2023 American Water Resources Association

National Capital Region Water Resources Symposium

Equitable and Resilient Water Resource Management and Practices

Friday, April 14, 2023

8:30 a.m. – 4:30 p.m.

University of the District of Columbia (UDC)

UDC Student Center – Level 1

4200 Connecticut Ave., NW, Washington DC 20008

Booklet of Abstracts

(Unedited)

- Concurrent Oral and Poster Sessions -

CONTENT

*Session No. corresponds to sessions in the symposium program.

Session 1

Community-Driven Water Resource Projects

Moderator: Shane Putnam, Dewberry

Community-Driven Research on Sanitary Sewer Overflows and Basement Backups

Authors: Dr. Rachel Rosenberg Goldstein, Assistant Professor, Water Quality, Outreach, and Wellness (WOW) Lab, Maryland Institute for Applied Environmental Health, School of Public Health, University of Maryland, College Park, MD 20742, USA; Dr. Marccus D. Hendricks, Associate Professor, Stormwater Resilience Infrastructure and Justice (SIRJ) Lab School of Architecture, Planning & Preservation University of Maryland, College Park, MD 20742, USA; Dr. Priscila B. R. Alves, Postdoctoral Research Associate, Stormwater Resilience Infrastructure and Justice (SIRJ) Lab. School of Architecture, Planning & Preservation, University of Maryland, College Park, MD 20742, USA; Emily M. Healey, PhD Student, Maryland Institute for Applied Environmental Health School of Public Health, University of Maryland, College Park, MD 20742, USA

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Abstract: Exposure to raw sewage from failing infrastructure can lead to negative health outcomes, distress, and feelings of disenfranchisement, particularly in marginalized urban communities. Over 75,000 sanitary sewer overflows (SSOs), the release of untreated sewage from a municipal sewer system, occur annually in the U.S. As a result, communities are persistently exposed to raw sewage, likely containing waterborne pathogens and possibly antibiotic-resistant (AR) bacteria. We visited 39 homes in Baltimore City, MD where backups occurred and conducted visual household inspections, residential surveys, and interviews about impacts and experiences with these events. We also collected water (n=6) and surface swab samples (n=40) from impacted indoor areas. Water and surface samples were analyzed for E. coli and AR bacteria, including methicillin-resistant Staphylococcus aureus. 55% of survey respondents had experienced SSOs or backups within the previous 6 months, however many ranked the condition of their home sewer lines as good or excellent. Our preliminary results identified E. coli in 16% of water and 20% of surface samples. One surface and one water sample contained antibiotic-resistant S. aureus. Only 70% of survey respondents had done clean-up or remediation after a sewage overflow event. Climate change will continue to stress crumbling infrastructure, potentially exposing communities to pathogens.

Equity Guide For Green Stormwater Infrastructure Practitioners

Presenter: Beatrice Ohene-Okae, DC Department of Energy and Environment

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Abstract: This presentation will briefly introduce attendees to the Green Infrastructure Leadership Exchange as a resource for peer learning to support green stormwater infrastructure (GSI) and describe the process for developing the **Equity Guide For GSI Practitioners**. Participants will be introduced to the various types of equity identified by the Exchange and will hear about how GSI can contribute to advancing equity, with a focus on some of the programmatic and project impacts at the Department of Energy and Environment (DOEE).

Installing Residential BMPs in Underserved Communities in Prince George's County, MD

Presenter: Michelle Kokolis, University of Maryland Environmental Finance Center, Program Manager – Water Quality and Community Engagement

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Abstract: Since 2018, the University of Maryland Environmental Finance Center (EFC) has partnered with the Maryland Black Mayors, Inc. (MBM) to train municipal leaders in Prince George's County, MD on stormwater management topics. This partnership has provided an opportunity to better understand the complexities of implementing stormwater management projects at the municipal level, especially in small communities that are historically underserved. Residents experience a myriad of stormwater challenges, many of which municipal governments are not equipped to assist with. For this reason, one of the most frequent requests EFC receives from municipal leaders is to provide residents with the technical assistance necessary to effectively manage stormwater at home. In order to build real capacity in these communities, EFC is focusing on establishing a strong pipeline of community leaders, moving from education, to public outreach, to residential project implementation. Most recently, these efforts have resulted in a project with six municipalities to install thirty residential best management practices including conservation landscaping, rain water harvesting, and tree plantings.

