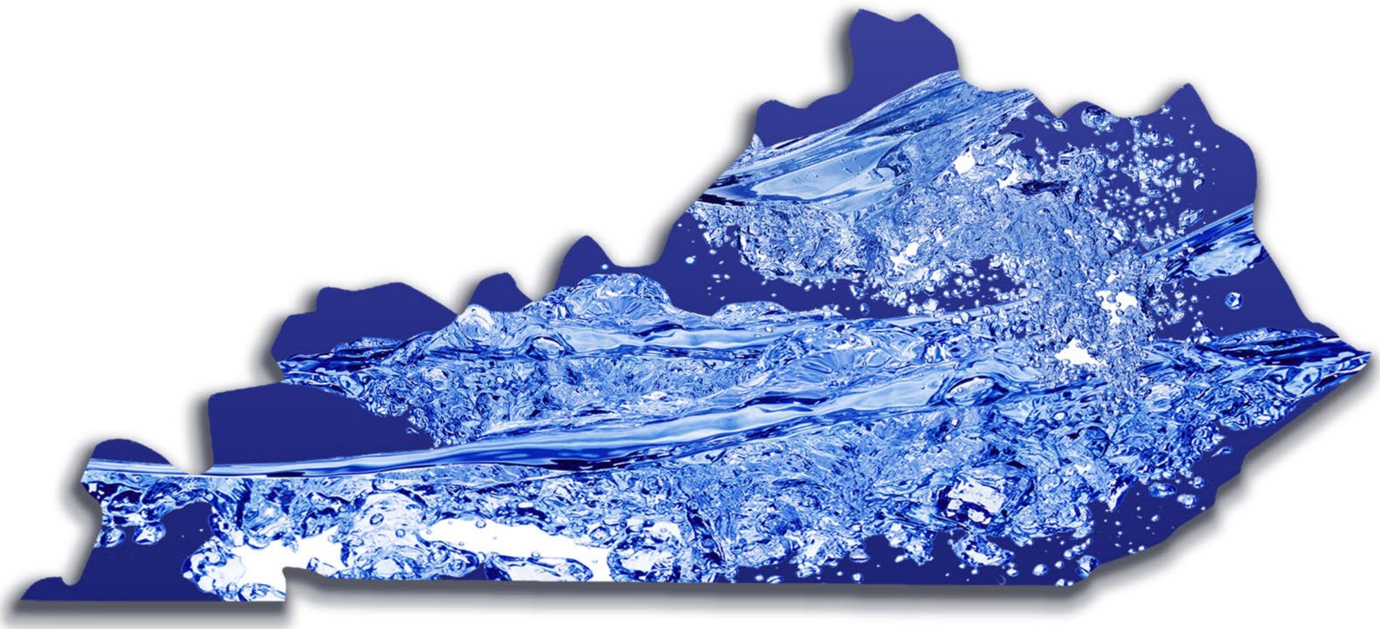
2024 Kentucky Water Resources Annual Symposium



September 27, 2024

Central Bank Center | Lexington, KY

Kentucky Water Research Institute

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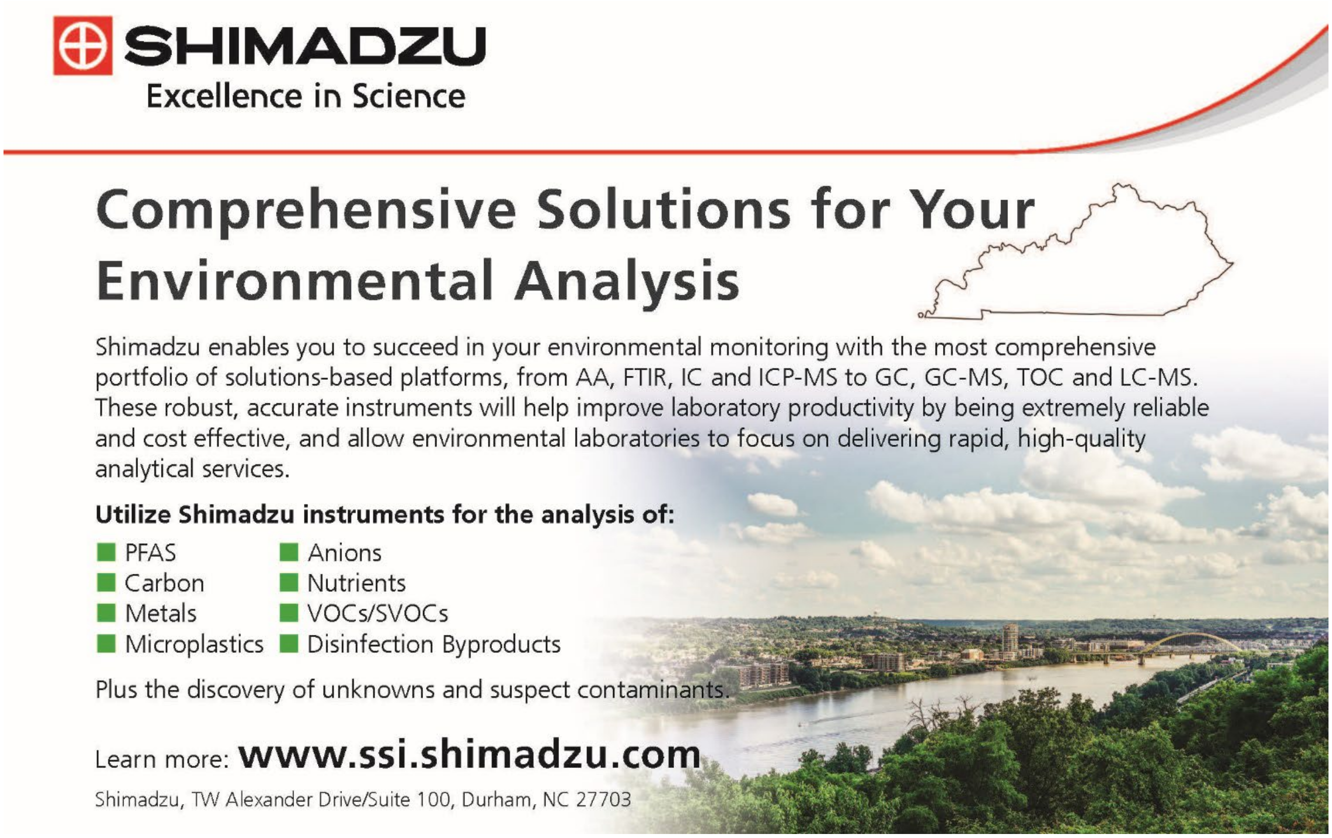

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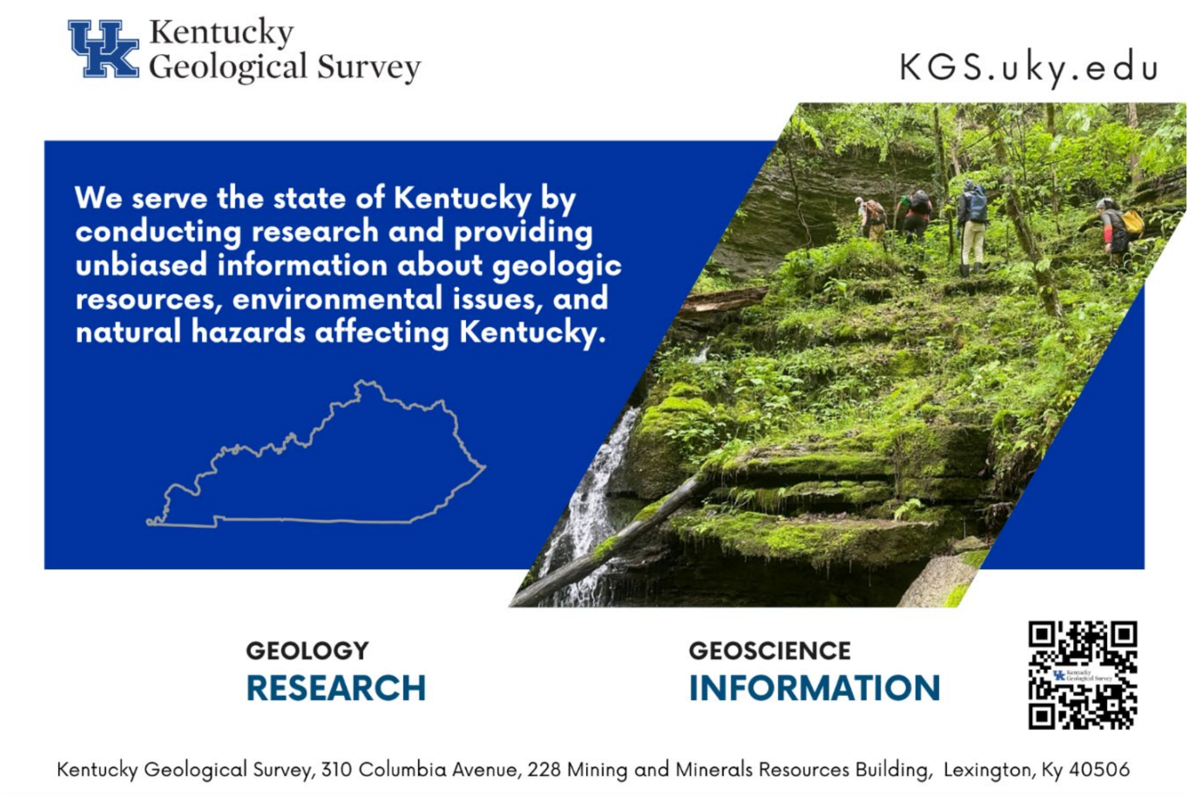

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Plenary Session

Michael Borchers, Hydrology and Hydraulics Section Chief, USACE

Climate Resiliency: How the Corps' Is Managing Infrastructure Through Climate Change

Michael Borchers, P.E. – Michael Borchers is the Branch chief of the Hydrology and Hydraulics Branch at the Louisville Kentucky District, Corps of Engineers and has been with the agency for the past 15 years. Mr. Borchers and currently oversees a staff of 45 professionals responsible for a wide range hydrologic and hydraulic studies, basin water quality, reservoir regulation, environmental restorations, and climate resiliency analyses. The climate team within the H&H Branch is unique to the Louisville District. The team is heavily involved in the development of various tools that are used to determine climate vulnerability of USACE and DoD infrastructure and advise on climate resiliency planning to help mitigate adverse effects of climate change. The team has done analyses all over Kentucky, the nation, and the world.

Mr. Borchers is the chair of the national Water Management Community of Practice organization for the Corps and heads a national support team focused on development on new modeling techniques for the regulation and analysis of watersheds throughout the nation.

Mr. Borchers has an interest in new management technics focused on mentoring, team building, and personal/professional development. He is a strong believer in empowering people to do great work through creativity, dedication, and public service.

Previously, Michael lead teams developing Corps watershed analysis models as part of a national effort. He graduated with a Master's Degree in Civil Engineering from the University of Louisville, and is a licensed Professional Engineer in the state of Kentucky.

Michael also holds a B.S. in Geology from The Ohio State University. In previous lives, he was a geomorphologist, landscaper, archeologist, beer brewer, and a vagabond.

He has a passion for the outdoors, mainly river rafting and backpacking. He can often be seen staring out of a window wondering how he got an office job.

Agenda

2024 Kentucky Water Resources Annual Symposium

September 27, 2024

Central Bank Center, Lexington, Kentucky

Registration and Continental Breakfast (8:00 a.m. - 8:50 a.m.)

PLENARY SESSION (8:50 a.m. - 09:50 a.m.)
Location: Meeting Rooms 12 & 13

8:50 *Welcome, Introductions, and KWRI Updates,* Jason Unrine, Director, KWRI.

9:10 *Climate Resiliency: How the Corps' Is Managing Infrastructure Through Climate Change,* Michael Borchers, Hydrology and Hydraulics Section Chief, USACE.

9:40 Q & A.

Break/Poster Viewing (09:50 a.m. - 10:20 a.m.)
Location: Meeting Rooms 10 & 11

SESSION 1 (10:20 a.m. - 12:00 p.m.)
Location: Meeting Rooms 9 & 14

Track 1A - Room 9—Watershed & Hydrology

Moderator: Malissa McAlister

10:20 *Machine Learning in Hydrology: Challenges and Opportunities*, Arlex Marin-Ramirez, Civil and Environmental Engineering, UL.

10:40 *Advancing Watershed Management and Planning Using Integrated Data Monitoring Networks*, Jason Polk, Center for Human GeoEnvironmental Studies, WKU.

11:00 *Contributions of Small Towns to Impervious Area of Rural Watersheds in Eastern South Dakota,* John McMaine, Biosystems and Agricultural Engineering, UK.

11:20 *Project Management Best Practices: Challenges and Advances for Working in Urban Hydrologic Systems,* Adam Desloge, Center for Human GeoEnvironmental Studies, WKU.

11:40 *It'll Buff Out: Riparian Reforestation Improved Streamwater Quality in Urban Streams in Lexington, KY,* Kenton Sena, Lewis Honors College, UK.

Track 1B - Room 14 — Water Treatment

Moderator: Donna McNeil

Drinking Water Affordability in Kentucky, Mary Cromer, Ella Helmuth, & Rebecca Shelton, Appalachian Citizens' Law Center, Inc.

Modeling the Tradeoff Between Water Loss and Water Quality in the Martin County Water Distribution System, George Fordjour, Civil Engineering, UK.

Assessing Toxicity of Nanomaterials (Hexagonal-Boron Nitride and Phosphorene) and Per– and Polyfluoroalkyl Substances (PFAS) Towards Caenorhabditis Elegans, Lucca Madeo Cortarelli, Plant and Soil Sciences, UK.

Unraveling the Regulatory Policy Landscape of Per– and Polyfluoroalkyl Substances (PFAS): A Comprehensive View, Ariel Robinson, Civil Engineering, UK.

**Impact of Water Containment "Cocktails" on Treatment Wetland Biogeochemical Processes*, Emily Nottingham Byers, Soil Drainage Research Unit, USDA-ARS Columbus, OH.

* Denotes project supported by USGS 104b grant funds.

AWARDS LUNCHEON (12:00 p.m. - 1:00 p.m.)
Location: Meeting Rooms 12 & 13

SESSION 2 (1:00 p.m. - 2:20 p.m.)
Location: Meeting Rooms 9 & 14

2A - Room 9—Groundwater

Moderator: Steve Evans

1:00 *On the Role of Soil Permeability and Precipitation Rate in Saturation of Shallow Subsurface*, Fereydoun Najafian Jazi, Civil and Environmental Engineering, UL.

1:20 *Investigating Groundwater Dynamics and Aquifer Recharge Patterns in Barbados Using Forensic Hydrology,* Ben Hauschild, Center for Human GeoEnvironmental Studies, WKU.

1:40 *Hydrochemical Delineation of Stormwater Infiltration and Recharge in the McConnell Springs Basin, Lexington, Kentucky*, Alan Fryar, Earth and Environmental Sciences, UK.

2:00 *Protecting Kentucky's Geo-Heritage: A Dye Trace Investigation to Study Groundwater Resources in the Glenns Creek Drainage Basin, Franklin and Woodford Counties, Kentucky*, Lee Anne Bledsoe, Crawford Hydrology Laboratory, WKU.

2B - Room 14—Nutrients & Sediment

Moderator: Andrea Drayer

Nutrient Trends in Kentucky: Making Progress with a Changing Climate, Josiah Frey and Caroline Chan, KDOW.

Predicting Cyanobacteria Harmful Algal Bloom Toxins and Genes in the Ohio River and Wabash River, 2020-22, Angie Crain, USGS, Ohio-Kentucky-Indiana Water Science Center.

Investigating Sediment Transport in Fluviokarst Systems Using Sensor Networks in the South Elkhorn Watershed, Melissa Beckman, Civil Engineering, UK.

Phosphorus Dynamics in a Palustrine Wetland Chronosequence in the Jackson Purchase Region, Cora Aossey, Plant and Soil Sciences, UK.

