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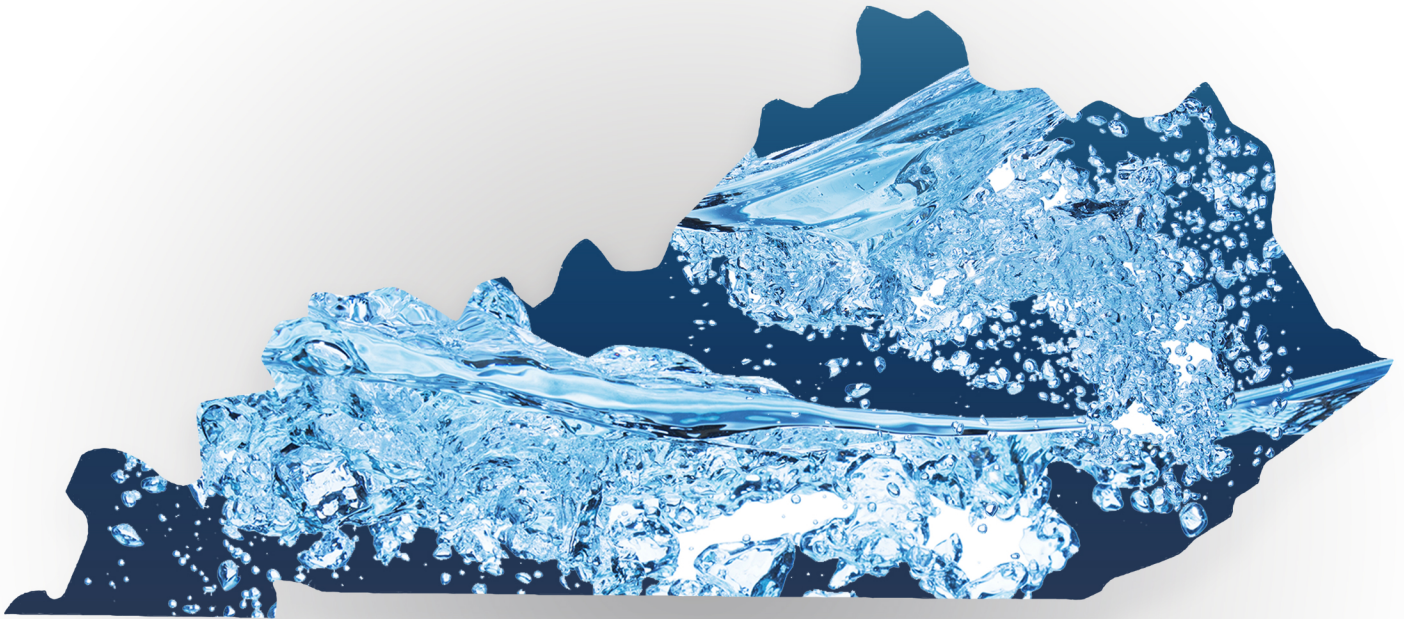
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Kentucky Water Resources Annual Symposium



March 19, 2018

Marriott Griffin Gate Resort | Lexington, KY

 Kentucky Water
Resources Research
Institute

Sponsored by:
Kentucky Water Resources Research Institute
Kentucky Geological Survey
U.S. Geological Survey
Kentucky Division of Water

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AGENDA

Kentucky Water Resources Annual Symposium

March 19, 2018

Marriott Griffin Gate Resort, Lexington, Kentucky

- 7:30 Registration
- 8:00 Welcome & Introduction by Dr. Lindell Ormsbee, Director, Kentucky Water Resources Research Institute, University of Kentucky

PLENARY SESSION

- 8:30 *Joining Forces to Tackle the Dead Zone*, Amanda Gumbert, Agriculture Extension Programs, University of Kentucky
- 8:50 *Water Resources Applications of KyAPED Airborne LiDAR Data: A New Era for Hydrosience in Kentucky*, Bill Haneberg, Kentucky Geological Survey, University of Kentucky
- 9:10 *Temporal Performance Assessment of Wastewater Treatment Plants by Using Multivariate Statistical Analysis*, Milad Ebrahimi and Thomas D. Rockaway, Center for Infrastructure Research, University of Louisville

9:30 - 10:30 Poster Session 1

Track 1

1A—Groundwater and Karst

- 10:30 *Analysis of the Ambient Groundwater Quality Monitoring Network Data*, Caroline Chan and Robert Blair, Kentucky Division of Water
- 10:50 *Improving Karst/Sinkhole Hazard Assessment for Kentucky*, Junfeng Zhu, Kentucky Geological Survey, University of Kentucky
- 11:10 *Combination of Wind and Stack Effects on Indoor, Atmospheric, and Subsurface Domains in VI Studies*, Elham Shirazi and Kelly G. Pennell, Dept. of Civil Engineering, University of Kentucky
- 11:30 *Characterization of Spring Discharge and Karst Drainage at the Homeplace on Green River, Campbellsville*, Charles J. Taylor, Kentucky Geological Survey, University of Kentucky

Track 2

2A—Membranes and Pollutant Removal

- Ozonation, Biofiltration and the Role of Membrane Surface Charge and Hydrophobicity in Removal and Destruction of Algal Toxins at Basic pH Values*, Joyner Eke, Dept. of Chemical and Materials Engineering, University of Kentucky
- Iron/Palladium Nanoparticles Immobilized Membrane Platforms for Chlorinated Organics Treatment*, Hongyi Wan, Dept. of Chemical and Materials Engineering, University of Kentucky
- Using a Bio-Derived Solvent to Cast Polysulfone Ultrafiltration Membranes*, Xiaobo Dong and Isabel C. Escobar, Dept. of Chemical and Materials Engineering, University of Kentucky
- Selenium Removal Using Activated Alumina in a Packed-Bed Reactor*, Yuxia Ji and Yi-tin Wang, Dept. of Civil Engineering, University of Kentucky

11:50 - 1:10 Awards Luncheon: Awards for Outstanding Contributions Related to Water Resources

1B—Biology

- 1:10 *Kentucky Lake Undergoing a “Change of State”: Trend Analyses Indicate Potential Tipping Points Are Being Reached for Several Limnological Variables*, D. White et. al, Hancock Biological Station and Dept. of Chemistry, Murray State University
- 1:30 *A Preliminary Environmental Assessment of the Green River, Mammoth Cave National Park Following the Removal of Lock and Dam #6*, Michael Compton, Brian Yahn, and Logan Phelps, Kentucky State Nature Preserves Commission
- 1:50 *Water Quality and Primary Productivity in Minor E. Clark Fish Hatchery Ponds*, Brian C. Reeder, Dept. of Biology and Chemistry, Morehead State University

2B—Sediments and Nutrients

- Water, Sediment, and Nutrients Data Streams in a Fluviokarst Watershed in the Kentucky Bluegrass: Insights from Elemental, Isotopic, and High Resolution Sensor Data*, Admin Husic et al., University of Kentucky
- Effects of Stream Restoration on Pollutant Load Reductions in an Urban Watershed*, Sam Austen and Carmen Agouridis, Biosystems & Ag. Engineering, University of Kentucky
- Watershed Sediment Transport Modeling Using Dynamic Lateral, Longitudinal, and Vertical Sediment (Dis)connectivity*, Tyler Mahoney et al., Dept. of Civil Engineering, University of Kentucky

1C—Hydrology

- 3:10 *Comparing the Hydrological Function of Natural and Constructed Ridge Top Isolated Wetlands*, Jonathan M. Malzone and Ethan Sweet, Dept. of Geosciences, Eastern Kentucky University
- 3:30 *Streamflow Gain and Loss, Hydrograph Separation, and Water-Quality of Abandoned Mine Lands in the Daniel Boone National Forest, Eastern Kentucky, 2015-17*, Mac A. Cherry, U.S. Geological Survey Ohio-Kentucky-Indiana Water Science Center
- 3:50 *Hydrology: Old Science, New Applications for the Blanchard River in Ohio*, Erman Caudill, Stantec Consulting Services Inc.

2C—Soils and Agriculture

- Soil Phosphorus in Urban Kentucky: Lawn and Gardening Our Way to Hell in a Vegetable Basket*, Brad Lee, Dept. of Plant & Soil Sciences, University of Kentucky
- Optimizing Yield and Water Use Efficiency of Soybean Production in Kentucky – Experimental and Modeling Approach*, Maria Morrogh Bernard and Montserrat Salmeron Cortasa, Dept. Plant and Soil Sciences, University of Kentucky
- Variations in Soil Saturated Hydraulic Conductivity Across Multiple Land Uses in Fayette County, Kentucky*, Dwayne Edwards, Carmen Agouridis, and Sam Austen, Biosystems & Agricultural Engineering Dept., University of Kentucky, and Y.M. Huang, Lafayette High School

4:15 Student Award Presentations and Closing Remarks

Poster Session 1: (9:30 - 10:30)

- The Ecological Importance of Perched Aquifers and their Hydrological Connectivity to Ridge Top Ephemeral Wetlands in Daniel Boone National Forest*, Ethan Sweet and Jonathan Malzone, Dept. of Geosciences, Eastern Kentucky University
- Water, Bugs and Bacteria: Creating a Water Quality Monitoring Program for the Wheeling Creek Watershed in the Northern Panhandle of West Virginia*, James Wood et al., West Liberty University, Murray State University, Marshall University, and University of Kentucky
- Use of eDNA to Detect Salamander Species in Central Kentucky Streams*, Ronald B. Sams et al., Dept. of Science and Health, Asbury University
- Hydrogeological Properties of Natural and Constructed Wetlands in Kentucky's Daniel Boone National Forest*, Selsey A. Stribling and Jonathan M. Malzone, Dept. of Geosciences, Eastern Kentucky University
- Use of eDNA in Multiple Species Fish Biomass Determinations in Small to Mid-sized Lotic Systems*, Ramon A. Guivas, Kyle T. Laufenburger, Ben F. Brammell, Dept. of Science and Health, Asbury University
- Rainfall Runoff Model Development Using HSPF for a Flood Control Reservoir System to Examine Long Term Benefits*, C.V.Chandramouli, Mingda Lu, and Linji Wang, Mechanical and Civil Engineering Dept., Purdue University Northwest.
- Examining the Usefulness of Self Organizing Maps in Drought Analysis*, Yuqian Jia, C.V.Chandramouli, Mechanical and Civil Engineering Dept., Purdue University Northwest
- Modeling and Evaluating the Influences of Class V Injection Wells on Urban Karst Hydrology*, James Shelley, Jason Polk, Matt Powell, Dept. of Geography and Geology, Western Kentucky University and City of Bowling Green
- Isomotive Dielectrophoresis Based Characterization of Chlamydomonas Cells*, M.Z. Rashed et al., University of Louisville and Murray State University
- Role of Cross-Linker Concentration on the Performance of pH Responsive Membrane and its Application on PCB 126 Degradation*, Mohammad Saiful Islam et al., Dept. of Chemical and Materials Engineering, University of Kentucky
- The Effect of Applied Electric Potential on the Performance of Nanofiltration Membranes*, Sarah Kintner, Dept. of Chemical and Materials Engineering, University of Kentucky
- Polyphenolic Nanocomposite Materials for the Capture and Sensing of Chlorinated Organic Contaminants in Water Sources*, Angela M. Gutierrez et al., Dept of Chemical and Materials Engineering, University of Kentucky
- Investigation of a Lignin-Derived Solvent in Polymeric Membrane Fabrication*, Josh Bolvin, Xiaobo Dong, Isabel Escobar, Dept of Chemical and Materials Engineering, University of Kentucky
- Investigation of Phosphorene's Potential Properties in Membrane Filtration*, Joyner Eke, Dept. of Chemical and Materials Engineering, University of Kentucky
- Investigation of a New Mixing Method in the Preparation of Polymeric Solutions for Membrane Fabrication*, Monica Alden, Xiaobo Dong, Isabel Escobar, Dept. of Chemical and Materials Engineering, University of Kentucky
- Water Quality Analysis in Municipal Water Supply System for Lexington, KY with a Focus on Corrosivity*, Amanda R. Sherman et al., University of Kentucky
- An Opportunity for Environmental Ag Education: Using GIS Technology to Compare Beef Cattle Density on Water Quality Parameters in Two Barren County, KY Streams*, Tammy Barnes, Amanda Gumbert, and Brian Lee, Cooperative Extension Service and Dept. of Landscape Architecture, University of Kentucky
- Assessment of MRSA Presence in Lexington, Kentucky WWTPs with New Selective Growth Media*, Atena Amirsoleimani and Gail Brion, Dept. of Civil Engineering, University of Kentucky

Poster Session 2: (2:10 - 3:10)

1. *Kentucky Lake Undergoing a “Change of State”: Trend Analyses Indicate Potential Tipping Points Are Being Reached for Several Limnological Variables*, S. Hendricks et al, Hancock Biological Station and Dept. of Chemistry, Murray State University
2. *Investigating Preferential Sewer Pathways: Geospatial Screening and Field Sampling to Reduce Inhalation Exposure Risks*, Evan J. Willett and Kelly G. Pennell, Dept. of Civil Engineering, University of Kentucky
3. *Fate and Transport of Volatile Organic Compounds (VOCs) in a Sewer System: Numerical Model and Field Study*, Mohammadyousef Roghani and Kelly G. Pennell, Dept. of Civil Engineering, University of Kentucky
4. *Soil Moisture Conditions and Yield Across Fragile Soils Under Irrigated Management in Western Kentucky*, Jesse Bowling et al., Dept. of Geography and Geology, Western Kentucky University, Dept. of Plant & Soil Sciences, University of Kentucky, Kentucky Geological Survey, and USDA Natural Resource Conservation Service
5. *Nutrient Contamination from an Agricultural Non-Point Source and its Mitigation: A Case Study of EKU Meadowbrook Farm, Madison County, KY*, Walter S. Borowski et al., Dept. of Geosciences, Eastern Kentucky University
6. *Characterization of Groundwater and Surface Water Geochemistry in an Agricultural Setting at EKU Meadowbrook Farm, Madison County, KY*, Reid E. Buskirk, Walter S. Borowski, and Jonathan M. Malzone, Dept. of Geosciences, Eastern Kentucky University
7. *Nutrient Export from a Proximal, Intermittant Stream Draining EKU Meadowbrook Farm, Madison County, KY*, James Scott Winter, Walter S. Borowski, and Jonathan M. Malzone, Dept. of Geosciences, Eastern Kentucky University
8. *Spatial Characterization of Soil Saturated and Near-Saturated Hydraulic Conductivity at the Field Scale*, Xi Zhang and Ole Wendroth, Dept. of Plant and Soil Sciences, University of Kentucky
9. *Soil Properties of Farms in Marion County, KY*, G. J. Barnes, Steven Still & Iin Handayani, Hutson School of Agriculture, Murray State University
10. *Using Anthropogenic Compounds in Sewage to Create New Fecal Source and Fecal Age Indicators for Use in Protecting and Improving Water Quality in Kentucky Watersheds*, Ashley M. Hall and Gail Brion, Dept. of Civil Engineering, University of Kentucky
11. *Blue Water Farms: Edge-of-Field Monitoring of Nutrient and Sediment Loss from Wetland Watersheds in the Northern Mississippi Embayment*, Leighia Eggett et al., University of Kentucky
12. *Blue Water Farms: Edge-of-field Monitoring of Nutrient and Sediment Loss from No-Till Corn and Soybean Fields in the Lower Green River Watershed*, Mark Akland et al., University of Kentucky
13. *Edge-of-Field Modeling to Quantify the Contribution of Macropore Flow into Nitrogen Loading for Poorly Drained Agricultural Fields*, Saeid Nazari, William I. Ford, Kevin W. King, Biosystems and Agricultural Engineering, University of Kentucky and USDA-ARS Soil Drainage Research Unit
14. *High Resolution Sensing of Nitrogen Dynamics in a Mixed-Use Appalachian Watershed: Influences of a Backwater Riparian Wetland*, Alexandria Jensen, William Ford, Biosystems & Agricultural Engineering Dept., University of Kentucky
15. *Climate Change Impacts on Sediment Transport in Kentucky: Sensor Validation, Controlling Processes, and Future Projections*, Nabil Al Aamery, Tyler Mahoney, Jimmy Fox, Dept. of Civil Engineering, University of Kentucky
16. *Water Supply Impacted by Algae and Sedimentation in Kentucky: Advancing Sensors and Nonconservative Tracers*, Brenden Riddle et al., Dept. of Civil Engineering, University of Kentucky
17. *Coupled Hydraulic and Sediment Transport Modeling of a Fluvial Karst Aquifer in the Bluegrass Region of Kentucky*, Ethan Adams et al., University of Kentucky
18. *Temporal Variations of High Resolution Nutrient Concentrations in Mature vs. Immature Karstic Watersheds*, Evan Clare, Tyler Mahoney, Jimmy Fox, Dept. of Civil Engineering, University of Kentucky
19. *Synthesis of Biologically-Inspired Nanofiltration Membranes Using Protected and Mutated Aquaporins*, Priyesh Wagh and Isabel C. Escobar, Dept. of Chemical and Materials Engineering, University of Kentucky

RECIPIENTS OF INSTITUTE AWARDS

Bill Barfield Award for Outstanding Contributions in Water Resources Research

Susan Hendricks (2018)	James Dinger (2011)
Jim Kipp (2017)	Alice Jones (2010)
Stephen F. Higgins (2016)	Sylvia Daunert (2009)
Dibakar Bhattacharyya (2015)	Gail Brion (2008)
James C. Currens (2014)	David White (2007)
Art Parola (2013)	Wes Birge (2006)
Andrew Ernest (2012)	Don Wood (2005)

Lyle Sendlein Award for Outstanding Contributions in Water Resources Practice

Barry Tanning (2018)	Linda Bridwell (2011)
Lynn Jarrett (2017)	Greg Heitzman (2010)
Steven K. Hampson (2016)	Susan Bush (2009)
Richard Warner (2015)	Steve Reeder (2008)
Derek R. Guthrie (2014)	Bill Grier (2007)
Sandra Gruzsky (2013)	Jack Wilson (2005)
Michael Griffin (2012)	

Robert A. Lauderdale Award for Outstanding Contributions in Water Quality

Charles Martin (2018)	Amanda Gumbert (2011)
Amy Sohner (2017)	Malissa McAlister (2010)
Paulette Akers (2016)	Bruce Scott (2009)
Dale Reynolds (2015)	Ken Cooke (2008)
Brian C. Reeder (2104)	Judith Petersen (2007)
H. David Gabbard (2013)	Eddie Foree (2006)
Henry Francis (2012)	

PLENARY SESSION

JOINING FORCES TO TACKLE THE DEAD ZONE

Amanda Gumbert¹, Rebecca Power², Beth Baker³, Matt Helmers⁴, Wes Burger³, Mike Schmitt⁵, Eric Young⁶, Robin Shepard⁷, Mike Daniels⁸, and Katie Flahive⁹

¹Agriculture Extension Programs, University of Kentucky, Lexington, KY

²North Central Region Water Network, University of Wisconsin-Madison, Madison, WI

³College of Forest Resources, Mississippi State University, Starkville, MS

⁴Ag & Biosystems Engineering, Iowa State University, Ames, IA

⁵Department of Soil, Water, and Climate, University of Minnesota, St. Paul, MN

⁶Southern Association of Agricultural Experiment Station Directors, Raleigh, NC

⁷North Central Cooperative Extension Association, Madison, WI

⁸Crop, Soil & Environmental Science, University of Arkansas, Little Rock, AR

⁹U.S. Environmental Protection Agency, Washington, DC

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The Northern Gulf of Mexico Hypoxic Zone measured 22,720 square kilometers (8,776 square miles) in July 2017, the largest on record. The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force) was formed in 1997 to investigate the causes of and coordinate activities to reduce the size of the hypoxic zone in the Gulf. In 2013, land-grant university representatives from 12 Mississippi River basin states joined together to form a sister organization to the federal task force. Southern Extension and Research Activities committee number 46 (SERA-46) is one of a group of formal USDA-NIFA and land-grant university funded committees designed to promote multistate research and extension activities. SERA-46 was created to operationalize a Non-funded Cooperative Agreement between the Hypoxia Task Force and land-grant university Extension and Experiment Stations in the North Central and Southern Regions of the United States. SERA-46 brings together researchers and extension specialists sharing a common interest and expertise related to the environmental, social, and economic factors that contribute to nutrient loss from agricultural lands, state-level nutrient impairments, and hypoxia in the Gulf of Mexico.

SERA-46 and the Hypoxia Task Force established common shared priorities in May 2015. Shared priorities serve as a basis for projects involving SERA-46 members related to strengthening networks, conservation systems research and outreach, and monitoring and tracking progress toward achieving the goal of reducing the hypoxic zone to 5,000 square kilometers. Special project funds from US EPA, the Walton Family Foundation, and other partners have assisted in the progress of priorities such as developing social measures of impact for use in priority watersheds; strengthening a network of watershed leaders (including those that are farmers) to increase the effectiveness of strategies for reducing nutrient losses from agricultural lands; and developing a framework to report progress with nonpoint source nutrient reduction.

