# 2022 National Capital Region Water Resources Symposium

## Booklet of Abstracts
## (Unedited)

## Research & Technology Presentations
## - Concurrent Oral and Poster Sessions -

**American Water Resources Association**
**National Capital Region Section**

**University of the District of Columbia**

**April 8, 2022**

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## Concurrent Sessions

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

## Session 1

# Increasing the Resilience of Water Infrastructure to Climate Change

**Moderator:** Jason Giovannettone

### A Systematic Review of Municipal Smart Water for Climate Adaptation and Mitigation

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**Abstract**
This study examines how research on smart water is contributing to climate resilient municipal water systems around the globe. We identify smart water research trends over time, relationships with climate adaptation and mitigation goals, and applicability to places with developed or developing water and electrical infrastructure. To do so, we systematically review the literature, identifying research on ICT-enabled technologies related to water supply, wastewater, and stormwater management. We assess the relationship between each study and climate adaptation and mitigation objectives: managing greater variation in water quantity, leading to scarcity and increased stormwater; managing declining water quality; and low-carbon water systems. We find 96 relevant studies and identify five major categories of research addressing climate adaptation and mitigation: monitoring; modeling; system design; system feedbacks; uptake and implementation. We find there is a recent acceleration in smart water research, with a concentration of studies focused on modeling. There is an emphasis on water efficiency using data from Advanced Metering Infrastructure, which is most applicable to cities with developed water grids and consistent electrical supplies. Secondarily, there is a concentration of work using distributed sensors for early detection of water quality degradation, which is being done in all municipal contexts. There is far less research on uptake and implementation of smart approaches, especially at the institutional level. In addition, there is relatively little work that explicitly relates smart water technologies to reducing greenhouse gas emissions. While smart water approaches are applicable everywhere, there is a need to for expanded focus on areas without developed water grids or consistent electricity for smart water to meaningfully contribute to Sustainable Development Goal 6.

**Building Resilience and Adapting to Climate Change Impacts for Drinking Water and Wastewater Utilities**

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**Abstract**
To reduce the risks associated with climate-related hazards, the Environmental Protection Agency's (EPA) Creating Resilient Water Utilities (CRWU) initiative provides training through a collaborative technical assistance community and online tools designed to educate the water sector on climate science and adaptation options. This session will communicate the real-world challenges and successes of utilities in adapting to the impacts of climate change. EPA will highlight the Climate Resilience Evaluation and Awareness Tool (CREAT), an application that guides water utility managers through a climate risk assessment process and helps them evaluate adaptation priorities. In addition, CRWU's Data Maps provide easy-to-access historical and projected climate data from CREAT that are useful for utility decision making. A case study will be presented by a water utility that has worked with CRWU (TBD). Information presented will include experiences and lessons learned by the utility in the adaptation planning process, as well as their use of EPA's CRWU tools. The presentations will be followed by an audience-driven question and answer session.

**The US Municipal Debt Market as the Vehicle for Financing Climate Adaptation and Water Infrastructure**

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**Abstract**
A major obstacle to enacting climate adaptation over the past decade has consistently echoed the theme, "who will pay, and why?". While much of popular discourse on climate-related infrastructure investment focuses on Federal level initiatives (e.g., Build Back Better), the U.S. municipal debt market will likely be the primary vehicle for financing climate adaptation. This ecosystem already contains the apparatus and self-preservation incentives for doing so: municipal creditors are increasingly concerned about climate change, as most communities in the US are significantly underinsured for climate risk, leaving property value and commensurate property taxes used to service debt at risk to erosion. Cities can (and have already started to, e.g., Virginia Beach) issue municipal bond debt to finance climate infrastructure. There is a crucial opportunity over the coming few years build a rigorous data-driven "climate currency" that connects all stakeholders of this market, empowering issuers (notably including water systems) to invest in climate resilient infrastructure. There is also an urgent need to integrate climate and environmental justice considerations explicitly in the process; those communities that are most vulnerable to climate risks are also those who have been historically

marginalized and often lack robust access to the debt market. This presentation will connect dots between climate, social inequality, the municipal bond market, and practitioners working in water resources and civil engineering.

