NC STATE UNIVERSITY

2023 EWC

Environmental, Water Resources and Coastal Engineering

GRADUATE RESEARCH SYMPOSIUM

Department of
Civil, Construction, and
Environmental Engineering

Friday, March 10, 2023

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The environmental, water resources, and coastal engineering (EWC) group holds an annual research symposium every spring semester. This student-organized symposium features research poster and oral presentations by graduate students to highlight some of the current research conducted by this group, as well as a keynote speech by an invited speaker. The symposium provides an opportunity for students to gain experience in preparing and delivering presentations of their research.

CONTENTS

Meagan Mauter

Stanford University

Associate Professor of Civil & Environmental Engineering and Global Environmental Policy

Professor Meagan Mauter directs the Water & Energy Efficiency for the Environment Lab (WE3Lab) with the mission of providing sustainable water supply in a carbon-constrained world. Ongoing research efforts include: 1) developing desalination technologies to support a circular water economy, 2) coordinating operation of decarbonized water and energy systems, and 3) supporting the design and enforcement of water-energy policies.

Professor Mauter also serves as the research director for the National Alliance for Water Innovation, a $110-million DOE Hub addressing U.S. water security issues. The Hub targets early-stage research and development of energy-efficient and cost-competitive technologies for distributed desalination of non-traditional source waters.

Education

Ph.D., Chemical & Environmental Engineering, Yale University, 2011

M.S., Chemical & Environmental Engineering, Yale University, 2007

B.S., Civil & Environmental Engineering and History, Rice University, 2006

Honors & Awards

Senior Fellow, Stanford Woods Institute for the Environment

Senior Fellow, Precourt Institute for Energy

Associate Professor (by courtesy), Chemical Engineering, Stanford

ACS Sustainable Chemistry & Engineering Lectureship Award

ASCE Walter L. Huber Civil Engineering Research Prize

James J. Morgan Environmental Science & Technology Early Career Award Lectureship

KEYNOTE ABSTRACT

Build (Back) Wiser: Maximizing the Value of Infrastructure Investments for Human and Environmental Benefit

Recent bipartisan infrastructure spending promises to repair the nation's aging water, energy, and transportation systems and prepare the nation's infrastructure for future climate scenarios. But this allocation represents only a fraction of the American Society of Civil Engineers estimated $2.5 trillion infrastructure investment deficit. How do we bridge this value gap? The answer is to "build back wiser" by investing dollars in digitized, versatile, distributed, and inclusive infrastructure systems. This keynote lecture will highlight opportunities for wise infrastructure investments across the Environmental, Water Resources, and Coastal Engineering research space, provide specific examples relevant to Prof. Mauter's work in securing U.S. water supply through water reuse, and encourage attendees to critically position their work in the context of next generation infrastructure systems. The strategies that researchers pursue for infrastructure redesign will determine service quality, equity, resiliency, cybersecurity, climate preparedness, and costs for generations.

AGENDA

Time	Event
12:00 - 1:00	Lunch
1:00 – 1:10	Judge instructions
1:10 – 1:30	Short oral presentations I
1:30 – 2:15	Poster session
2:15 – 2:25	Break/networking
2:25 – 2:45	Short oral presentations II
2:45 - 3:20	Poster finalists
3:20 – 3:30	Break/networking
3:30 - 4:30	Keynote – **Meagan Mauter**
4:30 – 4:45	Awards and Close

Oral Presentations

01 **Hemant Kumar**
Energy, Modeling, and Systems Analysis

02 **Stephanie Starr**
Environmental Process Engineering

03 **Jessica Gorski**
Coastal Engineering

04 **Sean W. Daly**
Global WaSH

05 **Ashley Bittner**
Air Quality

06 **Smitom Borah**
Water Resources Engineering

Quantifying the food-energy-water nexus at regional scales: Inter-sectoral tradeoffs under hydroclimatic extremes

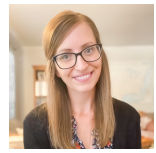
Presenter: Hemant Kumar
Co-author(s): L. You, S. Arumugam

Research Question: How to model the food, energy, and water (FEW) systems to quantify impact of changes in one component on other components?

The nexus between food, energy, and water (FEW) systems plays a critical role in a region's food, energy, and water security especially in basins with intensive agricultural water use. Studies have used multiple approaches - optimization models, simulation models, and trade-off analyses - to investigate the nexus and characterize the dependence of one system over another. However, recent reviews have noted that the development and adoption of analytical methods to study the nexus have been relatively slow despite increasingly complex conceptualizations. The nexus has been generally studied at national scale with few regional studies. Systematic regional studies are important to understand regional variations in the nexus as national data can obscure the regional differences. We employ a data-driven approach to analyze the FEW nexus at the regional scale by considering large-scale river basins across the United States. We characterize the mean state of the nexus by analyzing the exchanges between FEWS subcomponents. We also study the associated inter-annual temporal variations of the nexus flows due to climatic stresses such as floods and droughts. The basin selection covers a broad range of attributes: rainfed agriculture, surface water irrigation, groundwater irrigation, hydropower, and biofuel production. This work develops on the integrated water resource management towards interdisciplinary research by establishing key relationships of water-and-food and water-and-energy processes and interactions. This work would provide early warning and monitoring to possible externalities and unintended consequences due to the nature and interdependence of these three systems.

Keywords: *FEWS, food-energy-water nexus,*

Thermal Reactivation of Spent Granular Activated Carbon (GAC) Containing Per- and Polyfluoroalkyl Substances (PFAS)



Presenter: Stefanie Starr
Co-author(s): W. Prescot, S. Jackson, D. Knappe

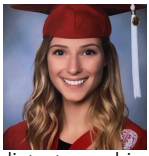
Research Question: What are the conditions that effectively mineralize PFAS during the thermal reactivation of PFAS-laden GAC?

Thermal reactivation of spent granular activated carbon (GAC) is a management strategy that permits GAC reuse. The fate of per- and polyfluoroalkyl substances (PFAS) during thermal reactivation of spent GAC is poorly understood. This study aims to identify thermal reactivation conditions that effectively mineralize adsorbed PFAS. Thermogravimetric analysis (TGA) experiments with PFAS, PFAS/hydroxide mixtures, and PFAS/natural organic matter (NOM) mixtures in the absence and presence of GAC were conducted to determine the thermal stability of 4 perfluoroalkyl carboxylic acids (PFCAs), 3 perfluoroalkyl sulfonic acids (PFSAs), and a fluorotelomer sulfonic acid (FtS). Constituents in the off-gas from TGA experiments were collected with XAD sorbent tubes, impingers, and SUMMA canisters. Impinger solutions and TGA pan residues were analyzed for anions and cations using ion chromatography (IC). Targeted PFAS analysis of impinger solutions was performed with liquid chromatography-tandem mass spectrometry (LC-MS/MS). Targeted and non-targeted analysis of (semi-)volatile fluorinated compounds was conducted by high-resolution gas chromatography-mass spectrometry (GC-HRMS). Results to date showed that thermolysis of all tested PFAS in the absence of GAC was complete at temperatures used to reactivate GAC. In contrast, thermolysis of two adsorbed PFAS was not complete at 800ºC. Salt forms of PFAS were thermally more persistent than acid forms, and PFSAs were more persistent than PFCAs. Results from IC, LC-MS/MS and GC-HRMS analysis accounted for 11-106 % of the fluorine content of the initially added PFAS and show that the addition of a base or NOM enhances the mineralization of some PFAS.