WATER RESOURCES APPLICATIONS OF KYAPED AIRBORNE LIDAR DATA: A NEW ERA FOR HYDROSCIENCE IN KENTUCKY

William C. Haneberg
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Since late 2017, Kentucky has been one of the few states to have publicly available statewide airborne LiDAR topographic coverage. Both gridded digital elevation models (DEMs) and ungridded point clouds are available. With a 5 ft (1.5 m) cell size, the Kentucky LiDAR DEMs are approximately 44 times more resolute and provide substantially better vertical accuracy than previously available 10 m DEMs. Statewide LiDAR coverage will allow Kentucky water scientists, engineers, and planners to work at a level of detail and sophistication not previously possible. Potential applications of the statewide LiDAR data, illustrated in this presentation using examples from Kentucky and elsewhere, include:

- Watershed visualization to enhance communications and stakeholder engagement.
- Surficial geologic mapping for land use planning and hazard assessment.
- Geomorphological studies to understand the long-term evolution of fluvial systems.
- Watershed and channel network delineation.
- Surface and shallow subsurface water flow routing and wetland delineation.
- Aquatic habitat carrying capacity and population dynamics simulations.
- Forest canopy and wildfire fuel loading evaluations.
- Rainfall triggered landslide and sediment loading susceptibility modeling.
- Sinkhole and karst feature delineation.
- More accurate identification of flood-prone areas.
- Fracture trace mapping for bedrock aquifer system studies.
- Geomorphological change detection as multiple coverages become available.

Experience has shown that the biggest impediment to full utilization of airborne LiDAR topographic data may be lack of familiarity with the data and software capabilities coupled with preconceived notions about the potential uses of topographic data. Some users, for example, may see only the possibility for smaller contour intervals because they are not familiar with the variety of sophisticated analyses available using modern GIS and LiDAR software. To help alleviate that problem, the Kentucky Geological Survey has established a Digital Earth Analysis Lab to help promote and support the widespread application of airborne LiDAR data to practical and research problems within the commonwealth.

TEMPORAL PERFORMANCE ASSESSMENT OF WASTEWATER TREATMENT PLANTS BY USING MULTIVARIATE STATISTICAL ANALYSIS

Milad Ebrahimi, Ph.D. Candidate, and Thomas D. Rockaway, Ph.D., PE
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For wastewater treatment plants, many samples are obtained and tested to assess performance throughout the day. However, the analyzed samples often indicate conflicting results or trends whereby it is difficult to determine if the plant is performing as expected. The objective of this study is to create a framework where statistical techniques are used to quantitatively assess the overall quality of wastewater treatment effluent with respect to intended applications. To develop the procedures, the study evaluated the performance of the Floyds Fork Wastewater Treatment Plant in Louisville, KY and worked to address the following objectives:

1. Identify the temporal characteristics of each monitored parameter
2. Develop Wastewater Quality Index (WWQI) to quantitatively define wastewater quality
3. Define the statistical interrelationships between different parameters
4. Introduce a finite set of uncorrelated variables which, within a minimum loss of original information, can represent the overall characteristic of wastewater
5. Develop multivariate statistical models to numerically express and forecast the significant quality parameters based on the measured historical process database

To comprehensively analyze the composition of wastewater and assess the treatment process performance, data from Louisville MSD's routine monitoring program were utilized. Collectively 9,180 samples were obtained from twelve quality and quantity variables between 2010 and 2016. The measured parameters include BOD, TSS, P, N, DO, pH, MLVSS, flow rate and the recycled activated sludge rate.

Preliminary, descriptive statistics were used to identify temporal fluctuation of each monitored parameter. However, a single parameter or one set of parameters cannot appropriately characterize the waste stream or comprehensively assess the treatment system efficiency. To overcome this challenging issue, two approaches were implemented:

- 1) The Wastewater Quality Index (WWQI) was introduced to efficiently summarize the numerous monitored parameters into a single unit-less number.
- 2) Multivariate statistical techniques and exploratory data analyses were applied to provide a comprehensive methodology for long-term assessment of wastewater characteristics as well as treatment process performance. The incorporated technique includes:
 - Correlation analyses: to determine the extent specific parameters were statistically correlated.
 - Principal component analyses (PCA): to investigate the interrelationships between a large group of variables, and to convert a large number of original correlated variables into a finite set of uncorrelated components. The derived components represent the information of the whole dataset with minimal loss of original information.
 - Statistical modeling: to develop models that can predict important quality parameters based on input conditions. The modeling approach was carried out by combining three

statistical methods including correlation, multivariate regression, and ANOVA analyses.

By developing the WWQI, the quality of influent and effluent wastewater was ranked from zero to 100. For the Floyds Fork analysis, the influent WWQI value was between 45 and 60 indicating the water quality was frequently threatened or impaired and would be threatening or potentially damaging to a receiving water. After treatment, the effluent WWQI was consistently between 96 and 100 indicating that the stream could be released to receiving waters with little threat of impairment. The analysis showed that the treatment process average resulted in a 51 percent improvement of the wastewater quality.

Application of the Pearson product moment correlation analysis on each pair of influent and effluent variables showed that out of twelve measured quality parameters for influent and effluent, four parameters were responsible for the variation of quality indexes.

Performing the PCA technique, the dimension of the data set decreased from fifteen variables to five factors which represent influent quality characteristic, influent quantity loading, influent and effluent ion activity, effluent oxygen demanding, and effluent nutrient loadings. The derived components described approximately 75.25% of the total variability of the data set and represented the overall variation in wastewater quality during the period of study.

The forecasting model development was carried out by considering the measured parameters during 2010 to 2015 as the training data. As a result, six descriptive numerical models were developed to predict influent and effluent phosphorus, BOD, and WWQI parameters. The developed models were then subjected to validation processes based on the results from the monitoring program conducted in 2016. All the established models showed high levels of statistical significance in addition to admissible accuracy in terms of fitting with the training data parameters, with 81.8% average accuracy, and validating with the testing dataset, with average relative prediction error of 2.9%.

The presented techniques and procedures in this research provide an assessment framework for the water/wastewater infrastructure monitoring programs and can be applicable to different treatment plants.

SESSION 1A: GROUNDWATER AND KARST

ANALYSIS OF THE AMBIENT GROUNDWATER QUALITY MONITORING NETWORK DATA

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The Kentucky Interagency Groundwater Monitoring Network (or Network) was established to meet three major goals relative to groundwater resources: 1) provide baseline data; 2) characterize the resource; and 3) disseminate the information collected. Previous studies have had a relatively narrow scope and focused on either characterizing the current condition of groundwater in specific river basins or regions of Kentucky or evaluating a single parameter statewide. This report represents the initial examination of statewide trends in groundwater quality based on data collected through the Network over the course of 20 years. In general, data indicate that groundwater quality in Kentucky continues to be suitable for many purposes and that trends are observed for several analytes. The analyte groups and specific analytes evaluated for this study are summarized in the table below.

Analyte groups and specific analytes in this study:

Analyte Group	Summary Comments	Included in Analysis
Bulk Parameters	Basic chemistry and general water quality	pH, Field Conductivity, Temperature, Total Hardness (calculated)
Nutrients	Naturally occurring and NPS influence	NO ₃ , NO ₂ , PO ₄ , TKN, Total Nitrogen
Major Inorganic Ions	Water-rock chemistry and NPS influence	Cl ⁻ , F ⁻ , SO ₄ ⁻
Metals	Water-rock chemistry	Al, As, Ba, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Zn
Organics	NPS influence	Pesticides: Alachlor, Atrazine, Cyanazine, Glyphosate, Metalochlor, Simazine
Volatile Organic Compounds	NPS and point source influences	Benzene, Ethylbenzene, Toluene, Xylenes, Methyl-tert-butyl ether (MTBE)

Basic descriptive statistics were performed on all analyte groups, giving the number of samples, percent of non-detections, quartiles and standard deviation. Trends were determined by calculating the Kendall's tau-b for each station. While significance of a trend was not determined for each station, a determination of a monotonic trend for stations within subgroups

(physiographic region, wells, springs, or all sites) was determined. Trends were calculated for all analytes within analyte groups with the exception of pesticides and VOCs. The high proportion of non-detections for pesticides and VOCs made tests for trends impossible.

Trends were found within each analyte group. Additionally, trends for analytes varied for each physiographic region evaluated. In general, increasing trends were more frequent in the Mississippian Plateau physiographic region and in stations that are springs, as opposed to wells. An obvious contributor to this result is the power found in detecting trends with a larger number of samples or stations. Of the six physiographic regions, the Mississippian Plateau has 24 of the 49 stations. The sample size difference between wells and springs is large, but not as marked – 20 wells versus 29 springs. Adding monitoring stations in the under-represented physiographic regions as well as more wells to the Network would be needed to resolve this issue.

While baseline data have been gathered and groundwater resources have been characterized, continued and expanded monitoring will further our understanding of groundwater quality in Kentucky. The finding of trends points to ongoing changes in this resource, with implications regarding land-use activities, protection and conservation efforts, and public health and economic development. With continued vigilance, stresses on this resource can be addressed and rectified before negative outcomes are realized.

IMPROVING KARST/SINKHOLE HAZARD ASSESSMENT IN KENTUCKY

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Karst and sinkholes are well recognized as geologic hazards in Kentucky and were included for risk assessment in the 2013 State Hazard Mitigation Plan. In the 2013 plan, karst/sinkhole hazard was assessed statewide using a formula that sums the percentage of areas with potential for karst development and the percentage of areas of sinkhole occurrence to calculate karst/sinkhole hazard scores. Because areas identified as having the potential for karst (mapped outcrops of carbonate bedrock at or near land surface) are much larger than areas of mapped sinkhole occurrences (which are closed depressions identified on 1:24,000-scale topographic maps), the spatial distribution of the karst/sinkhole hazard scores is mostly dominated by karst potential information and is little influenced by sinkhole occurrences. However, sinkhole occurrence is a proxy measurement of karstification, which is also influenced by additional important hydrogeologic factors including soil thickness, bedrock porosity and permeability, topography, and surface and subsurface drainage. Because the formation of sinkholes is generally recognized as the most prominent karst-related hazard in Kentucky, we believe the method used to assess karst/sinkhole hazard should give more weight to the information on sinkhole occurrences.

To better incorporate information about sinkhole occurrences, we tested two modifications to the 2013 karst/sinkhole hazard assessment method. The first modification assigns a higher weight to areas of sinkhole occurrence than to areas with karst potential. The second modification substitutes sinkhole density (number of sinkholes per square kilometer) for percentage area of sinkhole occurrences, and equally weights sinkhole density and karst potential area.

For the first method, we found that it is difficult to adjust sinkhole-occurrence weights in a way that meaningfully improves upon the 2013 hazard scores. The spatial distribution of karst/sinkhole hazard scores calculated from the second method better reflects sinkhole occurrences while also considering information on karst potential areas. Using the second method, the karst/sinkhole hazard scores can potentially be further improved as more accurate sinkhole density can be obtained when high-resolution topography maps derived from LiDAR become available statewide.

COMBINATION OF WIND AND STACK EFFECTS ON INDOOR, ATMOSPHERIC, AND SUBSURFACE DOMAINS IN VAPOR INTRUSION STUDIES

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Vapor intrusion (VI) is a process in which volatile organic compounds (VOCs) volatilize from contaminated groundwater or soil and transport through the subsurface into overlying buildings. Indoor air contamination caused by VI is difficult to characterize because indoor air concentrations varies temporally and spatially in homes throughout impacted communities. Different sources have been known for this variability, two of them are the building air exchange rate (AER) and pressure difference between indoor and outdoor (ΔP). AER and ΔP in a building are influenced by different parameters such as wind and stack (temperature) effect, building characteristics, mechanical ventilation and occupant behavior (Figure 1). To date, a few VI models have been developed to evaluate the effect of wind flow and indoor air temperature on VI. Most of the wind-focused VI models have investigated how wind flows influence subsurface processes. There is a need to modify existing models to understand how wind flow and temperature collectively influence the VI exposure risks.

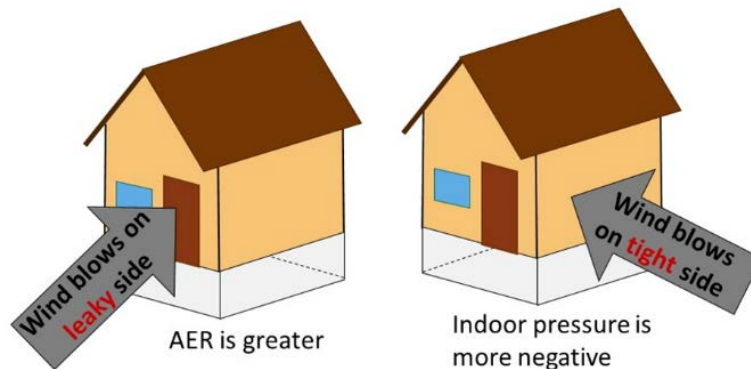


Figure 1: Wind direction effect on AER and ΔP

Source: Shirazi and Pennell (2017), *Environmental Science: Processes & Impacts*

In this study, we present results of a newly developed model that combines three different domains: the atmospheric domain (outdoor above-ground), indoor domain, and subsurface (groundwater contamination) domain. Using this new model, we investigate how wind flow above and around a building, as well as stack effects influences 1) the distribution of VOCs in the subsurface, and 2) indoor air pressure which consequently affects the indoor air concentration of contaminant.

The results of this research indicate that wind and stack effect influence both air exchange rate of the building and indoor pressure (Figure 2). As shown below, when wind speed increases, the building AER value increases. In addition, wind direction can influence AER, especially for a 10 m/s wind speed (Figure 2a). For a constant wind speed, AER reaches the highest value

when wind blows on the leakier (north and south) sides of the building and lowest values when wind blows on the tighter (east and west) sides of the building. Figure 2b shows that wind speed and direction influence the basement pressure which consequently influence the driving force for soil gas to enter the building and cause in VI exposure risks.

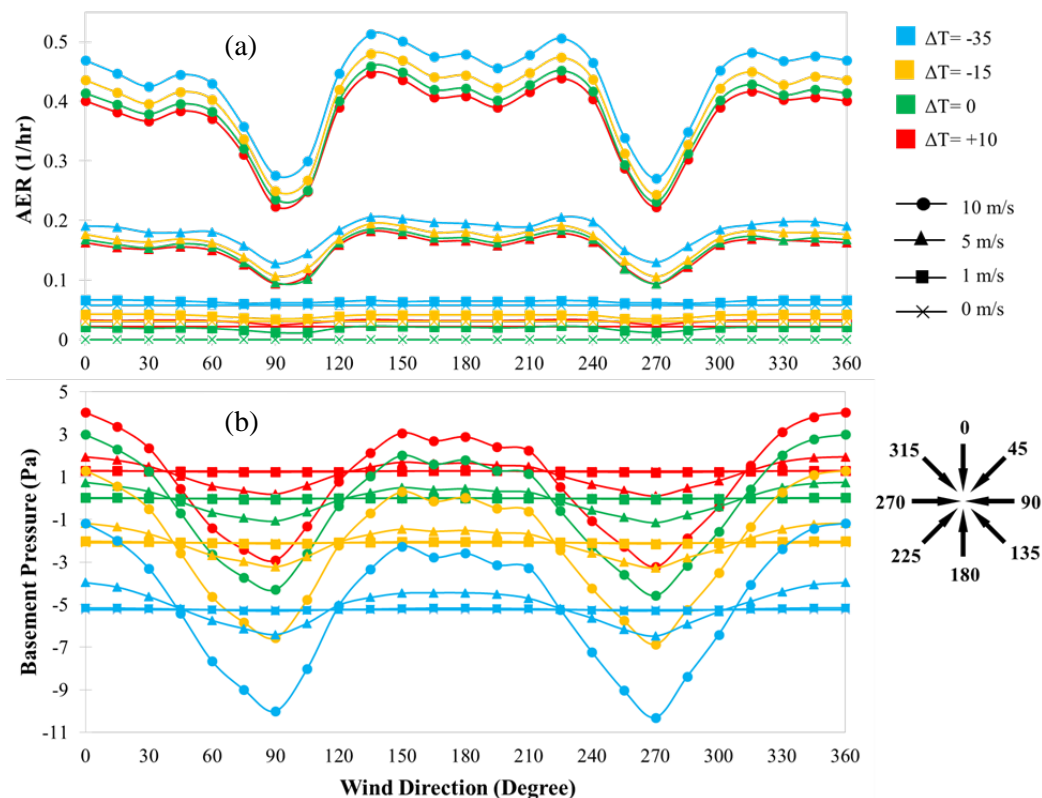


Figure 2: Wind and Stack Effect on Building AER (a) and Basement Pressure (b)

The mass entry rate of the contaminant through the foundation crack is inversely related to the basement pressure. The building AER is a dominant factor that controls the indoor air concentration in the first floor, however AER is not the dominant factor in the basement since the basement is tighter than first floor. These results highlight that building characteristics play an important role in changing indoor air concentration in different zones of buildings. More results and implications are included in a recently published paper in *Environmental Science: Processes & Impacts* (DOI: 10.1039/c7em00423k 19:1594-1607).

Acknowledgements: The project described was supported by a CAREER Award from the National Science Foundation (Grant Number 1452800) and by Grant Number P42ES007380 (University of Kentucky Superfund Research Program) from the National Institute of Environmental Health Sciences.

CHARACTERIZATION OF SPRING DISCHARGE AND KARST/SINKHOLE DRAINAGE FEATURES AT THE HOMEPLACE ON GREEN RIVER, NEAR CAMPBELLSVILLE

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Rolling topography shaped by sinkholes dominates much of the agricultural landscape in Kentucky's karst areas. Each sinkhole is an isolated topographic basin that captures surface runoff and drains it underground to subsurface karst conduits and eventually to karst springs and surface streams. Identification and mapping of sinkholes, subsurface karst flow routes, and springs receiving sinkhole drainage from farmland are needed to effectively monitor potential agricultural contaminants. Quantifying a receiving spring's discharge is necessary for estimation of agricultural contaminant loads, and characterizing the spring's response to rainfall-runoff is beneficial to the collection and interpretation of water-quality sampling data. These objectives are the focus of a current investigation being conducted by KGS in collaboration with the U.S. Department of Agriculture Natural Resources Conservation Service at The Homeplace on Green River, a historic farm near Campbellsville managed by a 501c3 organization promoting agricultural conservation and education.

A continuous-discharge monitoring station was established in June 2017 at a perennial spring that discharges from a small cave at The Homeplace. Water from the spring flows in a shallow channel consisting of alternating pools and riffles mostly filled with coarse, cherty gravel. Shallow water depth, the gravel bed load, and channel-bank instability make repeated accurate measurement of the spring's discharge a difficult task. To overcome these obstacles, we installed an aluminum flume, stilling well, pressure transducer, and data-logger/telemetry equipment. The flume creates a stable, artificial channel reach and enables accurate discharge measurements by constricting the width of flow and increasing flow velocities and water depths within it. Discharge is calculated using a mathematical equation that relates the depth of water measured at a single point in the flume to the volume of water flowing through the flume per unit of time. Water level (depth) changes in the flume are measured at 15-minute increments by the pressure transducer in the nearby stilling well, which is isolated from groundwater or surface water inflow but hydraulically connected to the flume. The water-level data are automatically transmitted four times a day by the telemetry system. Base-flow discharge of the spring appears to be a relatively steady 68 gpm (0.15 cfs); however, the spring's flashy response to precipitation ranges into the hundreds of gallons per minute. For example, rainfall associated with Tropical Storm Cindy on June 22–24 resulted in spring discharge that exceeded 550 gpm (1.23 cfs) at the peak of the storm pulse. The flume was washed out by an intense thunderstorm during November 2017, but will be reinstalled early in 2018. A multiparameter water-quality logger will also be installed at that time to begin monitoring changes in spring water pH, temperature, conductivity, and turbidity.

To delineate surficial drainage features on the farm and in the adjacent 22 mi² study area, we used processed LiDAR topographic data to identify probable sinkhole depressions and delineate topographic drainage divides between sinkholes and for watersheds of area streams. The LiDAR data were also used to estimate the maximum depths of each sinkhole depression

and identify probable locations of swallets (open sinkhole throats). LiDAR-indicated sinkholes were field verified with the assistance of the ArcGIS field mapping app Collector. This application allowed georeferenced notes and photos to be recorded that document the physically observable characteristics of individual sinkholes. In addition, in March-April 2017, we conducted electrical-resistivity surveys at five selected sinkhole locations on the farm. Anomalies indicating karst conduits at shallow depths and trending in the direction of the spring were identified on most ER survey profiles. No dye-tracer tests have been attempted as of yet to identify which sinkholes contribute drainage to The Homeplace farm spring, but this work is planned to begin in the spring of 2018.

SESSION 2A: MEMBRANES AND POLLUTANT

REMOVAL

OZONATION, BIOFILTRATION AND THE ROLE OF MEMBRANE SURFACE CHARGE AND HYDROPHOBICITY IN REMOVAL AND DESTRUCTION OF ALGAL TOXINS AT BASIC PH VALUES

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This study was directed at the investigation of technologies for treatment of water containing algal toxins at basic pH values. Ozonation, biofiltration and membrane filtration were examined for the removal of algal toxins, specifically microcystin-LR (MC-LR). Results indicated that, as expected, ozonation completely destroyed MC-LR in water, while biofiltration using naturally-occurring bacteria did not show a significant reduction in MC-LR concentration even after 8 days of contact time. More compelling were the membrane filtration results, which showed that water affinity interaction was not the only governing factor influencing the removal of MC-LR by membranes. It was found that charge interactions between membranes and MC-LR played an important role in the rejection. MC-LR was completely removed from the feed water only by hydrophobic neutral and positively-charged membranes. Furthermore, due to charge interactions, MC-LR reversibly adsorbed to neutral hydrophobic membranes, but it irreversibly adsorbed to positive hydrophobic membranes.