**Developing Climate-Resilient Codes and Standards: Approach and Implications**.

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**Abstract**
Central to the success in addressing infrastructure needs and challenges is significant fiscal and intellectual investment in climate-resilient infrastructure. To help the Nation achieve these twin goals, promoting the development of climate-resilient codes and standards is of strategic importance. A formal collaboration between the Nation's largest provider of climate information, the National Oceanic and Atmospheric Administration (NOAA) and the world's largest civil engineering professional society, the American Society for Civil Engineers (ASCE) is necessary and ongoing. The expressed focus of such a collaboration is on advancing the use of NOAA produced climate science and understanding within engineering practice for the design and construction of climate-resilient infrastructure. Specifically, the development and updating of ASCE codes and standards by a series of exchanges between NOAA and ASCE, facilitated by a dedicated boundary organization, and focusing on the co-development of problem definition and technology transfer mechanisms. In recognition of this need, NOAA is working with the University of Maryland's Center for Technology and Systems Management (CTSM) to act as the boundary organization between NOAA and ASCE to bring onboard and engage the broader civil engineering community and other stakeholders. By helping to ensure that the design and construction of infrastructure is informed by the best available scientific understanding of future weather and climate conditions, such an effort should increase the pace of climate adaptation and reduce design, construction, and maintenance costs as well as the costs of climate-related natural disasters.

# Session 2

## Data Management Systems & Emerging Technologies

**Moderator**: Leila Farhadi

### Data and Machine Learning Operations: Architecture Design for Estuarine Water Quality

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**Abstract**
Estuarine water quality is declining worldwide due in part to the combined impacts of land use change and warming temperatures. Meanwhile, recent advancements in computing have accelerated the speed of data processing, algorithm testing, and model deployment. Additionally, standardized practices known as Machine Learning Operations (MLOps) have evolved, helping both to deploy models at scale and to leverage complementary software development and data operations frameworks. In this presentation, we describe an architecture for MLOps-powered estuarine water quality monitoring and modeling using the Chesapeake Bay as a case study. We discuss the synthesis of routine water quality monitoring data, collected by Chesapeake Bay Program partners, with observations from satellite sensors to facilitate algorithm testing and continued model training. We also examine the insights gained by synthesizing data from citizen science efforts throughout the Bay watershed. Throughout, we consider the differences in model design, development, and deployment between small-scale research analytics paradigms and production-scale big-data solutions for estuarine water quality.

### Robust Water Pollution Prediction Using Long Short-Term Memory (LSTM)

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**Abstract**
Water quality prediction is an active area of research. From data acquisition, to feature selection to learning algorithms, the scientific community is making great strides to develop industry-ready products to monitor water pollution and provide smart ecoinformatics. There is still a gap to deliver a complete solution to needed countries and cities. Communities with legacy infrastructure and/or

outdated water monitoring and forecasting systems could greatly benefit from novel sustainable solutions. However, water pollution indicators, such as chlorophyll, pH, water temperature and dissolved oxygen, are nonlinear in nature and data collection suffers from noise and outliers. We proposed a LSTM based approach to deal with the nonlinearity of this time series prediction problem and an extended Kalman filter to deal with noise and outliers. The proposed recurrent neural network learns to predict the value of the next time step of the time sequence. We evaluate the prediction accuracy of our eK-LSTM variant using two of the most popular baseline models, and we obtain comparable performance.