POSTER SESSION (2:20 p.m. - 3:20 p.m.)
Location: Meeting Rooms 10 & 11

SESSION 3 (3:20 p.m. - 4:40 p.m.)
Location: Meeting Rooms 9 and 14

3A - Room 9—Flooding

Moderator: John McMaine

3:20 *NEW! National Weather Service Flood Inundation Mapping (FIM) "Putting Water on the Map"*, Ryan Sharp, NWS.

3:40 *U.S. Geological Survey Flood Alert Systems–Working to Protect Life and Property*, Thomas E. Harris, USGS.

3B - Room 14—Climate

Moderator: Lee Anne Bledsoe

**A Remote Sensing Application for Characterizing Small Wetland Ponds and Their Surrounding Landscapes in Louisville, KY,* Andrea Gaughan, Geographic and Environmental Sciences, UL.

Can Urban and Peri-Urban Constructed Ponds Serve as Carbon Sinks?, Andrew Mehring, Biology, UL.

(Session 3 continued on next page)

(Session 3 continued from previous page)

SESSION 3 (3:20 p.m. - 4:40 p.m.)
Location: Meeting Rooms 9 and 14

3A - Room 9—Flooding

Moderator: John McMaine

4:00 *Predicting Flooding in Vulnerable Communities Using the Latest Innovations,* Katherine Osborne, Stantec.

4:20 *Real-Time Monitoring and Modeling of Urban Karst Flooding for Hazard Mitigation: Case Study of Fairview Plaza, Bowling Green, KY,* Alex Sitz, Center for Human GeoEnvironmental Studies, WKU

3B - Room 14—Climate

Moderator: Lee Anne Bledsoe

4:00 *Community Perspectives on Wetland Health and Use in Louisville, KY,* Kalpana Venkatasubramanian, Geographic and Environmental Sciences, UL.

4:20 *Spatial Patterning of Resources Can Affect Microbial Carbon Dynamics in Hydric Mineral Soils,* JB Moon, Biological Sciences and the Watershed Studies Institute, MSU.

Student Awards (4:40 p.m. - 5:00 p.m.)
Location: Meeting Rooms 10 & 11

Adjourn (5:00 p.m.)

Poster Session (2:30 p.m. - 3:30 p.m.)

1. *Fabrication of a Composite Polymeric Membrane Made with Eco-Friendly Solvents for Water Filtration,* Sophia Tseng, Chemical Engineering, University of Kentucky.
2. *Deep Eutectic Solvent-Resistant Membranes for Sustainable Lignin Recovery in Agricultural Biomass Processing: A Comparative Study,* Odianosen Ewah, Chemical Engineering, University of Kentucky.
3. *Riparian Repairing: Effects of Conservation Efforts on Microbial Communities and Soil Characteristics,* Cooper Samuelson, Lewis Honors College, University of Kentucky.
4. *Life Cycle Assessment to Inform Sustainable Design of Constructed Wetlands*, David Hancock, Civil Engineering, University of Kentucky.
5. *Navigating Sustainability Impacts of Bioretention Design for Stormwater Reuse*, Isaac Oluk, Civil Engineering, University of Kentucky.
6. *Cooling Tower Stormwater Harvesting Project,* Keren Kenner, Civil Engineering, University of Kentucky.
7. *Fate and Transport of Nanopesticides in Agricultural Field Plots in Central Kentucky*, Caleb Stickney, Biosystems and Agricultural Engineering, University of Kentucky.
8. *Glenns Creek Watershed Project,* Steve Evans, Kentucky Water Research Institute, University of Kentucky.
9. **Investigating Controls of Flash Floods in the Headwaters of the Cumberland Plateau Using Process Based Modeling*, Luke Ott, Civil and Environmental Engineering, University of Louisville.
10. *Assessing the Impacts of Climate Change on Headwater Streamflow Regime in Appalachia, USA*, Hasan Taylan, Civil and Environmental Engineering, University of Louisville.
11. *Blue Water Farms: Edge Of Field Nutrient and Sediment Monitoring Network in Western Kentucky*, Brad Lee, Plant & Soil Sciences, University of Kentucky.
12. *Phosphorus Removal at the West Hickman Wastewater Plant – What Can Be Done to Quickly Solve This Arising Problem?, Kyle E. Kmiec,* Lexington-Fayette Urban County Government, Division of Water Quality.
13. **Stable Isotope Tracing of Nitrate Sources during Precipitation Events in a Kentucky Karst Watershed*, Carion Williams, Earth & Environmental Sciences, University of Kentucky.
14. *Evaluating Karst Susceptibility and Vulnerability for the Lincoln Trail Area Development District, Kentucky, from High-Resolution Data and a Ranking-Based Approach*, Junfeng Zhu and Hudson Koch, Kentucky Geological Survey, University of Kentucky.
15. *On-Farm Water Management Small Scale Grants for Kentucky Specialty Crop Growers*, Cindy Finneseth, Horticulture, University of Kentucky.
16. *Sampling Kentucky Ground and Surface Water Sources Used for Produce Pre- and Post-Harvest Activities*, Cindy Finneseth, Horticulture, University of Kentucky.
17. *Surface Roughness and Topographic Change at a Reclaimed Mine Site. A Preliminary Assessment Using Lidar Data,* Demetrio P. Zourarakis, Martin-Gatton College of Agriculture, Food and Environment, University of Kentucky.
18. *Helping Small-Scale and Socially Disadvantaged Farmers with Irrigation Water Quality*, John Thomas, Cooperative Extension, Kentucky State University.
19. **Investigating Methane Fluxes and Porewater Chemistry in Proximity to Bald Cypress "Knees"*, Skylar Ross, Earth and Environmental Sciences and the Watershed Studies Institute, Murray State University.
20. **Impacts of Duckweed (Lemna and Wolffia spp.) on Carbon Storage and Decomposition in Small Ponds*, Josh A. Snipes, Biology, University of Louisville.
21. **Evaluating the Effects of Ecological Restoration Efforts on Stream Health in the Inner Bluegrass Through eDNA Assessment of Invertebrate Communities,* Sara A. Brewer, Science and Health, Asbury University.
22. *Community-Based Participatory Research on Drinking Water Disinfection Byproducts in Appalachia,* Jason Unrine, Kentucky Water Research Institute, University of Kentucky.
23. *Hybrid Solutions for DOT applications for Proactive Road Flooding Alerts*, Chuck Kozora, OTT Hydromet

* Denotes project supported by USGS 104b grant funds.

Past Recipients of Institute Awards

William Barfield Award for Outstanding Contributions in Water Resources Research

Christopher D. Barton (2023)

Lindell Ormsbee (2022)

Carmen Agouridis (2021)

Chris Groves (2020)

Jimmy Fox (2019)

Susan Hendricks (2018)

Jim Kipp (2017)

Stephen F. Higgins (2016)

Dibakar Bhattacharyya (2015)

James C. Currens (2014)

Art Parola (2013)

Andrew Ernest (2012)

James Dinger (2011)

Alice Jones (2010)

Sylvia Daunert (2009)

Gail Brion (2008)

David White (2007)

Wes Birge (2006)

Don Wood (2005)

Lyle Sendlein Award for Outstanding Contributions in Water Resources Practice

Roger Recktenwald (2023)

Peter Goodmann (2022)

Kurt Mason (2021)

Richard Walker (2020)

Jack Stickney (2019)

Barry Tonning (2018)

Lynn Jarrett (2017)

Steven K. Hampson (2016)

Richard Warner (2015)

Derek R. Guthrie (2014)

Sandra Gruzesky (2013)

Michael Griffin (2012)

Linda Bridwell (2011)

Greg Heitzman (2010)

Susan Bush (2009)

Steve Reeder (2008)

Bill Grier (2007)

Jack Wilson (2005)

Robert A. Lauderdale Award for Outstanding Contributions in Water Quality

Tom Biebighauser (2023)

Christopher Lorentz (2022)

Russ Turpin (2021)

John Webb (2020)

Maggie Morgan (2019)

Charles Martin (2018)

Amy Sohner (2017)

Paulette Akers (2016)

Dale Reynolds (2015)

Brian C. Reeder (2014)

H. David Gabbard (2013)

Henry Francis (2012)

Amanda Gumbert (2011)

Malissa McAlister (2010)

Bruce Scott (2009)

Ken Cooke (2008)

Judith Petersen (2007)

Eddie Foree (2006)

Session 1A: Watershed and Hydrology

Machine Learning in Hydrology: Challenges and Opportunities

Arlex Marin-Ramirez[1], David Tyler Mahoney[1], Steven Evans[2]
[1]Civil and Environmental Engineering, University of Louisville
[2] Kentucky Water Research Institute, University of Kentucky
[1]arlex.marin@louisville.edu

Interest in machine learning (ML) has proliferated through the hydrologic sciences in recent years (Figure 1). This growth has been driven by the success of ML and AI in commercial sectors, making the necessary software and hardware more widely accessible, and by the increased availability of continuous hydrologic observations from in-situ and remote sensor datasets. Many studies now demonstrate that ML algorithms outperform classical process-based and conceptual hydrologic models when compared to observed data, with the added benefit of often being easier to implement.

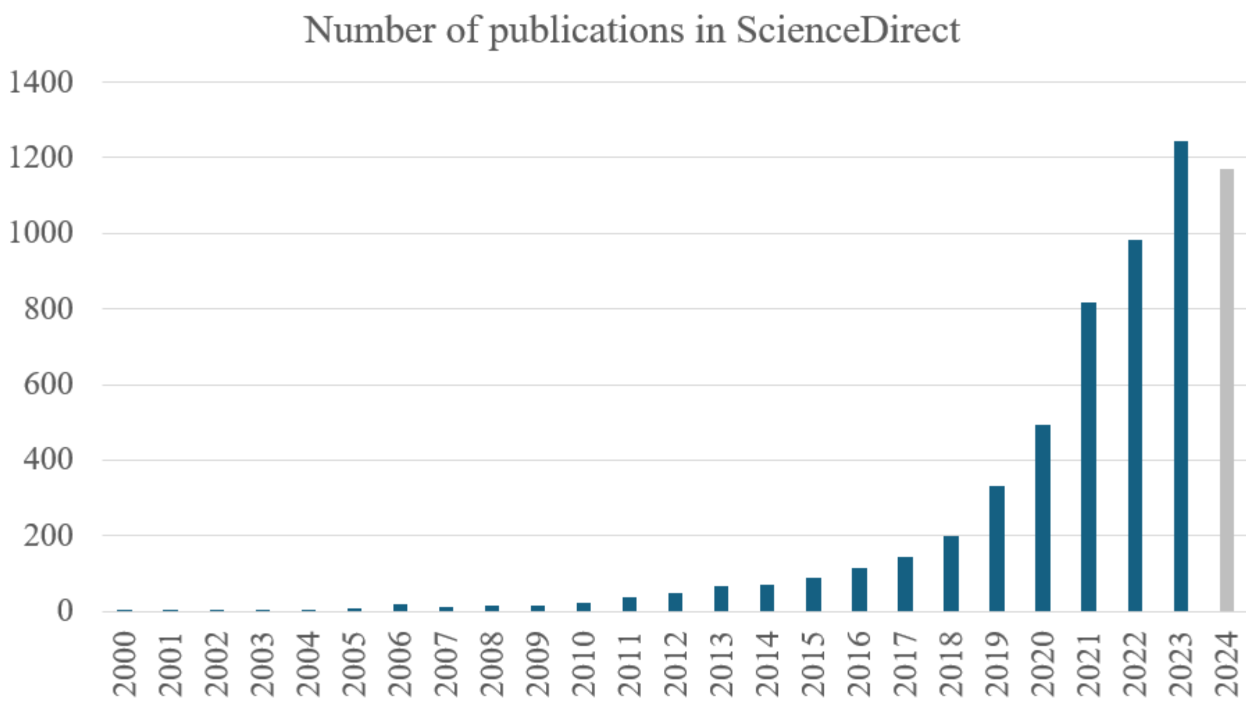

Figure 1. Number of articles containing the terms "Machine Learning" AND "Hydrology" based on a search in ScienceDirect. The search was conducted on July 2, 2024, therefore the number of publications for 2024 is incomplete.

Despite the promise of ML models, their adoption in hydrology faces several critical limitations. Key among these are: (1) a limited ability to interpret results due to the black-box nature of ML models; (2) the lack of physical consistency in relationships captured by these algorithms (e.g., conformity to the conservation laws), which limits when predictions can be trusted; and (3) extensive data requirements, which limit their use in data-scarce regions. However, ongoing research is rapidly addressing these issues to facilitate wider adoption of ML models in hydrology.

Given the growing interest and high expectations for ML to support hydrologic science and water management, active discussion within the hydrologic community is essential. The objective of this talk is to provide an overview of machine learning for hydrological applications with the aim of fostering such discussions. We will demonstrate the use of ML to simulate basic hydrologic processes like rainfall-runoff generation and how to identify relationships between hydrologic variables through data mining. Drawing on our own experiences with implementing ML models in hydrology and sharing specific examples from our work, we will highlight both the challenges and opportunities of ML implementation, illustrating common obstacles and practical solutions. Covered topics will include basic concepts in ML, types of ML algorithms and when their use is appropriate, data sources and preprocessing for training ML models, and methods for interpreting results. Finally, we will suggest educational materials for those interested in incorporating ML into their hydrologic analyses. The talk will be directed towards a wide range of audiences, including those with limited background in ML or computer programming.

Advancing Watershed Management and Planning Using Integrated Data Monitoring Networks

Jason S. Polk[1], Adam Desloge[1], Brittany Pekara[1], Trayson Lawler[1], Adam Shelley[2], Nick Lawhon[3], Matt Powell[3]
[1] Center for Human GeoEnvironmental Studies, Western Kentucky University
[2]Kentucky Water Research Institute, University of Kentucky
[3]Environmental Compliance Division, Department of Public Works, City of Bowling Green, Kentucky
[1]jason.polk@wku.edu

Advancing whole-basin watershed management using the newest technology and software through an integrated monitoring network approach is both possible and affordable for any size community or watershed. Now, it is cheaper and easier than ever to collect accurate, high-resolution data for myriad environmental parameters. In urban karst areas, where complex hydrological processes from underground river, springs, sinkholes, and modified stormwater drainage systems influence flooding, water quality issues, and create environmental hazards, the need for collecting comprehensive data to address problems ranging from stormwater flooding to contamination events grows more pressing as development, population, and climate continue to evolve. Stormwater runoff is highly susceptible to contamination from non-point source pollution and causing flood impacts following rain events, which varies spatially and temporally in an urban karst landscape. To counteract the impacts of contamination and drainage issues, Best Management Practices (BMPs) are implemented to reduce the effects of stormwater runoff and comprehensive water quality monitoring is becoming a more common practice; however, the unpredictable nature of storm events can make methods for effectively monitoring impacts difficult in trying to capture first flush inputs, flood threats, and sedimentation sources.

Over the past decade, the city of Bowling Green, Kentucky has served as a natural laboratory for developing an approach to integrate a variety of hydrologic monitoring methods to establish best practices for collecting both real-time and static data, including rainfall, weather variables, water quality parameters, water levels, BMP scoring, and stormwater inspections, among others. Using a network approach to collect data across platforms and integrate it into public facing online datasets and modeling outputs, successful techniques and methods have been developed using a comprehensive dataset that provides insight to both long-term and real-time response needs. Here, a complete overview of developing an integrated monitoring network that is applicable to both complex urban karst areas and non-karst areas, is presented. Utilizing integrated real-time and static monitoring networks allows for improvements in stormwater runoff control, reduced erosion and sedimentation, more rapid contaminant detection and response, water quality improvements, and increased abilities to develop date-driven policies and regulations. The use of an integrated GIS-based dashboard to ensure user-friendly applications allows stakeholders to implement scalable, data-driven solutions for improved watershed management, while also including the general public in the process.