IRON/PALLADIUM NANOPARTICLES IMMOBILIZED MEMBRANE PLATFORMS FOR CHLORINATED ORGANICS TREATMENT

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Functionalized polyvinylidene fluoride (PVDF) membrane platforms were developed for environmentally benign in-situ nanostructured Fe/Pd synthesis and remediation of chlorinated contaminants (chloroform, carbon tetrachloride, TCE, PCE and polychlorinated biphenyls (PCBs)). To prevent leaching and aggregation, nanoparticle catalysts were integrated into membrane domains functionalized with poly (acrylic acid). Furthermore, nanoparticles of 24 ± 6 nm were observed inside the membrane pores. The quantification of nanoparticles properties (size, distribution and composition) versus depth underneath the membrane surface was also investigated by cross-sectioning the membrane samples with focused ion beam (FIB). The Fe/Pd nanoparticles immobilized membrane showed excellent performance in the TCE and PCBs degradation and also the repeated degradation experiments were conducted to demonstrate the reusability of Fe/Pd immobilized membranes. The membranes have also been used in remediation of real water samples from contaminated sites.

To increase the accuracy of kinetic analysis and modeling development for further optimization of membrane performance, the correlation between nanoparticle properties and depth inside membrane pores was studied by using FIB (figure 1). Particle size was uniform inside membrane pores at different depths (particle size: 24 ± 6 nm) but slightly smaller than those nanoparticles located on the surface (39 ± 9 nm). Besides, the distribution of particles as well as the functionalized membrane domain were analyzed in line-scan mode by using energy dispersive spectroscopy (EDS).

Over 96% degradation of 3,3',4,4',5-pentachlorobiphenyl was achieved at a residence time of 14.7 seconds in the membrane pores. The surface area normalized reaction rate (k_{sa}) was calculated (using LFR model) to be $0.171 \text{ L}/(\text{m}^2\text{h})$ in convective flow mode, which is 2.5 times the rate obtained in batch mode. The effects of temperature, pH values, as well as the morphology of Fe/Pd nanoparticles (figure 2) were also investigated. In addition to, our technology has been applied in treatment of real water samples containing chlorinated organics from a Superfund site. Dechlorination of the pollutants was achieved with our method and membrane scale up is in progress.

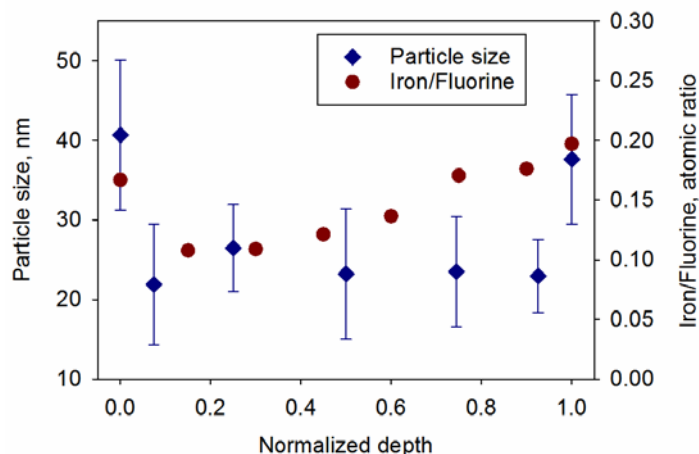


Figure 1. Fe/Pd nanoparticle size and distribution inside the membrane pores. Membrane thickness: 100 μm , fluorine is used as comparison because of the PVDF membrane domain.

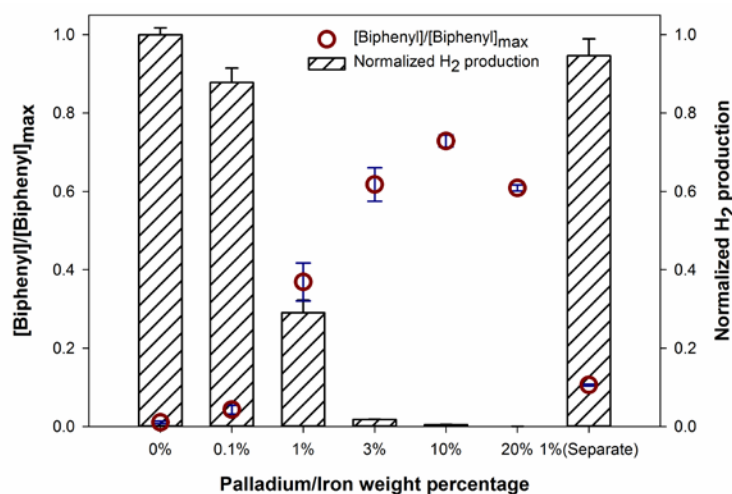


Figure 2. Dechlorination performance and H₂ production of Fe/Pd nanoparticles (different morphology) in water phase. Biphenyl is the product of PCB dechlorination. Besides Pd coated on Fe, isolate Pd nanoparticle and Fe nanoparticle were well mixed and tested as a comparison.

For membrane regeneration and reuse, both NaBH₄ and H₂ method were investigated. In XRD analysis, the Fe/Pd particle samples (which were deliberately oxidized and then reduced) exhibited the same crystalline patterns as the original samples. The membrane was tested for reactivity after four degradation cycles with regeneration between each cycle. The increase of surface particle size of 22% resulted in a decrease of 9.7% PCB conversion for the 4 hr reaction time.

This research is supported by the NIEHS-SRP grant P42ES007380.

USING A BIO-DERIVED SOLVENT TO CAST POLYSULFONE ULTRAFILTRATION MEMBRANES

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Organic solvents derived from petroleum sources, such as N-methyl-2-pyrrolidone (NMP) and dimethylacetamide (DMAc), have been traditionally used to fabricate polymeric membranes. These solvents have a negative impact on the environment and human health since most of them are volatile and hazardous; therefore, using renewable solvents derived from biomass would be of great interest in order to make membrane fabrication sustainable. In this study, methyl-5-(dimethylamino)-2-methyl-5-oxopentanoate (Rhodiasolv® PolarClean) was used because it is a bio-derived, biodegradable, nonflammable and nonvolatile solvent. Polysulfone was chosen as the polymer to fabricate membranes due to its thermal stability, strong mechanical strength, good chemical resistance and antifouling properties. The thermodynamics aspects of the polysulfone/PolarClean/water system were investigated. From cloud point curves and theoretical predictions, PolarClean showed the potential to be a solvent for polysulfone as compared to traditional petroleum-derived solvents. Polysulfone membranes prepared with PolarClean were also investigated in terms of their morphology, porosity, water permeability and protein rejection, and subsequently, compared to membranes prepared with petroleum-derived solvents. Overall, PolarClean showed a potential to replace petroleum-derived solvents in fabrication of polymeric membranes.

SELENIUM REMOVAL USING ACTIVATED ALUMINA IN A PACKED-BED REACTOR

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Selenium is a typical aqueous contaminant in United States as limited to 0.05 mg/L by EPA. Two dominant inorganic oxyanions, selenate (Se(VI)) and selenite (Se(IV)), can be easily found in water due to their high solubility. Selenium released from manufacture industries of glass, pigments, fossil fuel, emulsion and metal alloys is toxic to human beings as well as aquatic lives and damages the ecological environment. Treatment technologies to remove selenium including microbial reduction and adsorption using activated alumina have been studied in recent years. Both treatment processes were reported able to remove selenium effectively but with deficiencies. In the microbial selenium reduction process, Se(IV) reduction was relatively slow and required a long period to achieve complete reduction compared with Se(VI) reduction. In the process of adsorption onto activated alumina, the adsorption capacity of Se(VI) was significantly lower than Se(IV) and can be interfered by kinds of anions including bicarbonate, sulfate, phosphate, etc. Thus, in order to enhance the removal efficiency, a combined process of both microbial reduction and adsorption was designed to remove selenium complementarily.

In this study, a packed-bed reactor packed with 40 g activated alumina and cultured with the bacterial strain *Shigella fergusonii* was applied at feeding Se(VI) concentrations of 10 and 50 mg/L, and an HRT of 3.4 days was performed. The result shows that selenium can be removed complementarily by both adsorption with activated alumina and microbial selenium reduction leading to the improvement of removal efficiency. Approximately 4.3 mg/L and 19.7 mg/L of Se(VI) was detected in the effluents at feeding concentrations of 10 and 50 mg/L at the end of the experiments, respectively, indicating that Se(VI) has been significantly removed compared with 9.95 mg/L and 47.9 mg/L using single adsorption process. Insignificant Se(IV) accumulation was observed as Se(IV) generated from Se(VI) reduction was further absorbed by activated alumina.

SESSION 1B: BIOLOGY

KENTUCKY LAKE UNDERGOING A “CHANGE OF STATE”: TREND ANALYSES INDICATE POTENTIAL TIPPING POINTS ARE BEING REACHED FOR SEVERAL LIMNOLOGICAL VARIABLES

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The Kentucky Lake Long-term Monitoring Program (KLMP) was begun in July 1988 to understand the basic limnology of this very large Tennessee River reservoir and to document patterns and trends. A wide variety of biological, chemical, and physical measurements are taken every 16 days (32 days December – February) at 12-14 lake sites and several tributary sites. Trend analyses reveal important changes taking place in the lake over the past 30 years. Some variables appear to have reached “tipping points” resulting from changes in the watershed and/or from species invasions.

Mean water temperature has steadily increased by 2 °C over the 30-year period of record. Mean total alkalinity has increased from 50 to 60 mg CaCO₃/L (Fig. 1). Mean chloride ion concentration has doubled from 5 mg/L to 10 mg/L (Fig. 2). Secchi depth (Fig. 3) and 1% light penetration have increased by 0.5 meters and 2.5 meters, respectively. Silicon dioxide has increased 1.5 mg/L, and soluble reactive phosphate has increased 0.1 mg/L. Significant decreasing trends over 30 years include sulfate, down from 20.0 to 8.8 mg/L; turbidity down from 15 to 4 NTU's, primary production down from 40 to 30 µg C/L/h, and oxidation-reduction potential down from 0.3 to 0.2 mv. Dissolved organic carbon has decreased from 2.5 to 2.0 mg/L. Variables that have remained relative constant include chlorophyll-*a*, total nitrogen, and total phosphorus. Many of the changes in the variables discussed above were also driven by strong seasonal effects.

It is obvious that many of the decreases and increases result from synergistic relationships among the parameters particularly as they relate to changes in ecosystem processes and invasive species. While present in the Ohio River for more than 30 years, silver carp (*Hypophthalmichthys molitrix*) only recently has become a super invader in Kentucky Lake. Its long-term effects on the phytoplankton and zooplankton populations remain to be determined, but the decrease in primary production over the past several years is unmistakable even though chlorophyll-*a* has remained fairly constant.

Zebra mussels (*Dreissena polymorpha*) had become established in the Ohio River basin by 1992. They were reported from the Tennessee River basin at the same time but only as occasional sightings. The lack of reproducing populations was attributed to Ca⁺⁺ levels below the 21-23 mg/L threshold. Between 2012 and 2017, Ca⁺⁺ levels increased from ~15 mg/L to

above the threshold. Reproducing zebra mussel populations appeared for the first time in the spring of 2017. The source(s) of the Ca^{++} have yet to be determined but likely come from increased use of road deicing brine (CaCl_2) and from runoff and precipitation containing higher alkalinity (CaCO_3). As with silver carp, zebra mussels are voracious filter feeders. The effects of the combination of both species on the Kentucky Lake ecosystem will be quite interesting to see. Over the past few months, there has been a noticeable change in Secchi depth with visibility going from ~2 to over 4 m.

The KLMP database has detected several significant changes in water quality and biology over the past 30 years. Alterations in land use and the effects of invasive species appear to be the primary drivers. The trends appear to be irreversible and have led to a “change of state” for Kentucky Lake.

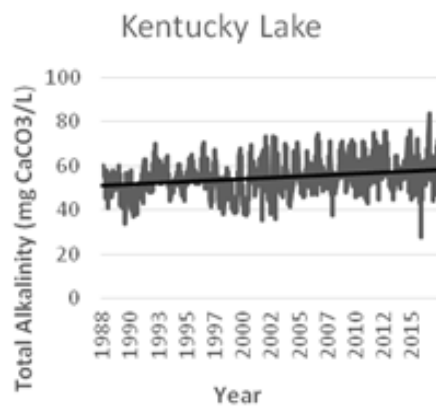


Fig. 1. Long-term total alkalinity trends

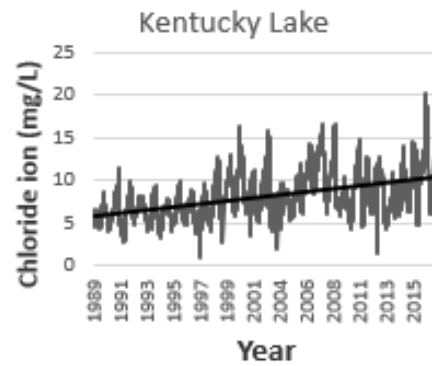


Fig. 2. Long-term chloride trends

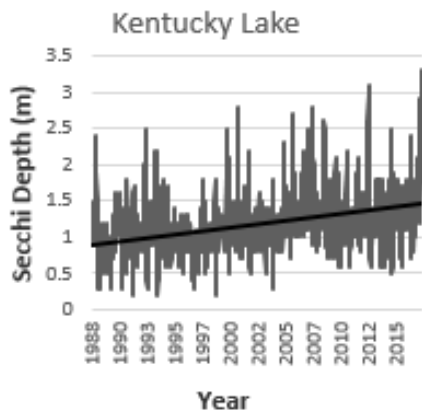


Fig. 3. Long-term Secchi depth trends

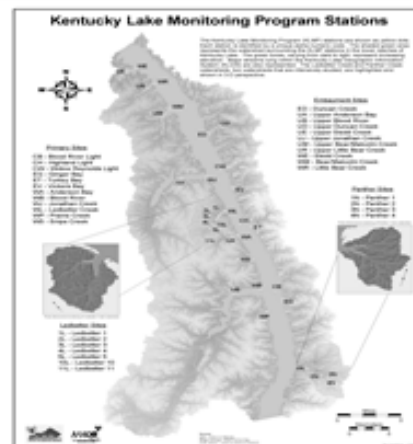


Fig. 4. KLMP watershed map

PRELIMINARY ENVIRONMENTAL ASSESSMENT OF THE GREEN AND NOLIN RIVERS IN MAMMOTH CAVE NATIONAL PARK FOLLOWING THE REMOVAL OF LOCK AND DAM #6

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A partnership between the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Park Service, The Nature Conservancy, Kentucky Department of Fish and Wildlife Resource, Kentucky State Nature Preserves Commission (KSNPC), and the Kentucky Waterway Alliance was established to oversee and evaluate the removal of the 110-year-old lock and dam #6 (L&D 6) on the Green River near Brownsville, Kentucky, after it breached in November 2016. The objectives of the dam removal were to eliminate the public safety hazards, restore the immediate section of the Green River within Mammoth Cave National Park (MCNP) to more natural hydrological conditions, and to document the environmental response and recovery. During the summer and fall 2017, KSNPC staff conducted baseline surveys to assess the current physical and biological conditions from approximately 24 river kilometers (15 miles) upstream within the Green and Nolin rivers that were formerly impacted by L&D 6. The initial surveys indicated that the free flowing hydrological conditions of the Green River expanded approximately 16 river km downstream following dam removal (Figure 1). However, the presence of lock and dam #5 near Glenmore, Kentucky, still impounded the Green and Nolin rivers upstream to Crump Island and Second Creek, respectively.

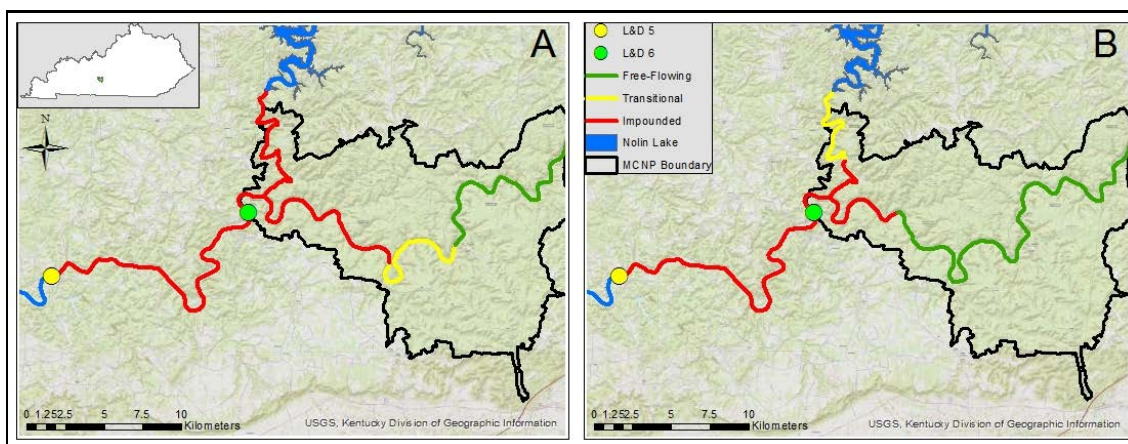


Figure 1. Historical (A) and current (B) hydrology of the Green and Nolin rivers near MCNP.

The instream habitat within the impounded section was predominantly comprised of mud and sand (84%), while the substrate composition within the free flowing section was more variable and evenly mixed among mud and sand (47%), and gravel and pebble (39%). The riparian zone along both hydrological sections exhibited numerous areas of extensive bank erosion and collapse, exposing large areas of bare soil and canopy loss. An estimated 60% of the banks within the impounded section had experienced bank failure, while the free flowing section experienced approximately 15%. Plant composition and richness along the riparian zone was relatively the same among the hydrological sections (Table 1). The invasive herbaceous

species, oriental lady's thumb (*Persicaria longiseta*) and Japanese stiltgrass (*Microstegium vimineum*), were common and are indicative of disturbed habitats. The macroinvertebrate fauna had greater richness in the free flowing section, but the overall composition of the fauna was largely comprised of the same three to five taxa. This indicates that even though different hydrological conditions currently exist, the fauna still represents an assemblage of the historical hydrological conditions. Twenty-seven species of mussels were encountered, including the federally endangered species, fanshell (*Cyprogenia stegaria*) and sheepnose (*Plethobasus cyphus*). Mussel richness and abundance were greatest within flowing habitats (i.e., riffle and run). The fish fauna was diverse with 58 native species. The free flowing section of the river had the greatest richness and abundances, however, low abundance of benthic species (bottom dwelling) within this section suggest that the fish fauna is more indicative of the historical impounded conditions.

Table 1. Mean taxa richness of biological groups within hydrological and habitat categories.

Biological groups (number of sites per category, respectively)	Hydrology		
	Impounded	Flowing	
Vegetation (9, 6)	10.6	10.5	
Macroinvertebrates (3, 2)	29.7	40.0	
Fish (3, 2)	20.0	44.0	
	Habitat type		
	Impounded	Flowing	Pool
Mussels (3, 14, 10)	1.3	9.3	2.3

Overall, the removal of lock and dam #6 decreased the permanent and seasonal impoundment of the Green River by 16 river km. It is hypothesized that the flora and fauna will recover over time as the river corridor stabilizes and the smaller substrate particles are distributed further downstream. The rate and degree of recovery will vary among biological groups and within the different hydrological regimes. It is recommended that monitoring continue and the data be thoroughly analyzed to fully understand and assess the recovery of the river and its biological and physical components, with adaptive management implemented to amend for the dynamic environment.

WATER QUALITY AND PRIMARY PRODUCTIVITY IN MINOR E. CLARK FISH HATCHERY PONDS

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Minor Clark Fish Hatchery has greater than average fish production and survival. The water source for hatchery ponds is relatively low alkalinity, low nutrient, Cave Run Lake. We examine nutrient limitations using bioassays, and determined that primary producers were phosphorus (P) limited, with a secondary nitrogen (N) limitation when fertilized. We also examined if pond sediments were a source of nutrients to photoautotrophs during fish rearing. Examination of five-year changes in available nutrient concentrations, and sediment phosphorus adsorption-desorption isotherms, suggest that sediments have been losing N and P to the water column, but that this ability has diminished over time. We have measured primary production with diel oxygen curves, chlorophyll *a* concentrations, and algal counts. There is a strong correlation between nutrient additions and primary production, and some indication of a carbon limitation if N and P fertilization are extraordinary. Managers have found that by reducing some of the nutrient loading, they have been able to maintain adequate primary production to support fish survival and growth, while minimizing overfertilization problems (such as anoxia).