**A Reduced-Adjoint Variational Data Assimilation for Estimating Soil Moisture Profile and effective Soil Hydraulic Parameters using HYDRUS 1D model**

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**Abstract**
Soil moisture plays a significant role in the terrestrial water cycle. It is very important to obtain information about soil moisture due to its profound impacts on practical water resource applications such as flood forecasting, weather and climate prediction, crop growth monitoring, and water resource management. Therefore, accurate estimation of soil moisture is of critical importance for land-atmosphere interaction studies. One of the common methods in estimating soil moisture is to simulate soil moisture by running land surface models (LSMs) with meteorological data and other parameters (e.g. initial soil moisture profile and soil hydraulic parameters) as inputs. The simulated soil moisture performs well when both the model parameters and meteorological forcing are accurate. This can be realized at only a very limited number of sites, where a variety of measurement instruments are installed. When running the model on a large scale, it is very difficult to accurately obtain model inputs and parameter values. Microwave remote sensing data has offered another means to map land surface soil moisture on a large scale. However, they only provide soil moisture on the surface, upper few centimeters of soil column. Data assimilation (DA) methods can consistently couple both modeling and observations and thus yield superior estimations of model's parameters. In this research the potential of using surface soil moisture observations (satellite remote sensing data) for estimation of initial soil moisture profile and the effective soil hydraulic parameters using a variational data assimilation approach is explored. Proper orthogonal decomposition (POD), model reduction technique, is used to approximate the gradient calculation in variational data assimilation and reduce the order of its adjoint. Through synthetic study surface soil moisture observations are assimilated into a 1-D soil moisture model (HYDRUS-1D) using the new reduced-adjoint variational data assimilation (RA-VDA) scheme to estimate the initial soil moisture profile and the effective soil hydraulic parameters.

The accuracy and feasibility of the proposed approach is evaluated and recommendation for large scale application using remote sensing data are proposed.

**Large Scale Mapping of Evapotranspiration and Recharge Fluxes Using Variational Data Assimilation Framework**

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**Abstract**

Evapotranspiration and recharge fluxes are key components of global water-energy-carbon cycles, thus have major impact on agriculture, water supply, climate etc. These fluxes are interconnected and depend on the soil moisture content. Sequence of land surface state observations of moisture (SM) and temperature (LST) contain implicit information that can be used to map evapotranspiration and recharge fluxes. A point-scale variational data assimilation framework that was evaluated in a synthetic study is implemented in large areas of the Oklahoma and Kansas states by assimilating remotely sensed SM and LST observation. Geostationary Operational Environmental Satellite (GEOS) land surface temperature and Soil Moisture Active Passive (SMAP) surface soil moisture observations were assimilated into a coupled water and energy balance model to estimate the optimal parameters (evaporative fraction, bulk heat transfer coefficient, soil saturated hydraulic conductivity, Brooks-Corey parameter) of evapotranspiration and recharge fluxes. The estimated soil moisture, evapotranspiration and recharge fluxes were validated against in-situ observations. The results show significant improvement from the open loop estimate due to data assimilation. The consistency of the framework was also checked by evaluating the relationship between estimated parameters and environmental variables.

## Session 3

## Advances in Stormwater & Flood Management Research

**Moderator:** Celso Ferreira

### Alternative TMDL Allocation Schemes using Game-Theoretic Modeling

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**Abstract**
The allocation of total maximum daily loads (TMDLs) often requires balancing trade-offs between the associated jurisdictional regulatory burdens and the health of the watershed. Thus, the simple allocation approach may result in basin-wide inefficiencies when the most effective watershed improvements are not distributed evenly throughout the jurisdictions. With this in mind, this work develops a game theoretic model to explore jurisdictional cooperation opportunities for watershed improvements. To test the general approach, a market-based scheme for sediment TMDL allocation trading is applied to the Anacostia Watershed. The relationship between upstream runoff reduction and downstream erosion mitigation is also examined from a game theoretic perspective.

### Prioritizing Stormwater Infrastructure Improvements Under a Changing Climate

Gustavo de A. Coelho[1], Celso M. Ferreira[1], Jeremy Johnston[1], James L. Kinter III[2], Ishrat J. Dollan[1], and Viviana Maggioni[1] [1]Sid and Reva Dewberry, Civil, Environmental and Infrastructure Eng. Dept., George Mason University, VA, [2]Center for Ocean-Land-Atmosphere Studies and Depart. of Atmospheric, Oceanic and Earth Sciences, George Mason University
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**Abstract**
Understanding the impacts of a changing climate on stormwater infrastructure is key for supporting flood resilient cities and communities. The objective of this study was to assess future changes in extreme precipitation and the potential impacts on flood engineering design to assist decision makers on identifying needs and prioritizing improvement on stormwater infrastructure. We used

recent global climate model simulations to estimate extreme precipitation changes for multiple planning horizons, i.e., 2020, 2040, 2060, 2080, and 2100, and incorporated these changes into current engineering design standards for obtaining future design storms.