Session 2

Water Quality Monitoring And Restoration

Moderator: Arash Massoudieh, Catholic University of America

Assessing The Efficacy Of Bioretention Cell In Treating Stormwater Quality

Authors: Tolessa Deksissa, Sania Rose, Thomas Beights, and Sebhat Tefera, Water Resources Research Institute, College of Agriculture, Urban Sustainability, and Environmental Sciences, University of the District of Columbia

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Abstract: Stormwater pollution is one of the challenges of modern pollution control in urban areas. To address this challenge, bioretention cells are one of the most popular best management practices, collectively known as "green infrastructures" (GIs), implemented by cities. Bioretention cells are designed to slow down the peak surface flow while removing contaminants from stormwater runoff; however, there is limited field data that shows the effectiveness of bioretention cells as a filter or sponge media in removing priority pollutants. Lack of field data is the major challenge in advancing stormwater quality mitigation measures as well as exploring the potential use of treated stormwater. The purpose of this work is to address the knowledge gap in the effectiveness of bioretention in treating stormwater quality while assessing the potential use of treated stormwater runoff for urban gardening. The composite sample of each storm event was analyzed for key water quality parameters, including the sixteen priority polycyclic aromatic hydrocarbons (PAHs), trace metals, and basic water quality parameters such as total suspended solids, total nitrogen, total phosphorous, nitrate plus nitrite, and orthophosphate. The performance of bioretention in treating stormwater was analyzed based on the event mean concentrations of these water quality parameters. The findings of this research will contribute to the advancement of the triple bottom line benefits of bioretention cells as stormwater GIs in various ways, including the advancement of bioretention design and the potential use of treated stormwater.

A Watershed Approach To Restoration And Ecological Uplift In The Long Branch Central Watershed

Authors: Gregory Zuknick, CERP, Restoration Ecologist, Biohabitats, Inc., Jennifer Zielinski Missett, PE, Senior Project Manager and Water Resources Engineer, Biohabitats, Inc.; Charles Smith, Chief, Watershed Projects Implementation Branch – Central Stormwater Planning Division, Fairfax County Department of Public Works and Environmental Services; Shannon Bell, PE, Project Manager and Engineer, Fairfax County, Department of Public Works and Environmental Services

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Abstract: Fairfax County is taking a watershed approach to restoration and ecological uplift in the 3.7-square mile Long Branch Central watershed. The restoration work is driven by a local sediment TMDL requiring a reduction of 2,433 tons/year to address benthic impairments. Watershed planning efforts in the County typically occur at a large watershed scale but are applied to isolated reaches and are focused on constructing highly stable transport channels that prevent future erosion but may degrade habitat. However, this Long Branch effort is a departure from previous convention by creating a cohesive watershed plan to allow restoration benefits and uplift to be more easily measured and quantified.

Approximately 12 miles of stream corridor, 150 outfalls, and 21 stormwater facilities were assessed for restoration potential. A prioritization process balancing ecological benefits, ancillary benefits and feasibility resulted in identification of 17 stream restoration and five stormwater retrofit projects.

Projects will be designed in nine groupings to allow for better understanding of upstream and downstream influences. Fifteen construction groupings consist primarily of stand-alone projects; some have been bundled to reduce overall disturbance and trail interference. Design and construction will begin in the headwaters and work downstream.

A robust monitoring program, including watershed-wide and project-specific monitoring, is underway to inform design and evaluate restoration success. Monitoring parameters and purpose are aligned with the project goals derived from the Fairfax Ecological Recovery Wheel and the Stream Functions Pyramid.

DC Stream Condition Index

Presenter: Alicia Ritzenthaler, Environmental Protection Specialist at the District Department of Energy and Environment

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Abstract: The District of Columbia Department of Energy and Environment (DOEE) collects a significant amount of water resource data across multiple monitoring programs. These data are shared via a number of mechanisms, including the Municipal Separate Stormwater System (MS4) annual report and the Integrated 303(d)/305(b) Report. However, because these documents are prepared for regulatory compliance, the data provided within these formats can be complex and may not be meaningful to non-technical audiences. While DOEE will continue to monitor streams to meet regulatory reporting requirements, DOEE has developed a "Stream Condition Index (SCI)" specifically for the general public to learn about stream health in the District.