SESSION 2B: SEDIMENTS AND NUTRIENTS

WATER, SEDIMENT, AND NUTRIENTS DATA STREAMS IN A FLUVIOKARST WATERSHED IN THE KENTUCKY BLUEGRASS: INSIGHTS FROM ELEMENTAL, ISOTOPIC, AND HIGH RESOLUTION SENSOR DATA

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The physical and biochemical fate of contaminants within karst systems is poorly understood. The gap in knowledge is of particular concern given the susceptibility of karst waters to contamination and their wide use as a water source. In Kentucky, approximately 55% of the land surface is underlain by rock with karst potential and close to two million Kentuckians access groundwater reserves for drinking water purposes. Data streams in karst systems are typically collected at arbitrarily selected wells and the terminal springhead, but due to the spatially heterogeneous nature of karst terrain and the high connectivity between surface and subsurface pathways these locations may not adequately characterize contaminant fate. Few studies have long-term water quality data at highly coupled surface and subsurface locations within a fluviokarst aquifer.

The objective of this study was to elucidate the pathways of water within karst systems, the biochemical processing and temporary storage of contaminants, and the fate of terrestrially derived matter within the subsurface. To that end, we collect spatial and temporal data over the course of half a decade (ranging from hourly storm data to bi-weekly integrated data) from surface tributaries feeding the karst system, the longitudinal midpoint of the subsurface conduit, and the primary spring. Event-based sampling highlights the physical transport and turbulent mixing of karst pathways, low-flow sampling isolates in-conduit biochemical processes from surface recharge, and long-term bi-weekly sampling indicates seasonal and yearly trends in water quality data. Samples were analyzed for sediment carbon (C) and nitrogen (N), stable C and N isotope composition of sediment ($\delta^{13}\text{C}_{\text{Sed}}$ & $\delta^{15}\text{N}_{\text{Sed}}$), nitrate (NO_3^-), oxygen (O) and N isotope composition of NO_3^- ($\delta^{15}\text{N}_{\text{NO}_3}$ & $\delta^{18}\text{O}_{\text{NO}_3}$), hydrogen (H) and O isotope composition of water ($\delta^2\text{H}_{\text{H}_2\text{O}}$ & $\delta^{18}\text{O}_{\text{H}_2\text{O}}$), and C isotope composition of dissolved inorganic C ($\delta^{13}\text{C}_{\text{DIC}}$). In addition, high resolution sensor data streams were analyzed from the primary springhead.

Results emphasize the role of pathway mixing and karst storage in controlling contaminant flux from the karst watershed. Further results indicate biochemical enrichment of heavier isotopes within the surficial fine-grained laminae (SFGL) of the karst conduit. The authors encourage karst watershed scientists to consider variable flow pathways and the impact of the SFGL on sediment and nutrient delivery to improve the accuracy of model predictions and aquifer assessment.

EFFECTS OF STREAM RESTORATION ON POLLUTANT LOAD REDUCTIONS IN AN URBAN WATERSHED

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Streams draining urban lands consistently suffer from “urban stream syndrome” (Walsh et al., 2005), which is characterized by flashy hydrology, elevated concentrations of nutrients and contaminants, altered morphology, decreased amounts of organic matter, and poor biotic richness. Urban streams are often incised, over widened, lack bed complexity, have small hyporheic zones, have narrow floodplain corridors bordered by structures and utilities, and lack woody material. Restoring urban streams is a challenging endeavor, particularly when restoration goals include water quality and habitat improvements, the top two components of the Stream Functions Pyramid (Harman et al., 2012). Notable water quality impairments in many urban streams include elevated nutrient, sediment, and pathogen concentrations (Walsh et al., 2005). Of particular concern is nitrogen (N) and phosphorus (P) as these two constituents, in excess levels, promote eutrophication. In the U.S., eutrophication is one of the leading water quality impairments (Sharpley et al., 2003). Stormwater best management practices focus on reducing pollutant loads from upland sources, but do not address pollutant removal in the stream itself. Restoring the hyporheic zone, particularly through the addition of woody material in the floodplain, could promote retention and processing of instream pollutants (Valett et al., 1996).

In 2013, a nearly 950 ft of an unnamed headwater tributary (UT) to the South Elkhorn Creek at the Montessori Middle School of Kentucky (MMSK) was restored using regenerative design techniques whereby a floodplain-wetland complex was created. The restoration resulted in a wide, wetland-like floodplain, comprised of a rock base that was overtopped with a filtration media (approximately 30% woodchips and 70% topsoil). This combination of regenerative design and woody material addition to floodplain soils, may improve the quality of downstream receiving waters indicating such stream restoration efforts may serve as a viable TMDL.

The **purpose** of this work is to determine the effectiveness of using regenerative design techniques coupled with a designed filter media to improve water quality of urban streams. **Specific objectives** of the project are to: 1) determine the effect of the MMSK stream restoration project on hydrology, 2) determine the ability of the MMSK stream restoration project to improve water quality, and 3) educate water managers, design professionals, and other stakeholders on strategies to restore urban streams and improve water quality.

Prior to restoration, the University of Louisville (U of L) Stream Institute monitored the hydrology (storm and base flows) and water quality (PO₄-P, NO₃+NO₂-N, NH₃-N, BOD, pH, EC, and DO) at three locations on the stream (see Figure 1) for a one-year period (Parola et al., 2013). These data were provided to the PIs by the U of L Stream Institute. The upstream and downstream extents of the project are equipped with trapezoidal flumes and stage height recorders (HOBO water level loggers) for continuous discharge measurements. Floodplain

cross-sections, at the upstream and downstream weirs, were surveyed to develop stage-discharge relationships when flood stage exceeds weir capacity. Three well transects, each consisting of six wells were installed along the project reach to evaluate water levels and constituent concentrations within the restored floodplain. Water levels within the wells are measured bi-weekly. During equipment installation, it was noted that two pipes, 24-inch and 42-inch diameters, discharged into the project reach. Discharge in both pipes is measured using ISCO 4250 flow meters (one per pipe). Bi-weekly grab samples are collected from the three locations along the stream (upstream, downstream, and middle) and the wells and analyzed for PO₄-P, NO₃-N/NO₂-N, NH₃-N, Cl⁻, SO₄, TOC, DOC, *E.coli* (stream only), TSS, and turbidity using standard methods (APHA, 1992). Bi-weekly, *in situ* measurements of pH, EC, DO, and temperature (measured using a YSI 556 multiprobe system) are taken at the three stream sample locations and at each well. A rain gauge was installed at the project site to provide precipitation data.

Data collection is actively on-going and is expected to conclude summer of 2018. Comparisons between upstream, middle, and downstream hydrology and instream water quality will be conducted following the completion of the data collection period.

WATERSHED SEDIMENT TRANSPORT MODELING USING DYNAMIC LATERAL, LONGITUDINAL, AND VERTICAL SEDIMENT (DIS)CONNECTIVITY

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Recent geomorphologic literature suggests that sediment (dis)connectivity, which describes the detachment and transport of sediment from source to sink in the lateral, longitudinal, and vertical directions between geomorphic zones, is a major control on sediment transport. However, we find that few contemporary sediment transport and watershed erosion models incorporate sediment connectivity concepts and in the present study, we advance this modeling framework by applying the model to a lowland, bedrock-controlled catchment in Kentucky, USA. Bedrock controlled catchments are potentially unique due to the presence of bedrock outcrops, which cause longitudinal impedance to sediment transport within the stream corridor. We argue that given the now widespread availability of high-resolution topographic and landscape feature datasets, the time is ripe to advance watershed and sediment transport modeling *via* the improvement of the spatiotemporal setting. Therefore, this study was motivated by the need to formulate a sediment transport model that couples sediment (dis)connectivity knowledge with erosion and transport equations to predict sediment flux for bedrock-controlled catchments.

This modeling framework couples a watershed-scale erosion model with an instream sediment transport model that incorporates sediment (dis)connectivity knowledge from field reconnaissance and GIS analyses. Upland sediment connectivity is predicted and reflects the co-occurrence of both hydrologic and non-hydrologic sediment detachment and transport, sediment supply availability, and disconnectivity. The integration of the net watershed probability of connectivity yields an estimate of the active watershed area in terms of upland sediment transport when multiplied times the entire watershed area. Within the stream corridor, we simulate connectivity by discretizing fluid and sediment pathways due to barriers that impede longitudinal sediment transport such as bedrock outcrops and manmade check dams. Discretization of the reaches was aided by field reconnaissance and visual stream assessments. The instream model predicts erosion and deposition of sediment from the bed, banks, and SFGL within each reach and sediment yield at the watershed outlet at the ten-minute time step.

The simulated sediment flux was calibrated and validated using the existing historic sediment dataset collected by the authors. The probability of sediment connectivity model highlights the disconnected nature of the upland ephemeral network within the watershed. In general, the model predicted that little connectivity occurs over the course of the year within the uplands and only 13% of the catchment contributed sediment to the stream network on the most connected day of the year. Furthermore, this modeling effort hopes to show how the digitization of the bedrock outcrops affects erosion and deposition rates within the stream corridor and how the explicit simulation of upland sediment erosion impacts the transport capacity of the fluid. This research is applied to the Upper South Elkhorn watershed, a lowland, bedrock-controlled catchment in the Bluegrass Region of Kentucky, USA. Through this study,

we hope to elucidate further the governing processes that dictate sediment transport in lowland, bedrock-controlled catchments. Given the recognized importance of lowland catchments in worldwide sediment yields, investigating these processes will assist future consultants and researchers in managing water supply and water quality.

SESSION 1C: HYDROLOGY

COMPARING THE HYDROLOGICAL FUNCTION OF NATURAL AND CONSTRUCTED RIDGE TOP ISOLATED WETLANDS

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Natural and constructed ridge top isolated wetlands in the Daniel Boone National Forest, Kentucky both provide a range of ecological services such as drought resilience, native species habitat, and source water for game animals. However, the natural and constructed systems do not hydrologically function the same way. Natural ridge top wetlands tend to dry out by mid-summer, while constructed wetlands generally retain water all year. The hydrological controls that led to this variability were not quantified, making conservation and restoration efforts difficult to define. The United States Forest Service and Eastern Kentucky University began an ongoing partnership in 2016 to determine the hydrologic function of natural and constructed ridge top wetlands in order to make data driven conservation and restoration decisions. Six ridge top wetlands (three natural and three constructed) were instrumented and mapped for this study. Groundwater levels, surface water level, soil moisture, and precipitation were monitored in each wetland monthly by manual measurements or in 15 minute intervals using sensors. Soil physical properties (porosity, structure, grain size, and permeability) were determined from soil cores that were analyzed at Eastern Kentucky University's hydrology laboratory. Each wetland was mapped via optical or laser transit so that a digital elevation model could be constructed to compare surface morphology. Evapotranspiration of groundwater was calculated from sensor data of groundwater level. One wetland was instrumented with 30 groundwater wells in order to completely map aquifer dynamics and model groundwater recharge on the ridge tops. Results indicated that natural ridge top wetlands are connected to groundwater, which seasonally recharges in the spring and is depleted in the summer. The surface morphology of the wetlands appears to control how long the wetland has surface water into the summer. The main controls include average slope and hillslope structure. Natural wetlands with high slope and smooth features tended to fill with runoff after rainstorms and leak slowly into the ground while natural wetlands with lower slopes and soil mound features tended to have more extensive groundwater resources. These groundwater resources recharged in winter-spring, which created groundwater discharge that sustained the wetland into later summer months. Forest vegetation consumed groundwater in low slope wetlands at a rate high enough to dry the system in 2-20 days. Summer storms recharged the system, which provided extra water to forest vegetation during summer droughts. In contrast, constructed wetlands tended to have small watersheds with compacted soils that allowed slow leakage. While groundwater was found connected to the constructed systems, groundwater flow was slow and there was no evidence of groundwater consumption by vegetation.

STREAMFLOW GAIN AND LOSS, HYDROGRAPH SEPARATION, AND WATER-QUALITY OF ABANDONED MINE LANDS IN THE DANIEL BOONE NATIONAL FOREST, EASTERN KENTUCKY, 2015-2017

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During 2015-17, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Agriculture Forest Service (USDA FS), carried out a study to characterize the hydrology and water chemistry in the Rock Creek, Wildcat Branch, and Addison Branch areas of the Daniel Boone National Forest (DBNF). The study areas contain abandoned mine lands which have been the focus of remediation efforts in recent years. Synoptic surveys were used to identify streamflow gaining and losing reaches, and characterize water-quality field measurements in the study areas. In addition, continuous water quality and streamflow were measured at the Rock Creek near Yamacraw, Kentucky gaging station (USGS 03410590).

Base flow was estimated in the Rock Creek Basin using six hydrograph separation methods: (Base-Flow Index (BFI; Standard and Modified), HYSEP (Fixed Interval, Sliding Interval, and Local Minimum), and PART) to separate total streamflow into base flow, streamflow derived from groundwater, and runoff, streamflow that originated from precipitation. Good agreement was observed between mean base flow index (BFI) values for all hydrograph separation methods. The predominate source of water to Rock Creek below 137 cubic feet per second (cfs), irrespective of method, was base flow with runoff being the predominate source of water above 137 cfs. Approximately 84-percent of mean daily discharge values during the study period were below the 137 cfs threshold and likely derived from groundwater. The data suggests base flow, compared to runoff, was the more dominate source of total streamflow in Rock Creek during the study period. The karst topography caused appreciable streamflow losing and gaining reaches in both study areas.

The synoptic surveys indicated the quality of water at Rock Creek (median pH: 6.98 standard units, mean specific conductance: 392 $\mu\text{S}/\text{cm}$) was less influenced from acid-mine drainage (AMD) than Wildcat (median pH: 3.68 standard units, mean specific conductance: 835 $\mu\text{S}/\text{cm}$) or Addison Branches (median pH: 3.23 standard units, mean specific conductance: 2,000 $\mu\text{S}/\text{cm}$). Continuous water-quality measured at the USGS gaging station Rock Creek near Yamacraw, Kentucky showed circumneutral pH values and specific conductance values that ranged between 30 to 259 $\mu\text{S}/\text{cm}$. The results of the study will aid the U.S. Forest Service with their remediation efforts in the study watersheds.

HYDROLOGY: OLD SCIENCE, NEW APPLICATIONS FOR THE BLANCHARD RIVER IN OHIO

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The Blanchard River system in northwest Ohio drains an area of about 350 square miles before it flows through the City of Findlay in Hancock County, Ohio. Findlay has a population of only about 40,000, but several corporations are there including: the Cooper Tire & Rubber Company, Marathon Petroleum, Whirlpool, and others. The watershed is mostly agricultural upstream of Findlay, but the Blanchard River tends to exceed its bank capacity often and expand quickly into the relatively flat floodplain. Unfortunately, the City of Findlay is in harm's way, as evident by a large flood in 2007 that flooded much of downtown. It happened again in 2017.

The problem has been studied throughout the years, but the 2007 and 2017 events amplified interest in a solution. A large flood diversion project was being proposed for the Eagle Creek tributary of the Blanchard River near Findlay. The diversion would reduce flood risks for the City under certain conditions, but it was expensive and had a marginal benefit-to-cost ratio. There was also some concern that a large storm in another part of the watershed could still cause flooding. Stantec revised the hydrologic and hydraulic studies and recommended alternate flood risk reduction measures that included channel widening and a series of dry detention basins in other locations in the watershed. The measures were just as effective as the diversion channel, had a lower up-front cost, and could be phased in over time. The new program was more robust and would be effective for storms throughout the watershed.

This presentation includes a brief discussion of Stantec's hydrologic analyses for the Blanchard River Flood Risk Reduction Program. Previous hydrology efforts were based on SCS Type II rainfall events applied uniformly to the entire watershed. Stantec divided the study into smaller pieces and applied spatial and temporal storm patterns often used in probable maximum precipitation (PMP) analyses as design variables. Stantec worked with meteorologists from Applied Weather Associates to develop site specific data for the study. We assessed and scaled historic storms typically used to generate statewide PMP estimates to a smaller area and more frequent design storm basis. Custom areal reduction factors, similar to those that were used with NOAA Atlas 2, were determined and custom storm orientation and temporal patterns, similar to those described in NOAA HMR 52, were applied to design storms. Several storm center locations were tested to assess model sensitivity.

The result of Stantec's approach was a more efficient design process, with better results and a more accurate representation of residual risk for the proposed projects.

SESSION 2C: SOILS AND AGRICULTURE

SOIL PHOSPHOROUS IN URBAN KENTUCKY: LAWN AND GARDENING OUR WAY TO HELL IN A VEGETABLE BASKET

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An excess of phosphorus (P) in the environment can lead to eutrophication and degradation of surface waters. Research at the University of Kentucky has demonstrated that at soil test P levels greater than 60 mg kg^{-1} , P becomes water soluble and has a greater potential to reach surface and ground water than at concentrations below 60 mg kg^{-1} . Often the public blames water quality impairments on agricultural practices that lead to sediment and nutrient runoff without reflection on personal practices at home that may also impair local water bodies. An investigation of the temporal and spatial distribution of all soil P tests collected over 25 years (1990 – 2014) from row cropped fields and pastures (agriculture: 810,978 tests) compared to residential home lawns and gardens (urban: 179,184 tests) was conducted. Amongst all of the soil tests collected, 79% of all urban soil tests were greater than 60 mg kg^{-1} while only 34% of all agriculture soil tests were greater than 60 mg kg^{-1} . In 119 out of 120 counties, the average soil test is 93 mg kg^{-1} higher in urban soils relative to agricultural soils. Amongst physiographic regions, the Bluegrass has a significantly higher average soil test P levels (ag: 156 mg kg^{-1} , urban 261 mg kg^{-1}) than any other region. The lowest average soil test P levels were found in the western Coalfield (agriculture: 76 mg kg^{-1} , urban: 137 mg kg^{-1}) and western Pennyrite (agriculture: 68 mg kg^{-1} , urban: 142 mg kg^{-1}). Temporally, the state average amongst all agricultural soils was 62 mg kg^{-1} in 1990 and has decreased steadily to 51 mg kg^{-1} in 2014, demonstrating that the agricultural community has been effective at reducing P levels in their row-crop fields and pastures. Alternatively, the state average soil test P amongst all urban soils was 94 mg kg^{-1} in 1990 and has increased to 113 mg kg^{-1} in 2014. These results indicate that there is an impactful educational opportunity in the urban sector to improve nutrient management and the reduction of P released to the environment.

OPTIMIZING YIELD AND WATER USE EFFICIENCY OF SOYBEAN PRODUCTION IN KENTUCKY- EXPERIMENTAL AND MODELING APPROACH

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Water limitation is one of the main causes for the gap between potential and actual yields in many soybean production areas of the US. In Kentucky, the estimated yield gap ranges from 12 to 32%, and was partially associated to the ability of different soils to hold water (Egli and Hatfield, 2014). Currently only 5% of soybean production in the state is irrigated (USDA-NASS, 2017). Continuous water availability under both rainfed and irrigated conditions thus pose a threat for stable high row crop productivity in the state. It is critical to quantify yield productivity and water use efficiency (WUE) across a range of management options to develop sustainable recommendation practices. We hypothesize that management recommendations of planting date and maturity group (MG) selection that maximize yield and WUE will differ from irrigated to rainfed conditions.

Field experiments took place in Lexington and Princeton, KY during 2017. The experimental design was a split-split-plot with four replication. The main factor was planting date (May 16th and June 21st in Lexington, May 23rd in Princeton), the second factor was irrigation (rainfed vs irrigated) and the third factor was soybean maturity (MG 2, 3, 4 and 5). A total of 16 cultivars were used, with four cultivars nested within each MG. Phenology stages were monitored, and during-season destructive samples were taken to estimate crop and seed growth rate. Drip irrigation was applied to the irrigated treatments when the soil-water deficit reached 30 mm. Soil-water deficit values were estimated based on weather data and a daily soil-water balance. Daily crop evapotranspiration (ET) for the irrigated treatments were estimated using the standardized dual-crop coefficient Penman-Monteith approach (FAO-56) (Allen, 2006) and used to calculate preliminary WUE data for the irrigated treatments presented in Table 1. Actual ET values for each treatment under both irrigated and rainfed conditions will be estimated using a mechanistic crop-soil-water model (DSSAT-CROPGRO; Hoogenboom et al., 2017). The suitability of the model to predict ET will be assessed based on the model ability to predict yield and plant growth differences across the different treatments in the study.

Irrigation increased yield by 13 to 30% in Lexington depending on maturity group and planting date (Table 1). For planting dates in May, irrigation increased yields by 16 to 30%, while for late planting dates in June, irrigation increased yields to a lesser extent (6 to 13 %). In Princeton, irrigation did not produce a significant yield increase in most cases, and yields were reduced by 11% in MG 3 cultivars. (Table 1). The MG cultivar choices that would maximize yield within a location and planting date were different for the rainfed compared to the irrigated treatments (Table 1). For example, for planting dates in May at Lexington, MG 3 to 5 cultivars would maximize yields under rainfed conditions, while earlier soybean maturities (MG 2 to 4 cultivars) would maximize yields under irrigation. The study was successful identifying management options that can increase WUE under irrigated conditions while maintaining yield productivity. Short-season MGs showed a higher WUE compared to later MGs (Table 1).