Hydrologic and hydraulic simulations were performed to evaluate current and future performance of the stormwater system of the City of Takoma Park, and a method for prioritizing improvements was defined. The results showed that the region is already experiencing extreme precipitation changes and that current intensity-duration-frequency curves will become obsolete along the 21st century. This research was conducted as part of the AGU Thriving Earth Exchange program in a partnership between the City of Takoma Park, George Mason University and American Geophysical Union, which aims to help local governments to make more informed decisions when evaluating the potential impact of climate change in the current and future infrastructure.

**Flood Forecast Alerting based on NOAA's National Water Model**

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**Abstract**

In 2018, Wood kicked-off a project with the Maryland Department of the Environment (MDE), Maryland Environmental Service (MES), the US Army Corps of Engineers (USACE) to research the use of NOAA's National Water Model (NWM) for riverine flood forecasting.  The National Water Model (NWM) "is a hydrologic model that simulates observed and forecast streamflow over the entire continental United States (CONUS).  We coupled the NWM data with FEMA Risk MAP HEC-RAS models to build a pilot system for flood forecast alerting and inundation mapping. Using lessons learned from that pilot, our Wood project team was successful in winning internal R&D funding through a CoLab Challenge to build a more robust solution.  The new project is a web application that brings the alerting and mapping into a single platform.  Clients and other stakeholders will be able to customize their experience, building personalized alerts for their areas of interest and flood severity levels, receiving either email or text message alerts.  This presentation will provide a brief background on the NWM, provide a quick tour of our RiverSignal project and share key insights we've learned from working with the forecast data.

**Regional Hydrological Methods for Estimation of Maximum Flood Discharges in ungauged Dry Streambeds, Gobi Region, Mongolia**

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**Abstract**
Estimating maximum rainfall discharge with different return periods is one of the most sophisticated problems and also practical important in hydrological engineering. Recent development of the Gobi region in Mongolia with mining and infrastructure urgently requires need of different type's hydrological data and outputs of research studies to solve different practical issues related to water use and protection. At same time, faces serious lack observed data on climate and hydrology of the region. The study covers estimation of rainfall maximum flood discharge along the small creeks and dry beds in the selected region. The study area is located in the southern Gobi region of Mongolia, namely in territory of Omnegobi and Overkhangai provinces. During field study and measurement 35 river and pebble have chosen and checked their location, identified terrain pattern, conducted cross section 27 sites and data have been processed using geological information system. The catchment area of the selected creeks and dry beds varies from 0.4 to 95.2 $km^2$ with length of 17.9 km. For flow velocity estimation, the Chezy-Manning and V.V.Golubetsov's (year) methods were used. The V.V.Golubtsov formula to calculate flow velocity is modified for the Gobi region as $V=1.14*h^{0.67}*J^{0.17}$ and flow velocity over pebbles is calculated with this empirical formula to compare flow velocity calculated by horizontal cross section. The correlation coefficient R between these velocities is R=0.90, and standard error=$\pm$0.06 m/s, showing that is possible to calculate flow velocity over pebbles. The maximum flood discharge with 100 year return period is estimated by the method so called: rainfall intensity method" adopted for Mongolian condition and applied for small rivers with catchment area of less than 200 $km^2$.
*Key words:* Gobi region, dry bed, maximum flood rainfall flood discharge