Keywords: *PFAS, granular activated carbon, thermal reactivation, thermal degradation*

3

Deterministic, Dynamic Forecasts of Storm-Driven Erosion during Ian (2022)



Presenter: Jessica Gorski
Co-author(s): R. Luettich, M. Bilskie, D. Passeri, R.C. Mickey, J. C. Dietrich

Research Question: How well does deterministic morphological modeling predict storm-driven erosion?

The U.S. Atlantic and Gulf coasts are vulnerable to storms, which can cause erosion of beaches and dunes that protect coastal communities. Real-time forecasts of storm-driven erosion are useful for decision support, but they are limited by computational resources and uncertainties in dynamic coastal systems. Current methods for erosion forecasts are based on empirical equations, which do not represent dynamic sediment transport, and on surrogate models, which rely on simplified representations of the system. However, with advancements in high-resolution geospatial data and computational efficiencies, there is an opportunity to apply morphodynamic models for deterministic forecasts as a storm approaches.

In this study, we apply the state-of-art model eXtreme Beach (XBeach) for real-time forecasts of erosion during Ian (2022). Sandy beaches along the U.S. Atlantic and Gulf coasts are represented with thousands of one-dimensional transects, which are selected for real-time forecasts based on the storm's track and projected landfall locations. A key contribution of this study is the automation of the modeling system, so the framework can be applied to different regions of the coast as the track shifts. To demonstrate this, forecasts for Ian (2022) were initiated several days before the initial landfall location in Fort Myers, Florida, and continued as the track made a secondary landfall near Georgetown, South Carolina. Results are compared spatially to the observed post-Ian topography using changes to dune crest elevations and volumes, and temporally to the predicted total water level at the forecasted moment of dune impact.

Keywords: *Storm-driven erosion, coastal modeling, nearshore morphodynamics*

4

Estimating Exposure to E. coli and Antimicrobial Resistant E. coli via Drinking Water in Bekasi, Indonesia and Impacts of Point-of-Use Drinking Water Treatment

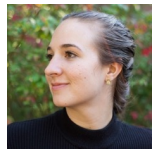
Presenter: Sean W. Daly
Co-author(s): T. Foster, C. Priadi, J. Willetts, G. L. Putri, A. R. Harris

Research Question: What is the exposure to generic and cefotaxime-resistant E. coli for residents of Bekasi, Indonesia?

The rise of antimicrobial resistance (AMR) presents itself as a rapidly worsening global health threat. Household water treatment and storage (HWTS) strategies are commonly employed in low-income settings to reduce ingestion of unsafe drinking water. In order to evaluate the potential exposure to fecal contamination and cefotaxime-resistant E. coli via drinking water in Bekasi, Indonesia, we collected drinking water samples from approximately 45 water sources during both wet season (2020) and dry season (2021), representing 48-49 households. Monte Carlo simulations were then used to estimate daily exposure to both E. coli and resistant E. coli based on the data collected in the study setting. Then, changes in exposure were estimated based on different E. coli log-removal rates representing HWTS scenarios. Generic E. coli was detected in 67.5% of water samples and cefotaxime-resistant E. coli was detected in 28.1% of water samples. When the median simulated individual achieves compliance with the World Health Organization (WHO) drinking water quality standard (<1 CFU E. coli per 100 mL), over 67% and 28% of the population are still exposed daily to generic and cefotaxime-resistant E. coli, respectively. When 100% of the simulated population achieve compliance with the WHO standard, approximately 14% and 1% of the population are still exposed daily to generic and resistant E. coli, respectively. This work highlights weaknesses in HWTS strategies, explores limitations with common water quality monitoring methods and regulatory standards, and identifies individuals with high risk of exposure to antimicrobial resistant organisms.

Keywords: *antimicrobial resistance; point-of-use water treatment; exposure assessment*

Characterizing Emissions from Diverse Domestic Biofuel Uses in Rural Malawi



Presenter: Ashley Bittner
Co-author(s): E. Lipsky, T. Ghambi, A. Grieshop

Malawi is a low-income, energy-poor rural country in Southern Africa, where only ~9% of the population has electricity grid access. The majority of household energy is provided by biofuel use, i.e. collected firewood and/or charcoal. Many of the common emission sources in Malawi and their respective emission factors (mass of pollutant emitted per mass of fuel burned) are unquantified, limiting understanding of air quality trends and impeding evaluation via atmospheric models. As an initial step, we identify various, diverse small-scale biomass burning activities (cooking, charcoal making, brick burning, whiskey distillation, etc.) for emission characterization. We conduct village-level emission sampling using a portable Stove Emission Measurement System (STEMS). The STEMS measurement system records real-time measurements of carbon monoxide (CO), carbon dioxide (CO2), particulate matter (PM) scattering, black carbon (BC) absorption and integrated measurements of PM and organic carbon/elemental carbon (OC/EC). In summer 2017, we monitored 2 charcoal ovens, 3 whiskey distillation events, and 20 cooking events [13 three-stone fires (TSF) and 7 simple improved clay cookstoves (ICS)]. Preliminary analysis of all cooking events showed that the improved clay cookstoves had ~40% lower CO and ~50% lower PM average emission factors (EFs) than the TSF. The cookstove pollutant EFs measured in this study are comparable to those measured in previous studies. The average CO EFs associated with charcoal making and whiskey distillation were ~56% and ~27% higher, respectively, compared to cooking events. The PM EFs followed a different trend: relative to cooking events, charcoal making had an average PM EF ~44% lower, while the average PM EF for whiskey distillation was ~30% higher. In addition to these preliminary results, we will discuss supporting measurements (BC absorption, modified combustion efficiency, etc.) used to characterize biofuel burning emissions.

Keywords: *biofuel combustion, air pollutant emissions, low-income countries, field measurements*

Variability of internal phosphorus loading in large water bodies across the United States

Presenter: Smitom Borah
Co-author(s): D. Obenour

Phosphorus (P) management is essential to control eutrophication in many lakes and reservoirs. It can enter these water bodies from several point and non-point sources as well as from the bottom sediments by recycling. Accounting for these different sources can result in more effective P management strategies. However, while several studies have been conducted to quantify external loads, quantifying internal load is less common and more uncertain. Several statistical models have been developed to quantify the sediment P release, but the existing models have poor performance across large spatial scales. In this study, we developed a new model to estimate the sediment P release in over 3000 large lakes and reservoirs across the United States. This regression model is based on sediment core studies under dark anoxic conditions from about 40 sites across the United States. It uses water-column total P concentration (TP), water temperature (T), and lake morphometry to explain about 60% of the variability in the observed data. To facilitate nation-wide sediment P release estimation, random forest models were developed to predict waterbody TP and T based on mean lake depth, lake and watershed area, air temperature, summer rainfall, land-use, and ecoregions. The combined modeling results are used to assess the variability in internal load and its contribution to watershed P budgets across different regions of the country. The model can also be used to provide initial estimates of internal loading for individual water bodies, which can be further refined through site-specific measurements and modeling efforts.

Keywords: *internal phosphorus loading, random forest model, average lake phosphorus, hypolimnetic temperature*

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16 **Ryan McCune**
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17 **Sophia Rosenberg**
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18 **Kingston Armstrong**
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19 **Chandramauli Awasthi**
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20 **Jessica Levey**
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P1

Methods and Applications for Quantifying Variability in Human Exposure to Urban Air Pollution

Presenter: Sailaja Eluri
Co-author(s): H. C. Frey

Research Question: How to quantify variability in air pollution exposure for an urban area?