This presentation will describe how we:

- Used existing data gathered though multiple DOEE monitoring efforts to minimize the need for additional DOEE resources to create the tool.
- Selected metrics that are easily understood by the public, can describe the nuance of local watershed health, and appropriately reflect impacts from the city's ultra-urban environment.

We will also discuss how we are communicating the results of our SCI to the general public and those with non-technical backgrounds in an intentional, accessible way via a public-facing website which allows users to explore the website by watershed or metric.

Mapping Diffuse Recharge Flux Using Reduced-Adjoint Variational Data Assimilation Method By Assimilating SMAP Soil Moisture Observations

Authors: Parisa Heidary[1], Leila Farhadi[1], Muhammad Umer Altaf[2]

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Abstract: Quantifying the magnitude and the spatial patterns of groundwater recharge is important for understanding and managing groundwater systems. Groundwater recharge is a complex process, which depends on several factors, including the moisture and the hydraulic properties of soil in the vadose zone. Despite the importance of this flux there are no direct measurements that can allow any mapping and regional estimation of the rate of recharge. The research objective of this study is to propose a data assimilation framework to quantify and map the patterns and dynamics of diffuse recharge flux by accurately estimating its key state and parameters such as soil moisture profile and effective soil hydraulic parameters. In order to achieve this objective, a state-of-the-art data assimilation technique is used to estimate these parameters from implicit information contained in surface Soil Moisture (SM) observations which are widely available by remote sensing in a wide range of spatial and temporal scales. The proposed approach uses the reduced order variational data assimilation scheme called Reduced-Adjoint Variational Data assimilation that assimilates SMAP SM data into HYDRUS-1D model, a highly nonlinear soil water model, to produce accurate estimates of the effective soil hydraulic parameters and the soil moisture profile. Consequently, more accurate spatial patterns of diffusive recharge flux are obtained following the Darcy equation. The method is implemented over an area of 12,000 km2 in the U.S. Southern Great Plains for water year 2021 (Oct 2020-Sep 2021), and its performance is evaluated through comparison tests using available ground measurements datasets.

Poster Displays

A Direct Insertion Data Assimilation of Sea Surface Height in a Storm Surge Model

Authors: Soelem Aafnan Bhuiyan[1], Viviana Maggioni[1], Celso Ferreira[1],Azbina Rahman[1,2]

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Abstract: Natural hazards like hurricanes, cyclones, and typhoons frequently cause major economic and livelihood damage in coastal areas around the world. Worldwide, scientific communities are making relentless efforts to improve the accuracy and reliability of water level and flood inundation extent prediction by advancing our capacity on storm surge forecast and early warning systems. Existing scientific tools such as in-situ measurements, numerical models, and satellite missions aid the efforts of storm surge prediction. However, assimilation of the latest satellite altimetry data from the NASA's Surface Water and Ocean Topography (SWOT) into a storm surge model offers an additional dimension to such efforts. Therefore, this work will test the hypothesis that assimilating SWOT-like sea surface height observations within a storm surge model can improve the estimation of storm surge dynamics for operational forecast. A synthetic experiment was developed based on Hurricane Irene, which moved along the US East Coast in 2011. With a focus on the Chesapeake Bay area, we developed the framework for the ADCIRC storm surge model to simulate coastal water levels. Preliminary results indicate that the assimilation of synthetic SWOT sea surface height observations has the potential to reduce errors in the ADCIRC simulations, especially when the satellite has shorter revisit times.

An Assessment Of Urban Agriculture Practices For Mitigating Climate Change

Authors: Christopher Edozie Iweriebor, Graduate Student, PSM Urban Agriculture, University of the District of Columbia.

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Abstract: Climate change has led to extreme weather events including extreme heat, drought, heavy downpours, flooding, sea level rise, decreased water availability, erosion, increasing ocean acidity, increasing wildfire incidence and severity, insect outbreaks, and tree diseases, among others. (Archer et al., 2022; Balch et al., 2020; Land [Basel], 2022; Rakovec et al., 2022; Salomón et al.,2022). The subject of climate change therefore demands urgent and continuous action from every citizen of every country by way of mitigation to prevent the atmosphere from warming to extreme temperatures. We have also been adapting to climate change by altering our behavior in several ways, knowing that we cannot completely eliminate greenhouse gas emission. Sustainable agriculture practices are one of the ways we can mitigate climate change. I have researched urban agriculture practices for mitigating climate change. The reason is to enlighten more urban farmers to adopt these practices to protect the environment and protect human and other life forms on earth.

