. The Midwestern states have the largest potential for rP among both sources with a high degree of co-location with agricultural P consumption, indicating untapped potential for a circular P economy in this globally significant grain producing region.

Podium Presenter #8

(Newmark 3310)

Puthussery Joseph – 2:00 PM to 2:20 PM

Real-time measurement and source apportionment of five different endpoints of the oxidative potential of ambient particulate matter at an urban site

In this study, we developed a real-time multi-endpoint online system for measuring the oxidative potential (OP) of ambient particulate matter (PM) based on five different acellular endpoints: oxidation of dithiothreitol (DTT) and ·OH generation in DTT assay; glutathione (GSH) consumption, ascorbic acid (AA) consumption, and ·OH generation in surrogate lung fluid (SLF, mixture of GSH, AA, uric acid, and citric acid). We coupled an analytical automated instrument with a mist chamber particle collector and deployed it at a roadside site in Champaign, Illinois for ~2 months. We determined the diurnal trends in the ambient PM OP with a 3-hour time resolution and investigated their association with various chemical species in PM. Source apportionment analysis based on positive matrix factorization identified the dominant redox-active PM sources and their relative contributions. The highly time-resolved OP source contribution data obtained from this study would provide a better mechanistic understanding of the redox properties of PM.

Podium Presenter #9

(Newmark 2311)

Ye Quanhui – 2:20 PM to 2:40 PM

A magnetic nanoplatform to construct innovative bio-nano hybrid materials for sustainable resources recovery

A critical challenge for resources recovery is to selectively capture and concentrate the target resource from complex waste solutions in a form that could be recovered. Proteins with high substrate affinity and selectivity could be harnessed for selective biosorption and recovery of the target compounds. Immobilization of proteins on magnetic nanoparticles (MNPs) holds great potential to enhance protein stability and to enable a facile recovery and reuse of the biosorbent via a magnet. The presented work developed an innovative magnetic-responsive nanoparticle platform for protein immobilization via SpyTag/SpyCatcher chemistry, using two fluorescent proteins (i.e., enhanced green fluorescent protein (EGFP) and red fluorescent protein (RFP)). More importantly, our results showed that MNP could successfully immobilize metal-binding protein to selectively capture and recover rare earth elements. Results from this work provide a novel magnetic nanoplatform for the construction of bio-nano hybrid materials (i.e., protein-based MNPs) for sustainable resources recovery.

Podium Presenter #10

(Newmark 3310)

Pavizhakattumadom Saptharishi Ganesh Subramanian – 2:20 PM to 2:40 PM

Assessing the influence of human-related activities on generation of indoor aerosols and their potential contribution to fomites

Crowded indoor spaces are highly susceptible to SARS-CoV2 super-spreading events. Inhalation of fine aerosol particles carrying infectious virus is one of the principal modes causing SARS-CoV-2 infections. We measured the particle number concentration (PNC) and CO2 in a crowded café as well as in a sealed clean chamber with controlled human activities to address the influence of occupancy on indoor air quality. The café results showed that PNC and CO2 increased linearly with occupancy. The chamber results show that PNC growth from human presence varied widely among the individuals and was highest during exercise. A lower CO2 growth was observed for the masked scenarios indicating CO2 retention in the mask dead volumes and possibly lower O2 inhalation in a tight fitted mask. Interestingly, reduced PNC growth from masking was only observed for exercise activity indicating that particles exhaled via respiration in a clean environment constitute only a small fraction of the total particles generated by human activity. These findings hint towards other possible infectious pathways, e.g., fomite aerosols, responsible for super-spreading events in crowded indoor spaces with high PNC.

Podium Presenter #11

(Newmark 2311)

Bhagwat Sarang – 2:40 PM to 3:00 PM

Sustainable Production of Acrylic Acid via 3-Hydroxypropionic Acid from Lignocellulosic Biomass

Lignocellulosic biomass is a promising renewable feedstock for sustainable biofuels and bioproducts manufacturing. Among emerging bioproducts, 3-hydroxypropionic acid (3-HP) as a platform chemical can be upgraded to commercially significant chemicals such as acrylic acid. We designed, simulated, and evaluated (via techno-economic analysis, TEA, and life cycle assessment, LCA) biorefineries producing acrylic acid via fermentation of lignocellulosic hydrolysate to 3-HP. The biorefinery could produce acrylic acid with a minimum product selling price (MPSP) of $1.72−2.08·kg-1 (5th−95th percentiles; baseline $1.83·kg-1). Advancements in key technological parameters could enhance biorefinery performance (MPSP $1.29−1.52·kg-1, ~88% probability of market-competitiveness, global warming potential 3.00 [2.53−3.38] kgCO2-eq·kg-1, fossil energy consumption 39.9 [31.6−45.1] MJ·kg-1). We explored implications of alternative fermentation regimes (neutral/low-pH fermentation across titer−yield−productivity combinations) and feedstocks (first-/second-generation feedstocks across price and sugar/carbohydrate content). This work highlights the ability of agile TEA−LCA to screen promising designs, navigate sustainability tradeoffs, and prioritize research needs in biofuels and bioproducts development.

Podium Presenter #12

(Newmark 3310)

Shetty Nishit – 2:40 PM to 3:00 PM

Measuring light absorption by freshly emitted organic aerosols: optical artifacts in traditional solvent-extraction-based methods

Good estimates of Organic aerosol (OA) light absorption are necessary to better predict radiative forcing due to these aerosols in climate models. Here, we performed a comprehensive laboratory study involving three solvents (water, methanol, and acetone) to investigate the bias in absorption coefficients obtained from solvent extraction-based photometry techniques as compared to in-situ particle phase absorption for freshly emitted OA from biomass burning. We correlated the bias with OC/TC mass ratio and single scattering albedo (SSA) and observed that the conventionally used correction factor of 2 for water and methanol-extracted OA might not be extensible to all systems and suggest caution while using such correction factors to estimate particle-phase OA absorption coefficients.