Contributions of Small Towns to Impervious Area of Rural Watersheds in Eastern South Dakota

John McMaine[1]
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Impervious surfaces like roads, buildings, roofs, limit water infiltration into the soil and alter the natural hydrologic cycle. This change in land cover has consequences for water quality and quantity. It leads to increased runoff volume and peak flow which can result in flooding, channel erosion, and stream instability. The impact of impervious cover change on water resources has been studied in high-density urban areas. However, the contribution of rural areas to total impervious surfaces has not been well studied. Regulatory frameworks, like Small Municipal Separate Storm Sewer Systems (MS4) have been put in place to tackle the problem of increased impervious cover. However, these regulations historically have only applied to towns with a population of 10,000 or more. It is likely that communities with a population less than this range also impact and are impacted by stormwater and water management because of impervious cover, but lack the technical, financial, and social capital to effectively manage water from impervious surfaces. This research aims to investigate the change in impervious cover in small towns and rural watersheds and the relationship between population change in small towns and impervious cover change.

To achieve this, 236 small towns with populations under 10,000 and 1036 HUC-12 watersheds in eastern South Dakota were evaluated for impervious cover and population change. Additionally, the contribution of small towns to impervious cover in watersheds was examined. Data from the National Land Cover Database (NLCD) for the years 2001 and 2019 was utilized to assess impervious changes, while census data from 2000 and 2020 helped in examining population shifts. The study first assessed the impervious cover change by considering the four developed classes in the NLCD and then employed an index using the four developed classes to calculate a total impervious value for each town and watershed. All the land cover change analysis completed in Google Earth Engine and ArcGIS Pro was used to create maps and shapefiles.

By understanding the relationship and extent of change in impervious cover the gap in current water resource regulations can be bridged to ensure that smaller communities are not left behind in environmental protection and sustainable development efforts. The study allows us to better understand the relationship between impervious cover changes and population dynamics, which will lead to more informed and responsive policy-making that will better safeguard our natural resources. These insights will guide investment in water management for sub-10,000 resident communities. A similar study will be conducted in Kentucky to quantify potential challenges faced by small towns and rural communities in Kentucky.

Project Management Best Practices: Challenges and Advances for Working in Urban Hydrologic Systems

Adam Desloge[1], Jason S. Polk[1]
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In recent years, with the concurrent advancement of technology and understanding of environmental system processes, the collection of, and need for, large, high-resolution datasets in research continues to evolve. The progression of environmental monitoring technology has ushered hydrology, in particular karst systems, into the "Big Data" realm, enabling users to collect and aggregate millions of data points from a variety of sources, providing both new insights and data collection challenges. In karst areas, threats from geohazards include contaminated groundwater, flooding, sinkhole development, drought, and other hydrologically-driven issues. Stormwater issues continue to cause challenges in NPDES and MS4 communities related to threshold event triggers and modernizing and streamlining data collection both in the field and remotely. In order to remediate and mitigate these problems, the use of advanced monitoring equipment (e.g., data loggers, real-time data transmission, etc.) to be able to not only detect instantaneous changes in parameters, but also to build long-term, high-resolution baseline datasets from which to understand subtle changes in the system and develop predictive models is possible. In the field, sampling resolutions are also improving, due to increased capacity for field analyses of certain parameters, such as discharge and analyzing in situ water quality parameters. Additionally, the study of these processes can now generate enough data to inform complex hydrologic neural network and adaptive learning models, as well as calculate with high accuracy discharge, contaminant loadings, and volumetric flooding risks, as well as inform safety and mitigation planning for both government and private sector stakeholders.

Collectively, these scenarios raise the question of the most practical, accurate, and affordable methods for different research and monitoring needs in these scenarios. Here, the advances and challenges of amassing data in complex hydrologic environments, like urban karst systems, are discussed using several case studies, including the advantages and disadvantages of large datasets, types of software and applications, best practices in field data collection and project management, and their effect on data quality and stakeholder benefits. In addition, guidelines for developing project metrics, organizing workflow, and practical tips for data collection and management are provided to assist government agencies, environmental consulting firms, and research scientists and students, along with potential evolution pathways for project management in the future.

It'll Buff Out: Riparian Reforestation Improved Streamwater Quality in Urban Streams in Lexington, KY, USA

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[2]Department of Forestry and Natural Resources, University of Kentucky
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Urban development impairs streams by altering hydrological regimes and compromising water quality. Streamflow in urban streams is fundamentally altered due to conversion of watershed area to impervious surfaces, such as parking lots and roads, and streamwater is polluted by automotive fluids, lawn applications, industrial effluents, human and pet waste, and other contaminants. In undeveloped watersheds, forests (and especially forested riparian zones) provide critical water quality improvement and runoff attenuation services, slowing the movement of water across the land surface, improving infiltration, and filtering sediment and other contaminants. However, riparian areas in the urban landscape are also frequently compromised by streamside development, mowing, or other management decisions. Because of the benefits provided by forests, reforestation of urban watersheds is a priority. The Lexington-Fayette Urban County Government has been a leader in urban reforestation for over 25 years, establishing forest patches in previously mowed land every year since 1999 through the Reforest the Bluegrass program. However, the effects of this program on water quality improvement have not been experimentally evaluated. Water quality monitoring using a paired upstream/downstream sampling approach was initiated in Summer 2020 to evaluate effects of riparian reforestation on water quality. Analysis of this dataset is ongoing, but preliminary analyses suggest water quality improvement across multiple analytes from upstream to downstream sampling locations across multiple sites and times. For example, nitrate concentrations decreased significantly in three sampled sites, with mean decreases ranging from 14 – 50%. Consistent significant improvements in water quality across multiple reforested sites demonstrate the effectiveness of riparian reforestation for improving stream-water quality. Continued urban reforestation efforts should prioritize riparian and floodplain areas, where available, to maximize stream-water quality benefits alongside other benefits of urban reforestation.

Session 1B: Water Treatment

Drinking Water Affordability in Kentucky

Mary Cromer[1], Ella Helmuth[1], Rebecca Shelton[1], Ricki Draper[2]
[1] Appalachian Citizens' Law Center, Inc.
[2]Independent Researcher
[1]mvcromer@aclc.org

The recent historic levels of investment in water infrastructure both at the state and federal levels has brought much needed attention to the plight of struggling water systems. In particular, the Bipartisan Infrastructure Law's focus on directing federal funding to disadvantaged communities has focused many state and federal officials on the task of assessing and comparing the overall status of water systems. This type of systems-level approach is important to the goal of more equitable distribution of infrastructure funding. However, to ensure progress toward the basic human right of access to safe, affordable water for every household, policymakers must consider water affordability at the household level. For many households, it is becoming increasingly difficult to pay their monthly water bills as water rate increases continue to outpace inflation. Not only are water bills rising, but households' overall water burdens (i.e., the percentage of income spent on water) are also increasing. The inability of customers to pay their water bills often creates instability and shortfalls in the systems' revenue, but still yet, water burden indicators are not often sufficiently considered in conversations about helping struggling systems.

The focus of the report, released in September 2023, is on household water affordability across Kentucky. The report provides a snapshot analysis of water burdens across the state based on data collected in 2021 and 2022. The report finds that there are significant differences in water bills across the state and, as such, income is not the sole driver of water unaffordability in Kentucky. The report analyzes water burdens at the census tract level for different income quintiles to provide a more robust analysis of affordability than more typical measures that rely solely on median household income. The report finds that households at the top of the lowest quintile in income distribution across the state have trouble affording water. Overall, the report finds that there is as much as a twenty-fold difference in water burdens across the state. The presentation will summarize the report and its recommendations. The presentation will also offer suggestions for future research and possible collaborative work to further address the problem of drinking water unaffordability in the state.

Modeling the Tradeoff Between Water Loss and Water Quality in the Martin County Water Distribution System

George Fordjour[1], Lindell Ormsbee[1], Scott Yost[1]
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Ensuring safe and high-quality drinking water while minimizing water losses is a critical challenge for many water utilities, especially those in rural Kentucky. Chlorine disinfection, while effective in eliminating pathogens, can lead to the formation of potentially harmful disinfection by-products (DBPs). This study employs KYPIPE, a comprehensive hydraulic and water quality modeling software, to investigate chlorine and DBP dynamics within the Martin County (MC) water distribution system, which has experienced significant water losses. Accurate prediction of these parameters is crucial for optimizing disinfection strategies, mitigating DBP risks, and identifying opportunities for water loss reduction.

The KYPIPE model was first calibrated and validated using historical water quality, operational data, and extensive field data collected from the MC water distribution system. Simulations were conducted to assess the impact of varying operational parameters on chlorine residuals, DBP formation, and water loss throughout the network. The results of this study provide valuable insights for possible disinfection strategies, mitigating DBP risks, and improving water loss management in the Martin County system, ultimately highlighting the potential uses of such models in contributing to the delivery of safe, high-quality, and sustainable drinking water to consumers.

Assessing Toxicity of Nanomaterials (Hexagonal-Boron Nitride and Phosphorene) and Per- and Polyfluoroalkyl Substances (PFAS) Towards Caenorhabditis Elegans

Lucca Madeo Cortarelli[1], Anika Azme[2], Jerilynn Hutton[1], Nirupam Aich[2], Jason Unrine[1], Olga Tsyusko[1]
[1] Department of Plant and Soil Sciences, University of Kentucky
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The two-dimensional (2D) nanomaterials with unique physical and chemical properties, such as hexagonal-Boron Nitride (h-BN), have been increasingly tested and evidence suggests they may potentially be used as means for degradation of persistent organic contaminants, per- and polyfluoroalkyl substances (PFAS). PFAS are contaminants of emerging concern due to their widespread presence in water systems and their environmental impact. To ensure a safe-by-design approach is adopted for usage of 2D nanomaterials for PFAS degradation, we tested toxicity of this nanomaterial and representative long-chain PFAS (PFOA and PFOS) individually as well as in the individual exposures. A powerful toxicity model, a nematode, *Caenorhabditis elegans* was used to screen for toxicity across different endpoints including mortality, reproduction, growth, locomotion, and lipid accumulation. The endpoint specific to PFAS, due to their lipid metabolism disruption ability, is lipid accumulation. We quantified this to measure changes in fat distribution of nematodes at PFAS concentrations lower than 1 mg/L through imaging and fluorescence intensity quantification after Nile Red staining. Exposure solutions were analyzed via LC-MS/MS to quantify actual PFOA/PFOS concentration exposures. Preliminary data point towards h-BN not inducing significant mortality up to 25 mg/L with growth (length and surface area) being a more sensitive endpoint with significant results at 10mg/L. Further, the results suggest that PFOA and PFOS both induce significant or close-to-significant increased lipid accumulation in nematodes. The identified safe h-BN concentration will be used in the combined exposures with PFAS to identify the nanomaterial potential for PFAS breakdown into less toxic compounds. These and future findings guide future assays to measure contaminant and nanomaterial effects towards nematodes to encourage the adoption of safe-by-design approaches to environmental remediation.

Unraveling the Regulatory Policy Landscape of Per- and Polyfluoroalkyl Substances (PFAS): A Comprehensive View

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Per- and polyfluoroalkyl substances (PFAS) are a class of anthropogenic chemicals encompassing more than 15,000 constituents. PFAS have been used extensively since the 1940s in consumer products, industrial processes, and, most notably, in aqueous film-forming foam (AFFF) for emergency response. Though PFAS has garnered a ton of attention over the past few years, the regulatory policy process has been evolving since the early 2000s, cycling through agenda setting, policy formulation, decision making, and currently residing between policy implementation and policy assessment (see Fig. 1). In April of 2024, the United States Environmental Protection Agency (USEPA) published the Final PFAS National Primary Drinking Water Regulation which imposes enforceable maximum contaminant levels for six compounds. As public drinking water systems strive to meet the 2024 standards, evaluating the vulnerability of drinking water sources to PFAS contamination has become an urgent need. Across the nation, states have varying technical, financial, political, and human resources to address this need. For example, in states where primary PFAS sources exist, viable responsible parties have been engaged in the PFAS regulatory discussions, and state agencies have been actively engaged in PFAS risk assessment and mitigation for many years. However, that is different for Kentucky. In this study, Kentucky is presented as a case study because it is representative of the geographic “middle” of the U.S. Additionally, many inflammatory disease risks associated with PFAS exposures are exacerbated by health disparities in the Appalachian and Delta regions which encompasses nearly 2/3 of Kentucky’s land resources and where inflammatory disease risk exceed national averages for the 1.6 million Kentuckians who live there.

This research evaluates federal and state policies on national and federal levels, exhibiting the journey to regulation on the state and federal levels by using geospatial mapping, PFAS drinking water sampling and analytical results, and the presence of over 1,000 presumed PFAS sources in Kentucky. A temporal gap in the national and Kentucky regulatory processes has been identified and will be discussed. This research aims to serve as a guide to understanding PFAS regulatory policy actions, implications for Kentucky, and future visions for other exposures besides drinking water.

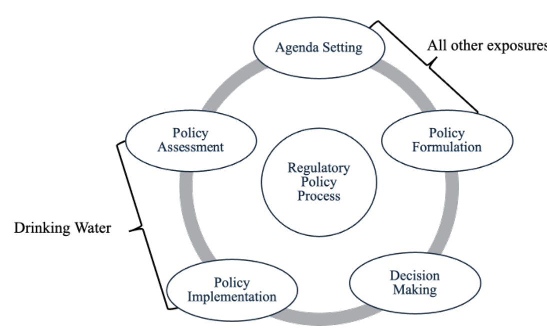

Figure 1. The national regulatory policy process for PFAS

Impact of Water Containment "Cocktails" on Treatment Wetland Biogeochemical Processes*

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Wetland treatment systems are used extensively across the world to mitigate surface runoff. While wetland treatment for nitrogen mitigation has been comprehensively reviewed, the implications of other contaminants of potential concern such as Per- and polyfluoroalkyl substances (PFAS), common-use pesticides, and pharmaceuticals on nitrogen removal remain relatively unreviewed. Therefore, this study sought to determine the impact mixtures or "cocktails" of contaminants have on nitrogen removal processes (e.g., microbial denitrification, plant uptake). The contaminants of potential concern were determined based on their occurrence across Kentucky surface waters in both urban (imidacloprid, caffeine, and PFOS) and rural (atrazine, glyphosate, and sulfate) environments. Two types of constructed wetlands, floating treatment wetlands (FTW), and free water surface wetlands (FWS), were tested to determine the impact that wetland design has on nitrogen and contaminant removal potential along with planted and un-planted controls, equating to 24 mesocosms with replicates. Five experiments were completed to determine if the contaminants of potential concern impacted nitrate removal when they appeared alone and together in various mixtures. This was followed by a ^{15}N enrichment tracer study to identify how specific nitrogen processes in these wetlands were altered by the additional contaminant mixtures. Contaminant mixtures were observed to inhibited nitrate removal compared to the presence of each individual contaminant. However, by the end of each 10-day experiment, all nitrate added was removed from the wetlands despite the contaminant type and mixture present. Additionally, the FWS outperformed the FTW earlier in the growing season (May-June) when the water temperatures were lower, while the FTW outperformed the FWS when the water temperatures warmed up and plant growth occurred later in the season (July-August). By understanding the impact different types of contaminants have on nitrogen removal processes within these systems, treatment wetlands can be specifically designed to treat and manage individual and mixtures of contaminants of potential concern while sustaining nitrogen removal goals.

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Session 2A: Groundwater

On the Role of Soil Permeability and Precipitation Rate in Saturation of Shallow Subsurface

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Heavy rainfalls have always been a great concern worldwide due to their role in occurrence of floods which can cause costly damages to residential buildings and roads and pose a threat to human lives. Therefore, many studies have been devoted to exploring the formation of small streams during the precipitations, which eventually converge to form floods. Despite significant attention to above-ground factors involved in flood formation, less attention has been paid to the role of subsurface soil in this process. However, during rainfall events, the porous nature of subsurface soil allows at least a part of the rainfall to infiltrate into the pore space of the unsaturated shallow subsurface, preventing the accumulation of surface water. Nevertheless, if the rainfall continues to the point where the unsaturated zone becomes fully saturated, flooding becomes inevitable. Consequently, it is important to investigate the time required for unsaturated subsurface soils to reach full saturation when exposed to heavy rainfall.