Assessing IACUC Protocol for a Small-scale Aquaponic System

Authors: David Lowe, Rose Keythe, Ariel Verbrugge, Michael Whyte, Dr. Tolessa Deksissa

Abstract: Aquaponics is an agricultural production system that integrates intensive farming of fish and vegetables returning nutrient-rich wastewater for growing plants in tandem on a continuous recirculating system. Nevertheless, the Institutional Animal Care and Use Committee (IACUC) protocol are limiting the advancement of this system. The objective of this project is to assess ways to synthesize and implement the IACUC protocol for small-scale urban farmers. IACUC protocols are robust in nature and without the proper utilization can be costly and cumbersome to apply in small, non-commercial-sized aquaponics systems, thus limiting farmers' ability to carry out research and innovation in the aquaponic industry domain of agriculture. This work reviewed the IACUC protocols and criteria, and current peer-reviewed publications related to aquaponics, and prepared more concise guidelines to share with small-scale farmers and those newly entering the field. The findings of this research work help urban farmers and sustainability to successfully implement the IACUC protocol requirements to ensure the operation of aquaponics systems remains safe, healthy, and productive, for fish, plants, researchers, and consumers. In creating

such conditions, IACUC-compliant systems will be apt to carry out research and development projects and further scientific discoveries in the field.

Basement Backups and Bacteria: Evaluating the Risk of Residential Exposure to Antibiotic-Resistant Bacteria from Sanitary Sewer Overflows and Basement Backups

Authors: Emily M. Healey[1], Dr. Priscila B. R. Alves[2], Dr. Marccus D. Hendricks[3], Dr. Rachel Rosenberg Goldstein[4],

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Abstract: Studies have identified wastewater as an environmental source of antibiotic-resistant (AR) bacteria, a critical public health threat, creating exposure risks when wastewater enters homes during sanitary sewer overflows (SSOs) and basement backups. To understand the risk of AR infections due to backups in homes, we evaluated the presence of E. coli, methicillin-resistant Staphylococcus aureus (MRSA), methicillin-susceptible Staphylococcus aureus (MSSA), coagulase-negative staphylococci (CoNS), and methicillin-resistant coagulase-negative staphylococci (MR-CoNS) in impacted homes. We collected surface swabs (n=40) and standing water (n=6) from 39 homes in Baltimore City, MD where backups occurred. Samples were processed using modified standard membrane filtration and confirmed with biochemical and molecular techniques. Eight homes (20%) had E. coli on surfaces impacted by SSOs and backups. No MRSA was found on surfaces, but 3 homes (7%) had MSSA on surfaces. Additionally, 3 homes (7%) had CoNS and 1 (2%) had MR-CoNS on surfaces. Of the 6 homes with standing water, 3 (50%) had E. coli, 1 (16%) had MRSA, and 1 (16%) had CoNS present in water samples. Neither MSSA nor MR-CoNs were isolated from any water samples. Results suggest that SSOs and backups could expose communities to AR bacteria. Additional sampling is needed to further assess these risks.

Carbon Neutral Field Work To Quantify And Model Microplastics In Sligo Creek

Authors: Grace Pooley Deans, PhD candidate; Dr. Jason H Davison, Assistant Professor; Catholic University of America, Department of Civil and Environmental Engineering

Abstract: Plastic waste is a major human and environmental health issue garnering increased attention both in the media and in research. The present work proactively addresses plastic waste in urban waterways, instead of further downstream in marine environments. Our research team developed the PARticle-Tracking Inversion (PARTI) software package to predict starting microparticle locations based on field-identified downstream particle counts. The team devised a carbon-neutral bicycle-powered sampling campaign on the Sligo Creek catchment in Montgomery County, Maryland. Samples were collected by pumping creek water through stainless steel mesh filters (mesh pore sizes of 914 and 352 µm) every 0.5 mile along the 10 mile creek. These filters were optically analyzed for microparticles and the resulting counts were used as input for predicting source locations using the PARTI system.