## Session 4

## Advances in Water Infrastructure Research & Technology

**Moderator:** Mathini Sreetharan

**An Agile and Expandable Tool for Modeling Hydraulics and Water Quality Processes in Water Systems**
Arash Massoudieh, Professor, Civil and Environmental Engineering Dept., The Catholic University of America
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**Abstract**
In this presentation, I will discuss the development of an agile and flexible tool for constructing models of a various range of natural and engineered water systems. Engineered and natural water systems can consist of a diverse range of components, including surface water, soil, groundwater, streams, pipes, pumps, ponds, reservoirs, and other things, each represented by different sets of governing equations. Furthermore, when using models to make predictions about the behavior of systems, their response to changes in environmental conditions, operation schemes, and designs, or to optimize them, users may be interested in various aspects of the systems such as hydraulics, hydrology, water quality, energy use, costs, and other factors. So having access to an agile and flexible tool that can accommodate representing a wide range of features with different governing equations and can solve the problem for the desired state variables (e.g., water balance, pollutant transport, energy) is highly desirable. In this presentation, I will present various aspects of a newly developed open-source, flexible and expandable tool for this purpose called "OpenHydroQual." In the *OpenHydroQual* framework, models of water systems can be represented as an interconnected network of *blocks* and *links*. The users can define their model components with user-defined properties and governing equations that can ultimately determine the exchange of state properties between the blocks. Some examples of the systems that can be modeled using *OpenHydroQual* include stormwater management and stormwater control measures (SCMs), pipe pump systems, rainfall-runoff modeling, groundwater flow and transport, surface and groundwater quality, integrated urban water management, stream restoration, and water and wastewater processes.

**Energy and Water Quality Management in Water Distribution Networks Considering Variable Speed Pump and Tank Drain-out Scheduling**

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**Abstract**
Concerns about global warming and reducing greenhouse gas emissions on one side, and the need to improve the quality of service to customers on the other side, have driven Energy Water Quality Management Systems (EWQMS) to be one of the top priorities for water utilities nowadays. Storage tanks and pump operation/scheduling have been instrumental in driving optimal energy cost and associated energy consumption operational plans and policies. However, recent successes in water conservation have raised the subject of water age as an issue in these systems. Therefore, we need holistic solutions to manage these operations and to mitigate possible water quality issues. In this paper we employed a multi-objective optimization model coupled with a simulation engine to handle the challenge between energy cost and water quality management in distribution networks. Variable speed pump (VSP) and storage tank drain-out scheduling were used to manage the network. Applying the procedure on a benchmark example showed that the VSP scheduling model couldn't find reliable solutions (in terms of water quality) without the accompaniment of tank drain-out scheduling.

**A Sswiss-Army Knife Approach: Application of High-RateContact Stabilization at Blue Plains**

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**Abstract**
When combined with carbon-efficient nutrient removal systems (short-cut nitrogen removal), high-rate activated sludge (HRAS) systems provide a potential pathway towards energy neutrality at Water Resource Recovery Facilities (WRRFs) (Rahman et al., 2020). However, the operational conditions of HRAS system can lead to a very dynamic process resulting in inconsistent clarifier performance and poor effluent quality, which in turn, reduces the net COD captured and energy recovery through anaerobic digestion (Miller et al., 2016). High-rate Contact Stabilization (CS) or RAS aeration has shown to enhance extracellular polymetric substances

(EPS) production and bioflocculation by imposing a feast-famine regime (Rahman et al., 2016). Hence, full-scale CS was implemented to the currently existing infrastructure at Blue Plains (baseline-stepfeed) in April 2020. After more than a year of operations, the full-scale high-rate CS implementation resulted in multiple benefits including improved bioflocculation, lower effluent suspended solids (ESS), more reliable ESS, better and more efficient carbon capture, improved oxygen transfer, potential energy savings for the enhanced nitrogen removal (ENR) system and reduced volatile organic sulfur compounds (VOSC) emission. The simplicity of the technology together with the wide range of impacts makes this an attractive option.