Under scenarios of similar yields across two MG options, shorter-season cultivars offered the advantage of increasing WUE. As an example, for May planting dates in Lexington, MG 2 to 4 cultivars would produce similar yields but MG 2 would increase WUE by 23% compared to MG 4 cultivars (Table 1).

Preliminary results from this study indicate that state MG recommendations might need to be re-adapted depending on water management and availability, and that informed decisions on MG selection could have a significant impact on WUE without a yield penalty. Data from 2018 and estimations of ET and WUE under rainfed conditions based on crop model simulations will be used to provide management recommendations that increase water productivity for soybean production in KY.

Table 1. Average yield (kg ha^{-1}) for rainfed and irrigated treatments, yield increase due to irrigation (%), water use efficiency (WUE, kg mm^{-1}) and total evapotranspiration (ET, mm) by location, planting date, and soybean maturity group (MG). Data from 2017 at Lexington and Princeton, KY.

Maturity group	Location	Planting date	Yield (kg ha^{-1}) Rainfed	Yield (kg ha^{-1}) Irrigated	Yield increase due to irrigation (%)	Irrigated treatments	
						WUE (kg mm^{-1})	Total ET (mm)
2	Lexington	May	4301 b	5599 a	30*	12.3 a	454
3	Lexington	May	4822 a	5758 a	19*	11.2 ab	515
4	Lexington	May	4671 a	5398 a	16*	10.0 b	542
5	Lexington	May	4960 a	4587 b	-8	7.5 c	610
2	Princeton	May	4231 b	4344 b	3	10.3 a	422
3	Princeton	May	4957 a	4425 b	-11*	9.6 a	487
4	Princeton	May	5015 a	5460 a	9	10.5 a	519
5	Princeton	May	4254 b	4307 b	1	6.8 b	631
2	Lexington	June	3833 b	4212 b	10*	12.0 a	350
3	Lexington	June	4188 b	4727 a	13*	12.2 a	388
4	Lexington	June	4550 a	4799 a	5	11.1 b	433
5	Lexington	June	3454 c	3695 c	7	7.8 c	476

‡Different letters indicate significant differences ($p < 0.05$) across MGs within a location and planting date. *An asterisk represents a significant effect of irrigation within a location, planting date, and soybean MG treatment ($p < 0.05$).

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VARIATIONS IN SOIL SATURATED HYDRAULIC CONDUCTIVITY ACROSS MULTIPLE LAND USES IN FAYETTE COUNTY, KENTUCKY

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Nonpoint source pollution, flooding and other phenomena depend heavily on the seemingly simple, yet notoriously inconsistent, relationship between rainfall and runoff. Methods are available to account for some of the major sources of variation in the rainfall-runoff relationship. Even so, it is prudent to validate the benefits of these methods under a variety of circumstances and, in view of the importance of the issue, to continue to seek improvements in rainfall-runoff modeling.

The objective of this study was to examine relationships between soil hydraulic conductivity, a soil characteristic that is key in the rainfall-runoff relationship, and more easily-obtainable soil parameters (e.g., bulk density and texture). Soil cores (5.7 cm diam. x 6.0 cm length) were collected from 24 sites in Fayette County, Kentucky, which varied according to land use (residential, pasture, industrial and parks), hydrologic soil group as mapped by USDA Natural Resources Conservation Service staff (hydrologic soil groups B and C) and, in the case of residential land use, the age of the residence (new, medium and old). Saturated hydraulic conductivity of the samples was determined using a constant head permeameter, and the data were analyzed for significant relationships with other soil parameters. The findings indicate that, under conditions of this study, saturated hydraulic conductivity is more closely related to dry bulk density than any other soil parameter investigated. The implications on runoff estimation, and on all processes that are dependent on runoff, are potentially significant.

POSTER SESSION 1

1. THE ECOLOGICAL IMPORTANCE OF PERCHED AQUIFERS AND THEIR HYDROLOGICAL CONNECTIVITY TO RIDGE TOP EPHEMERAL WETLANDS IN DANIEL BOONE NATIONAL FOREST

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Natural ephemeral wetlands situated among the ridgetops in the Daniel Boone National Forest serve as reservoirs that recharge a shallow groundwater system. Unique interactions between surface and groundwater in these isolated systems provide substantial support for the native ecosystem, serving as a breeding ground for amphibians and as source water for vegetation—especially in periods of drought. Currently, it is not understood how groundwater could provide regional biodiversity, a drought buffer, or a crucial role in biogeochemical cycling. It was the goal of this research project to define the seasonal controls of groundwater levels within the aquifer system. This was accomplished by:

1. Monitoring groundwater and surface water in a representative wetland in the Daniel Boone National Forest, Kentucky;
2. Quantifying the physical properties of the aquifer and groundwater evapotranspiration rate;
3. Numerically modeling the groundwater recharge rate required to sustain groundwater levels by analytic element method.

Monitoring and aquifer tests were conducted in the summer of 2016 and 2017. All data gathered in the field was introduced into a computer model to simulate the groundwater processes. The results of our research indicate that groundwater stored within hillslopes acts as a reserve for the surface water during the winter months and contributes further support for the ecosystem. In the dynamic transition from winter to summer months, vegetative water use intensifies during leaf-out (~0.002-0.005 m/d) and eventually overcomes the groundwater recharge rate (0.0017-0.003 m/d), which can completely desiccate the system. Periodic storm events inundate the wetland, recharging both the surface and groundwater. These sub-seasonal storm events maintain groundwater levels for up to 20 days, before vegetation depletes the stored water.

2. WATER BUGS AND BACTERIA: CREATING A WATER QUALITY MONITORING PROGRAM FOR THE WHEELING CREEK WATERSHED IN THE NORTHERN PANHANDLE OF WEST VIRGINIA

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Monitoring water quality with a network of volunteers is increasingly being utilized as a viable way to collect data and assess water quality issues within municipalities and throughout watersheds. We propose to establish a long-term data collection plan for the Wheeling Creek in West Virginia. Wheeling Creek originates in Pennsylvania and flows west into West Virginia and then into the Ohio River, bisecting the City of Wheeling. Old infrastructure (storm drains and sewer lines) and a deficiency in water quality data create numerous difficulties for municipalities wanting to improve water quality within their jurisdiction. Improvement of water quality is important because recreational use of the river (e.g. kayaking, fishing, etc.) is increasing and there is an increasing awareness of human pathogens associated with poor water quality. We intend to establish a weekly-monthly water chemistry data collection plan and a bi-annual macroinvertebrate sampling program utilizing established citizen science collection protocols. Undergraduate students will serve as leads in organizing the weekly/monthly water quality sampling program and the macroinvertebrate sampling in the spring and fall. Parameters of primary interest include pH, temperature, conductance, chloride, and dissolved oxygen, as well macroinvertebrate diversity. We also plan to collect data on *E. coli* and fecal coliform bacteria concentrations using the IDEXX system because high levels of *E. coli* in surface water has human health implications and sources of *E. coli* can often be eliminated with improvements or repairs to infrastructure. In addition, we intend to conduct a series of undergraduate research experiments to assess stream metabolism, nutrient dynamics, and microbial biofilms in Wheeling Creek and its tributaries. This data is intended to inform governmental officials, encourage community engagement with local waterways, and provide undergraduate research opportunities utilizing multiple assessment protocols including both field and laboratory methods.

3. USE OF eDNA TO DETECT SALAMANDER SPECIES IN CENTRAL KENTUCKY STREAMS

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Environmental DNA (eDNA) provides an effective, non-invasive method to determine organism presence or absence in an efficient manner. The majority of salamanders native to central Kentucky have an aquatic phase to their life cycle. Some *Ambystomid* species persist as aquatic larvae for just a few months while other sympatric species spend more than one year in the juvenile aquatic phase. We developed species specific eDNA primers for streamside (*Ambystoma barbouri*) and cave (*Eurycea lucifuga*) salamanders that effectively amplify salamander DNA filtered from stream water. We collected 1 liter water samples biweekly from February to July 2015 in three small streams in Jessamine County to examine season fluctuation in eDNA levels of different salamander species. Initial data reveal a complete absence of *A. barbouri* eDNA in early spring samples but high levels later in the spring corresponding with breeding and larval presence. RT PCR analysis is in progress in order to determine quantitative levels of both salamander species DNA at each collection. These data add to the growing pool of knowledge concerning eDNA monitoring of species and should provide useful reference data for future monitoring or range delineation studies.

4. HYDROGEOLOGICAL PROPERTIES OF NATURAL AND CONSTRUCTED WETLANDS IN KENTUCKY'S DANIEL BOONE NATIONAL FOREST

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Ephemeral wetlands are seasonally drying pools and are found throughout the Daniel Boone National Forest (DBNF), including on remote ridgetops. Additionally, over 400 artificial wetlands have been constructed in DBNF in the past few decades. However, research suggests that these wetlands do not accurately mimic the properties of natural ephemeral wetlands in DBNF. Instead of drying seasonally, these artificial wetlands often remain saturated year-round. There is little research comparing the hydrogeological properties of natural, ephemeral wetlands and artificial wetlands in DBNF. This project attempts to quantify the spatial variability in physical properties of a natural, ephemeral wetland and compares hydrogeological properties of three natural and three constructed wetlands in DBNF.

In order to examine variability of physical properties (heterogeneity) at a small scale, 30 PVC monitoring wells were installed in a natural ridgetop wetland in the spring of 2017. Horizontal soil heterogeneity and vertical soil heterogeneity were determined through slug tests and basic water chemistry sampling. Horizontal heterogeneity was found through determining the hydraulic conductivity (permeability) of the wetland's soil. To find the soil's permeability, 33 slug tests were administered and hydraulic conductivity was calculated via the Bouwer-Rice method. Temperature ($^{\circ}\text{C}$), dissolved oxygen (DO%), pH, and specific conductance (total salinity, $\mu\text{S}/\text{cm}$) were measured and mapped with a YSI probe in order to look for preferential groundwater flow patterns. Vertical heterogeneity was estimated by slowly lowering the YSI by 5cm intervals in the water columns of six monitoring wells. The slow YSI descent minimized mixing of the groundwater in each column. Finally, slug tests were conducted and compared between three natural wetlands and three constructed wetlands.

Our data found a discharge of water emanating from the wetland's pool which was about 4°C warmer than the ambient groundwater. This warmer water flowed through a preferential flow path, and the water was located on the aquifer's surface. Hydraulic conductivity varies by three orders of magnitude (0.007 m/d to 7.594 m/d) throughout the natural ridgetop wetland. Hydraulic conductivity is higher in the area of preferential flow from the wetland pool; in contrast, permeability is lower in regions which do not exhibit direct discharge from the pool.

Permeability is generally lower in the artificial wetlands. Sediments surrounding the three artificial wetlands consist of highly compacted clay, which likely prevents groundwater discharge from the wetland pool. The compacted clay is attributed to permanent saturation of artificial wetlands.

This summer, we will attempt to restore a constructed wetland in DBNF. To increase permeability, we will till compacted sediment surrounding the wetland pool so the pool can leak. With this additional groundwater discharge through a preferential flow path, the artificial wetland may begin to adopt seasonal drying patterns similar to natural, ephemeral wetlands in the DBNF.

5. USE OF eDNA IN MULTIPLE SPECIES FISH BIOMASS DETERMINATIONS IN SMALL TO MID-SIZED LOTIC SYSTEMS

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Species abundance plays a crucial role in freshwater ecology, specifically in understanding population dynamics and in biodiversity management. Current methods for estimating fish species abundance are effective but can be prohibitively time consuming, expensive, and lead to habitat damage and fish mortality. Environmental DNA (eDNA) shows great promise as a less invasive, more efficient method of obtaining quantitative data for species abundance. eDNA is a proven tool for detecting species presence/absence, but its effectiveness at gauging biomass is still under investigation. In the present study we propose generating population estimates for smallmouth bass (*Micropterus dolomieu*), central stoneroller (*Campostoma anomalum*), and rainbow darter (*Etheostoma caeruleum*) in central Kentucky streams using electrofishing and triple-pass depletion. Population estimates will be made using a modified version of the Zippin equation. Species specific primers and probes and real-time quantitative PCR (qPCR) will be used to analyze eDNA collected at each sampling site. The relationship between eDNA concentration and abundance/biomass will be statistically evaluated in SPSS using two statistical models: generalized linear models (GLM) and a Type II regression model. Few studies correlating eDNA and fish biomass in lotic systems exist and these data should provide valuable insight into the utility of this technique in small to mid-sized lotic systems.

6. RAINFALL RUNOFF MODEL DEVELOPMENT USING HSPF FOR A FLOOD CONTROL RESERVOIR SYSTEM TO EXAMINE LONG TERM BENEFITS

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A system of flood control reservoirs was built in 1950s to control floods in the tributaries of the Ohio River system. These reservoirs also help in maintaining the inland navigation as well as serve as popular recreational sites. US Army Corps Louisville district maintains these reservoir systems in Indiana. In this study, Brookeville flood control reservoir located in Indiana is considered as a case study. This dam was constructed across East Fork tributary which drains to White River.

HSPF model (Hydrologic Simulation Program Fortran) is popularly used in Total Maximum Daily Load studies (TMDL). This model facilitates rainfall – runoff modeling of a watershed system (Kim et al 2007). In addition, it also facilitates in water quality modeling. Creating a HSPF model for a reservoir system will be a very useful tool to examine the benefits derived by the reservoir systems. In this work, HSPF modeling was used to develop rainfall runoff model for the Brookville Dam. Using US EPA BASINS software, watershed delineation and HSPF model initiation was done initially. With the USGS flow observation stations, HSPF model was calibrated and validated. Calibrated HSPF model was used to generate the flood peaks without the reservoir and flood stages were examined to study the benefits of reservoir system.

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7. EXAMINING THE USEFULNESS OF SELF ORGANIZING MAPS IN DROUGHT ANALYSIS

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Self Organizing Maps (SOM) were used successfully in the past to identify outliers in hydrologic data analysis. Unlike popular artificial neural network training schemes like back propagation which is supervised learning algorithm, SOM is an unsupervised artificial intelligence technique in which the datasets given for training were clustered to different neurons using Euclidian distances. This method is very rapid and can be applied in large datasets (Kalteh et al 2008). Neurons in SOM can be arranged in different topologies. Data assigned to different neurons are clusters with similar characteristics. In this study, SOM was attempted for drought analysis to examine the advantages.

As a case study, Upper Mississippi river basin precipitation gages were considered for SOM based drought analysis. In total, 68 stations with 60 years of record were used in this work to create temporal clusters using SOM. Very well-known Standard Precipitation Index (SPI) based drought classification scheme (McKee et al, 1993) used in US Drought Monitor (Syabola et al, 2002) was used in conjunction with SOM to examine the data clusters created by SOM. This research study indicates that the SOM based regional drought classification is very rapid and very similar to SPI based classification scheme.

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8. MODELING AND EVALUATING THE INFLUENCES OF CLASS V INJECTION WELLS ON URBAN KARST HYDROLOGY

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The response of a karst aquifer to storm events is often faster and more severe than that of a non-karst area. Many urban karst areas (UKAs) are plagued by groundwater flooding resulting from the highly permeable and diffusive aquifers. In UKAs, municipalities often struggle with flood management, because traditional strategies are ineffective. The City of Bowling Green (CoBG), Kentucky is a representative example of an area plagued by karst flooding, despite several decades of research and work done to understand and mitigate the issues. The CoBG, like many UKAs, uses Class V Injection Wells to reduce the severity of flooding. The overall effectiveness, siting, and flood impact of Injection Wells in UKA's are still lacking; their influence on groundwater quantity and quality are evident from recurring problems of flooding and groundwater contamination. The purpose of this research to examine Class V Injection Wells in the CoBG to determine how Injection Well siting, design, and performance influence urban karst hydrology. The study uses high resolution monitoring, hydrograph recession analysis, geostatistical techniques, and hydrologic modeling (WMS-GSSHA) to evaluate Injection Well and spring responses during baseflow conditions and storm events. Through quantifying the hydrodynamic properties of the karst aquifer and the influences from the surrounding environment, it is possible to establish a relationship between precipitation events and the drainage capacity of the Injection Wells and the underlying karst system, as well as explore possible siting issues contributing to the efficiency of the system.

9. ISOMOTIVE DIELECTROPHORESIS BASED CHARACTERIZATION OF CHLAMYDOMONAS CELLS

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Phytoplankton growth is a function of light and temperature, buoyancy, inorganic nutrient availability, interactions with organic compounds, organic micronutrients, and competition and predation factors [1]. Phytoplankton assemblages in water bodies have been studied extensively over the past century and are excellent indicators of environmental conditions that determine water quality. Therefore, understanding the physiological status of live phytoplankton cells in aquatic environments is important because of their function as primary producers, their position at the base of aquatic food webs, and their ability to rapidly respond to environmental change.

Dielectrophoresis (DEP) is the phenomenon in which a particle, such as a living cell, is moved by the interaction between a non-uniform electric field and its induced polarization. Isomotive dielectrophoresis (isoDEP) is a cell analysis and characterization technique that uniquely utilizes a constant gradient field-squared (∇E_{rms}^2) resulting in a uniform DEP force. The resultant constant (isomotive) particle translational velocity can be tracked using particle tracking velocimetry (PTIV) software to extract the cell/particle dielectric properties. The results obtained in this work are expected to significantly enhance the research on characterization and differentiation of phytoplankton cells and their viability more inexpensively than other existing methods.

The DEP force of a homogeneous spherical particle is

$$F_{DEP} = 2\pi\epsilon_m a^3 Re[f_{CM}] \nabla E_{rms}^2 \quad (1)$$

$$f_{CM} = \frac{\epsilon_c^* - \epsilon_m^*}{\epsilon_c^* + 2\epsilon_m^*} \quad (2)$$

where ϵ_c^* , ϵ_m^* are the complex permittivity of the fluid medium and cell defined as $\epsilon^* = \epsilon - (\sigma/\omega)j$, a is the particle radius, f_{CM} is the Clausius-Mossotti factor, E is the electric field which gives information about the cells interior properties and characteristics.

Characteristic analysis for Chlamydomonas cells (diameter:10-15 μm , Ph=8.5, suspended in pure lake water ($\sigma_m = 19.3 \text{ mS/m}$) was achieved by using a microfabricated prototype isoDEP device from a conductive silicon wafer (1-10 $\Omega\text{-cm}$) whose patterned features served as electrodes and microchannel sidewalls simultaneously [2] that are fabricated to follow a

specific curvature inherited from Pohl's [3] electrode design to ensure a constant (∇E_{rms}^2).

The AC frequency (stimulus) is swept over a specified range to obtain a comprehensive f_{CM} spectrum of the *Chlamydomonas* cells. If $\text{Re}[f_{CM}]$, which is the real part of f_{CM} function, which depends on the angular frequency (ω) of the applied voltage. Negative DEP (nDEP) was noticed where the phytoplankton translates towards the lowest stimulus force point (Fig._1), force at frequencies below the estimated crossover frequency of 11.6 kHz, and a positive DEP (pDEP) starting from that frequency, where cells started to increase their translational velocities outward the high field with increasing the frequency above the later frequency reaching the MHz range. It's noted that the cells' viability can be uncertain after the application of the AC signal (1000 V/m) for 10-12 minutes [4] based on which requires continuous inspection of the cells from time to time while conducting the experiment – work is ongoing to assess the viability of exposed cells.

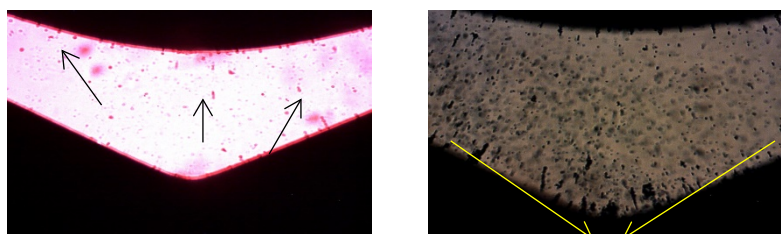


Figure 1: left) Microscopic Image of phytoplankton translating in radial motion in the microchannel under the Positive DEP force observed when applying 20 V_{pp} at 600 kHz. Right) Negative DEP force observed when applying 34 V_{pp} at 1 kHz. Arrows indicate the radial translation towards low/high Electric field points.

CONCLUSION

Recent findings show that isoDEP is a simple, inexpensive technique that performs at higher throughput compared to other techniques, offering a realtime analysis of the physiological status of phytoplankton assemblages in situ. Those results will be confirmed using 3DEP platform from DEPTech Ltd. This information would give important insight into the overall health of an aquatic ecosystem.