Determining Risk Exposure To Methicillin-Resistant Staphylococcus Aureus In Paint Branch Tributary

Authors: Jack Keane[1], Emily Healey[1], Andrew Kim[1], Deepak Menon[1], Qianyao Si[2], Priscila B. R. Alves[2], Marccus Hendricks[2], Rachel Goldstein[1]

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Abstract: Increasing extreme precipitation events can result in a range of contaminants, including antibiotic-resistant bacteria, entering local waterways. The Paint Branch tributary stream is part of the Anacostia watershed and located in College Park, Maryland. Running through the University of Maryland (UMD), College Park, this stream is home to diverse plant and animal life, but also provides multiple opportunities to collect surface contaminants, and for human exposure. During the Summer of 2022 we collected water samples from Paint Branch (n=30) before and after rain events upstream and downstream from a stormwater pipe that deposits runoff from the University campus. We used culture-based techniques and PCR confirmation to

evaluate the presence of methicillin-resistant Staphylococcus aureus (MRSA) in the water samples. Our preliminary results indicated two presumptive MRSA isolates (7%), one collected before, and one after, a rain event. These preliminary results suggest the need for additional research into the risks of exposure to antibiotic-resistant (AR) bacteria from a range of natural water bodies. Also, because of the dynamic character of the UMD, we also highlight the need for furthering this study, mainly due to the exposure of students and professionals within the campus.

Determining The Impact Of Well Maintenance, Condition, Type, And Location Factors On E. Coli And Total Coliforms In Maryland Farm Private Drinking Water Wells

Authors: Cameron Smith[1], Andrew Lazur[2], Alan Leslie[2], Benjamin Beale[2], Kelly Nichols[2], Shannon Dill[2], Sarah Hirsh[2], Jeff Semler[2], Andrew Kness[2], Emily Healey[1], Jack Keane[1], Raul Cruz-Cano[3], Rachel Goldstein[1]

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Abstract: In 1974 the Safe Drinking Water Act was passed to improve drinking water quality and set a limit for acceptable contaminant levels as provided by the U.S. Environmental Protection Agency (EPA). However, the EPA does not regulate or monitor the drinking water quality of private wells. EPA estimates that over 23 million households in the U.S. obtain drinking water from private wells. The possible presence of contaminants in private wells poses a public health risk. The team collected 67 water samples from Maryland farms with private wells located in seven regions and 19 counties of Maryland. We evaluated water samples for Escherichia coli and total coliform bacteria to understand the risk of contamination for Maryland private well owners. We also determined the impact of well conditions, maintenance, and location on the presence of E. coli and total coliforms in well water. Our preliminary results found that 10% (7/67) of wells were positive for E. coli and 39% (26/67) were positive for total coliforms. Fisher's Exact Test shows that region was the only significant factor impacting E. coli levels ($p=0.001$). These findings emphasize the importance of well water testing and maintenance for private well owners.

Drinking Water Equity Issues In The US Using Spatial Analytics

Authors: Sakira Del Rosario and Juneseok Lee Ph.D, P.E, D.WRE, Civil and Environmental Engineering, Manhattan College, Riverdale, NY

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Abstract: The objective of this study is to identify drinking water equity disparities within the US communities and investigate their probable causes for better management/mitigation considering inherent equity issues. The project will explain the correlation between socioeconomic status (income, housing prices, education level, race, etc.) vs. the frequency of drinking water quality complaints in the US communities. Residents in many large US cities are able to report their water quality complaints into 311 databases funded by the local governments, where the data is then made publicly available. We will combine the demographics data from ACS (American Community Survey) and the number of water quality complaints made available in the 311 databases, and the level of bottled water consumption for our analysis. All the datasets will be utilized in the framework of spatial analytics techniques (e.g., geographically weighted regression and hot spot analysis) to gain deeper understanding whether underrepresented communities have higher instances of drinking water quality problems. The involved spatiotemporal analytics approaches will help identify the vulnerable drinking water quality communities by considering the zip codes, education level, race, median household income, and median home value. Healthy potable water is a basic necessity for everyone irrespective of socioeconomic status.