## Poster Displays

**Baltimore City Irrigation Water Quality: The Current Water Use and Needs from Baltimore City Farmers and Gardeners**

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**Abstract**
The number of U.S. urban farms is increasing, yet irrigation costs and water availability are critical challenges for these farmers. Rainwater harvesting could address urban farm water constraints. Despite farmers' interest in rainwater harvesting, it remains uncommon among urban farmers. It is critical to understand barriers to rainwater harvesting among urban farmers. The Baltimore City Agricultural Irrigation Water Quality 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. Our project is testing the quality of irrigation water sources among Baltimore City farmers and gardeners (n=12) and surveying participants about their water needs and concerns. Preliminary results found that these farmers and gardeners are concerned about water costs and availability. Participants wanted to be involved in this project for various reasons, but primarily related to the health or safety of their irrigation water. Based on these findings, Baltimore City farmers and gardeners also have questions about harvested rainwater use such as the safety, maintenance, cost and city policies regarding this water source. This project adds to the current knowledge about urban farmers needs regarding irrigation water sources.

**Evaluating Indicator Bacteria and Heavy Metal Presence and Concentration in Irrigation Water on Urban Farms in Baltimore City, MD**

Emily M. Healey, PhD Candidate; Rachel Rosenberg Goldstein, Assistant Professor; Cameron Smith, M.S. Candidate; Alex Broussard, MPH Candidate; Esha Saxena, Mya Smith and Emily Speierman , Undergraduate Students; University of Maryland, School of Public Health, Maryland Institute for Applied Environmental Health; Marcus Williams, Andy Lazur and Kelsey Brooke, University of Maryland Extension.
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**Abstract**
Alternative water sources are imperative to addressing climate change's impacts on freshwater accessibility and availability. Harvesting rainwater could provide cost-effective irrigation water for urban farms, which experience challenges with irrigation costs and water availability. To protect farmers and consumer health, it is critical to evaluate the water quality of the harvested rainwater. Our project aims to test the quality of irrigation water sources used by Baltimore City farmers and gardeners (n=12). 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, water samples (n=27) from each water source on partner sites were collected and tested for total coliforms, *E. coli*, and heavy metals (arsenic, cadmium, chromium, and lead). Preliminary results showed that only one sample (1/27; 4%) from one of the 12 sites (8%) had an *E. coli* concentration (CFU/100mL) above the Food Safety Modernization Act (FSMA) standard for agricultural water. All samples tested were below the drinking water standards for heavy metals. These results contribute to the knowledge urban farmers need to make decisions on irrigation sources.

**Trends in Regional Extreme Precipitation across the Continental United States**

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**Abstract**
Sustainable water resources management requires reliable monitoring and identification of extreme precipitation patterns. This study investigates projected trends of extreme precipitation in the 21st century using gridded Community Earth System Model Version 2

(CESM2-LE, 100km/daily) large ensemble simulations of the Coupled Model Intercomparison Project Phase 6 over the continental United States (CONUS). A total of 70 ensemble members are studied under the SSP3-7.0 medium to high range emission scenario. Extreme precipitation is studied in terms of daily annual maximum precipitation and its trends during 86 years (2015-2100) are evaluated using the Theil-Sen approach. Preliminary findings on projected daily annual maximum precipitation trends suggest that the northeastern and southeastern portions of CONUS will experience increasing magnitudes in the $21^{st}$ century. This study proposes a broadly applicable approach to analyze future precipitation trends for better understanding regional vulnerability to extreme climatic events (droughts and floods).

**Stormwater Quality Treatment Using Bioretention for Landscape Irrigation Use**

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**Abstract**
Bioretention is a popular best management practice that effectively retains and treats stormwater quantity and quality. Nevertheless, the effectiveness of bioretention cell in removing urban pollutants for landscape irrigation reuse of treated stormwater is not well understood. Reusing stormwater for irrigation is challenged by elevated levels of pollutants including heavy metals and bacterial loading. Even if the bioretention media has shown promise in the removal of these pollutants in a laboratory environment, field data is limited. The objective of this project is to assess the removal efficiency of a conventional bioretention system in in situ treatment of stormwater runoff from an adjacent parking lot. Stormwater was sampled during rain events before entering the system and at the outlet to determine the removal efficiency of the system. Water quality parameters tested include *E. coli* using Colilert®-18 reagent and Quanti-Trays, total nitrogen and total phosphorous using DR3900 spectrophotometer, total suspended solids, and metal elements using Inductively Coupled Plasma Mass Spectrometry. The result shows that bioretention can remove *E. coli* and some metal elements, but further study is required for landscape irrigation use of treated stormwater. The impact of this outcome this study enhances urban stormwater manager, engineers, and sustainability leaders improvise the design and implementation bioretention cells.