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10. ROLE OF CROSS-LINKER CONCENTRATION ON THE PERFORMANCE OF PH RESPONSIVE MEMBRANE AND ITS APPLICATION ON PCB 126 DEGRADATION

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This study has demonstrated the effects of changing cross-linker concentrations on the mass gain, water permeability, Pd-Fe nanoparticle (NP) loading, and the rate of degradation of 3,3',4,4',5-pentachlorobiphenyl (PCB 126) of pore functionalized polyvinylidene fluoride (PVDF) membranes. Results showed that responsive behavior of membrane could be tuned in terms of water permeability over a range of 270 to 1 L·m⁻²·hr⁻¹·bar⁻¹, which is a function of water pH. The NP size on the membrane surface was found in the range of 16~23 nm. With increasing cross-linker density the percentage of smaller NPs (<10 nm) increases due to smaller mesh size formation of during in-situ polymerization of membrane. NP loading was found to vary from 0.21~0.94 mg per cm² of membrane area depending on the variation of available carboxyl groups in membrane pore domain. The NPs functionalized membranes were then tested for use as a platform for the degradation of PCB 126. The observed batch reaction rate (K_{obs}) for PCB 126 degradation for per mg of catalyst loading was found 0.08~0.1 hr⁻¹. Degradation study in convective flow mode shows 98.6% PCB 126 is degraded at a residence time of 46.2 seconds. The corresponding surface area normalized reaction rate (K_{sa}) is found about two times higher than K_{sa} of batch degradation; suggesting elimination of the effect of diffusion resistance for degradation of PCB 126 in convective flow mode operation. Finally, statistical analysis based on experimental results allows us to depict responsive behavior of functionalized membrane.

11. THE EFFECT OF APPLIED ELECTRIC POTENTIAL ON THE PERFORMANCE OF NANOFILTRATION MEMBRANES

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The demand for freshwater is rising alongside global population and urbanization, but the current freshwater supply is being depleted faster than it can be restored by natural means. It has been estimated that by 2025, nearly 2 billion people will be living in absolute water scarcity. Membranes are favored over many other technologies for water treatment because, in principle, they require no chemical additives, can be used isothermally at low temperatures and they do not require regeneration of spent media. Membranes that can reject salts, produce good permeate flux and require minimal cleaning are highly demanded. In this study, we examine the effect of an applied electric potential on the surface of a polymeric membrane, sulphonated poly ether ether ketone (SPEEK). The synthesized membranes were characterized through pore diameter studies, performance was evaluated through water permeability studies and salt rejection, and the morphology was imaged after each cycle.

12. POLYPHENOLIC NANOCOMPOSITE MATERIALS FOR THE CAPTURE AND SENSING OF CHLORINATED ORGANIC CONTAMINANTS IN WATER SOURCES

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There is an ever-growing need to provide access to safe drinking water worldwide at low production and operation costs that can meet EPA quality standards. Current remediation technologies have failed to maximize pollutant removal without becoming cost-prohibitive. As a potential low cost remediation technology for water treatment, our group has developed a magnetic nanocomposite platform that allows for the capture of polychlorinated biphenyls (PCBs) and related contaminants with a range of affinities and selectivities. This nanocomposite platform incorporates polyphenols (e.g., plant-derived flavonoids) that offer high affinity for PCBs and related environmental contaminants and present strategies for fluorescence-based sensing. In one method, a surface initiated polymerization of poly(ethylene glycol)-based and polyphenolic-based crosslinkers on the surface of iron oxide magnetic nanoparticles was utilized to create a core-shell nanocomposite. In another method, a bulk polymerization method was utilized to create macroscale films composed of iron oxide nanoparticles incorporated into polyphenolic-based polymer matrices that were ultimately processed into microparticles. In some materials, N-isopropylacrylamide (NIPAAm) was incorporated to develop temperature responsive polymers, which transition from a hydrophilic state to a hydrophobic state with a small change in temperature. Furthermore, we have synthesized novel polyphenol-based monomers to incorporate into the nanocomposite platform that can present affinity for specific contaminants. Overall, the produced nanocomposite materials can specifically bind chlorinated organics, can rapidly separate bound organics from contaminated water sources using magnetic decantation, and have unique options for contaminant release and material regeneration. The polyphenol functionalities used to bind organic pollutants were quercetin multiacrylate (QMA), curcumin multiacrylate (CMA), 4, 4'-dihydroxybiphenyl diacrylate (44BDA), 4-phenylphenol monoacrylate (4PPMA) and 2-phenylphenol monoacrylate (2PPMA), and these are expected to have affinity for chlorinated organics. All materials were extensively characterized using methods such as transmission electron microscopy (TEM), dynamic light scattering (DLS), Fourier transform infrared spectroscopy (FTIR), and thermal gravimetric analysis (TGA). Pollutant binding studies were performed using PCB 126 as a model system and chlorinated organic pollutants to determine binding affinity and capacity, and this was quantified using GC-ECD. It was demonstrated that the materials effectively bound PCBs, and the addition of the polyphenols provided a greater affinity.

13. INVESTIGATION OF A LIGNIN-DERIVED SOLVENT IN POLYMERIC MEMBRANE FABRICATION

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Membrane filtration has been at the forefront of water purification for decades. However, one major drawback to consider is the use of ecotoxic solvents during the synthesis of polymeric membranes. A contradiction is found in the creation of a product to remove toxic chemicals, while producing potentially harmful byproducts in its synthesis. A proposed solution is the introduction of green, eco-friendly solvents to replace commercial, toxic ones. Research was conducted on gamma-valerolactone (GVL), a promising candidate as a green solvent. GVL was tested with two polymers: polysulfone (PSF) and cellulose acetate (CA). Using the Flory-Huggins thermodynamic model, it was calculated that CA would be more favorable because it readily dissolves in GVL at room temperature. A ternary diagram was constructed through cloud point data over concentrations of 1% to 20% CA in GVL. This predicts a two-phase region to verify the transition to solid phase when immersed in water (the nonsolvent). Subsequently, experiments were using 17% CA in GVL to monitor membrane properties and compare them to membranes made using traditional solvents. However, it was found that without a pore-forming additive, membranes made with GVL did not produce comparable flux values.

14. INVESTIGATION OF PHOSPHORENE'S POTENTIAL PROPERTIES IN MEMBRANE FILTRATION

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Phosphorus, which constitutes about 0.1% of the earth crust, is one of the most abundant elements. It exists as several allotropes which include white, red and black phosphorus. Phosphorene can be exfoliated from bulk BP in the same way as graphene from bulk graphite. Phosphorene distinguishes itself from other 2D layered materials by its intrinsic structural anisotropic features, which gives it some interesting properties. It possesses anisotropic physical (electronic band structure, electrical transport, thermoelectric) and mechanical (critical strain, Poisson's ratio, Young's modulus) properties, which have not been fully explored. More interesting is the presence of a natural band gap, which essentially allows the conducting properties to be switched on and off. Biofouling mitigation is a key concern in the field of membrane separation. In this study, we explore the unique properties of phosphorene in developing novel nanocomposite membranes.

15. INVESTIGATION OF A NEW MIXING METHOD IN THE PREPARATION OF POLYMERIC SOLUTIONS FOR MEMBRANE FABRICATION

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A crucial step in any membrane formation is the creation of the dope solution from the powdered polymer and solvent. Due to the high viscosity of dope solutions, it can take between 24 and 72 hours for complete dissolution to occur using conventional mechanical mixing (i.e., stir plate and stir bar). The objective of this project was to evaluate the use of a planetary mixer as a viable alternative to mechanical mixing for dissolving high molecular weight polymers for membrane applications. The mixer is designed to mimic planetary motion, so it rotates and revolves simultaneously. This study focuses on using the planetary to mix cellulose acetate (CA) and n-methyl-2-pyrrolidone (NMP) as the polymer and solvent, respectively. Dope solutions were created both with the traditional stir bar and with the planetary mixer. Membranes were then cast from the dope solutions using the phase inversion method. The membranes were tested to determine if there were significant differences between those created with the conventional stir bar and those created with the planetary mixer. The membranes' flux, rejection rates, and pore sizes were all compared. Results showed that the planetary mixer and stir bar membranes had comparable rejection rates, and that the mixer led to membranes with marginally higher flux values.

16. WATER QUALITY ANALYSIS IN MUNICIPAL WATER SUPPLY SYSTEM FOR LEXINGTON, KY, WITH A FOCUS ON CORROSIVITY

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The Flint water crisis, caused by the release of lead into the city's public water supply system (PWS) due to a source water switch, led many to question the safety of their own drinking water. In Spring 2016, University of Kentucky students from the hydrogeology class (ESS 585) collected and analyzed eight water samples from their homes. The results were unexpected. While none of the samples exceeded the EPA's drinking water MCL for lead (15 µg/L), the sampled water had higher corrosivity than the drinking water in Flint based on the chloride sulfate mass ratio (CSMR). The average CSMR from these samples was 2.9 whereas a CSMR of 1.6 was reported for the drinking water in Flint. A CSMR value less than 0.58 implies that corrosion is limited.

Concerned with the observed high corrosivity, we conducted a follow-up study to evaluate Lexington's PWS water corrosivity and its seasonal variation. We hypothesize: 1) the high corrosivity observed in Spring 2016 is resulted from winter road salt application and the low level of lead in drinking water, despite a high CSMR value, is due to the addition of corrosion inhibitors; and 2) water quality can change in relation to approximate pipe travel distance and pipe material.

A GIS ArcMap model was developed to aide in the selection of eleven PWS sampling locations within New Circle Rd. Based on pipe material, pipe diameter, and pipe distance, the risk for metals leaching into drinking water was evaluated using the Cost Distance tool in ArcGIS. The resulting model visually ranked the distribution network showing areas of high (value 5) to low (value 1) risk for the potential to leach metals from pipes under corrosive conditions. The 11 sample sites were then selected to cover areas with different risks. One additional site was a source water sample from the Kentucky River collected near the Lexington's PWS intake.

To assess seasonal variation and possible road salt contributes to corrosivity, the twelve selected sites were sampled in Spring and Fall 2017. The samples were analyzed for metals and major ions. At the time of collection, standard water quality parameters (pH, temperature, DO, specific conductance), as well as, phosphate and silica, were measured. Phosphate and silica are commonly used corrosion inhibitors. The chemical analysis showed only one sample exceeded the drinking water MCL for lead and the average CSMR value was 0.184 for Spring 2017, 0.417 for Fall 2017; both were much lower than that observed in spring 2016. The data

also indicated that the concentrations of dissolved metals increased with pipe distance and were affected by pipe material. The measured phosphate and silica concentrations suggested that corrosion inhibitors are used in treating Lexington's drinking water.

Our study provides a better understanding of tap water quality in Lexington, especially water's corrosivity and potential risks. Water corrosivity appears to be low in general, but can increase significantly during snowy winters with high road salt application. The presence of phosphate-based and silica-based corrosion inhibitors likely lessen the leaching of metals under corrosive conditions, but risk remains. The increases in metal concentrations with pipe distance and the influence of pipe material on metal concentrations require the local drinking water agencies pay close attention to areas with high risk of metal leaching. The ArcGIS model developed in this study can be helpful in locating potential areas of concern for metals leaching in Lexington's water supply distribution system.

17. AN OPPORTUNITY FOR ENVIRONMENTAL AG EDUCATION: USING GIS TECHNOLOGY TO COMPARE BEEF CATTLE DENSITY ON WATER QUALITY PARAMETERS IN TWO BARREN COUNTY, KY STREAMS

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A majority of Kentucky's impaired streams are the result of non-point pollution with the top causes of water impairment being sediment (31%), pathogens (31%) and nutrients (17%) (KYDOW). Poor pasture quality from animal over stocking can denude forage thus increasing stormwater runoff and erosion, resulting in not only excess phosphorus (P) and nitrogen (N) but enterobacteria such as E. coli (KYDOW) in the receiving waterbodies.

Kentucky is the largest beef cattle producer east of the Mississippi River with the state inventory being one million brood beef cattle (USDA-NASS). Typical beef cow management is pastured based, with most of the animals spending a majority of their lifetime on pastureland. A substantial number of cattle are located in south-central Kentucky with Pulaski and Barren counties having the greatest populations (USDA-NASS). Barren County has one of the highest densities in the state with close to 300 head per sq. mile of classified pastureland.

Cooperative Extension works to educate our shareholders on issues that could or do affect KY communities by using research based information. The producers often do not have the time nor inclination to research how farming practices affect water quality. Land use practices influence water quality, and bad water quality negatively affects the farmer's businesses. Some beef cattle producers can be very slow to adopt BMPs even though they may be profitable and promote clean water. One of the biggest challenges for Extension Agents is audience engagement. The use of GIS technology can enhance the dissemination of research-based information in a form that is viewable and understood (Bacic et al., 2006).

The first objective is to identify locations for targeting educational efforts concerning water quality issues related to animal production in Kentucky. Counties with the greatest beef cattle density were determined via the USDA-NASS. Using ArcMap, the county polygon boundaries were layered, then data fields were added to determine density of all cattle, dairy cattle and beef cows per square mile of classified pastureland. This information was utilized in the selection of Kentucky counties in which to target Agriculture Water Quality and Nutrient Management Plan Workshops. The second objective is to illustrate land use effects on water quality in counties with high beef cow density. Caney Fork and Nobob Creek (HUC 14 subwatersheds) in Barren County were selected for geospatial comparison and scenario modeling in GIS. Caney Fork is reference stream because of its Outstanding State Resource Waters (KYDOW) while Nobob Creek is a stream of interest because its headwaters have land use management problems such as cattle overstocking, poor pasture management, and cows in the creek.

When evaluating potential beef cow production impacts on water quality, several variables need to be considered. Concentrating pasture-raised cattle on rolling land, not unlike some of Kentucky's high beef producing counties, can increase the runoff sediment and manure amount especially in poor pasture conditions. Increasing forage cover should decrease the amount of surface P and sediment runoff to a point. Topography and soil type also influences stream P load and sedimentation. If topography is very steep, forage cover may not have enough of a mitigating impact on resulting water quality, for example. Incorporating GIS technology into characterizing potential nutrient and sediment runoff can be a valuable tool when nutrient management planning, suggesting a particular Best Management Practice (BMP), or calculating the cost/benefit ratio. This poster is a starting point for exploring how to strategically incorporate GIS technology into nutrient management planning and UK Ag Cooperative Extension environmental educational opportunities to Kentucky beef cattle farmers. Specifically, producing a visual illustration that predicts how changes (if needed) in grazing management on a shareholder's land can influence water quality in the watershed.

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18. ASSESSMENT OF MRSA PRESENCE IN LEXINGTON, KENTUCKY, WWTPS WITH NEW SELECTIVE GROWTH MEDIA

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The rapid adaptation of antibiotic resistant bacteria to selective pressures is producing new strains of potent human pathogens. These adaptations occur by the exchange of genetic information (DNA) across bacterial species in packets known as mobile genetic elements (MGEs). MGEs can increase bacterial virulence, multiply antibiotic resistance, and add information that lead to the formation of biofilms and other factors that enhance environmental resilience. Therefore, bacteria with adaptive MGEs persist longer in the environment, and spread further outside their normal niches, leading to increase outbreaks of endemic disease across different parts of the world. Engineered systems like WWTPs have been reported as a potential reservoirs of pathogenic bacteria, and potential adaptive hotspots where bacteria evolve their virulence in the presence of multiple antimicrobial and heavy metal resistance genes, MGEs, and the bacteriophage vectors. *Staphylococcus aureus* (SA) adapts readily to selective pressures and evolves to methicillin resistance *Staphylococcus aureus* (MRSA) which causes hospital infections because of hospital acquired MRSA (HA-MRSA) and community infections referred to community acquired MRSA (CA-MRSA). It is important to understand the role that WWTPs play in the fate and transport of SA. Environmental persistence of SA has been reported in recreational marine waters, beach sands, river outlets, and sewage treatment plants, and the presence of MRSA has been recorded in the wastewater influent and sludge. However, MRSA presence in these environmental niches may be overestimated due to the presence of methicillin-resistant *Staphylococcus epidermidis* (MRSE) and its co-growth with SA. The concentration of MRSE is much higher than MRSA in sewage as *Staphylococcus epidermidis* (SE) shares the *mecA* gene and resultant penicillin binding protein with MRSA. It is thought that MRSE provided the MGEs that created the first MRSA. Methods that rely heavily upon either the presence of the *mecA* gene, or the expressed protein, can result in false positive-MRSA when SE co-growth is not suppressed.

In this study, the presence and the fate of MRSA were investigated in three different sections of two local WWTPs, Town Branch (TB) and West Hickman (WH) WWTPs, in Lexington, Kentucky. Samples were taken from influent, effluent of final sedimentation tank and final treated sewage effluent. These two WWTPs are similar in flow rate and types of processes; however, they collect different types of sewage from their sewer-sheds. TB plant collects wastewater from urban areas including several hospitals and high density housings (Prison, nursing homes, hotels, etc.) in addition to wastes from metal plating from industrial processes, while WH's influent primarily contains sewage from suburban neighborhoods with single-family dwellings. In this study, a new selective enrichment media was developed to suppress the growth of SE and allow for selective growth of SA from sewage samples. In this new developed media, acriflavine was added to mannitol salt broth (MSB) and agar to suppress the growth of SE, and allow selective growth enrichment of SA from complex wastewater samples, resulting in the ability to produce a clean, isolated colony of MRSA, with no SE bacteria or genes. About 200 ml grab samples were centrifuged at an appropriate speed and duration to

sediment bacteria out of the samples. Then, the resulting pellet was enriched with the addition of an equal volume of 2X acriflavine, polymyxin B and potassium tellurite augmented MSB. Polymyxin B was applied to reduce the growth of gram negative bacteria in wastewater samples. Potassium tellurite was added to the MSB to enhance SA respiration, and provide a visual signal (black precipitant) for easier discrimination of samples positive for presumptive *Staphylococcus*. The mixture was kept in incubator at 37°C for 48 hours, then vortexed prior to centrifugation. The resultant pellet was spread onto mannitol salt agar (MSA) augmented with acriflavine and incubated for 48 hours at 37°C. Yellow colonies with SA characteristics were counted and either 10 colonies, or up to 10% of colonies, were streaked onto new acriflavine augmented MSA-filled petri dishes to create single colony clone isolates. To confirm a single isolate as a presumptive SA, multiple isolates from the streak plate were tested with the coagulase tube test (SA (+), SE (-)). To further identify a coagulase positive, presumptive SA isolate as a MRSA colony, ELISA testing was conducted on another clone from the same streak plate for the presence of the Penicillin- Binding Protein 2 (PBP2). Positive results from the ELISA test identified the colony isolates as MRSA colonies; non- positives were identified as MSSA.

For four sampling events, 537 colonies have displayed the characteristic growth of SA (yellow colonies on acriflavine-augmented MSA and coagulase positive). From all SA colonies, 68 of them were classified MRSA based on the presence of the penicillin-binding protein. The presence of MRSA was identified in both TB and WH influents and persisted through the WH sedimentation tank. Table 1 summarizes all results related to four sampling events. Totally, 68 MRSA colonies were confirmed at the end. However, the relative ratio of MRSA colonies to MSSA was different between the WWTPs, with the suburban WH plant having a higher ratio, or more MRSA per MSSA. After identification of MSSA and MRSA isolates, a colony from the MRSA identified streak plates was re-grown in augmented MSB and frozen. Then, a subset of 18 of these MRSA isolate regrowths were selected for DNA extraction and genome evaluation by qPCR to confirm that there was no co-growth of SE in the new growth media and agar augmented by acriflavine. For the selected isolates, 50µl of the DNA extraction was checked for sufficient DNA and RNA content by NanoDrop, and then the extracts were shipped to the Genomic Research Lab of the Division of Infectious Diseases in the University of Geneva Hospitals in Switzerland, led by Dr. Francois Patrice for genetic analysis by PCR for a SE specific sequence he discovered. All 18 of the selected isolates were negative for SE genetic material, we have confirmed that our method allows for the enriched growth of SA with suppression of any genetic signals that may originate from SE.

Table 1: all collected colonies from four sampling events

4 Sampling events	Town Branch		West Hickman		Total Colonies
	Influent	Sedimentation tank	Influent	Sedimentation tank	
MSSA	211	26	210	22	469
MRSA [Coagulase (+) & ELISA (+)]	14	0	49	5	68
MRSA/MSSA ratio	0.07	0	0.23	0.23	

POSTER SESSION 2

1. KENTUCKY LAKE UNDERGOING A “CHANGE OF STATE”: TREND ANALYSES INDICATE POTENTIAL TIPPING POINTS ARE BEING REACHED FOR SEVERAL LIMNOLOGICAL VARIABLES

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The Kentucky Lake Long-term Monitoring Program (KLMP) was begun in July 1988 to understand the basic limnology of this very large Tennessee River reservoir and to document patterns and trends. A wide variety of biological, chemical, and physical measurements are taken every 16 days (32 days December – February) at 12-14 lake sites and several tributary sites. Trend analyses reveal important changes taking place in the lake over the past 30 years. Some variables appear to have reached “tipping points” resulting from changes in the watershed and/or from species invasions.

Mean water temperature has steadily increased by 2 °C over the 30-year period of record. Mean total alkalinity has increased from 50 to 60 mg CaCO₃/L (Fig. 1). Mean chloride ion concentration has doubled from 5 mg/L to 10 mg/L (Fig. 2). Secchi depth (Fig. 3) and 1% light penetration have increased by 0.5 meters and 2.5 meters, respectively. Silicon dioxide has increased 1.5 mg/L, and soluble reactive phosphate has increased 0.1 mg/L. Significant decreasing trends over 30 years include sulfate, down from 20.0 to 8.8 mg/L; turbidity down from 15 to 4 NTU's, primary production down from 40 to 30 µg C/L/h, and oxidation-reduction potential down from 0.3 to 0.2 mv. Dissolved organic carbon has decreased from 2.5 to 2.0 mg/L. Variables that have remained relative constant include chlorophyll-*a*, total nitrogen, and total phosphorus. Many of the changes in the variables discussed above were also driven by strong seasonal effects.