Enhanced Water Resources Management Through Bio-intensive Urban Agroecology

Authors: Rose Kaythe, Michael Whyte, Mchezaji Axum, Dr. Lavell Merrit, Dr. Tolessa Deksissa

Abstract: Bio-intensive Agroecology is a high intensity production practice of agriculture that spatially optimizes and enhances crop production and soil health to enhance water resources management. This innovative cultivation method creates the capacity for maximum production via high crop interlaying, positive micro climates that reduce water loss, enhanced soil fertility and water holding capacity for plants to uptake and hold water over traditional production methods. The objective of this project is to examine and synthesize research to demonstrate and implement bio-intensive protocols to advance and support the community knowledge of this sustainable and intensive crop and water conserving production practice. This comprehensive analysis of researched peer-reviewed publications and expert opinion and experiences stands to enhance Bio-

intensive Urban Agroecology education as it will benefit small scale urban agriculture food producers through maximized water resources management within the urban ecosystems. Thus, further research, education and practice of Bio-intensive growing is apt to benefit urban water resources management through optimized urban food production and enhanced soil fertility, leading to greater urban sustainability and resiliency.

Flood Risk Management Analysis to Predict Flooded Areas in Washington, D.C. using VH Bands Derived from Sentinel Images

Authors: Maura Kane-Seitz, George Washington University Undergraduate; Parisa Heidary, George Washington University Ph.D Candidate; Dr. Leila Farhadi, George Washington University Professor

Abstract: Flood risk management outlines the threat to communities and infrastructure posed by intense rainfall events. According to the World Meteorological Organization, 44% of global disasters have been associated with floods. In order to understand the risks associated with flooding in the future, it is important to analyze previous floods and find patterns to apply to future events. Washington D.C. is prone to three types of flooding: riverine, coastal and interior flooding. This study will focus on interior flooding, which is the result of heavy rainfall that causes a rise in water levels of a stream or typically dry land. Specifically, it will investigate the increase in the overall interior flooded area in Washington D.C. from 2015 to 2022 utilizing Sentinel-1 Ground Range Detected (GRD) data and detecting the VH (vertically transmitted and horizontally received) band before and after events. Using Google Earth Engine (GEE) a threshold is applied to the satellite images to detect changes from pre-flood event to post-flood event images, and finally determine the flooded areas. Through comparing the amount of flooding associated with rainfall events in DC during the same time of the year, predictions can be made regarding the future amount of interior flooding.

Impact Of Anacostia Water Exposure On Adult Zebrafish Behavior

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Abstract: This study examines the behavioral and physical changes that Zebrafish exhibit after long term exposure to water from the Anacostia River. We identified behavioral trends over time in adult Zebrafish through daily observations, weekly optomotor response behavioral tests and numerous water quality tests. To run our experiment, we set up two identical fish tanks and filled one with system water and the other with Anacostia water collected from Bladensburg Waterfront Park. Each tank had 6 Zebrafish total, 3 females and 3 males. By the end of our experiment, we noticed differences in survival and many behavioral differences. The fish in the Anacostia tank mainly stayed near the corners and edges of the bottom of their tank, suggestive of stress and anxiety, while the system fish tended to stay in the middle of the tank. These results suggest that adult fish behave differently in Anacostia water, consistent with our previous studies using larval zebrafish.

Optimal Pump Operations in Water Distribution Systems

Authors: James McCoy and Juneseok Lee Ph.D, P.E, D.WRE, Civil and Environmental Engineering, Manhattan College

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Abstract: In recent decades, optimal energy consumption and water quality measures have become critical criteria in design, operations, and management of Water Distribution Network (WDN) in addition to hydraulic requirements. The optimal pump scheduling (OPS) problem seeks to find the best pump operations during the given time period. Today, energy consumed by pumps is of major importance because of imposing less cost to utilities, as well as emitting less CO 2 to atmosphere. In addition, the strict requirements of drinking water quality standards have made it critical to perform systems level water quality analysis for a reliable decision making. From this point of view, many researchers have focused on the analysis and improvement of water quality measures along with hydraulic and economic indicators. Given that water pumping stations are among the most energy-intensive consumers, efficient pump operation is extremely important in terms of both the economy and the environment. To evaluate the solutions, EPANET 2.2, a hydraulics and water quality analyzing model will be used as the simulation engine. Moreover, a real-coded Non-dominated Sorting Genetic Algorithm (NSGA-II) will be employed in MATLAB environment as the optimization engine. Then, by bridging the two engines using EPANET-MATLAB Toolkit

model, a coupled simulation-optimization model will be formed to automate the communication between the EPANET and GA. This integrated model accordingly will make it possible to systematically explore the decision space to find the optimum solutions. The results will show the Pareto Optimal solutions that can lower the water age as well as energy costs. We will also find the optimal time as well as the pump operational patterns. The identified sets of solutions will help reduce the energy cost and water age.