This study scrutinizes this matter by developing a fully coupled thermo-hydraulic model using a commercially available finite element software, COMSOL Multiphysics. The model incorporates phase changes between liquid and gaseous water using a non-equilibrium phase change model. Additionally, it takes into account the advective flow of liquid water and the diffusive movement of water vapor. The influence of climate conditions is considered through a complex soil-atmospheric boundary condition for the surface, accounting for the surface evaporation/condensation, heat exchange, and most importantly, rainfall infiltration. The developed model is validated by simulating a non-isothermal experiment from the literature. To investigate saturation time under different conditions, various rainfall rates and soil permeabilities are employed in the validated model. Results are interpreted in terms of temperature and moisture content variations in the unsaturated layer, as well as saturation time under different scenarios. It should be noted that this study attempts to highlight the pivotal role of the shallow subsurface in flooding by accurately examining heat and mass transfer within unsaturated soils. However, further studies that can simultaneously simulate the formation of free water flow above ground and mass transfer within unsaturated subsurface are needed for a more precise analysis.

Investigating Groundwater Dynamics and Aquifer Recharge Patterns in Barbados Using Forensic Hydrology

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This study investigates water resource management challenges on the small, karstic island nation of Barbados, located in the North Atlantic Ocean bordering the eastern Caribbean Sea. The island's vulnerability to changing climate and storm patterns and sea level rise is compounded by its reliance on karst aquifers for its freshwater supply, which highlights the urgency for sustainable water resource management on the island. Through a multifaceted approach, including water level and precipitation monitoring, forensic hydrologic tracers (stable isotopes and dye tracing), and remote sensing analysis, this study endeavors to enhance the understanding of the groundwater dynamics, recharge patterns, and water resource availability in Barbados' karst environment. Through a collaboration with the Barbados Water Authority, this research seeks to provide valuable insights for improved water resource management approaches, addressing critical questions regarding groundwater-surface water interactions, recharge dynamics, and the influence of human activities on the islands' karst hydrology. Furthermore, through the utilization of the preexisting 3D-PAWS rainfall monitoring network, an investigation into the variations in precipitation both spatially and temporally will be conducted. This research contributes to a broader understanding of coastal karst islands and offers valuable insights for water resource management in similar regions around the world.

Hydrochemical Delineation of Stormwater Infiltration and Recharge in the McConnell Springs Basin, Lexington, Kentucky

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Management of stormwater in urbanized karst basins often involves conveying runoff through subsurface conduit networks from sinkholes to springs. Using electrical conductivity (EC), water temperature (T), and stable isotopes of water (oxygen-18 and deuterium [^{2}H]), we assessed the response of the McConnell Springs basin in Lexington, Kentucky, to precipitation during 2018, the city's wettest year since record-keeping began in 1888. The 12.1-km^2 basin is located in a primarily residential area with parks, schools, and light commercial development.

We logged EC and water T at 15-min intervals at the Blue Hole at McConnell Springs January 19 – October 12, 2018 (with gaps March 1–9 and April 20–May 2). We logged EC May 2 – October 12 at a large sinkhole adjoining the Campbell House Inn, which was linked by dye tracing to McConnell Springs. Stable isotopes were sampled February 2 – December 12, typically weekly, at the Blue Hole, the Campbell House sinkhole, and along sinking reaches of two streams (Vaughn's Branch and Wolf Run).

EC and water T fluctuations enabled delineation of recharge events. EC at the Campbell House sinkhole rose above baseline values (~ 0–90 µS/cm) when runoff resulted in ponding. We identified 35 instances of sinkhole ponding between May 5 and October 11, with durations of 2.25–212.75 hr (median 21.5 hr) and a maximum EC of 818 µS/cm. At the Blue Hole, EC ranged from 176 to 2937 µS/cm and was generally > 1000 µS/cm from January 19 to February 1. Water T ranged from 6.17°C on March 24 to 23.75°C on June 12. Baseline EC gradually declined from ~750 to 650 µS/cm between May and October, while baseline water T gradually increased from ~12 to 17°C between March and October. Lag times in EC responses between the Campbell House sinkhole and Blue Hole ranged from 1.64 to 23.14 hr. We identified 52 events at the Blue Hole with an EC change ≥ 100 µS/cm from baseline values; 44 of these had a water T change ≥ 1.0°C. Out of 18 events in January–March 2018, EC rose in 12 (by up to 1843 µS/cm) and water T fell in 17 (by up to 7.08°C). During April–October, EC fell in all 34 events (by up to 575 µS/cm), and water T rose in 32 events (by up to 7.15°C). January–March EC spikes at the Blue Hole were concurrent with road salt or brine application, which occurred within 2 days prior to each EC spike except January 23 (and had occurred January 12–19). Conversely, EC declines associated with storms reflected relatively dilute runoff.

Plots of δ^2H vs. δ^{18}O for each site were subparallel to the global meteoric water line ($\delta^2H = 8\delta^{18}O + 10$), indicating partial evaporation during recharge. Slopes of these plots ranged from 7.27 for the Campbell House sinkhole to 5.58 at the Blue Hole. This suggests that infiltration is relatively focused beneath the sinkhole, consistent with EC logging, whereas the Blue Hole receives a mixture of focused and diffuse recharge.

Protecting Kentucky's Geo-Heritage: A Dye Trace Investigation to Study Groundwater Resources in the Glenns Creek Drainage Basin, Franklin and Woodford Couties, Kentucky

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Kentucky's karst geology is inextricably linked to one of America's most distinct distilled beverages, bourbon whiskey. The unique combination of groundwater chemistry, fertile soils, humid-temperate climate, and the settlement of the Commonwealth by expert distillers from Europe has played an enormous role in the culture and history of the state and continues to influence our modern livelihoods. Karst is Kentucky's geo-heritage.

Karst is a landscape underlain by soluble bedrock and characterized by subsurface water flow that creates features such as caves, sinkholes, sinking streams and springs. This unique landscape and the water resources within are also extremely vulnerable to land-use impacts. Over half of the state is underlain by soluble limestone, with most bourbon distilleries located in the Inner Bluegrass karst region of north-central Kentucky (Currens 2002, Fryar 2009). In fact, the Kentucky Distiller's Association reports that as of 2018, 95% of the world's bourbon was produced here. To protect our natural resources, cultural heritage, and the current economic benefits of both, we must first understand land use interactions and water quality conditions. In karst, fluorescent dye tracing is used to trace groundwater flow paths and identify potential threats to our precious bourbon-making, groundwater resources.

In 2023, the Crawford Hydrology Laboratory partnered with the Kentucky Geological Survey and Castle and Key Distillery to delineate flow paths to springs along Glenns Creek using fluorescent dye tracing. The groundwater investigation consisted of three concurrent dye injections which confirmed interpreted basin divides between springs along Glenns Creek and the Cove Creek Spring basin to the north. The study also investigated potential causes of diminished flow at Old Taylor Spring, the main source of water for distillery operations. According to recent observations at the distillery, flow at the main spring had decreased by an unprecedented amount, from approximately 150 gallons per minute to zero flow on occasion. Land use changes and significant surface modifications within the Old Taylor Spring basin, which could impact flow and water quality, were observed and documented. Urban development in upgradient areas near Frankfort, as well as across Franklin and Woodford counties, was the impetus for the tracer study and findings now offer all water users, distilleries, agriculture, and tourism alike, information to better manage, protect, and sustain Kentucky's geo-heritage.

Session 2B: Nutrients and Sediment

Nutrient Trends in Kentucky: Making Progress with a Changing Climate

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Nutrient loads from the greater Mississippi River basin have created a hypoxic zone in the Gulf of Mexico. States within the basin determined in *The Gulf Hypoxia Action Plan 2008* (HTF 2008) to develop strategies to reduce nutrient loads and develop reasonable and appropriate watershed-specific plans to further manage nutrients. The Kentucky Division of Water, with its partners, developed a Nutrient Reduction Strategy to assist in this state and federal initiative to reduce nutrient loading to the basin and the size of the hypoxic zone.

A key element of this strategy is to monitor nutrient concentrations and loads over time to identify trends and track whether reduction strategies are effective. While monitoring is ongoing, analysis for trends is undertaken every few years. The latest trend analysis has been completed and results are being interpreted and prepared for an update report.

Aspects of this update include:

- Use of a different method for modeling loads – the Weighted Regressions on Time, Discharge, and Season (WRTDS). This method calculates flow-normalized loads to easily discern trends through the noise of fluctuating discharge (Lee et al, 2017).
- Comparison of Kentucky trends to those of the entire Mississippi basin.
- Comparison of percent reductions with the interim 2025 Task Force goals (HTF, 2015).
- Analysis of ammonia and nitrate to ascertain what is driving Total Nitrogen reductions.
- An examination of the impacts of climate change, particularly extreme precipitation, on loading patterns.

These factors will be pulled together to determine which implementation strategies are or are not working; what we don't know and where we don't know it; and, finally, next steps for tackling this problem.

Predicting Cyanobacteria Harmful Algal Bloom Toxins and Genes in the Ohio River and Wabash River, 2020-22

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Cyanobacteria harmful algal blooms (cyanoHABs) are a worldwide concern because they can cause a multitude of water-quality issues, including the potential to produce toxins that can affect waterbodies used for recreation and drinking-water supplies. The formation of cyanoHABs have been linked to the effects on increasing water temperatures and precipitation-driven nutrient runoff followed by drought-related nutrient retention in waterbodies. The frequency and severity of cyanoHABs-related events have increased in recent decades and will continue to create challenges to lakes and rivers in the future. Because of this, water-resource managers need tools to help predict when and where toxin-producing cyanoHABs may occur to allow for quick response and aid management decisions. This could be done using site-specific models that estimate the potential for elevated toxin concentrations and/or the presence of cyanoHAB genes.

More than five million people utilize the Ohio River as their source of drinking-water. In 2015 and 2019, toxic cyanobacteria harmful algal bloom (cyanoHAB) events were recorded, and health-advisories issued in the same 300-mile stretch of the Ohio River from Ashland, Kentucky to Louisville, Kentucky. During the summer and fall of 2020-2022, the USGS initiated a cyanoHAB monitoring strategy using discrete and real-time continuous measurements at select sites on the Ohio River and a Wabash River site. This study was conducted to develop real-time and comprehensive predictive models for combined toxins and cyanoHAB genes in select pools in the lower Ohio River and a lower Wabash River site. Real-time models include real-time measured environmental variables that do not require that a sample be collected; comprehensive models use a combination of discrete sample-based measurements and real-time variables. The methods and model results will be discussed and are expected to provide guidance and perspective for future cyanoHAB studies in rivers.

Investigating Sediment Transport in Fluviokarst Systems Using Sensor Networks in the South Elkhorn Watershed

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Fluvial systems are common in central Kentucky, USA. The various fluviokarst features, such as sinkholes and swallets, impact sediment transport processes. It is difficult to accurately account for the sediment processes in fluviokarst systems because, generally, all hydrologic models are inadequate in simulating the connectivity between the surface and the subsurface water flow. Therefore, we used high-resolution sensors (SUNA and YSI EXO3) to assess water and sediment yield trends in the Upper South Elkhorn watershed for 2017-2023. We performed QAQC on the collected data and visualized the baseflow seasonality and sediment transport. We built sediment duration curves based on 15-minute sensor readings and daily averaged results. Also, we unmixed baseflow and runoff in the watershed by building an empirical model for the hydrograph and sediment graph decomposition. We found that groundwater flow dominates this system's water and sediment yield. Approximately 85% of the water reaching the outlet can be classified as groundwater contribution. The baseflow suspended sediment concentration shows pronounced seasonality, with more sediment transported during summer. Our findings paved the way for more adequate model representation of water and sediment movement and yield in the karst system.

Phosphorus Dynamics in a Palustrine Wetland Chronosequence in the Jackson Purchase Region

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The U.S. Department of Agriculture – Natural Resources Conservation Service Agricultural Conservation Easement Program (ACEP) Wetland Reserve Easements (WRE) is focused on converting marginal agricultural lands which frequently flood to wetlands in order to restore hydrologic function and enhance wetland habitat. Currently, there is a gap in knowledge of how phosphorus (P) dynamics develop as these wetlands are converted from row crops such as soybeans to wetland vegetation over time. Wetlands may be anticipated to act as a P sink; however, the seasonally wet environment could result in a release of dissolved P over time. In this study, we have used a chronosequence of former farmlands now converted to inland, fresh water (palustrine), forested wetlands in the Jackson Purchase region of Kentucky to evaluate the mobility of P over time. Phosphorus content in the nonlabile and labile P pools at three soil depth intervals (0-10, 10-30, and 30-60 cm) have been evaluated on a 10-m grid within a paired chronosequence of wetlands at three distinct ages (0, 7, and 33 years), thus providing a space-for-time set of examples of conversion from row-crop to recovered wetland. The results will be discussed and are expected to further our knowledge of P retention in soils when row-crop lands are converted to forested palustrine wetlands

Session 3A: Flooding

NEW! National Weather Service Flood Inundation Mapping (FIM) "Putting Water on the Map"

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Flooding is the most frequent severe-weather related threat and the costliest natural disaster in the United States. To improve flood warning communication and help emergency managers prepare for and respond to flooding, the National Weather Service (NWS) has begun to add new experimental flood inundation mapping (FIM) services to its suite of forecast products. These new services complement and support the issuance of flood watches and warnings by providing a visualization of where flood waters are expected. By putting water on the map, decision makers can readily see the potential impacts rather than relying on memory or flood impact statements from past events. The new FIM services are now available, providing initial mapping capabilities for 10% of the U.S. population including much of eastern Texas and parts of the mid-Atlantic and Northeast. NWS FIM services will be expanding to an additional 30% of the U.S. including Kentucky and much of the Ohio Valley in October 2024. When fully deployed across the entire U.S. in 2026, flood inundation mapping will be available for 110,000 river miles near NWS River Forecast Center forecast point locations, and for 3.4 million river miles covered by National Water Model forecasts.

This presentation will have a look at the new FIM services that NWS forecast offices will be providing to emergency managers and other local hydro partners starting late Fall 2024 in Kentucky. An overview of the different types of FIM and their availability will be discussed. Examples of FIM including a local case study will be presented with a focus on how emergency managers and local officials can use NWS FIM services to preposition people and resources ahead of, during and after flood events. This new flood inundation modeling capability will hopefully provide actionable information for emergency and water resource managers to prepare, mitigate and respond to floods.

U.S. Geological Survey Flood Alert Systems- Working to Protect Life and Property

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The mission of the U.S. Geological Survey (USGS) is to provide reliable scientific information to describe and understand the Earth and minimize loss of life and property. In the wake of the disastrous flooding in eastern Kentucky July 26-30, 2022, where up to 16 inches of rain fell in a five-day period, the USGS worked with local partners to install and operate gages and Low-Cost Alert System (LoCas) sites to better protect people and property in the region. This presentation will focus on USGS flood alert systems located on Wolf Creek in Ohio and two LoCas sites, one USGS river gage, one lake gage, and three precipitation sites in the Elkhorn Creek basin in Kentucky. This USGS alert system will give communities automated and cost-effective early alerts to quickly rising floodwaters, potentially saving lives and property. An overview will also be given as to the difference between USGS LoCas sites and a traditional USGS river gage and the difference in the quality of data.

Predicting Flooding in Vulnerable Communities Using the Latest Innovations

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The mountainous area of Eastern Kentucky is uniquely vulnerable to flash flooding. With steep slopes and narrow valleys cut by streams, much of the population is exposed to flood risk. In July 2022, Eastern Kentucky experienced historic and deadly flooding caused by intense rain resulting in the loss of 41 lives and severe infrastructure damage.

Kentucky Division of Water, in partnership with Stantec, developed a pilot project to enhance flood warning, mitigation, and resilience efforts by delivering a portal communicating flash flood inundation, depth, and probability mapping for one of the most vulnerable communities in Kentucky, Letcher County. Letcher County is a disadvantaged community with a poverty rate 150% higher than the national average. This pilot was supported by Flood Predictor, a proprietary product developed by Stantec, which applies machine learning flood-risk technology while leveraging FEMA’s Risk MAP data to deliver rapid results in near real-time. This presentation will detail the innovative methodology used to develop the modeling and mapping and share how this portal has successfully communicated flood risk, supported flood warning, and overall resilience within Eastern Kentucky.