Eighty percent of the people in urban areas are exposed to air quality levels that exceed World Health Organization (WHO) limits. Hong Kong (HK) is an urban area with ambient concentrations exceeding WHO limits. Exposure to air pollutants, PM2.5, NO2, and O3 causes adverse human health effects. Population-based exposure models are used to quantify variability in exposures for large populations. These models use ambient pollutant concentrations and meteorology, time-location data, microenvironmental measurements to estimate infiltration factors (Finf), and commuting data. Finf quantifies infiltration from outdoors to enclosed microenvironments and is estimated using slope of the linear regression of indoor and outdoor concentrations. The objectives of this research are to: (1) evaluate typically used regression methods to estimate Finf ; (2) estimate commuting data; (3) quantify inter-individual variability in exposures; and (4) evaluate exposure mitigation interventions and to enable policy planning. The population-based Air Pollutants EXposure model was adapted to estimate exposures for HK. Ambient pollutant concentrations and meteorology were obtained from air quality monitoring stations. Time-location data were generated from the survey data. Finf estimates from linear regression (LR) and linear mixed model (LMM) were compared. Commuting data were imputed using a gravity model. Inter-individual variability in exposures were estimated based on Finf estimated using LR. Exposures were compared for different ventilations to identify exposure mitigation strategies. Comparing the Finf estimates from LR and LMM helps in evaluation of the methods. The gravity model can be used to fill the data gaps in the commuting data. Population-based exposure models help assess the effect of exposure mitigations for large populations. Results from the work can be used for policy planning and applications.

Keywords: Inter-individual variability, Air Pollutants Exposure (APEX) Model

P2

Recent patterns and possible climate-driven changes in Southeastern wildland fire smoke impacts

Presenter: Megan Johnson
Co-author(s): F. Garcia Menendez

Research Question: Who is most frequently impacted by wildland fire smoke in the Southeast, and how might this be altered due to climate change?

Land managers in the Southeastern U.S. use prescribed fire extensively to meet objectives such as wildfire risk reduction, maintaining wildlife habitat, and supporting fire-dependent species. However, climate change will likely affect the use of prescribed fire as well as wildfire risk in the region. Wildland fire (wildfire and prescribed fire) is one of the largest sources of fine particulate matter air pollution (PM2.5) in the U.S. and is associated with negative impacts on human health. The Southeast has one of the largest populations living at the wildland-urban interface, which may be particularly vulnerable to health impacts from smoke. Using chemical transport modeling, U.S. EPA EQUATES datasets, and projections of changes in fire activity, we model possible mid-century scenarios of change in wildland fire PM2.5 across the Southeast. Projected changes in wildfire burned area are based on climate scenarios that incorporate population, land use, and economic changes. Altered prescribed fire activity is informed by survey responses from Southeastern burners and projected changes in acceptable meteorological conditions, or "burn windows." Changes in wildfire and prescribed fire contributions to regional PM2.5 are quantified and compared. Using census demographic data and U.S. EPA indices of existing social and environmental stress, we discuss the populations in the Southeast that most frequently experience wildland fire smoke and how the benefits and detriments of wildland fire activity may shift in the region.

Keywords: *wildfire, smoke, climate change, prescribed fire*

The influence of oxidative chemical treatments on the electron exchange capacities of activated carbon towards improved transformation of organic compounds

P 3

Presenter: Ethan Quinn
Co-author(s): D. Knappe, D. F. Call

Research Question: How can the electron exchange capabilities of activated carbon be utilized towards improved transformation of organic compounds?

Pyrogenic carbonaceous materials (PCMs), such as activated carbon (AC), can exchange electrons with aqueous contaminants. This reactive behavior may provide new strategies to thoroughly degrade organic contaminants. To realize these benefits, a better understanding of the chemical and physical properties that influence electron exchange is needed. To provide the basis for tailoring PCMs for specific contaminant transformations, we subjected AC cloth to hydrogen peroxide and nitric acid treatments. After the treatments, we used mediated electrochemical reduction (MER) tests to quantify the electron accepting capacity (EAC) of the AC. Our preliminary results indicate that both treatments resulted in several new chemical functional groups containing C=O and C-H bonds on the surface of the AC, as revealed by X-ray photoelectron spectroscopy (XPS) analysis. The MER tests showed that both treatments increased the EAC. In all cases, nitric acid treatment resulted in a higher EAC than hydrogen peroxide-treated AC, reaching as high as 409% larger EAC (9.2 mmol e-/g) than the pristine AC (1.8 mmol e-/g). For both treatments, pore volume and sample surface area decreased. Nitric acid treatment resulted in the largest decline in both pore volume and surface area with decreases of 25.9% (0.47 cc/g) and 16.6% (1271.89 m^3/g) respectively, compared to pristine AC (0.64 cc/g and 1525.96 m^3/g). Boehm titrations for each treated AC are currently being conducted to gather information on chemical differences within the larger microporous structure of the material. These results provide a foundation for customizing the redox activity of PCMs for organic contaminant transformations.

Keywords: *Activated carbon, redox, pyrogenic carbonaceous materials*

Does the disposal of PFAS-containing special wastes impact leachate PFAS concentrations?

P 4

Presenter: Vie Villafuerte
Co-author(s): M. Barlaz

Research Question: PFAS degradation

The presence of per- and polyfluoroalkyl substances (PFASs) in landfill leachate is well-documented. Several products that are known to contain PFAS (e.g., textiles, carpet, and food packaging) are disposed as municipal solid waste (MSW) at the end of their useful life so the presence of PFAS in leachate is not surprising. However, there is no information on whether adding PFAS-containing special wastes to MSW impact the PFAS concentrations in landfill leachate. Under Subtitle D, landfills may also receive non-hazardous solid waste in addition to MSW. These non-hazardous solid wastes include water treatment residuals, industrial waste, construction and demolition (C&D) waste, among others. This study will measure the extent to which the addition of these special wastes to MSW contribute to PFAS concentrations and alter the chemical signature in the leachate. The work is conducted in laboratory-scale anaerobic reactors filled with MSW plus a PFAS-containing special waste and an MSW-only reactor as the control. Six types of special wastes are used in this study and are screened for PFAS using PIGE (particle-induced gamma-ray emission spectroscopy) and methanol extraction methods prior to their addition to reactors: biosolids, contaminated soil, auto shredder residue (ASR), reverse osmosis (RO) concentrate, granular activated carbon (GAC) and ion exchange (IX) resin from treating PFAS-containing water. All reactors contain MSW as the baseline and will be operated until methane generation is established. Then, the special waste is mixed, and duplicate reactors are monitored and operated until PFAS leaching is complete or is asymptotically decreasing.