It is obvious that many of the decreases and increases result from synergistic relationships among the parameters particularly as they relate to changes in ecosystem processes and invasive species. While present in the Ohio River for more than 30 years, silver carp (*Hypophthalmichthys molitrix*) only recently has become a super invader in Kentucky Lake. Its long-term effects on the phytoplankton and zooplankton populations remain to be determined, but the decrease in primary production over the past several years is unmistakable even though chlorophyll-*a* has remained fairly constant.

Zebra mussels (*Dreissena polymorpha*) had become established in the Ohio River basin by 1992. They were reported from the Tennessee River basin at the same time but only as occasional sightings. The lack of reproducing populations was attributed to Ca⁺⁺ levels below the 21-23 mg/L threshold. Between 2012 and 2017, Ca⁺⁺ levels increased from ~15 mg/L to

above the threshold. Reproducing zebra mussel populations appeared for the first time in the spring of 2017. The source(s) of the Ca^{++} have yet to be determined but likely come from increased use of road deicing brine (CaCl_2) and from runoff and precipitation containing higher alkalinity (CaCO_3). As with silver carp, zebra mussels are voracious filter feeders. The effects of the combination of both species on the Kentucky Lake ecosystem will be quite interesting to see. Over the past few months, there has been a noticeable change in Secchi depth with visibility going from ~2 to over 4 m.

The KLMP database has detected several significant changes in water quality and biology over the past 30 years. Alterations in land use and the effects of invasive species appear to be the primary drivers. The trends appear to be irreversible and have led to a “change of state” for Kentucky Lake.

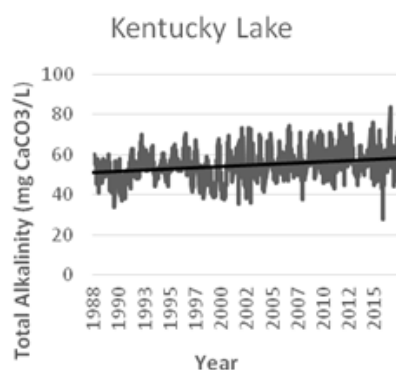


Fig. 1. Long-term total alkalinity trends

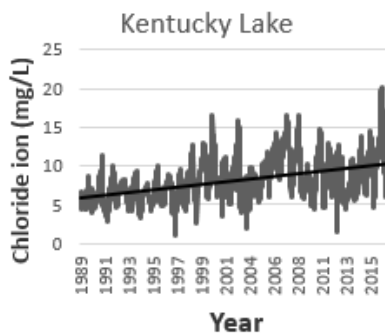


Fig. 2. Long-term chloride trends

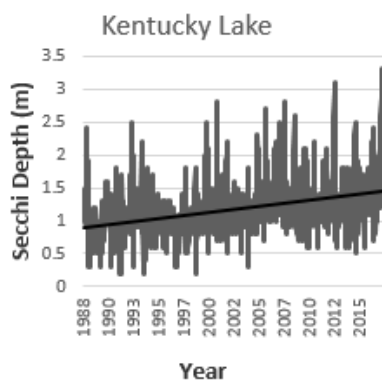


Fig. 3. Long-term Secchi depth trends

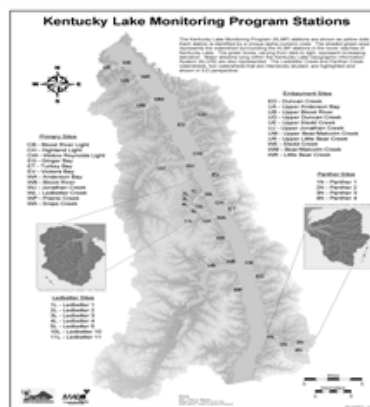


Fig. 4. KLMP watershed map

2. INVESTIGATING PREFERENTIAL SEWER PATHWAYS: GEOSPATIAL SCREENING AND FIELD SAMPLING TO REDUCE INHALATION EXPOSURE RISKS

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Hazardous waste sites are common across the United States (US). Superfund sites, generally regarded as the nation's worst hazardous waste sites, are found in every state and are managed by the federal government. While there are approximately 1,340 Superfund sites, in total there are more than 400,000 contaminated sites nationwide. For populations living close to these locations, exposure to contaminated environmental media, including groundwater, soil, and air, can lead to increased risk of adverse health effects. Vapor intrusion (VI) is one process by which nearby populations can be exposed to contaminants. A well-known issue at a significant portion of hazardous waste sites, VI refers to the migration of contaminant vapors from subsurface sources into indoor air environments.

Recent studies have shown that the existence of preferential transport pathways can complicate VI investigations and increase the geographic range and health risks associated with VI around hazardous waste sites. Sewers are preferential pathways of particular concern and are currently being investigated at many locations in the US and internationally. In the US, nearly one million miles of public sanitary sewer mains and half a million miles of private sanitary sewer laterals are buried in the subsurface. Many of these pipes have critical deficiencies that weaken a system's ability to operate optimally. Pipe deterioration over time allows infiltration of surface water and groundwater. Near contaminated sites, this can result in the migration of contaminated groundwater and vapors into the sewer system. Once in the sewer system, volatile organic compounds (VOCs) can migrate throughout the pipe network and infiltrate into connected buildings through non-vapor-tight plumbing connections. Researchers have shown that this unintentional entry of sewer gas can lead to contaminant concentrations in excess of protective, risk-based screening levels in indoor air.

The primary objective of this research project is to develop a screening-level method to identify critical characteristics of contaminated sites that highlight where additional evaluation of VI may (and may not) be necessary. Geospatial evaluation of sanitary sewers and hazardous waste sites is accomplished using spatial data and metadata available from city and regulatory databases. This analysis provides insight into which sites are likely to have elevated concentrations of hazardous contaminants in sewer gas and thereby increase exposure risks for populations living nearby.

Sites with groundwater contamination issues stemming from vapor-forming chemicals, such as petroleum hydrocarbons and chlorinated solvents, are more likely to have VI issues. Dry cleaning facilities are of particular concern because numerous petroleum-based and chlorinated

solvents have been used historically for dry cleaning operations, and these facilities are often located within residential areas.

Four sites have been selected for further evaluation by field sampling. Figure 1 shows a map of one of the sites. The star denotes the location of a former dry cleaning facility. The lines and arrows symbolize the location of sanitary sewer mains and direction of sewage flow, respectively. The circles represent the locations of sanitary sewer manholes. Lastly, the diamonds indicate the locations of groundwater monitoring wells where “hot spots” of tetrachloroethylene and trichloroethylene (i.e., chlorinated dry cleaning solvents) have been detected above maximum contaminant levels.



Figure 1: Site map showing locations of sanitary sewer mains, manholes, and contaminated groundwater hot spots

Preliminary screening indicates that sewer pipes adjacent to the selected study sites have great potential to be deteriorated and thus impacted by nearby contaminated groundwater and vapors. At each site, targeted sewer gas sampling of VOCs will occur at several sewer manholes, both close to and away from the known groundwater plumes. The results of this field study will complement the geospatial tool to improve screening criteria for identifying which sites have sewers that should be tested for VOCs. Considering the pervasiveness of hazardous waste sites and deteriorated wastewater infrastructure in the US, preferential sewer pathways may be fairly common. However, this tool could ultimately help determine which sewer systems are of greatest concern for this issue and should be selected for additional investigation or mitigation.

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3. FATE AND TRANSPORT OF VOLATILE ORGANIC COMPOUNDS (VOCs) IN A SEWER SYSTEM: NUMERICAL MODEL AND FIELD STUDY

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Vapor intrusion refers to the migration of volatile organic compounds (VOCs) vapors from any subsurface source into the overlying buildings. Until recently, vapor intrusion had been described by the migration of VOC vapors through soil and their infiltration into the indoor area through foundation's cracks. Several vapor intrusion field studies have not been well-explained by this conceptual model. Evidence has established that VOCs vapors can use alternative pathways to enter into the buildings. Sewer systems are one alternative pathway that have been recognized as important by the US Environmental Protection Agency's (USEPA's) most recent vapor intrusion technical guidance (2015).

There is limited information available regarding the occurrence of VOCs inside the sewer systems and this pathway has not been well characterized to date. This research investigates VOCs concentration and its spatial and temporal variations inside a sewer line adjacent to and extending hundreds of feet away from a previously defined vapor intrusion area, through conducting a field study. A numerical model is developed to improve our understanding about the results of the field study and evaluate parameters that govern VOCs mass transport and could be responsible for the observed temporal/spatial fluctuations of VOC concentrations inside the sewer system.

The numerical model simulates VOCs different mass transfer mechanisms within the sewer systems and assesses the sewer gas VOC concentration on different scenarios. By comparing the results of the developed numerical model with data measured during the field study, this research aims to improve the numerical model considerations. Figure 1 shows the area assessed by the numerical model. Slope of the sewer line, sewer lines diameters, sewer flow direction, sewer flowrate and several other details are considered in the numerical model.

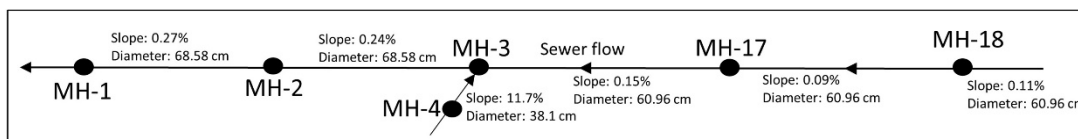


Figure 1: Sewer flow direction on the targeted Street.

The liquid gas mass transfer, vapor diffusion, adsorption and biodegradation are four major mass transfer mechanisms included in the proposed model effect of different parameters are investigated by considering various scenarios. Table 1 shows some of these scenarios. Figure 1 compares the results of these scenarios with measured TCE sewer gas concentrations conducted during the field study.

$$R_{total} = V \cdot \frac{dc}{dt} = R_{in} - R_{out} + R_{liquid-gas} + R_{diffusion} + R_{adsorption} + R_{biodegradation}$$

Table 1. Descriptions of the cases plotted on Figure 2

Case 1	Close sewer system, no tributary from MH-4, no drop structure, no adsorption
Case 2	Open manhole, no tributary from MH-4, no drop structure, no adsorption
Case 3	Open manhole, depth at MH-4=0.1 m, no drop structure, no adsorption
Case 4	Open manhole, depth at MH-4=0.1 m, drop height=0.25 m, no adsorption
Case 5	Open manhole, depth at MH-4=0.1 m, drop height=0 m, adsorption ($S_s = 250$ (mg/L); $S_d = 200$ (mg/L))
Case 6	Open manhole, depth at MH-4=0.1 m, drop height=0.25 m, adsorption ($S_s = 250$ (mg/L); $S_d = 200$ (mg/L))

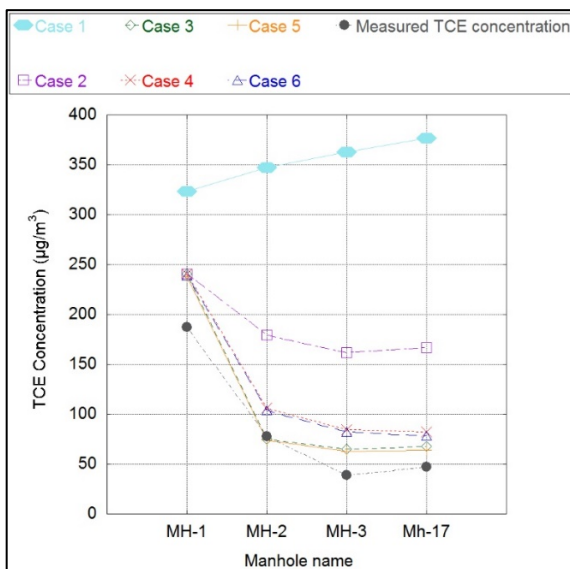


Figure 2. TCE measured concentration VS calculated concentration.

- Results of Case 1 and Case 2 do not match well with the field data; suggesting that the sewer line as a closed system with no tributary are not appropriate assumptions for this model.
- Case 3 and Case 5 match well with the filed data; suggesting that the scenarios with no drop structure are better matched with the results.
- Adsorption has a relatively slight effect on the sewer gas TCE concentration on these scenarios, but improves the model.

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4. SOIL MOISTURE CONDITIONS AND YIELD ACROSS FRAGIC SOILS UNDER IRRIGATED MANAGEMENT IN WESTERN KENTUCKY

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There has been a significant increase (204 percent) in the number of high-yield (300 to 1,200 gal/min) agricultural irrigation wells installed in the northern portion of the Mississippi Embayment in western Kentucky since the drought of 2012. Because large scale irrigation is relatively new to Kentucky, little is known about irrigated row-crop management in the state. The objective of this study was: 1. To demonstrate the utility of off-the-shelf water management technology including soil moisture sensors and irrigation well flow meters to producers and; 2. To evaluate soil moisture and yield under irrigation during the corn growing season in soils common in western Kentucky. The study site was an irrigated agricultural field in Hickman County, Kentucky. The predominant soil under the center pivot, as mapped by USDA-NRCS, is a Loring silt loam (fine-silty, mixed, active, thermic Oxyaquic Fragiudalf). These soils have a fragipan, which limits water infiltration, within 3 ft of the soil surface. The field has been in a no-till corn – soybean rotation for over 2 decades. Corn was grown at the time of this investigation. A flowmeter was installed between the well-head and irrigation pivot to quantify the amount of added water. In addition, groundwater elevation data were collected from the irrigation well by a pressure transducer. The soil moisture sensors (similar to gypsum blocks) measure soil moisture tension and were installed at 1, 2 and 3 ft depths within a row (between plants) at each of 7 locations under the center pivot and at 1 location outside the pivot. Data were collected every 30 minutes and transmitted from the field via cellular connection to a website where the data were posted. Corn yield estimates were made by hand harvesting 10 ft of plants from two rows adjacent to each soil moisture sensor array. Wet weather led to delays in side-dressing nitrogen which needed to be completed prior to equipment installation. Additionally, technical difficulties with the soil moisture sensor communication equipment caused us to miss one irrigation event and 2 rainfall events between May 10, 2017 (planting date) and July 18, 2017 (date of first soil moisture reading). As a result, data collection began at the late corn vegetative growth stages and continued through maturity.

It appears that climatic conditions were suitable for high yields in western Kentucky, with and without irrigation. Corn yield ranged from an average of 232 to 265 bu/A across the irrigated array locations; the dryland location yield averaged 262 bu/A. The similarity in yield between irrigated and dryland locations is probably due in part to the 11.4 inches of precipitation that fell between May 10 and Aug. 31 (maturity) occurred at critical growth stages required to

attain high yields. At most array sites, soil moisture at 1 ft exhibited an increase with precipitation and irrigation events, but was unchanged at 2 ft and 3 ft. This suggests that the majority of soil moisture utilized for crop growth during our monitoring period was coming from the near surface.

Though the farm owner/operator appreciated the ability to monitor real-time soil moisture field conditions while away on a 7-day trip, the technical difficulties associated with setting up the system made him hesitant to employ this technology in the future. He instead prefers monitoring soil moisture conditions using a hand-held sensor, obtaining readings at select locations within the field. He was, however, pleased to see the relationship between data obtained with the hand-held sensor and that of the *in-situ* moisture sensors demonstrated with this study.

5. NUTRIENT CONTAMINATION FROM AN AGRICULTURAL NON-POINT SOURCE AND ITS MITIGATION: A CASE STUDY OF EKU MEADOWBROOK FARM, MADISON COUNTY, KY

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Non-point sources are now responsible for most nutrient contamination in surface water and groundwater, leading to eutrophication and decreased water quality. Because of fertilizer use and animal husbandry, agricultural areas are prime sources for nutrient contamination. Consequently, it is advisable to mitigate entry of nutrients into watersheds from agricultural runoff and groundwater flow. Eastern Kentucky University (EKU) Meadowbrook Farm (Madison County, Kentucky) seeks to decrease its export of nutrients to Muddy Creek, which is tributary of the Kentucky River. To demonstrate the efficacy of any sequestration strategies, nutrient export must be measured both before and after sequestration efforts are implemented.

Over the past two field seasons, we have investigated the sources and behavior of dissolved nutrients (phosphate, PO_4^{3-} ; ammonium, NH_4^+ ; nitrate, NO_3^-) and other dissolved ions, and their transport via hydrologic pathways at the Farm. Here, we present our findings in three parts:

- 1) background nutrient concentration in surface water and groundwater during fair-weather times and identification of likely nutrient sources (Borowski et al.);
- 2) details of cation and nutrient drainage from the Farm during rain events (Buskirk et al.); and
- 3) quantification of nutrient export from a representative sub-watershed on the Farm during a major rainfall event (Winter et al.).

Meadowbrook Farm is a working farm raising crops (mainly corn and soybeans), and rearing dairy and beef cattle and other livestock. Livestock produce manure that is eventually applied to pasture and croplands; supplemental fertilizer is also used. These are the primary sources for excess nutrients that leave the Farm via overland and groundwater flow.

We sampled water from several different water sources and measured their nutrient content. Water types include that from drainage tiles, springs (groundwater), and surface water within intermittent streams on the Farm, other adjacent streams, and Muddy Creek. Water samples were passed through a 0.4 μm syringe filter and then preserved at a pH of 2 with sulfuric acid (H_2SO_4). Nutrient concentration, expressed in terms of phosphorus (P) and nitrogen (N) content, was measured colorimetrically using an UV-VIS spectrophotometer and the ascorbic acid (orthophosphate; P-PO_4^{3-}), sodium hypochlorite (ammonium, N-NH_4^+), and cadmium reduction (nitrate, N-NO_3^-) methods.

Nitrate is the nutrient contaminant with highest median concentration (~1.1 mg/L N-NO₃) in surface waters; median concentration for ammonium and phosphate are ~0.3 mg/L N-NH₄⁺ and ~0.03 mg/L P-PO₄³⁻, respectively. Relative to national data, Farm groundwater is enriched in all nutrients with median concentrations of ~0.04 mg/L N-NH₄⁺, ~7.3 mg/L N-NO₃, and ~0.04 mg/L P-PO₄³⁻. Enrichment in ammonium is more significant compared to that of nitrate and phosphate. These data provide fair-weather, background estimates for comparison to nutrient export that occur during rain events.

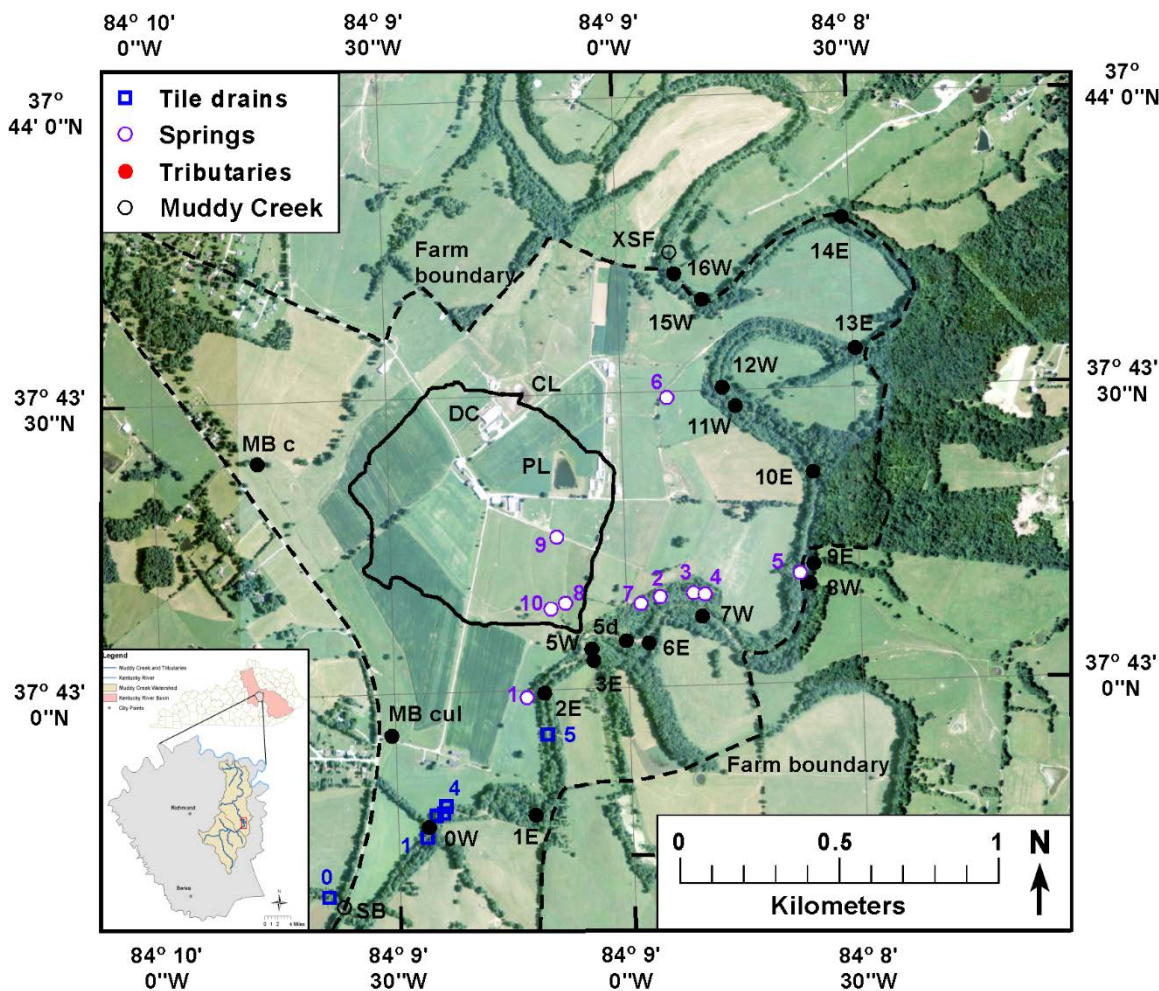


Figure 1. Map of EKU Meadowbrook Farm and sampling stations. The Farm (dashed outlined) is generally bounded by Muddy Creek on the east that flows from south to north. Symbols for sampling stations indicate water type. Note the black polygon that shows the BRC sub-watershed, which drains the cow (CL) and pig (PL) lagoons and the dairy complex (DC), as well as pasture and cropland. The BRC flows through at instrumented weir at station 5W.