Real-Time Monitoring and Modeling of Urban Karst Flooding for Hazard Mitigation: Case Study of Fairview Plaza, Bowling Green, Kentucky, USA

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The city of Bowling Green, KY is established on karst topography, a landscape notable for caves and sinkholes providing direct drainage into underground aquifers. Fairview Plaza, a highly urbanized area within the city, is prone to flooding because stormwater has become directed from the surrounding commercial and parking developments into a centralized drainage complex of injection well and sinkholes. These events have threatened property and and lives on numerous occasions. Alteration of the terrain has disrupted the natural draining leading to inundation of the sinkhole and pooling of water during intervals of intense precipitation. The purpose of this study is to model the effects of precipitation events on the Fairview Plaza water level and subsequent flooding. Data were collected at a one-minute resolution using real-time water level data loggers and precipitation gauges. Collected data were compared to the precipitation and water level data over multiple storm events to establish a flooding threshold for prediction of future flood conditions following storm events. Results of this study provide a better understanding of apparent flooding dynamics which can be utilized for future stormwater management practices. Real-time monitoring allows for improved safety measures using triggered warning lights and signage during storm events, along with public data display and alerts. These practices may improve safety and prevent damage to property at the studied site or other similar locations urbanized karst areas using technology combined with hydrologic modeling to mitigate the hazard.

Session 3B: Climate

A Remote Sensing Application for Characterizing Small Wetland Ponds and Their Surrounding Landscapes in Louisville, KY*

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Wetland composition, notably different types of photosynthesizing vegetation, plays a prominent role in modulating carbon source-sink status. Effectively capturing surface-level conditions of small ponds and characterizing their immediate surface surroundings provides important monitoring information for managing these waterbodies. In this work, we provide a remote sensing approach to classify end-of-growing season conditions (late August/early September) for small ponds and their surrounding land cover conditions for a set of small ponds in Louisville, KY. In doing so, we also address the efficacy of using medium to high spatial resolution data, multispectral imagery to accurately classify small wetland surface conditions and the surrounding landscape context.

Surface coverage of various vascular plants (e.g. algae, duckweed, lily pads, etc.) influences carbon dynamics and the ecological functioning of small ponds. This influence varies based on factors such as time of year, prevalence of vascular plants, and vascular plant type. For example, duckweed (family *Lemnaceae*) are commonly found in small ponds and wetlands, often with a bright green, full coverage mat during summer months. Duckweed cover can block oxygen diffusion while providing a source of labile organic matter as it decays, potentially favoring anoxic mineralization pathways that produce enhanced methane (CH_4) emissions. Additionally, the surrounding land use and land cover of small ponds varies along the urban-to-rural gradient. The varying types of land cover, both proximate and within a watershed area, contribute to various nutrients and particulate inputs that impact small pond conditions.

Remote sensing provides a complementary tool to in-situ measurements to characterize smaller ponds (<10,000 m2). While spatial and temporal resolution trade-offs with traditional sensors (e.g. Landsat) have made it challenging to capture surface detail as an appropriate scale for small ponds, the European Space Agency Sentinel 2a provides high spatial resolution (10m and 20m spectral bands) coupled with a 5-day return time which is an attractive alternative for monitoring and characterizing small ponds that might effectively address previous remote sensing challenges. Using Sentinel 2a imagery, we apply a non-parametric, ensemble-based random forest classifier to characterize landscape surface conditions and determine the predominant portion of surrounding land cover for ponds with the highest green photosynthesizing surface area (indicative of vascular plant coverage). Results with overall, producer, and user accuracies of >90% suggest Sentinel-2a spatial and temporal resolutions are effective in capturing small pond surface conditions, notably identifying vascular plant coverage from open water conditions. However, differentiation of specific vascular plant types requires further work. By utilizing this data and method, this study establishes foundation metrics for monitoring the health and productivity of small wetlands in carbon sequestration and production across seasons.

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Can Urban and Peri-Urban Constructed Ponds Serve as Carbon Sinks?

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The 2.6-9 million small (surface area <10,000 m^2) ponds and wetlands across the conterminous U.S. contribute at least 20% of our total standing water area. They often emit greenhouse gases (GHGs) at substantially higher rates per unit area when compared to larger bodies of water. However, small built impoundments also have the potential to serve as sites of carbon (C) sequestration that rival forests in C storage per unit area. Kentucky has lost an estimated 81% of its wetland area (>5,000 km^2) since the 1780s, and while wetland restoration may return a host of lost ecosystem services, most ponds built in urban and peri-urban areas contain very few emergent wetland plants. This may substantially limit rates of carbon dioxide (CO_2) uptake and C storage at the ecosystem scale.

Here we synthesize the results of research aimed at estimating the minimum surface area coverage by emergent wetland plants needed to offset emissions and generate a C sink in constructed ponds and wetlands. A portable GHG analyzer and floating static flux chambers were used to measure diffusive fluxes of CO_2 and methane (CH_4) along four-point transects across open water, and over emergent wetland vegetation at three or more locations within each pond. Algal biomass and floating vegetation areal coverage, layer thickness and density were estimated as well, and nutrient concentrations and environmental factors such as pH, temperature, photosynthetically active radiation (PAR), and dissolved oxygen were measured at each site. After flux measurements, emergent plants within the footprint of the flux chamber were harvested, dried, and weighed to estimate biomass per unit area. Emergent vegetation removed several times more CO_2 per unit area of pond than either algae or floating plants at the same light (PAR) levels. Using these data, we are able to compare fluxes within vegetated and open-water portions ponds and estimate the plant coverage needed to convert ponds into net C sinks. These data provide valuable recommendations to inform the management of built wetlands with the objective of maximizing C storage.

Community Perspectives on Wetland Health and Use in Louisville, KY

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Wetlands are one of the most productive ecosystems in the world, providing critical habitat to aquatic and terrestrial species, functioning as an important water purifier and protecting against floods. Wetlands also play an important role in climate change, with most vegetated wetlands being net sinks for carbon dioxide (CO_2). Within this, urban wetlands assume significance yet remain understudied. Their contribution to urban ecosystems is typically only assessed through their ecological functions, with less attention into their social and cultural value to communities. In a rapidly urbanizing world, where more than 50% of the population lives in cities, overcrowded and congested cities face several environmental challenges, coupled with rising threats from climate change and urban heat island effects. Urban communities thus face several stresses with implications for physical, mental and emotional health. In this context, there is a growing recognition of the contributions of urban wetlands as important spaces for enhancing environmental and social sustainability and well-being.

To better understand how residents in Louisville, KY perceive and interact with wetlands in public parks, we are undertaking a perceptions survey involving both laypersons and experts. A perceptions survey offers valuable insights into the role wetlands play by identifying use patterns in wetlands and the purpose behind them. We use a participatory community science approach to inform our survey methodology, by gathering data from members of the public towards increasing knowledge and understanding of environmental systems. Insights gained from surveys are crucial for identifying the multifunctionality of urban wetland ponds and work towards optimizing both ecological and social services from them. The goal is also to draw comparisons between layperson perceptions of wetland conditions and how accurately they reflect wetland health status based on expert perceptions.

Pilot survey (n=38) was carried out at three wetland ponds (June to December 2023) in Louisville, KY. Initial results showed that most participants considered wetlands as an important space with 80% agreeing that they are likely sinks for greenhouse gas (GHG) emissions. Nearly three quarters agreed that wetlands likely support the health of nearby ecosystems thus suggesting that park visitors have an appreciation for urban nature, particularly their local wetlands.

Survey instrument was modified to better capture aspects of wetland use participants found of most value. The modified survey is carried out across seven parks in Louisville. Initial results offer very positive affirmations for urban wetland use and value. The role of wetlands as providers of urban 'nature' and 'beauty' was chosen as most valuable by participants followed by opportunities to be close to plants and animals. A majority of the respondents continue to view wetlands as sinks for GHG emissions, demonstrating that laypersons are not entirely unobservant about the ecological value of wetlands. In presenting this ongoing work we argue that a

community science approach helps establish the saliency of the issue of wetland health in urban park systems. It also provides the opportunity for additional wetland monitoring by creating greater buy-in from members of the community. This is key to their timely conservation and management.

Spatial Patterning of Resources Can Affect Microbial Carbon Dynamics in Hydric Mineral Soils

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Microbial population growth varies as a function of resource concentration. The non-linear Monod model is the most widely used function to describe microbial growth, with linear growth at low resource concentrations and saturation at higher concentrations. Using this model along with scale transition theory, we would predict that microbial habitats with resources uniformly spread throughout would lead to higher population growth and subsequent activity than microbial habitats where the same concentration of resources is supplied in patches. We tested this prediction in small-scale mesocosms containing inundated hydric mineral soils with bald cypress needles acting as the dominant resource. Microbes were provided with either no needles, clumped needles, or uniformly distributed needles. The first trial was run for ~ 6 months, with a second trial underway. Net methane emissions have been collected ~ weekly after the removal of ebullition bubbles, and needle mass loss was measured at the conclusion of the first trial. During the first trial, needle mass loss followed predictions, with a 2% higher mass loss in the uniform treatment than in the clumped treatment. However, net methane emissions appeared higher in the clumped treatment compared to the uniform treatment. This effect was not statistically significant during the first trial but was during the first three months of our second trial. Net methane emissions reflect the balance between methanogenesis and methanotrophy. Given these results, we hypothesize that in this system, methanotrophy has primary control over net methane emissions due to the patchiness of the methane resource, limitations on oxygen diffusion to methane patches, and the non-linear relationship between carbon consumption via methanotrophy and the ratio of methane-to-oxygen resources. Further work will be needed to test this hypothesis. In our second trial, we are also assessing the effect of resource spatial patterning on methane ebullition using a semi-quantitative camera trap approach. These results are forthcoming.

Poster Session

1. Fabrication of a Composite Polymeric Membrane Made with Eco-Friendly Solvents for Water Filtration

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Water filtration via polymeric membranes is one of the most efficient ways to assure access to clean water. However, most membranes are made with petroleum-derived solvents which can be toxic to work with during fabrication and negatively impact the environment. In the interest of sustainability, research on alternative materials has shown that green solvents such as Rhodiasolv® PolarClean and gamma-valerolactone (GVL) can be used in conjunction with the polymers polysulfone (PSF) and polyvinylidene fluoride (PVDF) to fabricate membranes with high permeability associated with PSF and selectivity of PVDF. The objective of this research is to make a composite membrane using both polymers so that the filter can have the benefits of both. A composite membrane like this has not been made before, as it is difficult to cast the two layers simultaneously due to different viscosities, repulsive charges, and delamination. By characterizing PVDF and PSF membranes separately and then using different casting methods to combine them, a solution to this challenge can be found to cast a composite membrane. PSF and PVDF membranes were characterized by observing the phase inversion rate, diffusivity, water contact angle, pore structure, and permeability. Then, different casting methods were examined, first in lab scale casting with a doctor blade extrusion and then in scaled casting with a slot die coater. It was found that having a similar viscosity and rate of phase inversion aided in making a stable composite membrane. A sustainable composite membrane made of both PVDF and PSF will provide the benefits of both a higher flux and selectivity to increase the efficiency of water filtration. The main function of the composite membrane will be to filter out particles such as proteins, bacteria, and viruses to prevent disease.

2. Deep Eutectic Solvent-Resistant Membranes for Sustainable Lignin Recovery in Agricultural Biomass Processing: A Comparative Study

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The sustainable processing of agricultural biomass has become increasingly important in the pursuit of eco-friendly practices within the agricultural sector. Lignin, a complex aromatic polymer found in lignocellulosic biomass, presents a valuable resource when effectively separated from agricultural waste. This study focuses on the development and comparative analysis of deep eutectic solvent (DES)-resistant membranes for efficient lignin recovery, a critical step in sustainable biomass processing with significant implications for soil health and agricultural sustainability.

Our research investigates the performance of membranes fabricated from poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP), and polybenzimidazole (PBI), in recovering lignin from lignin-DES mixtures. These deep eutectic solvents offer advantages such as low toxicity and biodegradability, making them ideal for environmentally conscious agricultural applications. However, their corrosive nature necessitates the development of robust, DES-resistant membranes. This research aims to identify the most promising membrane candidates for efficient lignin recovery in sustainable agricultural biomass processing.

The findings have potential implications for soil amendment practices, as recovered lignin can be used to enhance soil organic matter content, improve soil structure, and promote carbon sequestration in agricultural soils. By advancing membrane technology for lignin recovery, this study contributes to the development of sustainable agricultural practices and the valorization of agricultural waste streams.

3. Riparian Repairing: Effects of Conservation Efforts on Microbial Communities and Soil Characteristics

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Urban environmental management is a growing field of study due to the increased risks of climate change and greater awareness of anthropogenic impact. However, the dominant urban management practice is mowing, which reduces biodiversity and compacts soil. Alongside this, urban development places extreme stress on streams, and managers and planners are increasingly interested in alleviating urban effects on streams. Riparian buffer zones have been proven to improve water quality and reduce nitrates in rural, agricultural settings, but there is not much research about their impact regarding environmental contaminants, soil characteristics, and microbial communities in urban areas. To better understand the benefits of riparian buffer zones, this study looks at soil compaction, infiltration, chemistry, and microbial communities across nine sites in Lexington, KY. At each site, compaction and infiltration were measured and soil samples were collected. Soil samples were split between soil fertility measurements and 16s rRNA microbial sequencing. Riparian buffer zones had statistically significant lower compaction ($1.07 * 10^6$ Pa, $1.40 * 10^6$ Pa) and statistically significant higher infiltration (9.76 L/hr, 4.88 L/hr) than mowed zones. Soil organic matter (5.18%, 4.27%) and potassium (226.52 mg/kg, 328.96 mg/kg) differed significantly between riparian buffer and mowed zones, while total nitrogen, phosphorous, pH, and Shannon alpha diversity had no significant differences ($p < 0.05$). Age was shown to be correlated with soil characteristics and Shannon alpha diversity in riparian buffer zones but had no impact on mowed zones. Beta diversity was statistically significant between the buffer and mowed zones ($p < 0.05$). Both the riparian buffer and mowed zones are dominated by the phyla of Proteobacteria (Pseudomonadota), Verrucomicrobia (Verrucomicrobiota), Acidobacteria (Acidobacteriota), and Actinobacteria (Actinomycetota). Compared to mowed zones, riparian buffer zones improved desirable soil characteristics related to urban environmental management.

4. Life Cycle Assessment to Inform Sustainable Design of Constructed Wetlands

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Constructed wetlands are a type of green infrastructure that seeks to improve water quality through natural processes, including vegetation, soils, and their associated microbial ecosystems. To better understand these systems, mesocosm wetlands with different designs (e.g. surface and subsurface flow regimes) were established in Summer 2022 in the city of Norman, Oklahoma, by researchers at the University of Oklahoma. The objective of this research is to estimate the potential global environmental impacts associated with both the construction and operation phases of a constructed treatment wetland using life cycle assessment (LCA). The LCA follows four steps: goal and scope definition, inventory, impact assessment, and interpretation. To estimate the environmental impacts of the construction phase, small scale mesocosms representing two potential flow regimes, surface and subsurface, have been constructed. The life cycle inventory for these established mesocosms was based on material and construction data provided by University of Oklahoma researchers. After the inventory was developed, impact assessment was conducted using the Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI), developed by the U.S. EPA. For the operation phase, a literature review was conducted to estimate direct greenhouse gas emissions that are produced during the system's lifetime, assumed to be 25 years. Emission data from these studies has been compiled and normalized to wetland surface area. To better understand the influence of specific design parameters, uncertainty and sensitivity analyses were conducted using Monte Carlo methods and Spearman's rank correlation coefficients, respectively. To better contextualize this research, a supplementary literature review was conducted for 82 studies applying LCA to treatment wetlands. This review considered functional unit, influent water source, and life cycle impact categories. The end goal of this research is to help inform sustainability decision-making regarding constructed wetlands for stormwater management and wastewater treatment and reuse.

5. Navigating Sustainability Impacts of Bioretention Design for Stormwater Reuse

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Modern urban environments not only reduce the pervious land area available for stormwater infiltration but also alter the quality of runoff, impacting its potential for harvesting and reuse. Bioretention systems, also known as rain gardens or biofiltration, offer a promising approach to decentralized and nature-based water infrastructure for managing, treating, and potentially reusing stormwater. Gaining insight into their sustainability implications would therefore enhance the design and operation of these systems for non-potable stormwater reuse beyond management and control goals. However, questions remain regarding potential human health risks and environmental impacts, and how to navigate potential trade-offs.