Keywords: *PFAS, solid waste, landfill*

P 5

Intermittent Heat Shocks Reduce Methane Gas Production and Promote Volatile Fatty Acid Generation during Anaerobic Co-Digestion of Food Waste

Presenter: Henzhou (Jenny) Ding
Co-author(s): F. L. de los Reyes III, M. Barlaz, D. F. Call

Research Question: How to recovery valuable liquid chemicals from food waste

Anaerobic co-digestion (AcoD) of food waste is a biological approach for generating resources such as biogas. Conventional co-digesters are methanogenic (i.e., designed to maximize CH_4 production); however, intermediate products, including volatile fatty acids (VFAs), have higher commercial value and are used in a variety of industries. To accumulate VFAs, methanogenesis must be slowed or inhibited. Some inhibitory strategies include: (1) changes in operational conditions; (2) inoculum pretreatment; and (3) addition of chemical inhibitors. Challenges of these methods include adaptation and recovery of methanogens over time, higher cost, and the toxicity and contamination of chemical inhibitors. Towards developing new strategies to reduce methanogenesis, especially in long-term AcoD systems, we examined the effect of intermittent heat shocks (50, 65, or 80 °C) compared to a control held at mesophilic conditions (37 °C). When CH_4 production began, intermittent heat shocks at all temperatures tested significantly decreased CH_4 production, while VFA production continued. As the temperature of the heat shocks increased, CH_4 production ceased for a longer time period and higher concentrations of longer chain VFAs were measured. At the end of the operation, CH_4 was reduced by 70-90% because of the heat shocks. Microbial community analysis based on 16S rDNA sequencing showed the heat shocks shifted the diversity of the microbial populations significantly. Moreover, we found positive correlations between several bacteria genera and individual VFA production under heat shocks of different temperatures. Findings from this research may provide new strategies to promote VFA production during the AcoD of food waste.

Keywords: *food waste, volatile fatty acids, anaerobic co-digestion, heat shocks, microbial communities*

P 6

Mechanisms of PFAS Sorption to Activated Carbon at Sorption Equilibrium

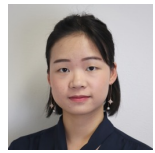
Presenter: Sarangi Joseph
Co-author(s): D. Knappe

Research Question: Describe intraparticle PFAS distribution, pore blockage, and sorption competition in bi-solute systems

Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals that widely occur in drinking water sources. Granular activated carbon (GAC) adsorption is widely considered to remediate contaminated water, but the fundamental mechanisms of PFAS adsorption are not well understood. An important goal of this research is to determine the distribution of PFAS inside of GAC particles when PFAS adsorb from single-solute and multi-solute systems. Five GACs were characterized to determine how GAC properties affect intraparticle adsorbate distributions. Batch adsorption and desorption isotherm experiments are being conducted with PFAS of different molecular weights (PFBS, PFHxS, PFOS) as well as with polystyrene sulfonate (PSS), a surrogate for naturally occurring organic matter. In addition, batch loading experiments were completed at relatively high PFHxS and PSS concentrations to determine intraparticle adsorbate distributions by microtome sectioning followed by time-of-flight secondary ion mass spectrometry (ToF-SIMS). In single-solute systems, PFBS adsorption and desorption isotherms were statistically similar, suggesting that PFBS adsorption is reversible on each of the evaluated GACs. For a reagglomerated coal-based GAC, PFHxS appeared to adsorb uniformly throughout the GAC particles having diameter ~20um and ~110um based on ToF-SIMS analyses. These results are consistent with PFBS adsorption isotherms being statistically similar for the two particle sizes. Experiments are ongoing to determine the effects of adsorbate and adsorbent properties on PFAS penetration depth into GACs of different particle sizes. The results generated in this research will improve our understanding of PFAS adsorption/desorption mechanisms with the goals of improving the production of highly effective adsorbents and supporting policy regarding the disposal of spent GAC.

Keywords: *Granular activated carbon, PFAS, PSS, ToF-SIMS*

Compare and combine: PFAS removal by granular activated carbon adsorption and anion exchange



P 7

Presenter: Lan Cheng
Co-author(s): Z. Hopkins, D. Knappe

Research Question: How is GAC compared to IX resin in PFAS removal?

"Concerns about the presence of PFAS in drinking water have led to a demand for effective PFAS treatment methods. Granular activated carbon (GAC) adsorption and ion exchange (IX) are readily implementable PFAS treatment methods. Based on results from rapid small-scale column tests (RSSCTs), we compared the performance of GAC and IX resin for the removal of 23 PFAS, including legacy perfluoroalkyl acids and fluoroethers with 3 to 9 fluorinated carbons. IX resin overall had a higher PFAS uptake capacity than GAC, especially for long chain PFAS and perfluoroalkyl sulfonic acids (PFSAs). We also investigated the benefit of combining GAC and IX resin in PFAS treatment by conducting RSSCTs with GAC and IX resin in series. We found that placing GAC ahead of an IX resin bed provides better PFAS removal efficiency than placing IX before GAC. This research will support the design of GAC and IX treatment processes in the context of PFAS remediation and drinking water treatment."

Keywords: *PFAS, IX resin, GAC, Drinking water treatment*

Impact of pre-treatment methods on THP-AD recalcitrant organics and specific anammox activity

P 8

Presenter: Michaela Morales
Co-author(s): F. de los Reyes, W. Khunjar, K. Bilyk, D. Wankmuller

Research Question: How can the anammox activity be improved when inhibitory substances are present after thermal hydrolysis in wastewater?

The City of Raleigh will implement thermal hydrolysis process (THP) and ANITA™Mox at the Neuse River Resource Recovery Facility (NRRRF) to enhance anaerobic digestion performance and reduce the high-ammonia concentration in the sidestream before returning it back to the head of the plant. ANITA™Mox is a newer technology that harnesses aerobic and anaerobic ammonia oxidizing bacteria (AOB and AMX, respectively) to perform deammonification, which can remove greater than 90% of ammonia and 75-85% of total nitrogen. While THP enhances anaerobic digestion performance, it also produces recalcitrant organics which are inhibitory to AOB and AMX. The goal of this research is to determine which pre-treatment methods can remove or transform the recalcitrant organics into less inhibitory products and quantify the impact through batch activity tests. First, powdered activated carbon (PAC) and alum sulfate will be tested for their ability to remove various COD fractions from THP-AD sludge. Promising pretreatment methods will be tested along with ozonation in a series of batch activity tests to quantify the improvement in AOB and AMX activity compared to a no pretreatment control. The results will inform Raleigh Water as they move forward with making their biosolids treatment as efficient and cost-effective as possible.

Keywords: *Anammox, thermal hydrolysis, deammonification, pre-treatment*

P 9

Fungal Bioremediation of Stormwater for Pesticide Removal

Presenter: Leah Weaver
Co-author(s): T. N. Aziz

Research Question: Is fungal bioremediation a viable treatment option for pesticides in stormwater?

Hydrophilic pesticides enter surface waters through stormwater runoff and threaten the health of our aquatic ecosystems. White-rot wood decay fungi can degrade these compounds, and their natural ecology make them well suited to passive fungal bioremediation applications. However, there is limited research on the viability of fungal bioremediation for treatment of stormwater. Through batch reactor experiments, we have established the ability of Phanerodontia chrysosporium to degrade imidacloprid, a neonicotinoid insecticide, greater than 50% within seven days in a synthetic stormwater system. These results suggest P. chrysosporium fungal bioremediation occurs quickly enough to be used as a media amendment in stormwater bioretention cells. In order to test the viability of this application, we plan to conduct further semi-batch experiments to understand the fungus' response to wet-dry cycling conditions and a non-sterile stormwater environment. In this presentation, we will describe the promises and challenges of fungal bioremediation as a tool for preventing ecological damage from pesticides and other emerging contaminants present in stormwater runoff.

Keywords: *stormwater, pesticides, fungal bioremediation, emerging contaminants*

P 10

Kinetics of Per- and Polyfluoroalkyl Substances (PFAS) Adsorption to Granular Activated Carbon (GAC)

Presenter: Marie Isabel Alexander Rodriguez
Co-author(s): D. Knappe

Research Question: Does PFAS sorption occur preferentially near the external surface, or uniformly across the surface of a GAC particle?