Predicting Urban Heat Islands In Washington, DC From Biophysical Parameters Derived From Landsat Images Using Gene-Expression Programming

Authors: Neha Ramanna, George Washington University Undergraduate; Parisa Heidary, George Washington University Ph.D Candidate; Dr. Leila Farhadi, George Washington University Professor

Abstract: The urban heat island (UHI) effect describes the phenomenon in which the core of a city experiences warmer temperatures than its periphery. Urbanization resulting from population growth leads to the increase of impervious surface area and in turn decrease of vegetated areas in cities. As increasing surface temperatures in urban areas pose a major concern for human health and the environment, it is important to monitor the spatial pattern and the size of UHIs. In rapidly growing urban areas such as Washington, DC, the severity of the UHI effect is expected to increase. This study investigates the spatio-temporal relationship of estimated land surface temperature (LST), as a proxy for the UHI, with normalized difference vegetation index (NDVI) and artificial surface index (ASI) in Washington, DC utilizing Landsat-8 TM/ETM+ images acquired from 2013-2022. A non-linear multivariable regression model for UHI is formed using the application of artificial intelligence by gene-expression programming (GEP), an extension to genetic programming. The dependent variable for the model is LST and the independent variables are NDVI and ASI. The regression model is data-based, using 70% of the collected satellite data for model training and 30% of the collected data for model validation.

Rainwater Harvesting Webinars To Increase Knowledge

Authors: Taeilorae Levell-Young[1], Kelsey Brooks[2,3], Marcus Williams[2], Andy Lazur[2], Rachel E. Rosenberg Goldstein[1]

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Abstract: Rainwater harvesting systems store rainfall for future use and can be an important alternative water source for irrigation. Rainwater harvesting has numerous benefits including self-reliance, reduced dependence on city water, and environmental benefits such as stormwater management. With an increase in extreme precipitation events and flooding, rainwater harvesting can reduce stormwater volume and capture nitrogen. As part of our Baltimore City Agricultural Irrigation Water Quality Project we held a series of six rainwater harvesting-related webinars for Baltimore farmers and gardeners from 2021-2022 on topics ranging from system design, maintenance, funding, treatments, and links between water quality and food safety. 150 people attended the webinars, and we collected survey information about rainwater harvesting experience and concerns. Most attended to learn about rainwater harvesting benefits (36%) and had either no concerns (18%) or design concerns (18%). Collaborators: Baltimore City Agricultural Irrigation Water Quality Project, the University of Maryland School of Public Health, Extension urban agriculture specialists, and the University of Maryland Extension funded by the Chesapeake Bay Trust and the Baltimore City Department of Public Works.

Socially Vulnerable People and Pipelines: A Geospatial Exploration of the Equitable Distribution of Grey and Green Stormwater Infrastructure in Washington D.C.

Authors: Minkyu Park[1], Rachel Marie Whiteheart[2], Priscila Barros Ramalho Alves[3], Marccus D. Hendricks[4]

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Professor of Urban Studies & Planning Stormwater Infrastructure Resilience and Justice (SIRJ) Lab, School of Architecture, Planning and Preservation, University of Maryland, College Park

Abstract: Historically, hazard literature has used social vulnerability to describe how social stratification, based on race, income, education, gender, and other factors, differentially affects the risks and impacts that a given community experiences in a disaster event. However, those studies do not show whether marginalized communities with less access to protective GSI green stormwater infrastructure are socially vulnerable or whether the vulnerable communities are relatively excluded from the flood mitigation benefits of stormwater infrastructure, linking the distribution of infrastructure only to specific socio-economic factors. This study explores the relationship between community social vulnerability and grey and green stormwater infrastructure distribution in Washington, D.C. by analyzing the correlation between social vulnerability indices, land use factors, and stormwater infrastructure capacity. The analysis reveals that both grey and green infrastructure capacity has statistically significant negative correlations with population density, imperviousness rate, and social vulnerability, suggesting that grey and green infrastructure is not equitably distributed throughout the city. Also, and that the areas of DC housing communities most vulnerable to disaster are those least served by DC's grey and green infrastructure. Our findings show that the infrastructure separation from planning could raise an equity issue in terms of flooding and give support to the role of infrastructure as a mechanism that deepens social vulnerability.