This study evaluates environmental and human health risks from urban stormwater reuse using bioretention mechanistic modeling paired with quantitative microbial risk assessment (QMRA) and life cycle assessment (LCA) under uncertainty. Design alternatives are compared for treating polluted stormwater. This study investigates the influence of different stochastic configurations of bioretention media (including sand, compost, woodchips, and loam) on removing pathogens, to model human health risks associated with reuse. Modeled health risks from *Campylobacter jejuni* and *Cryptosporidium* were analyzed for different exposure routes (i.e., ingestion through irrigated salad, washed salad, urban farming, and recreational swimming). Disability-adjusted life years (DALYs) across various population scenarios (i.e., 1,000; 50,000, and 100,000 people) were used to compare findings from modeled human health risks with literature-reviewed bioretention environmental impacts quantified with LCA.

Results showed that media composition had minimal influence on modeled human health risk. Under uncertainty (using Monte Carlo methods), the washed salad had the highest median annual risks from stormwater reuse compared to other exposure routes, with the health risk from *Cryptosporidium* being higher than that from *Campylobacter jejuni*. *Cryptosporidium* led to higher DALYs in the washed salad while DALYs from *Campylobacter jejuni* were high in irrigated salad. A correlation between runoff influent concentrations and modeled health risks was observed, emphasizing the importance of stormwater pretreatment in bioretention design. This study underscores the need to balance stormwater reuse benefits with potential public health and environmental risks. These findings will inform future research combining dynamic bioretention modeling, LCA, life cycle costing (LCC), and multi-criteria decision analysis to explore sustainability trade-offs and holistically guide bioretention design decisions for water reuse.

6. Cooling Tower Stormwater Harvesting Projects

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Approximately 40% of the annual water use of the University of Kentucky (i.e., 500 million gallons) is used in support of heating and cooling facilities. One of these facilities, Central Cooling Utility Plant (CUP) #4 uses over 45 million gallons of water a year. In 2023, a cooling tower stormwater harvesting project was implemented at CUP #4 which involved diverting, filtering, and treating stormwater from UK's south campus for use in augmenting the water used for evaporative cooling normally obtained from Kentucky American Water Company. In its first summer of operation, the project was able to save the University approximately $31,000 in operational costs.

This project involves the development and linkage of an EPA SWWM model of the University of Kentucky stormwater system with a KYPIPE model of the piping of the stormwater harvesting system for forecasting stormwater discharges and optimizing the performance and cost of the harvesting system. It is anticipated that the developed model will help in the operation of the existing facility as well as extending this concept to other UK cooling plants and other industrial and commercial applications.

7. Fate and Transport of Nanopesticides in Agricultural Field Plots in Central Kentucky

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Nanopesticides are an emerging class of pesticides associated with engineered nanoparticles. While nanopesticides provide agricultural and environmental benefits, their fate, transport, and persistence are not well understood nor are their potential impacts to the health of agroecosystems. Therefore, this project focused on the fate, transport, and persistence of two widely available nanopesticides, nano-imidacloprid insecticide and nano-copper hydroxide fungicide, as well as their impacts on nutrient cycling in agroecosystems. Research objectives included: 1) Quantify the transport and persistence of the target nanopesticides, 2) Determine nanopesticide impacts on soil nutrient cycling, and 3) Examine impacts of soil and rainfall conditions on nanopesticides transport and persistence.

Agricultural field plots were constructed and evaluated in Central Kentucky at the University of Kentucky North Farm. Thirty field plots measuring 2.4m x 6m and consisting of native soils surrounded by metal barriers were planted with pumpkin seeds in summer 2023. Plots were divided into five treatment groups: control (C), nano-copper hydroxide (Cu), nano-copper hydroxide and nano-imidacloprid (CuNI), nano-imidacloprid (NI), and standard imidacloprid (I). The application of differing pesticide combinations to the varying field plots allowed the impacts of the pesticides on nutrient retention to be analyzed. Further, the treatment combining nano-imidacloprid and nano-copper hydroxide provided data on potential interactions between the two pesticides. Immediately following pumpkin planting nano-imidacloprid and standard imidacloprid were applied as a soil drench to the relevant plots at agronomically recommended rates. Similarly, nano-copper hydroxide was applied directly to leaves once plants emerged at agronomically recommended rates. Rainfall runoff for every rainfall event capable of generating measurable runoff was collected from each plot between planting and harvesting during the growing season of 2023. Additionally, a single pre-planting/pesticide application rainfall event was also sampled to ensure all plots did not have residual pesticides from previous years. Soil samples were taken before planting and after harvesting to access for metals. Rainfall samples were analyzed in the field using a YSI EXO multiparameter sonde for physiochemical properties, then water samples were separated and preserved for later lab analysis for concentrations of: nitrate-N, ammonia-N, phosphate-P, total organic carbon, TKN, imidacloprid, imidacloprid byproducts, and copper. Based on preliminary results, imidacloprid is primarily transported off fields during the first flush rainfall event. Additionally, copper hydroxide nanopesticide was found to potentially increase the runoff of both nitrogen and phosphorus.

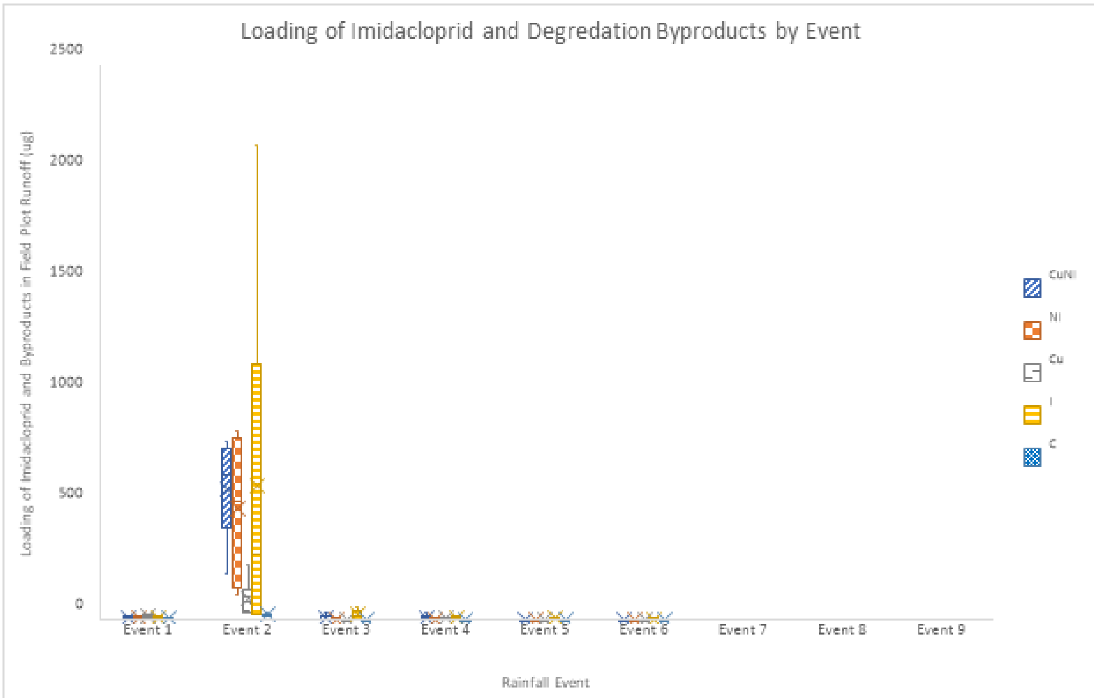

Figure 1: Loading of the sum of imidacloprid and its degradation by-products in runoff by treatment and event. Application occurred between events 1 and 2.

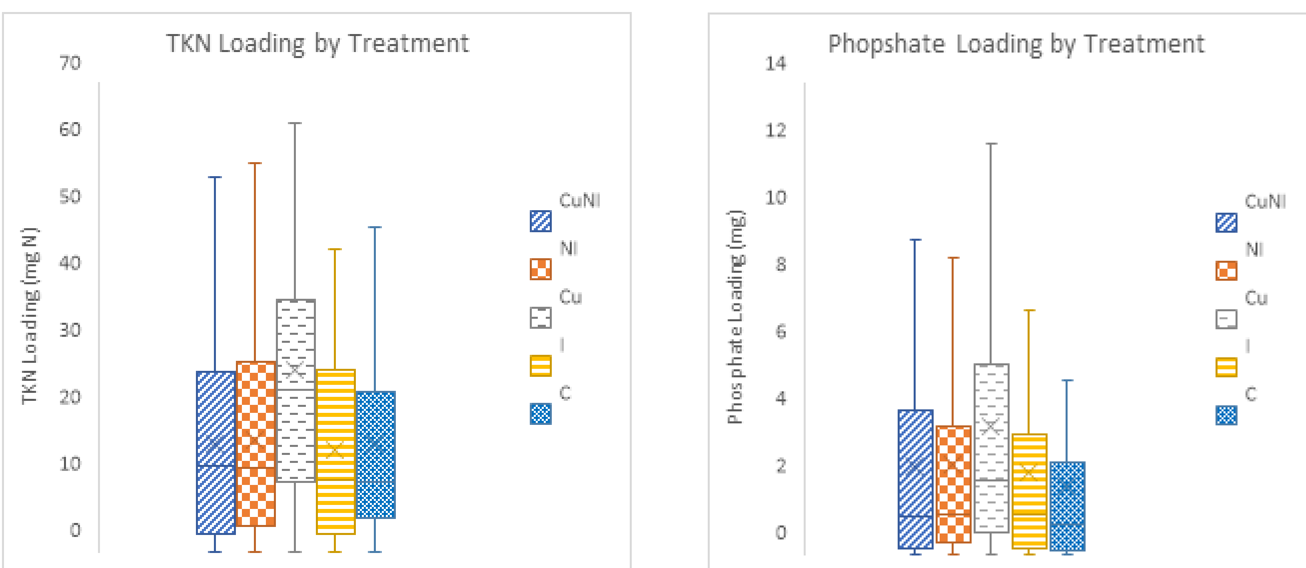

Figure 2: Total Kjeldahl Nitrogen (TKN) loading by treatment group (Left) and Phosphate (PO4) loading by treatment group (Right). Loading was highest for both from Copper Nanopesticide (Cu) Plots.

8. Glenns Creek Watershed Project

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The Glenns Creek Watershed in Woodford and Franklin County Kentucky supports some of Kentucky's most well-known, signature industries including thoroughbred horse farms and distilleries. The goal of this community engaged watershed planning project was to better understand the role of watershed resources in the local community and to characterize the health and impairments of the waterways.

A three-phase community informed research approach was utilized to understand the communities' perspectives on water resources to inform appropriate outreach and engagement approaches and choose the most successful path for watershed improvement. Interviews with 29 key community stakeholders and an online community survey with 49 participants. Results revealed community recognition of the importance of water resources for drinking water, on-farm usage, water recreation, and distillery source water use. While 60% use the waterways for some type of recreation, 67% either did not know or did not believe the water is safe for wading or swimming. Chief concerns included wastewater contamination, urban stormwater, litter, agricultural impacts from manure, overgrazing, or fertilizer use.

Monitoring for water chemistry, stream habitat, and aquatic macroinvertebrates was conducted over a one-year period from March 2021 to February 2022 by the University of Kentucky and Kentucky Division of Water. Follow on surveys were conducted to trace pollutant sources in key areas and to survey streambank erosion. Results showed impacts due to fecal indicator bacteria, nutrients, aquatic life, habitat degradation, bank erosion, trash and litter, and dissolved solids. In urban areas, potential pollution sources include human sewage, pet waste, lawn fertilization, impervious surface runoff, litter, and road salt. In rural areas, sources include legacy soil nutrients, manure management, rural septic systems, fertilizer management, livestock stream access, stream erosion, and low-head dams.

Focus groups are being held to prioritize best management practice selection to achieve pollution reduction goals.

9. Investigating Controls of Flash Floods in the Headwaters of the Cumberland Plateau Using Process Based Modeling*

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Climate change is expected to alter the frequency and magnitude of extreme precipitation patterns throughout much of the US. This threatens to increase flash flooding in many communities, particularly those located within floodplains, as found throughout central Appalachia. Yet, how climate change and flash floods manifest on the Cumberland Plateau in central Appalachia remains uncertain. In particular, little is known regarding the mechanisms controlling flash floods in small headwater streams, which make up over 80% of total stream network length in this part of the US. Our goal is to better understand flood response in headwater catchments and the role of these systems in the generation of floods in downstream water bodies. We investigated flood generation in headwater systems utilizing a ~20-year precipitation and hydrology dataset from UK's Robinson Forest. We analyzed bankfull flow events using an event-scale, process-based hydrologic model that estimated the contribution of headwaters to downstream floods and the dynamics of headwater streamflow during flood periods. This study characterized flooding responses to low, mid, and high-intensity precipitation events in both 1st order headwater streams (< 1-km^2) and larger 2nd and 3rd order streams in which those headwaters are nested (~14-km^2). Model calibration was carried out by optimizing discharge simulations at both the outlet of the watershed and within 1st order streams. Preliminary results indicated that 1st order streams play a large role in the volume of water transported during flooding events, contributing over 75% of the total volume transported at the outlet of the study watershed. Results also indicated that the variability in flood magnitude is associated with specific geomorphic and antecedent moisture conditions. For example, high correlation was found between hillslope area and the volume of discharge produced in a subcatchment. However, we found that this relationship varied as a function of storm intensity and duration. Utilizing this approach, we intend to evaluate flash flood response in other physiographic regions of the US and evaluate its utility.

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10. Assessing the Impacts of Climate Change on Headwater Streamflow Regime in Appalachia, USA

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Headwater streams are critical components of river networks, providing essential ecosystem functions such as nutrient cycling, habitat for diverse species, and regulation of downstream water quality. These streams are highly sensitive to changes in precipitation, temperature, and land use, making them particularly vulnerable to the impacts of climate change. The Appalachian region, with its unique physiographic characteristics and ecological significance, represents an important area for studying these impacts. Streamflow regimes, defined as the frequency, magnitude, duration, timing, and rate of change of surface streamflow, structure ecosystems and are critical measures for stream protection under the Clean Water Act. While the impact of climate change on streamflow regimes has been broadly quantified across much of the US, its effect on the Appalachian region remains uncertain. This study aims to quantify shifts in streamflow regimes due to climate change in undisturbed headwater catchments in Appalachia using hydrological signatures and trend analyses. We examine data from multiple headwater catchments in several Appalachian research forests, each with similar contributing areas but different aspects, flow directions, and structural configurations. To assess shifts in streamflow regimes, we utilize the Mann-Kendall trend test coupled with Sen's-slope analysis, focusing on hydrologic signatures reflecting the frequency, magnitude, duration, timing, and rate of change of surface streamflow. Our investigation encompasses multiple time scales and windows, providing an understanding of recent climate-change effects on headwater streamflow dynamics in Appalachia.

Preliminary analyses in the Cumberland Plateau of Appalachia in the University of Kentucky's Robinson Forest indicate that a dendritic catchment with evenly distributed aspect exhibited increased streamflow permanence and magnitude, while a trellis catchment with increased southern-facing slopes demonstrated increased duration of no-flow periods and higher magnitude of high-flow events. These findings provide valuable insights into headwater hydrology and its response to climate change, highlighting the significance of understanding hydrologic trends for informing effective water resource management strategies in the broader Appalachian region.

11.Blue Water Farms: Edge of Field Nutrient and Sediment Monitoring Network in Western Kentucky

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Blue Water Farms is a working partnership between nine anonymous landowners, Kentucky Soybean Promotion Board (KSPB), Kentucky Agricultural Development Fund (KADF), U.S. Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS), University of Kentucky Martin-Gatton College of Agriculture, Food and Environment (UK Martin-Gatton CAFE), and Kentucky Geological Survey (KGS) to reduce nutrient and sediment losses from agricultural fields through the application of best management practices (BMPs). This is a network of twenty-nine EOF water quality and quantity monitoring stations distributed throughout western Kentucky.