**Assessing Priority Pollutant in the Downstream Tributaries of the Anacostia River in Washington, DC: A case study of Polycyclic Aromatic Hydrocarbons and Trace Metals**

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**Abstract**
Anacostia River watershed is challenged with high contamination of priority pollutants of polycyclic aromatic hydrocarbons (PAHs) and trace metals. To address this challenge, availability of field data is crucial for source identification and mitigation. The objective of this study is to assess the knowledge gap related to these priority pollutants in the downstream tributaries of the Anacostia River in DC and its implication in possible on-site remediation techniques. Grab samples of surface sediment were collected from the downstream location of six tributaries of the Anacostia River in DC, including Watts Branch, Hickey Run, Lower Beaverdam, Fort Dupont, Pope Branch, and Kenilworth Marsh. Samples were analyzed for the PAHs and metal pollutants using Gas Chromatography and Mass Spectrometry, and Inductive Couple Plasma Mass Spectrophotometer, respectively. The result showed that there is variation of contamination consistent with the low impact development. Furthermore, there is a strong correlation among organic matter content and priority pollutants. The finding of this research project has significant contribution to the restoration effort in identifying the most contaminated tributaries and feasibility study of on-site remediation techniques including capping and dredging.

**Evaluating the Utility of Assimilating Satellite Observations of Sea Water Levels into a Storm Surge Model**

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**Abstract**
Natural calamities like hurricanes, typhoons, and cyclones are major causes of fatality and serious economic and infrastructural damage worldwide. Current state-of-the-art systems for storm surge forecasting and early warning systems still fall short in terms of

accuracy. This is in part due to the scientific challenges that arise when estimating flood inundation extent and sea water levels. Satellite observations, such as the ones from the upcoming NASA's Surface Water and Ocean Topography (SWOT) mission, can provide global information of oceans and surface water bodies. These products have the potential to advance our ability to reduce uncertainties in storm surge forecasting. The primary objective of this work is to assess the utility of assimilating satellite-based observations within the ADCIRC storm surge model. A test case is proposed along the United States East Coast and the Chesapeake Bay in the mid-Atlantic region during Hurricane Irene (August 21, 2011 – September 04, 2011). Input forcing data are collected from the US Navy Hurricane Database and ECMWF ERA5 re-analysis. The efficacy of merging synthetic SWOT observations with storm surge model estimates is evaluated using a simple data assimilation technique, i.e., direct insertion, which does not require any unbiasedness in the model and observations.

**Assessment of Rooftop Harvested Rainwater as Affordable Potable Water Source**

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**Abstract**

Rainwater harvesting is one of the main water conservation practices to mitigate water insecurity. The purpose of this review paper is to assess the potential of rooftop rainwater harvesting systems as a low-cost potable water source for households that have inadequate access to safe drinking water. Five case studies of rainwater harvesting systems in communities around the world were considered here: one in a hilltop neighborhood in Yaoundé, Cameroon, another in a rural village in the Philippines, another in rural central Texas, one more in central Mexico and the last in Yatta, Palestine. Three of the studies shared water quality test results and those reveal physico-chemical contaminants generally below maximum acceptable levels but heavy microbiological contamination. Use of the rainwater for potable purposes in the various communities is discussed along with water treatment methods. A community development approach along with several practical measures are proposed to safely harvest, treat, and store rooftop rainwater for potable use to alleviate water scarcity and associated harm to health and social well-being.