Per- and polyfluoroalkyl substances (PFAS) are anthropogenic recalcitrant contaminants that have been extensively used for industrial and military purposes since the early 1950s. Their removal from water is complex due to their unique properties. PFASs can lower surface tension, are thermal and chemically stable, and are highly soluble in water. Adsorption to granular activated carbon (GAC) is a widely employed technique for their removal from contaminated water. Nevertheless, PFAS adsorption and desorption kinetics are not well understood, and this knowledge gap prevents the effective prediction of GAC performance from bench-scale experiments or mathematical models. The aim of this research is to quantify PFAS adsorption/desorption kinetics in single- and multi-solute systems by conducting short-bed adsorber (SBA) tests. Results from SBA tests will be interpreted with mass transfer models to determine how the intraparticle diffusion coefficient varies with GAC particle size, GAC properties, and PFAS properties. Single-solute SBA tests will be conducted with five types of GAC crushed to 110, 320, and 710 um and five adsorbates (PFBS, PFHxS, PFOS, PFOA, and polystyrene sulfonate (PSS), a surrogate for naturally occurring organic matter). It is expected that by applying the shell adsorption framework model, adsorption kinetics for a given solute can be described by a single diffusion coefficient, regardless of GAC particle size. The results of this project are expected to help lower PFAS treatment costs and enable the optimization of GAC treatment systems to provide safer and cleaner drinking water.

Keywords: *water treatment, water quality, drinking water*

Scaling up Gas and Electric Cooking in Low- and Middle-Income Countries: Climate Threat or Mitigation Strategy with co-Benefits?

P 11

Presenter: Emily Marie Floess
Co-author(s): E. Puzzolo, D. Pope, N. Leach, C. J. Smith, A. Gill-Wiehl, K. Landesman, R. Bailis, A. Grieshop

Research Question: What are the climate and health impacts of rapid adoption of liquified petroleum gas (LPG) and electricity for cooking in low/middle-income countries?

2.8 billion people in low- and middle-income countries (LMICs) cook and heat using solid fuels, resulting in 2.6 million deaths annually from illnesses related to poor household air quality driven by particulate matter (PM). Combustion of solid fuels also emits short-lived climate forcers (SLCFs) including black carbon (BC), aerosol precursors and greenhouse gasses that contribute to climate warming. Liquified Petroleum Gas (LPG) and electricity are cleaner alternatives to traditional cooking fuels. We compare the emissions and climate impacts of residential cooking fuel adoption based on business as usual (BAU) and four transition scenarios of modern fuel use projected to 2040 for 77 countries with more than 1 million people cooking with solid fuels. We account for use-phase and upstream emissions and calculate climate impacts/benefits using a reduced form global climate model to calculate temperature differences associated with different scenarios, including a full transition (FT) to LPG and electricity. A FT to LPG and electricity results in significant health benefits with a 6.39 Mt (99%) reduction of PM2.5 by 2040. The reduction in climate forcers by 2040 results in a 6 milli C global temperature reduction compared to the projected overall 1.5 °C increase. Shifting from biomass-heavy to a fossil fuel-heavy cooking scenario results in a large decrease of SLCFs, with a .99 MT (99%) decrease of BC and 5.87 MT (82%) reduction in CH_4, and a more moderate decrease in CO2 emissions (reduction of 122 MT, 13%) due to the relatively high CO_2 upstream emissions. The biggest reduction in pollutants in a FT is for Sub-Saharan Africa, due to the high projections of PM2.5 and BC from charcoal use in the BAU scenario. These results help quantify the impacts of rapid scaling LPG and electricity for cooking needs in developing countries.

Keywords: *Household energy, energy transition, LPG, climate mitigation, air quality*

Unsupervised residential load disaggregation based on low-resolution smart meter data and surveys in a developing country context

P 12

Presenter: Ghazal Kamyabjou
Co-author(s): R. Meeks, A. Omuraliev, R. Isaev, J. X. Johnson

Research Question: What methods can effectively disaggregate residential electricity consumption in developing countries using low-resolution data to inform demand load forecasting and power planning?

"System monitoring and demand forecasting have become important aspects of power planning. Although load monitoring using smart meters data has been extensively studied in developed countries, it remains a serious challenge in developing countries. Despite the significant amount of work in non-intrusive load monitoring (NILM) methods in North America and Europe, the aspects such as cost and difficulty of access to high-resolution smart meters data remain a challenge for NILM algorithms in developing countries. Moreover, usage behavior patterns, type and number of appliances, and building materials differ in economically developing countries. In this study, we have unprecedented access to a data set of smart meter recordings (15-minute resolution) and a survey of Karakol, Kyrgyzstan. It provides a unique opportunity to develop a co-simulation NILM algorithm to disaggregate the electricity consumption into predefined categories of end-use consumption. Our proposed method couples a Hidden Markov Model algorithm with the EnergyPlus simulation program. HMM identifies the most probable activity chains of households based on 15-minute resolution electricity metering while EnergyPlus simulates the energy consumption of each house based on HMM activity chains and survey data. In this study, our algorithm breaks down the aggregated electricity use profile of residential buildings into end-use levels without having access to labeled data. The presented method can provide a forecasting model for power system planning in developing countries as appliance adoption grows over time, which changes total consumption and increasing peak demand."

Keywords: *NILM, Smart meter, residential load monitoring*

P 13

Cloudy with a chance of flooding: data-model intercomparisons of multi-driver coastal roadway flooding

Presenter: Thomas Thelen
Co-author(s): C. Dietrich, H. McCraw, M. Hino, K. Anarde

Research Question: What are the drivers of chronic coastal flooding that occurs outside of extreme storm events like hurricanes?

Sea-level rise (SLR) threatens coastal communities through flooding of low-lying infrastructure, including roadways and stormwater drainage networks. Here we focus on the causes of chronic coastal flooding that occurs outside of extreme storm events like hurricanes. Drivers for these floods can include tides, rainfall, wind setup, groundwater, riverine flow, and infrastructure failure. However, the contributions of drivers outside of sea-level rise, individually and in combination, are not well understood. Previous studies have shown that interactions between a couple of these drivers can increase flooding frequency (e.g., tides and rainfall runoff), but future flooding projections typically consider only SLR. Furthermore, communities like our study site of Carolina Beach, North Carolina rely on tidal forecasts for an indication of when roadway flooding may be imminent. However, these forecasts do not capture non-tidal contributions to total water level, like wind setup and rainfall runoff. As a result, coastal communities may not be alert to compound floods from multiple drivers if these floods occur outside of the highest forecasted tides. Here we couple the hydrodynamic model ADCIRC to simulate oceanic and riverine processes with the hydrologic and stormwater model 3Di that simulates rainfall runoff, groundwater, and 1D/2D flow to examine multiple drivers of flooding in Carolina Beach. Modeled inundation depths and extents are validated by water-level data collected within storm drains. Ultimately, the validated model will be used to simulate future flood hazard scenarios, and model results will inform a discussion of potential adaptation and flood mitigation measures with the community.

Keywords: *Coastal flooding, sea-level rise, modeling, sensors*

P 14

Storm Surge Predictions at Hyperlocal Sites

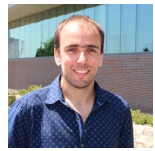
Presenter: Jenero Knowles
Co-author(s): C. Dietrich

Research Question: How do modeling decisions affect storm surge predictions?