Spatial Approaches To Refining Urban Catchment Delineation That Integrate Stormwater Network Infrastructure

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Abstract: Knowledge of catchment characteristics is essential to surface water monitoring and management, making accurate catchment mapping techniques important. Traditionally, topography is the primary data set used to model surface water flow

dynamics in undisturbed natural landscapes. However, urban systems also contain stormwater drainage infrastructure which can alter catchment boundaries and runoff behavior. To better delineate catchment boundaries that are jointly determined by topography and anthropogenic hydrologic change, we leveraged three spatial approaches to catchment mapping using the University of Maryland, College Park campus as a case study. ArcMap Tools (i.e. Raster Calculator) and QGRASS plug-in of QGIS were utilized to simulate the realistic directions of runoff flow and catchment boundary based on digital elevation information (DEM) and drainage infrastructure networks. Results of geographical ANOVA test indicate the statistical similarity of the catchment boundaries from the methods above ($p = 0.997$), supporting the feasibility of integrating elements of nature and infrastructure in mapping. Further onsite validations and discussion with stakeholders are needed to identify the optimal method with accurate catchment delineation. Refined mapping approaches being explored in this study would improve the accuracy of drainage catchment zoning in urban systems and the predictive stormwater management at catchment scales.

Testing for E.coli and Heavy Metals in Harvested Rainwater from Urban Farms and Gardens in Baltimore City, MD

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Abstract: With climate change impacting freshwater availability, alternative water sources such as harvested rainwater have the potential to be a powerful tool for urban farmers. However, it is critical to test harvested rainwater to confirm that it meets food safety standards to protect community health. The Baltimore City Urban Agriculture Irrigation Water Quality Project is a collaborative project between the University of Maryland (UMD) School of Public Health and UMD Extension, funded by the Chesapeake Bay Trust and the Baltimore City Department of Public Works. Through this project, we collected 52 water samples from 16 Baltimore City farms and gardens (10 using harvested rainwater, 5 using municipal water, and 1 using both) and 23 total water sources (16 harvested rainwater, 7 municipal water). We evaluated each sample for E.coli, total coliforms, and heavy metals (arsenic, cadmium, chromium, and lead). Preliminary results found that all municipal water samples were well below the Good Agricultural Practices (GAPs) irrigation water guideline for E. coli, and the E. coli concentration for only 2 harvested rainwater sites exceeded the GAPs guideline. Heavy metal concentrations for all water samples were below drinking water standards. This study provides important information on harvested rainwater quality for agricultural irrigation.

Water Demand Forecasting Using Various Machine Learning Techniques

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Abstract: Water demand forecasting is crucial in many aspects of Water Distribution Systems because it helps minimize cost, optimize operations, and provide strategies for water conservation. It plays a vital role in the planning, operations, and management of physical assets for water utilities such as pumping stations, treatment plants, tanks, and distribution networks, which rely on future consumption forecasts. For instance, water utilities need short-term water demand forecasting in order to provide a more stable urban freshwater supply that will be used in a timely manner by adjusting water supply to actual demand and consumption. This project will apply the various machine learning techniques to understand building water use patterns and to make a forecasting. The specific objectives of the research are to i) apply Auto-Regressive Integrated Moving Average (ARIMA) and Seasonal Auto-Regressive Integrated Moving Average (SARIMA) to forecast water demand in time-series data, ii) build and run time series data using various machine learning techniques (Support Vector Machine (SVM), Artificial Neural Network (ANN), etc.), iii) interpret modeling results, and iv) discuss the practical implications of using Machine Learning to water demand in time-series data. Machine learning techniques have the advantage of being able to forecast nonlinear relationships between response variables and their predictors in time series models with the presence of noisy data. The increasing use of smart water metering in the water sector has made available a great amount of data which may not be processed with traditional methods. Therefore, the need has emerged to identify new data analysis techniques able to extract valuable information from available data and support water utilities in their decision systems. Analytics in the Drinking Water Industry support improvements in demand side management and water distribution network efficiencies, lead significant water savings, promote customers' sustainable behaviors, identify peak hours of use, and facilitate water forecast demand modelling.