Twenty-two monitoring stations, located in the lower Green River and lower Cumberland River watersheds, are part of a national USDA-NRCS Environmental Quality Incentives Program (EQIP) conservation monitoring activity. Seven monitoring stations in the lower Green River, West Fork Clarks River, Obion Creek, and Mayfield Creek watersheds are located on retired cropland that is part of USDA-NRCS Agricultural Conservation Easement Program Wetland Reserve Easement (ACEP-WRE). BMPs were selected with input from landowners and include poultry litter incorporation, grassed waterways, water and sediment control basins (WASCoB), cover crops, and returning floodplains and other flood-prone, row-crop agricultural fields to forested wetlands.

NRCS Conservation Activity Codes 201 and 202 are followed for paired watershed study design and implementation. The outlet of each watershed is instrumented with a flume, an ultrasonic flow meter, an automated composite water sampler, and a rain gauge. Water samples collected from each runoff generating precipitation event are analyzed for nutrients (ammonium nitrogen, nitrite plus nitrate nitrogen, total Kjeldahl nitrogen, total dissolved phosphorus, and total phosphorus) and total solids at University of Kentucky labs. In addition, surface water discharge and precipitation measurements are recorded.

Runoff generating precipitation event-based water quality and quantity sampling began in 2018 with a staggered installation of monitoring stations until 2021 when all stations became active. Since then, due to landowner and funding changes, sampling has either been temporarily or permanently halted at ten monitoring stations. All stations have completed the baseline monitoring and are currently in the treatment monitoring phase. This long-term research project is ongoing but initial results show mixed results regarding nutrient and sediment retention using studied BMPs.

12. Phosphorus Removal at the West Hickman Wastewater Plant- What Can Be Done to Quickly Solve This Arising Problem

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The West Hickman Wastewater Treatment Plant in Nicholasville, KY has run into problems with its biological phosphorus removal (BPR) system. This system was implemented over a decade ago and had appeared to be running smoothly until phosphorus concentrations began to increase over time. With the seasonal KPDES permit limitations on the horizon, something was needed to figure out the cause of this problem and what could be done to implement a temporary fix to the plant that would be efficient and cost effective until a permanent fix was discovered. From this main query, several experiments were conducted over the course of two months to help determine a reasonable outcome.

The preliminary experiments were conducted to determine whether a denitrification zone would have a positive impact on the process and how long it would take for a return-activated sludge (RAS) sample to naturally denitrify. Next an inorganic chemical called poly aluminum chloride (PAC), which is commonly used as a coagulant in wastewater treatment plants, was tested to see how the sludge from the West Hickman plant would react with it. This chemical addition was also tested to determine if it assisted in lowering the phosphorus concentration of the plant effluent. Another series of experiments were conducted to test out different plant configurations of biological phosphorus removal by simulating small scale processes in ten-gallon (37.9 L) buckets. The different plant configuration set ups were: Phoredox (A/O), Conventional (A_2O), and Sidestream Enhanced Biological Phosphorus Removal (S_2EBPR). The S_2EBPR configuration was also tested with the addition of PAC to determine if adding it to the stream of effluent entering the final clarifiers was the best location. Based on the data from all these experiments, it can be determined that denitrifying the RAS before it enters the BPR tanks with the raw influent does have a positive affect on the release of phosphorus in the BPR tanks. After analyzing the data, PAC appears to lower phosphorus by a fixed amount depending on how many moles of the substance is added to the sample. Even with the presence of either low or high amounts of solids in the plant, the PAC still removed about the same concentration of phosphorus in each scenario when its concentration is within the range of high performance. This hypothesis still held true in the experiments where the S_2EBPR method worked in tandem with PAC. Furthermore, until the West Hickman Wastewater Treatment Plant is able to come up with a more permanent fix to the arising problem, the addition of PAC appears to be a very effective chemical remediation to lower phosphorus in their time of need.

13. Stable Isotope Tracing of Nitrate Sources During Precipitation Events in a Kentucky Karst Watershed*

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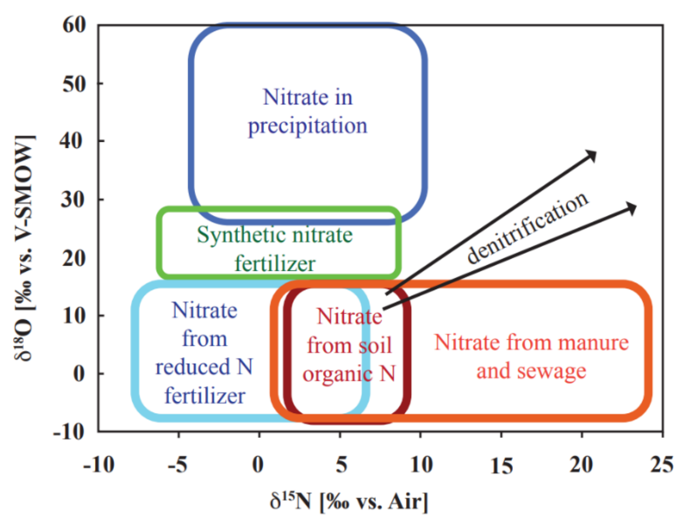
Excessive nitrate (NO3-) levels in aquatic ecosystems can lead to environmental and public health issues such as eutrophication, harmful algal blooms, and hypoxia. These problems are particularly severe in karst watersheds, where nutrients can be quickly transported to vulnerable regions. This study aims to identify and quantify nitrate sources in a karst watershed in Central Kentucky during precipitation events. Using stable isotope analysis of nitrate (δ15N and δ18O), we differentiate between atmospheric, agricultural, and other anthropogenic sources. Additionally, we employ δ17O nitrate to trace atmospheric sources and the influence of rapid flow paths in karst environments.

Camden Creek, located in the inner Bluegrass region (Woodford County), is our research site due to its extensive history of nutrient-dynamic studies within a karst agroecosystem. Previous research by Radcliffe and Ford (2020) on dissolved reactive phosphorus (DRP) emphasized the critical roles of storm events, seasonal variability, subsurface transport, and land use in nutrient dynamics. Their findings highlighted the complexity of nutrient transport in karst watersheds and the need for targeted management strategies to mitigate pollution. Our addition of nitrate isotope data will build on these findings.



Preliminary results from storm event nitrate isotope ratios show a significant influence of precipitation on nitrate isotopic compositions. We observed fluctuations in δ15N and δ18O values during storm events compared to baseline conditions. Specifically, δ15N values shifted from 7.1025 during baseflow conditions to 5.47 during the precipitation event, then to 5.41 directly after the precipitation event. These values indicate nitrate from reduced fertilizer being transported via runoff and infiltration into stream water. Rainwater infiltration leads to a complex mix of nitrate from atmospheric deposition, agricultural runoff, and other anthropogenic sources. δ15N values typically reflect agricultural contributions, while δ18O values indicate atmospheric deposition. Initial data reveal that during storm events, δ15N values suggest a predominant contribution from agricultural runoff, mobilized by increased surface flow and infiltration, while δ18O values indicate an influx of atmospheric nitrate from direct precipitation and rapid surface runoff. These shifts in isotope signatures during storm events support a blending of sources via dynamic mixing.

Ongoing work involves comprehensive sampling during storm events to capture the transient nature of nitrate transport in the karst system. We will collect samples from multiple sites within the watershed, including streams, groundwater, and precipitation, to build a robust dataset. This approach will help us examine temporal and spatial variations in nitrate concentrations and isotopic signatures, informing effective management strategies to mitigate nitrate pollution and protect environmental and public health. Future work will focus on interpreting the isotopic data to develop comprehensive strategies for nutrient management and pollution mitigation.

This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-02, WRRA 104B Annual Grant Program

14. Evaluating Karst Susceptibility and Vulnerability for the Lincoln Trail Area Development District, Kentucky, from High-Resolution Data and a Ranking-Based Approach

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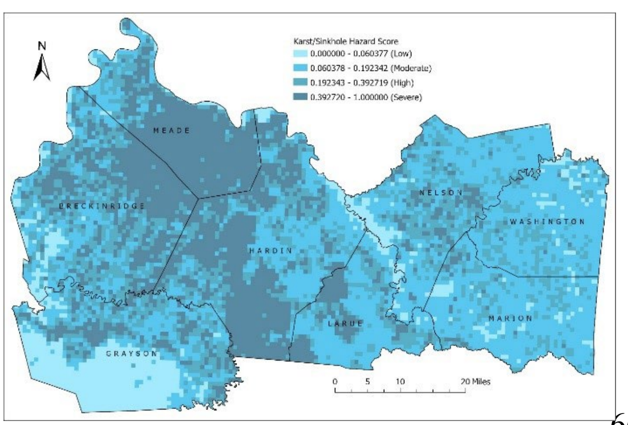
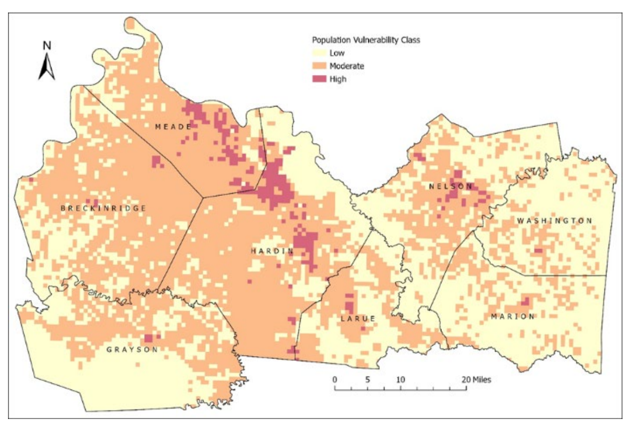
Karst-related subsidence and sinkhole collapses are nationally recognized hazards. In Kentucky, approximately 50 to 60 percent of the state has karst or potential for karst, and about three million Kentuckians live in karst areas. Although injuries and deaths related to sinkholes are rare, damage to buildings, highways, and other infrastructure is common. Sinkhole-related events cost tens of millions of dollars in damages annually for Kentucky. Understanding susceptibility to karst and sinkhole development is critical in assisting mitigation activities and reducing losses from sinkhole-related events.

More than 70 percent of the Lincoln Trail Area Development District (LTADD) areas in central Kentucky are underlain by karst topography. Sinkholes, sinking streams, and springs are widespread. To evaluate karst susceptibility and vulnerability for the region, we first utilized high-resolution lidar-derived digital elevation data and aerial photography with assistance from a neural network model to delineate sinkhole distributions. Our method mapped 50,944 sinkholes for LTADD, almost three times the number of sinkholes recorded in a 2003 sinkhole inventory for the same region. We then incorporated the improved sinkhole data with karst characteristics of the bedrock geology to derive karst hazard scores. These scores were classified into four levels to illustrate karst susceptibility variations in the region (figure on the bottom left). Finally, leveraging the karst susceptibility evaluated with new data, we developed a ranking-based approach to assess vulnerability of infrastructure and population to karst and sinkholes. Infrastructure was divided into five development classes based on percentage of assets. The development classes were then intersected with karst hazard categories to generate infrastructure vulnerabilities. Population vulnerabilities were assessed by grouping population data from the US 2020 Census into five classes and intersecting population classes with karst hazard categories (figure on the bottom right). Our next step is to apply this method to the Barren River Area Development District with an overall goal of improving karst susceptibility and vulnerability evaluation for all karst areas in Kentucky.





15. On-Farm Water Management Small Scale Grants for Kentucky Specialty Crop Growers

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Water is an essential input for specialty crop production and rarely is rainfall uniformly distributed. Crops are particularly sensitive to water stress at establishment which can lead to high mortality, suppressed growth rate, delayed maturity, and reduced yields. Other effects of moisture stress during production include diminished plant health, poor nutrient utilization, lower yields, and compromised crop quality. Farms in Kentucky use a combination of municipal, surface, and ground water sources to supply or supplement rainfall during production and post-harvest activities. Produce growers require a consistent, safe supply of irrigation water and are becoming much more interested in implementing water resilient strategies at all scales of operation.

In 2023, the Kentucky Horticulture Council (KHC) launched an On-Farm Water Management Small-Scale Grant (OFWM SSG) Program that provides financial support to promote water resiliency on farms in Kentucky producing specialty crops for commercial sale. The program originated with the Kentucky Agricultural Development Board (KADB) as a program for private farms interested in implementing best management practices for on-farm water management. This program transitioned from KADB to KHC in 2023.

Program eligibility requirements are based on farm income, presence of an existing water source, and inclusion of at least one Best Management Practice (BMP) with a direct water quantity benefit. Multiple practices and those with indirect benefits are also encouraged. USDA Natural Resources Conservation Service (NRCS) Conservation Practices establish guidelines for farm practices. The program is a 1-year cost-reimbursement grant, where applicants are eligible for reimbursement of 50% of the total project cost, up to $10,000. Eligible expenses are related to installation of water resource BMPs or approved innovative designs for water resource management. To extend the benefits of this program, growers must agree to an educational component where they transfer knowledge to other growers.

In year 1 (2023), 4 growers applied to the program, with 3 ultimately investing $49,039 in farm projects and $19,917 returned to growers in cost-share reimbursement. Between January and June of year 2 (2024), 8 growers have applied to the program, with 1 project completed totaling $34,605. Many other projects are progressing and will be completed before the end of the year. Implemented practices for completed projects are listed in Table 1.

Farm impact from implemented practices include: improved delivery of irrigation water; reduced dependency on municipal water sources; lower production costs through reduced municipal water usage; and improved water quality. Because of the high farm impact, KHC will request funds from KADB to continue this on-farm cost-share program in 2025-2026.

Table 1. Best Management Practices Implemented by Growers Participating in the Kentucky Horticulture Council On-Farm Water Management Small-Scale Grant Program (January 1, 2023 – June 30, 2024).

Best Management Practice (USDA Natural Resources Conservation Service Conservation Practice Code)
Irrigation Pipeline (430)
Irrigation System, Microirrigation (441)
Irrigation System, Surface and Subsurface (443)
Irrigation Water Management (449)
Sprinkler System (442)
Pumping Plant (533)

16. Sampling Kentucky Ground and Surface Water Sources Used for Produce Pre- and Post-Harvest Activities

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Agricultural water is defined by the FDA as water that is intended to, or is likely to, contact the harvestable portion of fruit and vegetable crops or food-contact surfaces. Contact may occur during pre-harvest (production) or post-harvest activities. Microbial water quality is generally based on detection of non-specific *E. coli*, an indicator of fecal contamination in a water source, although other pathogens can cause human health concerns.

Between 2019 and 2024, the Kentucky Horticulture Council (KHC) and the National Farmers Union's Local Food Safety Collaborative (LFSC) have partnered to educate Kentucky farmers on basic food safety practices and provide on-farm technical assistance. As part of this project, 36 growers across different regions of Kentucky participated in ag water sampling activities. A standard protocol was used to collect samples submitted to laboratories using FDA-approved testing methods to detect total coliforms and *E. coli*.

The Produce Safety Rule (PSR) of the Food Safety Modernization Act (FSMA) establishes science- and risk-based standards for the safe growing, harvesting, packing, and holding of fruits and vegetables grown for human consumption. Based on Subpart E of the PSR, acceptable sanitary profile characteristics for *E. coli* are 126 or fewer colony forming units (cfu) per 100 mL and 410 or fewer cfu per 100 mL for the geometric mean (GM) and statistical threshold value (STV), respectively, for production water. Post-harvest water must not contain any detectable *E. coli* (0 cfu per 100 mL sample). For ag water sources sampled in this project, *E. coli* ranged from <1 to 9,500 cfu/100mL per individual sample. Sample sets of 5 or more samples per water source had a calculated GM range of 1 to 417 cfu/100mL and STV range of 1 to 5,370 cfu/100mL, indicating a high level of variability.

The initial PSR required producers to collect 20 samples during the growing season to establish a baseline microbial water quality profile, then sample annually to maintain the profile. In May 2024, a new Rule was adopted eliminating mandatory sampling, requiring farms to conduct an annual systems-based agricultural water assessment to determine risk for each water source being used for pre-harvest activities. Compliance dates apply in 2025-2027, based on farm revenue tiers.