Storm surge —the rise in water above the normal tide level — is the leading cause of damages by hurricanes. To predict storm surge and flooding, modelers must represent the storm's effects on water levels over large regions, typically the coasts of one or multiple U.S. states. The accuracy of these model predictions is sensitive to the model resolution — the model's ability to represent small-scale flow pathways and barriers along the coast. Previous studies have examined the benefits of increasing resolution by refining the model before and during simulation, but with a focus on regional scales, e.g. at floodplains and coastal communities. There is a need to better understand how to develop models for storm surge predictions at hyperlocal sites, e.g. at a specific home or critical infrastructure. This study examines storm surge predictions at the Norfolk Naval Station in southeast Virginia. This site is critical for national security, but it is unclear how storm processes in the larger region affect the hyperlocal flooding at the site. A high-resolution model is developed and validated against observations of waves and water levels during Hurricane Irene (2011). The model investigates the effects of model resolution, via variations at the site and across the larger region, and domain size, by considering both the Chesapeake Bay and the western North Atlantic Ocean. This model will inform follow-on simulations of total water levels at the naval stations, and findings from this study will advise models of coastal flooding at military installations by the Department of Defense.

Keywords: *storm surge, flooding, modeling, coastal*

Toward Predicting High-Resolution Maps of Hurricane-Driven Coastal Flooding using Deep Learning



P 15

Presenter: Tomás Cuevas López
Co-author(s): B. Tucker, C. Dietrich

Research Question: Can we predict 2D high-resolution storm surge maps using deep learning?

Hurricane-driven flooding is a serious hazard for coastal communities. During storms, forecasters use computational models to predict nearshore and inland effects. A key input is the spatial resolution of bays, floodplains, coastlines, and other features that control flooding. Higher resolution can give more accurate results but also require longer runtimes, making it prohibitive to study the inherent uncertainties of the storm. Several studies suggest that a better way to forecast hurricanes is to simulate multiple realizations of the storm, including randomness in its characterization. With a well-trained machine learning (ML) model, the prediction of coastal flooding can be done in seconds. However, existing ML studies predict results only for certain stations instead of the full coastal environment and without considering variations in the tide and storm duration. We propose a ML method for forecasting high-resolution maps of coastal flooding considering tides and storms of any duration. To create the training library, we simulated 1,000 synthetic tropical cyclones, based on historical data for storms in the North Atlantic Ocean that passed near North Carolina. These simulations used a full-physics hydrodynamic model with a variable resolution of about 100 m near the coast. The outputs were downscaled to a greyscale image with a higher and constant resolution of 15 m, enhancing the flood predictions by considering small-scale features and making them easier for the ML model to interpret. In future work, this database of flood predictions will be used as training for a neural network to predict flood inundation depths at high resolution along our coast.

Keywords: *storm surge, hurricanes, hydrodynamic modeling, machine learning, high-resolution*

On-device machine learning for identifying the spatial extent of chronic coastal floods

P 16

Presenter: Ryan McCune
Co-author(s): E. Goldstein, K. Anarde

Research Question: Can machine learning be used to automatically detect and quantify flooding in coastal communities?

Coastal communities are flooding more and more often due to sea level rise. These chronic, shallow floods—also known as nuisance, high tide, or "sunny day" flooding—damage infrastructure, impact local economies, and affect transportation. Data on the incidence and spatial extent of these floods is scarce as they are hyper-local and often short-lived. This data gap has constrained our understanding of the frequency and social consequences of chronic coastal flooding. Here we present a low-cost camera with onboard machine learning (ML) that can detect roadway flooding while minimizing data transmission and maintaining privacy. The model is trained using images collected from a single Sunny Day Flood Sensor ("SuDS") installed in Beaufort, North Carolina. Extending the capabilities of this classification-based ML camera (i.e., "flood/no flood"), we also train an image segmentation model to identify the spatial extent of flooding within an image by classifying each image pixel into one of seven classes (water, road, building, vehicle, sidewalk, person, other). Ongoing work is focused on quantifying model error and improving the model's performance. Ultimately, the image-segmentation model will be deployed on-device. Camera-based data on flood incidence and extent will be compared to 1) survey data to better understand flood impacts and 2) road closure data to quantify disruptions to transportation networks.

Keywords: *Coastal flooding, sea-level rise, machine learning*

P 17

Modeling potential storm-driven barrier island morphological change in response to a coastal highway adaptation strategy in Rodanthe, NC

Presenter: Sophia Rosenberg
Co-author(s): J. Gorski, D. Anderson, E. Sciaudone

Research Question: What is the range of responses to island and dune morphology we may expect under a set of synthetic storms that characterize storms of varying intensity and duration?

During storms, incidences of overwash and breaching on barrier islands are a frequent occurrence, which can pose major issues for developed barrier island communities. Many communities have long-standing adaptation measures in place to protect infrastructure from overwash. In preventing overwash, humans induce narrow, low-lying barrier island geometries that become more vulnerable over time. Consequently, barrier island communities must continually adapt as climate change spurs rising sea levels and increases the potential for more severe storm events. The present case study focuses on a stretch of barrier island located in Rodanthe, North Carolina, the site of a recent adaptation strategy that involved relocating the road away from the ocean coastline into the backbarrier sound and ceasing human management of alongshore foredunes. This study's main goal is to better understand how an adaptation regime that allows overwash to occur in a previously managed area may alter island morphology in the near-term future due to storms. A two-dimensional (2DH) morphodynamic model (XBeach) was calibrated and validated for the area for ocean-side storms. Potential future storms were developed using a probabilistic approach, with wave height and storm surge scaled to typical profiles for tropical storms. The geomorphic response to synthetic storms are quantified by changes to total island subaerial volume and alongshore dune crest height, as well as spatial patterns of overwash in both the cross-shore and alongshore direction. Results will help identify potential land cover and habitat modifications that may occur in the near future. The methodology and overarching trends presented in this research are applicable to other barrier islands that have experienced long-term dune management, and may be helpful for natural resource managers who consider a similar adaptation approach.

Keywords: *storm, overwash, barrier island, XBeach, adaptation*

Agent-Based Simulation of Emergent Deicer Strategies that Reverse Freshwater Salinization

P 18

Presenter: Kingston Armstrong
Co-author(s): Y. Zhong, S. Bhide, S. Grant, T. A. Birkland, E. Berglund

Research Question: How Can Deicer Application Institutions Reverse Freshwater Salinization Syndrome?

Salt concentration in freshwater supplies has risen steadily due to human activities, leading to the Freshwater Salinization Syndrome (FSS). This increase in salinization can negatively impact human health and aquatic ecosystems. FSS is a common-pool resources problem that requires institutions to limit deicer application and improve salt assimilative capacity. To address FSS, an agent-based modeling approach was developed to explore the emergence of institutions that reverse the impact of deicer driven salinization. The agent-based modeling framework examined how the behavior of small business owners and impacted the soil-water system. Agents represent property owners who apply road salts that deice pavement during winter weather. The agents collectively develop deicer application institutions: rules that dictate the amount of applied salt and how to monitor for institution defectors. The simulation shows that stable institutions can lead to positive economic outcomes for stakeholders, based on their ability to apply salt and access high-quality drinking water. However, simulations with more stakeholders who do not comply with institutions can result in limited emergent stable institutions. The research shows that self-organized institutions can prevent long-term economic losses and mitigate FSS.