**Nationwide Tap Water Quality Analytics Using 311 Open Datasets**

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**Abstract**

In many large U.S. cities, residents can report water quality complaints using 311 systems, which provide government services through platforms such as non-emergency call lines, an online portal, and social media. We have observed an increasing trend in time series data collected for NYC 311 water quality complaints. With the increase in the quantity and sampling frequency of time series data, machine/deep learning could be crucial in analyzing time series data. The objectives of this research are to i) develop machine learning/ deep learning-based time series models to forecast water quality complaints data in large cities that have 311 data, and ii) assess the nationwide characteristics of large cities (e.g., New York, Boston, San Francisco, etc.). In the presentation, we will discuss their forecasting capacities and national-scale trends in detail. Machine learning-based spatiotemporal study about water quality complaints will be crucial in tackling/improving drinking water quality operations, planning, and management in the U.S. and worldwide.

**New Developments in Premise Plumbing Analytics and Modeling for Building Water Systems**

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**Abstract**

Water quality and hydrodynamics within building water systems are driven by the supply source, plumbing materials, system layout, and usage/operation patterns. Opportunistic premise plumbing pathogens continue to cause outbreaks of waterborne diseases such as Legionnaires disease, with severe consequences for human health. This study developed heat maps, identified water pathogen hotspots, and assessed the overall energy efficiency in building water systems utilizing premise plumbing modeling with EPANET, and EPANET-MSX. A building water system was modeled using an integrative hydraulic-water quality approach, taking into account plumbing operational components such as cold and hot water recirculation pipes/tanks, thermal mixing valves, pressure reducing valves, and the number of pressure zones, and considering heat transfer reactions and losses in the pipes/drop legs. It is critical to simulate the stochastic characteristics of complex building water systems, a critical step towards gaining a better understanding of building water systems that balances water conservation, energy efficiency, scalding risks, and water quality to improve system design, optimize system operations, and minimize public health risks.

**Water Resources of Mongolia**

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**Abstract**

Climate of Mongolia is arid and semi-arid, harsh continental with well-defined seasons, high annual and diurnal temperature fluctuations. Country mean of precipitation is low and reaches 230 mm. Country's mean elevation is 1580 м, from north and north-west side surrounded by high mountains, south and eastern part- Gobi and steppe, The Altai Mountain-heights 4267 m above the sea level. All Mongolian river drains into three main river basins of Mongolia so called Arctic Ocean Basin, Pacific Ocean basin and Central Asian Drainage Basin. Mongolia has around 4100 rivers with the total length of 67,000 km and average channel density of 0.05 $km/km^2$. Main runoff source is rainfall, winter snow, groundwater and glaciers in the Western part of Mongolia. Up to 70-90 percent of rainfall falling in the river basins is considered evaporate back to atmosphere and small portion spent for soil moisture of the basins. Total water resources of Mongolia are approximately 34.6 $km^3$. Groundwater storage estimated by hydrograph separation method is 12.6 $km^3$. About 83.7% of total water resources accumulates in lakes, 10.5% in glaciers and 5.8% in river system. 85% of surface water is fresh and 75% is Khovsogol Lake. Water available per capita is 13 740 $m^3$/capita/year and by this indicator Mongolia ranks 56th place amongst 182 countries. At present, over 80% of the water usage is supplied by groundwater and less than 20% is provided by surface water. According to a study conducted in 2018, Mongolia uses approximately 500 million $m^3$ water annually and based upon population growth, it is predicted to grow even more. Annual water usage by sector: drinking and consumption 80 million $m^3$ (14%), industrial services 63 million $m^3$ (11.1%), agricultural 305 million $m^3$ (53.5%), energy 32 million $m^3$ (5.6%), mining 90 million $m^3$ (17%). The drying up of lakes, rivers and springs and melting of glaciers has intensified in the last decades. The recent surface water resource inventory confirmed that 12-21 % of rivers; lakes and springs have dried up. In light of the above Mongolia must not only develop water resources but also improve water efficiency and implement water reuse.