Kentucky has over 2,173 farms growing vegetables for fresh market sales and an additional 2,274 orchards growing tree fruits and berries, according to the 2022 USDA Ag Census. More than 2,063 small-scale farm families grow produce for fresh market sales and more than 2,300 growers use irrigation technologies to manage crop moisture. KHC will continue to provide food safety education and work with produce growers on seasonal risk assessments to ensure best management practices for ag water sources used for pre- and post-harvest activities and implementing mitigation measures when a human health risk is determined.

17. Surface Roughness and Topographic Change at a Reclaimed Mine Site. A Preliminary Assessment Using Lidar Data

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Attempts at reforestation of reclaimed mine sites in Appalachia rely on subsurface ripping of reconstituted terrain surfaces [(1)]. A possible result of this management practice is an increase in surface roughness which may influence water movement and storage, and nutrient and sediment transport patterns[(2)(3(4)]. Mapping of surface roughness and micro-topography has been achieved by both field measurements and also proximal and remote sensing[(5)(6)(7)]. For almost a decade and a half, the Commonwealth of Kentucky has conducted laser altimetry surveys with fixed wing, crewed aircraft[(8)]. The existence of multi-temporal lidar datasets presents an opportunity for studying the evolving surficial characteristics of these young landscapes. This study involves two locations at a reclaimed mine site in Martin County, Kentucky where cross-ripping was conducted between December 20, 2022, and February 13, 2023, and as evidenced on multi-temporal lidar data (2019 and 2024) (Figs. 1a, 1b, 2a and 2b). QGIS Desktop software version 3.34.7-Prizren and ArcGIS Pro version 3.3.1 were used to calculate the spatial variations in roughness and topographic position index (TPI). As expected, an increase in roughness at both sites was observed. (Figs. 3a, 3b). Regular patterns of topographic variations were also evidenced at both sites (Figs. 4a, 4b). Additional results presented will include the effects on flow direction and accumulation and potential surface storage due to the practice of cross-ripping. These results merit further investigation for their implications on the hydrologic and hydraulic properties of these new
ecosystems.

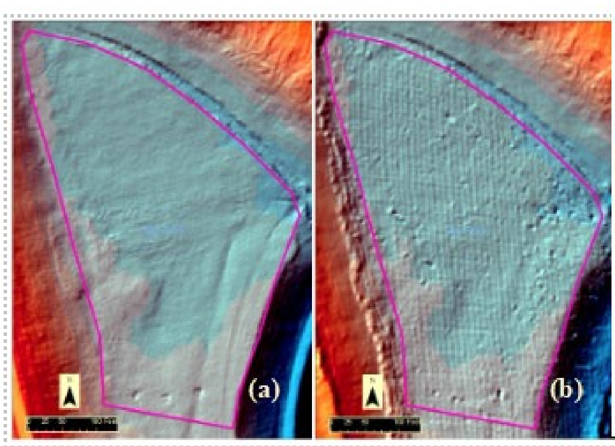

Figure 1: Area 1 (a) 2019; (b) 2024

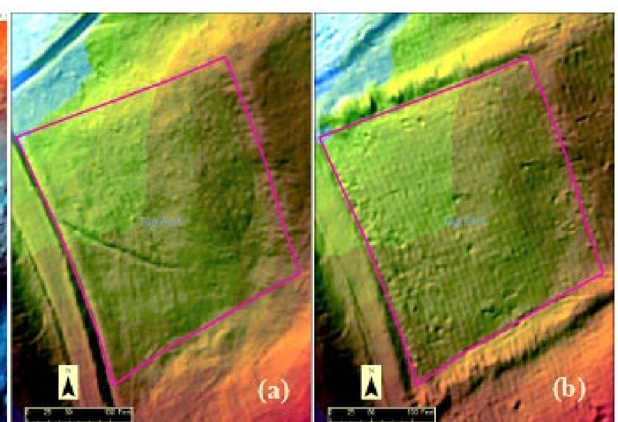

Figure 2: (a) 2019; (b) 2024

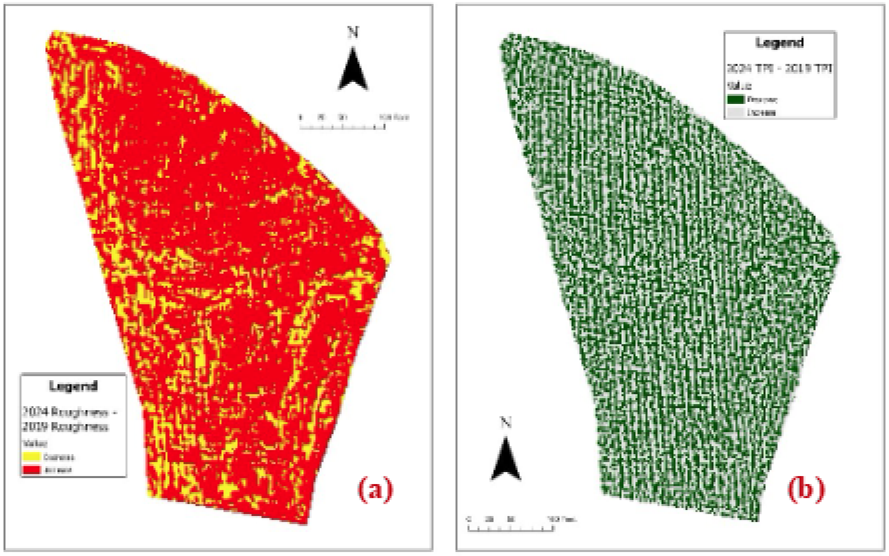

Figure 3: Area 1. (a) Difference in Roughness; (b) Difference in TPI

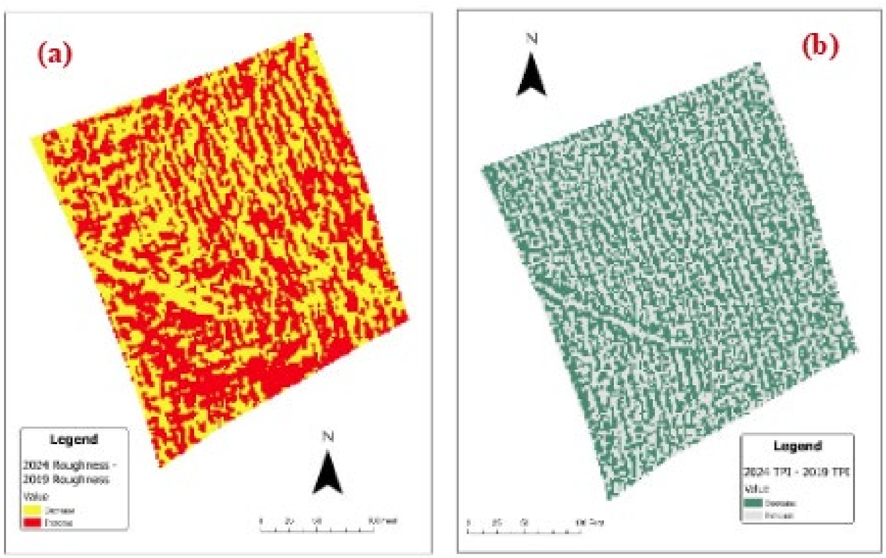

Figure 4: Area 2. (a) Difference in Roughness; (b) Difference in TPI

18. Helping Small-Scale and Socially Disadvantaged Farmers with Irrigation Water Quality

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More than 75% of farmers in Kentucky have produce sales of less than $25,000 per year; a threshold that is below which growers are strongly encouraged to implement the Produce Safety Rule (PSR) of the Food Safety Modernization Act (FSMA). Many growers use surface water sources for irrigation that can lead to pathogenic *Escherichia coli* (*E. coli*) contamination of produce. The purpose of this project is to improve income and economic opportunities for small and socially disadvantaged farmers by helping develop tools for improving water quality and improve produce safety and thereby increase grower production.

Since November 2022, water samples were collected from farms and tested for presence and enumeration of *coliform* bacteria along with *E. coli.* Testing was performed using an IDEXX Colilert Test using Quanti-Tray/2000 system using Most Probable Number Method (quantitative, MPN/100ml); a test approved by United States Food and Drug Administration's (FDA) 21 CFR 112 method.

As of July 2024, 279 individual tests have been performed, from 87 different producers across 13 counties throughout the Commonwealth of Kentucky. Overall, 77.1% of samples were detected with *E. coli* counts within the permissible limits of <126 CFU/100ml, of which 60.9% were groundwater and 16.1% were surface water sources. The remaining 22.9% of samples had *E. coli* counts >126 CFU/100ml, with 0.7% being groundwater and 22.2% surface water. This project provides technical support for small- and mid-sized producers to become compliant with regulatory and buyer specifications and standards to increase their direct market opportunities.

19. Investigating Methane Fluxes and Porewater Chemistry in Proximity to Bald Cypress "Knees"*

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Bald cypress (*Taxodium distichum*) is a dominant freshwater wetland tree species in the southeastern United States, containing exposed woody root structures known as "knees." Recent studies on wetland carbon emissions have focused on methane (CH_4) fluxes from tree stems, while few studies have investigated CH_4 fluxes from knees, and no studies, to our knowledge, have investigated how knees and their attached below-ground roots may alter soil environments. We are investigating the role of Bald cypress knees in carbon cycling by measuring CH_4 fluxes from the knee surface and adjacent soils and collecting porewater chemistry near and away from knees. We are measuring CH_4 fluxes from knees routinely with changes in water table depth along the edge of Kentucky Lake reservoir at Hancock Biological Station (HBS) and at two channel locations varying in elevation (upper and lower) within Clarks River National Wildlife Refuge (CRNWR). Knee CH_4 fluxes from both the lower (p-value < 0.001, $R^2 = 0.63$) and upper (p-value $= 0.006$, $R^2 = 0.35$) channels are positively correlated with water table depth during warm months, but no correlation is present during cold months. During these warm and wet months, knees in the lower channel have higher rates of CH_4 flux compared to those in the upper channel, likely due to closer proximity to the water table. Porewater chemistry (pH, temperature, conductivity, dissolved oxygen) is being sampled monthly in plots near and away from knees at CRNWR, HBS, and the edge of a depressional cypress pond at Murphy's Pond State Nature Preserve (MPE). In May of 2024, there was no effect of knees on porewater chemistry taken from a depth of 30 cm below the surface, suggesting knees may not affect basic chemical factors. However, the temperature was significantly lower (p-value $= 0.01$) at MPE compared to the other sites. Sampling is ongoing to see if this pattern holds and nitrate (NO_3^-) and dissolved organic carbon (DOC) samples will additionally be tested. Results from this study will be used to highlight the potential role of knees, and other roots, in biogeochemical cycling.

**This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-02, WRRA 104B Annual Grant Program*

20. Impacts of Duckweed (Lemna and Wolffia spp.) on Carbon Storage and Decomposition in Small Ponds*

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Duckweeds are a group of free-floating aquatic plants characterized by their extremely fast growth and ability to colonize the top of nutrient-rich bodies of water across the globe. Duckweeds may outcompete established plant species, reduce aquatic macrophyte and invertebrate abundance, block light and oxygen from entering aquatic habitats, and generate anoxic conditions below the surface of the water. These anoxic conditions may also impact the rate of organic matter decomposition in bodies of water covered by duckweed, but this hasn't previously been tested. The effects of duckweed cover on decomposition may be greater for wood, where the activity of enzymes needed to break down high concentrations of lignin may be hindered by duckweed-induced anoxia. Our study aimed to test this hypothesis by submerging sets of mesh bags, filled with either sugar maple wood or leaves, in two small ponds (one with complete duckweed cover and the other without) near Louisville, Kentucky. Five mesh bags were removed from each pond for measurements at 0, 7, 15, 30, 60, and 90 days of submersion. Once removed, leaves and wood were placed in an incubator with pond water, and microbial respiration rates were measured as oxygen consumption over time. After microbial respiration measurements, leaf litter and wood were dried, and decomposition was measured as % dry mass remaining. We predicted that microbial respiration and organic matter decomposition (mass loss) would be lower in duckweed covered ponds due to low dissolved oxygen selecting against obligate aerobic microorganisms. We will discuss the implications of our findings for carbon storage and carbon balance in small duckweed-covered ponds.

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**This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-02, WRRA 104B Annual Grant Program*

21. Evaluating the Effects of Ecological Restoration Efforts on Stream Health in the Inner Bluegrass Through eDNA Assessment of Invertebrate Communities*

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Despite the growing acknowledgement of the need for urban lotic system restoration, one of the recognized issues with these efforts is the lack of standardized evaluation of restoration success. Environmental DNA (eDNA) metabarcoding, which utilizes massively parallel sequencing to characterize community composition, has been recognized as a highly promising tool for urban restoration assessment. We utilized eDNA metabarcoding of invertebrate communities to evaluate the effectiveness of stream restoration efforts in seven streams in Lexington, Kentucky that have undergone reforestation or reforestation and channel restoration. eDNA water samples (2 liters) were taken at the base of the restored area and at a site 100-m above the start of the restored area in December 2023, March 2024, and June 2024. In addition, samples were collected in three relatively pristine and two heavily degraded sites within the ecoregion to provide reference data. DNA was extracted following established protocols, and invertebrate DNA amplified utilizing primers (fwhF2/EPTDr2n) demonstrated to selectively amplify Arthropod DNA (>97%) in previous studies. Primers were modified with tails which include Illumina sequencing primer binding sites and spacers (0-3) to increase amplicon size diversity. Illumina flow cell binding sites (p5 and p7) and i5 and i7 indices for sample identification were added with a second PCR, and samples were sequenced to a depth a 1 million reads/sample (Illumina NextSeq 2000). To the best of our knowledge, this study represents the first utilization of metabarcoding in the evaluation of urban restoration projects. These data should provide valuable insight into the effectiveness of restoration projects, particularly considering the variety of restoration techniques utilized within these sites, and guidance for future restoration efforts.

This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-02, WRRA 104B Annual Grant Program

22. Community-Based Participatory Research on Drinking Water Disinfection Byproducts in Appalachia

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Drinking water disinfection byproducts (DBPs) are the most common cause of health-based regulatory violations for drinking water in Kentucky and have been a source of concern among community members. For example, the Martin County Water District in eastern Kentucky experienced more than a decade of quarterly MCL violations for trihalomethanes and haloacetic acids. Rural drinking water systems in Appalachia face challenges both due to the complexity of the distribution networks required in the remote mountainous landscape and declining resources available for maintaining and operating infrastructure. Furthermore, there are complex seasonal and spatial patterns of DBP exposure within drinking water networks. In response, we have established a university-community partnership to help reduce exposure to disinfection byproducts in eastern Kentucky, focusing on Martin and Letcher Counties. This project uses citizen science to better understand how seasonal variation in source water chemistry, distribution network position, and home characteristics influence DBP exposure. Among the findings to be discussed are seasonal changes in bromide concentrations in source water as a driver of DBP formation as well as significant differences in bromide concentrations and bromide:chloride ratios among river basins. We will also discuss results from hydrologic models using KYPipe pipe flow software that are able to predict DBP concentrations in specific distribution network locations based on water age. These preliminary results have already yielded a better understanding of drivers of exposure in the region and provided utilities with tools that will enable them to optimize processes to help reduce DBP exposure.

23. Hybrid Solutions for DOT applications for Proactive Road Flooding Alerts

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As water managers and engineers, it's important to understand our watersheds, the urban landscapes, and their response to extreme events like heavy precipitation and rising surface water levels. These events can impact property, municipal infrastructure, and water quality. Of the numerous tools at our disposal, there are many benefits to continuous water monitoring systems, including knowing in time where flooding issues could occur, enabling proactive action. In this presentation, we will discuss the value of data collection as well as water monitoring tools. Together, we'll examine what these water level monitoring systems might look like in your community and how data can assist your community about the importance of being prepared for a large rain events, rising water levels, and water quality. As an example, we will focus specifically on a hybrid road/urban flood solution used for DOT clients for meeting required communication protocols as well as the added option of data integration with road mapping apps such as Google and Waze.