Keywords: *ABMs, CPRs, Salt, Groundwater, Salinization*

Adaptive Reservoir Operation Framework for Mitigating the Drought Risk for the Lake Jordan Reservoir under Potential Changes in Future Water Demand and Climate

P 19

Presenter: Chandramauli Awasthi
Co-author(s): S. Arumugam

Research Question: How can we inform the Lake Jordan reservoir operation based on monthly inflow and flood-flow to mitigate the potential drought risk in future?

The Lake Jordan Reservoir, located in the triangle area of North Carolina, has witnessed frequent drought events in the recent past. The reservoir, primarily built as a flood mitigation structure, is also critical for fulfilling the water demand of the area and for maintaining the water quality flow downstream of it. The expected increase in the water demand due to population increase in conjunction with potential climate changes, such as increased frequency of extreme rainfall, would make the reservoir operation challenging in the near future. In such a scenario, it becomes crucial to operate the reservoir such that the overall water supply needs can be met with the desired reliability while keeping the flood risk low simultaneously. We found that the current reservoir operation policy will not be able to maintain the water supply reliability. In our work, we propose an adaptive reservoir operation framework that can mitigate the potential drought risk on the reservoir without increasing the flood risk in the same proportion. We show the application of the proposed adaptive reservoir operation framework for both historical, and future demand and climate change scenarios. The proposed framework can assist the reservoir managers in its efficient operation and can also be extended for other reservoirs which are primarily operated for water supply and flood protection.

Keywords: *Drought risk, Reservoir operation, Lake Jordan Reservoir, climate change mitigation*

P 20

Changing Climate, Changing Demands, Static Practices: Are Reservoir Management Operations Effective in Meeting Environmental and Water Supply Demands Without Increasing Downstream Risk?

Presenter: Jessica Levey
Co-author(s): S. Arumugam

Research Question: Are reservoir operations effective in using available water storage in a reservoir system without increasing downstream risk?

Climate change is altering global hydroclimatology and the majority of the world's population will face freshwater scarcity threats in the near future; therefore, water resource management is critical for environmental, agricultural, and economic purposes. Specifically, reservoir management is crucial for water supply and quality. The United States Army Corps of Engineers' (USACE) controls most major reservoirs across the Southeastern US. Their objective is to meet the flood control standards by keeping the flood control pool empty. Operational policies on flood control fail to recognize the potential for season-ahead drought or slowly-increasing downstream water demand due to population growth. These operational curves were designed 30-40 years back and need to be assessed and altered for new hydroclimatological norms and with available skillful forecasts. This study a.) evaluates the historical use of flood storage volume in Southeast reservoirs b.) investigates the potential and risk associated with operating Southeast reservoirs at operational elevations for increased water conservation storage without increasing the downstream flood risks by simulating extreme inflow events for each monthly c.) generated synthetic inflows into each reservoir, using a Log-Pearson Type 3 (LPIII) distribution, and quantified the potential and risk associated with synthetically generated extreme events. Using the LPIII distribution allows us to account for future hydrologic shifts and changes in flood forecasts, which is important for real-time operations. As opportunities for new reservoirs do not exist, taking advantage of current skillful forecasts and proactive management techniques is important to meet the increasing water demand of growing communities.

Keywords: *Water resources management, droughts and floods, water scarcity, and reservoir management*

P 21

Compliance with Residential Water Use Restrictions: Analysis of Water Use Behavior using Smart Water Meter Data

Presenter: Faisal Alghami
Co-author(s): E. Berglund

Research Question: How do residential consumers respond to the water use restrictions in reducing outdoor water use?

Water restrictions can be used as a demand management strategy to reduce water consumed for non-essential uses and specify the time and day that households can use water for outdoor purposes. Demand management techniques, such as water restrictions, rely on the participation of consumers, however, and water utilities typically monitor compliance with water use restrictions through patrolling or neighborhood reporting. Advanced Metering Infrastructure (AMI) provides a new tool to evaluate compliance with water use restrictions. This research leverages an hourly demand dataset collected in Lakewood, CA, over a two year period at 18,000 residential accounts. Lakewood, CA, imposed restrictions on outdoor water use for residential accounts from 2015 to 2022, limiting the frequency and hours of outdoor water use. This research applied new and existing methods to estimate outdoor water use from hourly consumption data. The Minimum Day Method (MDM) and Minimum Hour Method (MHM) were implemented at both the network and account level to develop estimates of indoor water use, and indoor water use patterns were applied to calculate outdoor water use. Compliance at each meter was evaluated as the ratio of outdoor water demands that are applied within permitted hours to the total volume of outdoor water demands. Results demonstrate that the average compliance score ranges from 10% to 14% using MDM and MHM methods to estimate indoor water use. The results of this study provide insights into the impact of outdoor water use restrictions on water conservation and can inform decision-makers and water managers.

Keywords: *Water demand management, AMI, Outdoor Use*

Concentration and accumulation history of PFAS in Jordan Lake Sediments

Presenter : Nadia Sheppard
Co-author(s): B. McKee, D. Knappe

Research Question: The role of Jordan Lake bottom sediments as a potential storage reservoir for PFAS in the Cape Fear River system

Per- and polyfluoroalkyl substances (PFAS) are organic contaminants that widely occur in drinking water sources; however, the behavior of particle-bound PFAS in sediment deposits of lakes and reservoirs is not well understood. This research addresses the role of Jordan Lake bottom sediments as a potential storage reservoir for PFAS in the Cape Fear River system. Samples were extracted using a method based on EPA Method 1633. Extractions of ephemeral layer (top 10 cm) samples taken near the Haw River entry to Jordan Lake yielded summed quantifiable PFAS concentrations ranging from 2940-5430 ng/kg dry weight. PFOS and PFOA were the most frequently detected perfluoroalkyl carboxylic acids (PFCAs) and sulfonic acids (PFSAs). We also detected and quantified 5 additional PFCAs (PFBA, PFPeA, PFHxA, PFHpA, PFNA), 4 additional PFSAs (PFBS, PFPeS, PFHxS, PFHpS), and 6:2FTS. We detected but were unable to quantify 5 long-chain PFCAs (PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), 4 fluorotelomer carboxylic acids (6:2 FTCA, 6:2 FTUCA, 7:3 FTCA, 8:2 FTUCA), as well as PFAS from other subclasses (PFDS, n-MeFOSAA, n-EtFOSAA, PFHxSA, PFOSA, NVHOS). Further method development is necessary to quantify longer-chain PFAS. Experiments are ongoing to determine PFAS concentrations as a function of sediment age, as established by Pb-210 geochronology. Additional cores will be collected to understand PFAS concentrations in public water sources over time. The results generated in this research will give critical insights into the storage and potential release of PFAS into the water column via sediments.

Keywords: *PFAS, sediment, Cape Fear River*

Using Camera Images to Get Stream Depth

Presenter : Hart Henrichsen
Co-author(s): S. Arumugam

Flooding causes property and loss of life in urban areas throughout the United States. One challenge in understanding these extreme events is creating accurate models. Currently most urban flood models calibrate using high water marks. These high water marks are often scarce and do not contain any temporal information, limiting the ability for a model to calibrate accurately. One potential approach to collect information on urban flooding is to utilize inundation images collected from cameras spread throughout a city. We propose to utilize camera images available from the City of Charlotte, NC, to develop a machine learning (ML) model that associates the flood images with the stage and discharge data available within the city extent. The eventual goal of this trained ML model is to be used where traditional stream gauges are infeasible, such as in urban environments, to use camera images from a given location to estimate the flood inundation and discharge. Thirteen locations with USGS stream gauges have been selected in Mecklenburg County, North Carolina to test the accuracy of this ML model. These locations have preexisting cameras that take images every five to sixty minutes depending on location. By using multiple locations, the accuracy of the model will be tested at locations not previously trained using known USGS water depths. This provides a simple cost-effective strategy to provide urban flood information that can be used for both model calibration as well as for urban flood forecasting.

Keywords: *Water Detection, Flood Management, Computer Vision*

P 24

Water distribution infrastructure changes caused by COVID-19 prevention behaviors

Presenter: Brent Vizanko
Co-author(s): L. Kadinski, A. Ostfeld, E. Berglund

Research Question: How did changing water demands due to the COVID-19 pandemic impact water distribution infrastructure?

The COVID-19 pandemic dramatically changed daily routines for people across the globe due to the adoption of social distancing measures, e.g. restricted travel. Changes in daily routines created new water demand patterns, and the spatial redistribution of water demands in urban water distribution system networks affects the quality of delivered water. A range of factors influence individuals' social distancing decisions including demographics, risk perceptions, and prior experience with infectious disease. This research develops a comprehensive modeling framework to capture decisions to social distance, the effect of social distancing on water demands, and the effects on the performance of water infrastructure. First, Bayesian belief network (BBN) models are developed to simulate social distancing decision-making based on publicly available survey data describing COVID-19 risk perception, social distancing behaviors, and demographics. Feature sets are developed from a set of participant characteristics using forward selection and Naïve Bayes classifiers to predict behaviors, e.g. working from home. BBN model output is used within an agent-based modeling (ABM) framework to simulate how individuals interact within a community and dynamically adopt social distancing behaviors based on communication and transmission of infection. Agents represent individuals who transmit COVID-19, communicate with each other, decide to social distance, and exert water demands at residential and non-residential locations. Finally, the ABM is coupled with a water distribution model to simulate how changes in the location of demands affect water distribution metrics. The model is applied for a virtual city, Micropolis, to explore how varying population characteristics can affect water infrastructure. This research provides a new framework to develop and evaluate water infrastructure management strategies during pandemics.

Keywords: *water distribution system, COVID-19, infrastructure*

P 25

When extreme floods occur, do they occur everywhere?

Presenter: Kichul Bae
Co-author(s): S. Arumugam

Research Question: When extreme floods occur, do they occur everywhere?

Setting up policies for flood response and mitigation activities requires information on the widespread casualty it causes over a city/region/state. To understand the widespread impact, it is often important to quantify how floods are spatially correlated over a region and how that magnitude of correlation varies due to flood magnitude. In this research, we examine the spatial correlation of floods by calculating the Spearman correlation between the annual instantaneous peak flow data of the HCDN2009 sites, which are sites minimally impacted by human activity, over the coterminous United States (CONUS). We also compute the joint probability of a given return period flood occurring between different locations to assess how both correlations and flood magnitude vary over various hydrologic units over the CONUS. We also examine the trend in spatial correlation over time to understand whether spatial correlation structures show a systematic pattern due to potential climate change.

Keywords: *Widespread Flooding, Spatial correlation, Joint Probability, Climate Change*

The Role of Race in Access to Public Water and Sewer Services in Halifax County, North Carolina

Presenter : Banks Grubbs
Co-author(s): J. M. Gibson

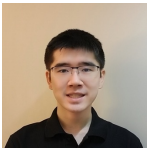
Research Question: What is the relationship between race and access to public water and sewer access in Halifax County extraterritorial jurisdictions?

Many studies have shown that Black people on the fringes of Southern towns and cities have been systematically denied access to public water and sewer services. This research investigates the relationship between race and access to these services within the six extraterritorial jurisdictions (ETJs) of Halifax County, North Carolina. Utilizing publicly available tax records and 2020 census data, we identified which residential tax parcels in each ETJ have access to public water and/or sewer service and determined the proportion of people per census block who identify as Black. We joined this data with additional factors, such as property tax value and population density, and conducted multivariate logistic regressions to quantify the relationship between access to public water and sewer and the proportion of Black people per block for each ETJ. We found a significant negative relationship between the proportion of Black people per census block and odds of access to public water service in Roanoke Rapids (OR=0.24, p=0.0237) and Littleton (OR=0.025, p=0.0162) ETJs, and the odds of access to sewer service in Roanoke Rapids (OR=0.04, p<0.001), Littleton (OR=0.027, p=0.0162), and Scotland Neck (OR=0.259, p=0.032) ETJs. These results suggest that Black communities in these ETJs have been historically denied access to public water and sewer service. However, additional investigation must be done to understand the full historical and social context for this exclusion.

Keywords: Infrastructure, rural health, environmental racism, public water, sewer

P 27

Assessing the effects of lead in private well water on educational outcomes among North Carolina children



Presenter: Timothy Leung
Co-author(s): J. M. Gibson

Research Question: Are child early life exposures to lead through private well water associated with academic performance later in life?

Lead is a corrosive-resistant, ductile, and malleable metal that is both naturally occurring and found in many manufactured products. However with its rise in usage, researchers determined that lead exposure is linked to severe health risks, especially among infants and young children. Although improvements to lead exposure have been quite significant in recent decades, there is a current misconception that lead exposure is no longer a health issue due to its elimination from products such as paints, gasoline, and plumbing materials. This is of particular concern for children that obtain drinking water from private wells since they have been found to have increased odds of elevated blood lead levels in comparison to children in homes connected to community water systems regulated under the Safe Drinking Water Act. To assess the damage induced by lead exposure, academic grade scores can be evaluated to compare students based on their environmental exposures. Therefore this research helps further shed light on the scale of impact that childhood lead exposures have on the academic performance years later.

Keywords: *Well water, academics, children, North Carolina*

P 28

Fecal contamination source tracking and forecasting to support recreational and cultural development in the Great Coharie River watershed

Presenter: Benjamin J. Clark
Co-author(s): D. Obenour, R. Emanuel, A. Harris

Research Question: What is the source of fecal contamination in the Great Coharie River and can contamination levels be predicted?

The Coharie Native American Tribe of Clinton, NC consider themselves river people, with the name of river they settled near, The Great Coharie River, being the inspiration for their tribal name. This tributary holds immense sentimental value to the Tribe. Recently the Tribe has been concerned with the declining water quality and environmental injustices that have been documented in the area 1–4. To address these concerns, a sampling scheme was constructed in partnership with tribal officials to include fortnightly and bi-hourly sampling at three locations in the watershed: Sevenmile Swamp, Marsh Swamp, and The Great Coharie River at Five Bridges Road. Bi-hourly sampling was dependent on seasonality and stream flow intensity. Each sample was tested for fecal indicator bacteria (FIB), nutrients and other water quality parameters. Data will be used for the future creation of statistical models to help the Coharie Tribe make educated decisions about water-based recreational and cultural activities. Preliminary findings suggest that the Great Coharie River consistently exhibits elevated levels of fecal contamination. After averaging E. coli concentrations for days with multiple observations, the geometric mean for days observed at Sevenmile Swamp, Marsh Swamp, and The Great Coharie River at Five Bridges Road were found to be 118 MPN/100 mL, 408 MPN/100 mL, and 134 MPN/100 mL, respectively. Two of these sites exceeded the 126 MPN/100 mL benchmark recommended by the EPA 5. These same sites exceeded the regulatory statistical threshold value of 410 MPN/100 mL on 15.6%, 56.2%, and 18.8% of the observed days 5.

Keywords: *Microbial Source Tracking; native community engagement; health risk*

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