6. CHARACTERIZATION OF GROUNDWATER AND SURFACE WATER GEOCHEMISTRY IN AN AGRICULTURAL SETTING AT ECU MEADOWBROOK FARM, MADISON COUNTY, KENTUCKY

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Agricultural activities often contaminate watersheds with excess nutrients leading to poor water quality and eutrophication. Eastern Kentucky University (EKU) Meadowbrook Farm raises crops and livestock, which contribute dissolved nutrients to the neighboring Muddy Creek watershed. Consequently, the Farm is developing methods to sequester phosphorous and limit nutrient contamination.

Before phosphorous sequestration methods can be tested, Farm surface water and groundwater geochemistry must be better understood to determine hydrological pathways for nutrients. We use naturally-occurring dissolved cations, pH, oxidation-reduction potential (ORP), specific conductivity (SC), dissolved oxygen (DO%), total hardness, and alkalinity as chemical tracers to parse the contribution of dissolved ions from different water sources, to recognize different water source chemistries, and to interpret storm events. To measure discharge from a proximal, intermittent stream that drains a representative and critical portion of the Farm, we used an instrumented, V-notch weir to examine storm-water flow during Tropical Storm Cindy (June 22-25, 2017).

Water samples taken from springs (groundwater), surface water, and storm water on the Farm were analyzed for various dissolved constituents. Dissolved cations were measured via ICP-OES (ACT Labs) for sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). pH, ORP, SC, and DO% were determined with YSI and Vernier probes. Alkalinity and total hardness were measured via the bromocresol green - methyl red and the EDTA digital titration methods, respectively. Dissolved ammonium (NH_4^+), nitrate (NO_3^-), and phosphate (PO_4^{3-}) concentrations were determined by colorimetry with a UV-VIS spectrophotometer via the sodium hypochlorite, cadmium reduction, and ascorbic acid methods, respectively.

Both groundwater and surface water sources exhibit similar ranges of pH (neutral to basic), ORP (oxidizing), alkalinity, total hardness, DO%, and SC. Source waters generally have high Ca^{2+} and Mg^{2+} , and low K^+ , Na^+ , PO_4^{3-} , and NH_4^+ concentrations. This strongly suggests that background chemistries of source groundwater and surface water are controlled by local limestone bedrock dissolution. Groundwater is further characterized by relatively high NO_3^- concentrations and low temperatures; in contrast, surface waters exhibit higher temperatures and lower NO_3^- concentrations.

During the Cindy event, concentration of Ca^{2+} , Mg^{2+} , and Na^+ within baseline source waters decreased with increasing discharge through the weir (Fig. 1), along with SPC, pH, and alkalinity. This behavior represents dilution of Farm groundwater by storm precipitation and

subsequent overland flow. However, K^+ increased from baseline concentrations, spiking concurrently with increased discharge through the weir, and then progressively decreased in magnitude over the duration of the storm (Fig. 2). These data suggest that K^+ was flushed from soil by rain waters.

Nutrient concentrations increase with increased discharge indicating transport by surface runoff. For example, PO_4^{3-} concentrations closely track and are proportional to discharge, which suggests PO_4^{3-} transport from the surficial soil substrate via flushing by precipitation (Fig. 3). NO_3^- exhibited nearly identical transport behavior as K^+ ; concentration spikes occur simultaneously with K^+ and discharge. However, NO_3^- levels reached a higher baseline concentration than pre-storm levels. The Cindy event suggests infiltration and retention of NO_3^- within soil and groundwater during fair weather, initial flushing during the rain event, and then prolonged NO_3^- release from Farm soil and groundwater.

Background concentration of NH_4^+ is generally 0.0 to 0.2 mg/L. Immediately prior to water flow over the weir during the Cindy event, concentrations were unusually high (~1.7 mg/L). During the first storm pulse, these high concentrations decreased significantly to <0.4 mg/L. Later in the main storm event, NH_4^+ tracked discharge from the weir and afterward returned to typical background concentrations. This behavior suggests rapid release of NH_4^+ from soil followed by accumulation within the weir pool and then subsequent flushing during the precipitation event.

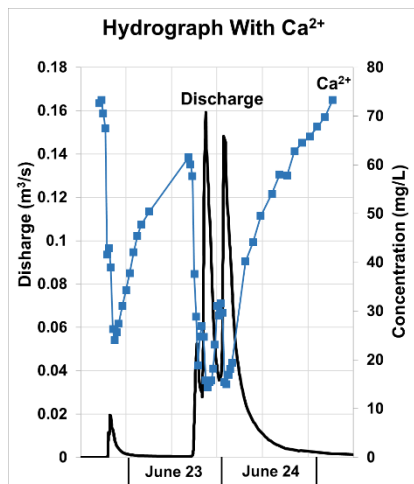


Fig. 1. Discharge hydrograph and Ca^{2+} concentration during Tropical Storm Cindy.

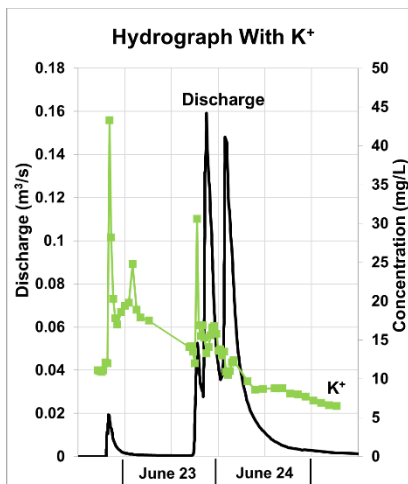


Fig. 2. Discharge hydrograph and K^+ concentration during Tropical Storm Cindy.

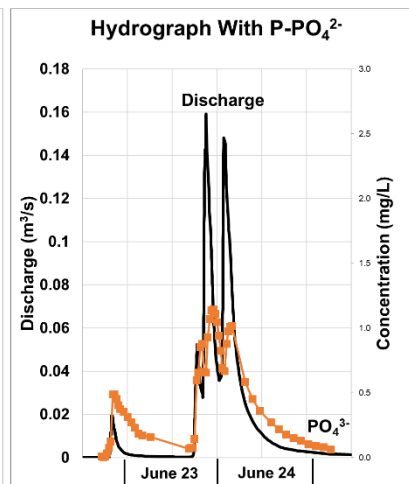


Fig 3. Discharge hydrograph and PO_4^{3-} concentration during Tropical Storm Cindy.

7. NUTRIENT EXPORT FROM A PROXIMAL, INTERMITTANT STREAM DRAINING ECU MEADOWBROOK FARM, MADISON COUNTY, KY

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Agricultural activities contribute significant amounts of nutrients that contaminate surface and subsurface water. Eastern Kentucky University (EKU) Meadowbrook Farm (Madison County, Kentucky) seeks to decrease its export of nutrients to Muddy Creek using sequestration techniques. The first step in the overall process is to determine nutrient export at present, before sequestration efforts take place. Here we estimate the export of phosphate, nitrate, and ammonium during Tropical Storm Cindy (July 22 to 24, 2017) from a proximal, intermittent stream, named the BRC. This stream drains a representative portion the Farm, receiving water from a dairy complex, pasture, and cropland.

To estimate nutrient export, both discharge and nutrient concentration must be determined. We have built a V-notched weir across the BRC drainage equipped with a datalogger that measures water elevation behind the dam, and an autosampler that captures water samples during rain events. Water level and discharge over the dam are proportional, so that discharge can be calculated during rain events. Nutrient concentration is measured for each water sample using accepted colorimetric methods: ascorbic acid (phosphate), cadmium reduction (nitrate), and sodium hypochlorite (ammonium).

Once discharge and nutrient concentrations are measured for the rain event, total nutrient mass can be calculated from the resultant curves (Fig. 1). Discharge and concentration data were parsed into 30-second time steps over the course of the entire, 72-hour rain event, and we used a cubic spline application (grafted into *MS Excel*) to produce a continuous function for each parameter. The area under the discharge and concentration curves yielded total solute mass for the Cindy event.

Based on these data and using the cubic spline technique, we estimate that the export of phosphorus was 3.1 kg P occurring as dissolved orthophosphate, and 6.3 kg N occurring as dissolved nitrate (5.3 kg) and ammonium (1.0 kg) during Cindy. We also intend to determine the amount of total phosphorus (orthophosphate, other forms of dissolved phosphorus, P contained within dissolved organics, and P adsorbed onto fine particulates) exported during Cindy, as well as estimating nutrient export for five other rain events captured during 2017.

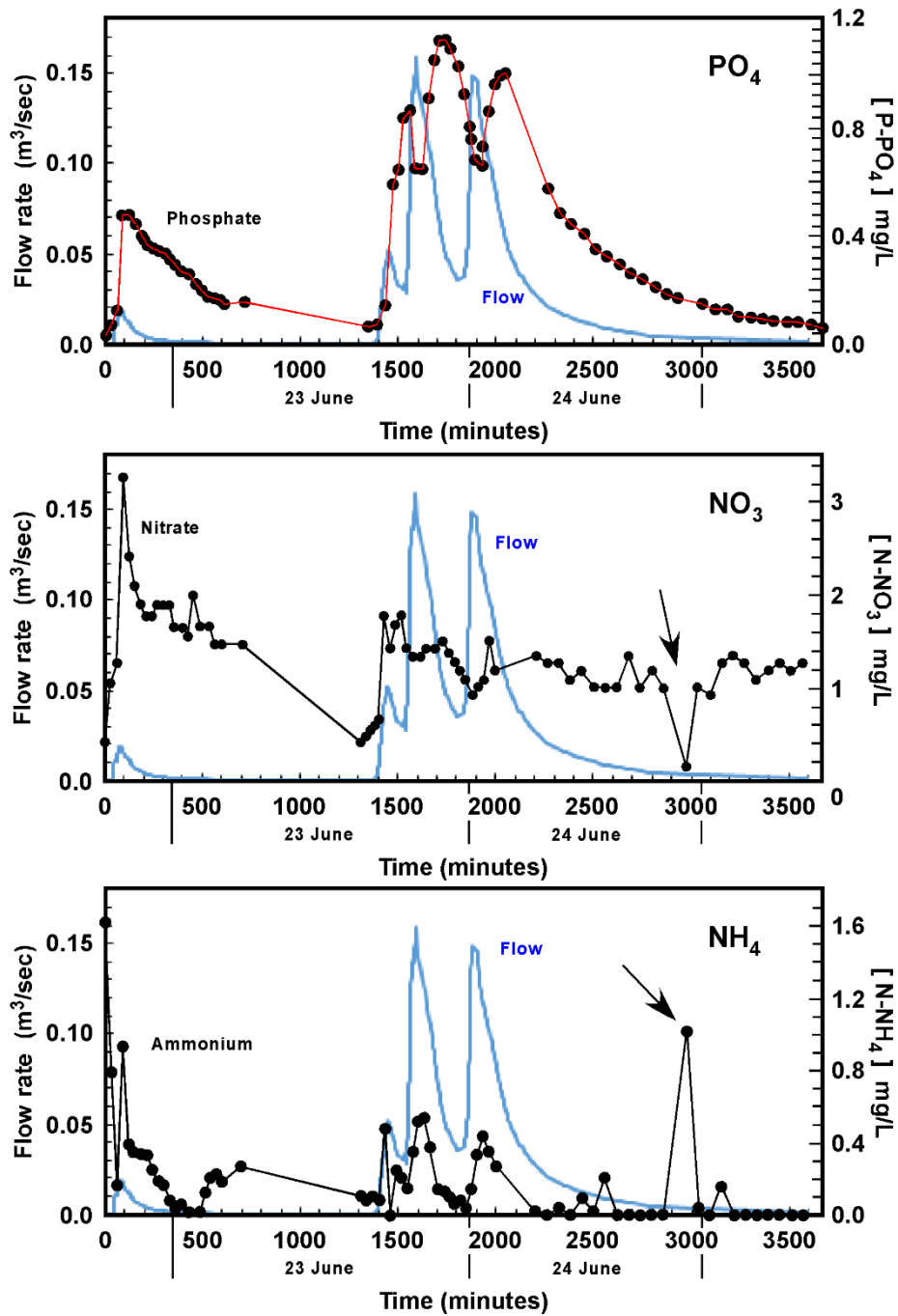


Fig 1. Graphs of water flow and nutrient concentration during Tropical Storm Cindy. These data were used to make export estimates for each dissolved nutrient during the rain event.

8. SPATIAL CHARACTERIZATION OF SOIL SATURATED AND NEAR-SATURATED HYDRAULIC CONDUCTIVITY AT THE FIELD SCALE

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Saturated and near-saturated hydraulic conductivity are important for assessing soil water movement and studying the effects of soil macro-pores on water flow. An accurate spatial characterization of wet-range hydraulic conductivity is therefore important for field water management. The interpolation of spatial data is generally performed with geostatistical methods (e.g., kriging and cokriging). Hydraulic conductivity data is usually limited since its measurement is time consuming and expensive. Cokriging, which estimates a variable that is under-sampled by considering its spatial correlation with an auxiliary variable that is more densely sampled, is usually more effective than kriging in estimating hydraulic conductivity. Therefore, the objective of this study was to characterize the spatial variability of wet-range hydraulic conductivity at a farmer's field with co-regionalization analysis.

Undisturbed soil cores were collected from surface soil (7~13 cm) at 48 locations with a distance of 100×50 m in a farmer's field in Princeton, Kentucky for measuring hydraulic conductivity. Saturated hydraulic conductivity was measured with a lab-permeameter based on Darcy's law. Near-saturated ($h = -1$ cm, $h = -5$ cm, and $h = -10$ cm) hydraulic conductivity was measured with a double plate pressure-membrane apparatus based on Buckingham-Darcy's law. Soil apparent electrical conductivity, which was used as an auxiliary variable to estimate hydraulic conductivity at a fine spatial resolution, was measured using a contact sensor Veris 3150. The interpolation of spatial data was performed by cokriging. Leave-one-out cross-validation was used to evaluate the accuracy of interpolation. Our study indicates that hydraulic conductivity and apparent electrical conductivity are spatially correlated. Saturated hydraulic conductivity exhibits strong spatial variability and macro-pores greatly influence soil water flow in the field.

9. SOIL PROPERTIES OF FARMS IN MARION COUNTY, KY

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Soil management practices are factors that affect soil quality. A soil that is subject to intense management has been shown to be more susceptible to erosion than soils subjected to no-till practices. Many farmers, however, still believe that at least some amount of plowing is necessary to increase aeration and allow easier access to nutrients by plant roots. The purpose of this research is to compare soils from farms under different management systems in Marion County, Kentucky. Samples will be collected from a conventional tillage plot, a no-till plot, a pasture used for grazing, and a wooded plot. Measures of soil organic matter, soil pH, soil water content, soil water holding capacity, and soil water content at field capacity have been collected. Analysis and interpretation of the data will be discussed in the poster.

**10. USING ANTHROPOGENIC COMPOUNDS IN SEWAGE TO CREATE NEW
FECAL SOURCE AND FECAL AGE INDICATORS FOR USE IN PROTECTING
AND IMPROVING WATER QUALITY IN KENTUCKY**

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In recent years, it has become apparent that established methods of fecal source tracking have their limitations. Some non-microbial methods have become obsolete due to the ubiquitous nature of some chemicals in the environment. Others, such as fecal coliform bacteria or PCR for bacterial gene sequences tend to be quite nonspecific and expensive. All of these methods have one thing in common; they cannot estimate the age of fecal materials like sewage. The lack of fecal age in these methods makes it hard to trace that pollution back to the point source. Many of the waterways we pollute feed into reservoirs used as drinking water sources. The Kentucky River supplies drinking water to 16% of the population of Kentucky; that is 710,000 people. The people in this watershed need to have ways to pinpoint areas for remediation to improve the quality of this vital water supply. As human impacts on surface waters continue to grow, an inexpensive, accurate method of fecal source tracking that has the ability to pinpoint where exactly fecal pollution is entering the environment is needed now more than ever.

The Environmental Research Training Laboratory, under the direction of Dr. Gail Brion designed a study to track Sucralose and acetaminophen through the wastewater treatment process. Samples of raw influent, pre-chlorination effluent, and post treatment effluent were taken during March 2016, February 2017, and June 2017 from Town Branch and West Hickman Wastewater Treatment Plants (WWTPs) in Lexington. Taking samples from both plants allowed for sucralose and acetaminophen levels to be compared across multiple facilities, and across their similar treatment processes. After looking at the preliminary data it is clear that both sucralose and acetaminophen are consistently present in WWTP influent (Table 1).

Site	Type	n	Acet (ng/mL)	Suc (ng/mL)	n	Acet/Suc Ratio	Std. Dev.
TB	RAW	15	80.8	40.2	15	2.50	0.88
	ST	8	<0.1	46.8		95% CI	4.04
	PTE	15	<0.1	43.5			0.95
WH	RAW	11	122.4	48.0	11	2.60	0.54
	ST	7	0.8	45.9		95% CI	3.58
	PTE	11	0.3	48.0			1.62

Table 1: Summary and combined data of WWTP studies.

Sucralose exits the plant in virtually unchanged concentrations whereas acetaminophen disappears below detection limits. Microbial decay of acetaminophen has been found to be significant, so the decrease across the activated sludge process is expected. It was also found that the ratio of sucralose to acetaminophen entering the two plants was not significantly different between plants, or over time (Table 1). Therefore, this ratio could be used to differentiate untreated from treated sewage in the environment, if more is known about the decay rate under environmental conditions.

Laboratory benchtop studies were done that simulated the natural rate of decay of acetaminophen relative to sucralose under different environmental conditions. Basically, either sewage influent or natural creek waters were spiked with acetaminophen and sucralose (if needed), held at a steady temperature in a batch system, with samples taken at different times throughout the 7 days of study. The kinetic decay studies were conducted at 21°C in March 2016 using WWTP influent, and again in June 2017 using spiked creek water. Cold weather studies were done at 4°C in February 2017 using WWTP influent and June 2017 using spiked creek water. It was found that the decay rate followed first order kinetics (Table 2) with slower decay rates at lower temperatures. It took about 48 hours for acetaminophen in sewage to decay below detection limits at 21°C. In creek water, acetaminophen took 92 hours to decay below detection limits at 4°C. Interestingly, inactivation of acetaminophen was not primarily linked to photo-inactivation, as the WWTP experiments were both done with only laboratory lighting and the creek water experiments were done in the absence of light (inside a refrigerator).

Simulated Decay Study Equations		
May 2016 21°C WWTP Influent	$y = -0.0596x + 2.9433$	$R^2 = 0.9778$
February 2017 4°C WWTP Influent	$y = -0.005x + 2.0296$	$R^2 = 0.99021$
June 2017 21°C Creek Water	$y = -0.0351x + 3.345$	$R^2 = 0.97767$
June 2017 4°C Creek Water	$y = -0.0009x + 2.2396$	$R^2 = 0.30654$

Table 2: Equations and R^2 values of the simulated decay studies of the Acet/Suc Ratio. Y is the predicted ratio and x is the time in hours since entering the environment.

Knowing that sucralose would be in samples that had received either treated, or raw sewage, a survey sampling of creek water throughout the Lexington area was done in April and July of 2017 to see what the values of sucralose were, and if the presence of acetaminophen might show reaches with fresher fecal signals. It was found that an average of about 0.2 ng/mL sucralose was present in creeks with a range of 0 ng/mL in a pristine setting to 0.408 ng/mL in an urban area. The maximum recorded sucralose concentration in creeks was more than 100 times less than found in sewage influent.

This approach using human specific chemicals that decay at very different rates needs to be expanded to look at other watersheds and other WWTPs to determine whether the ratio of these two human sourced personal care products can be used to reliably pinpoint sewage leaks. However, the preliminary results are promising and others in the field should evaluate if this approach can help them understand their watersheds and improve surface water quality for their communities.

11. BLUE WATER FARMS: EDGE-OF-FIELD MONITORING OF NUTRIENT AND SEDIMENT LOSS FROM WETLAND WATERSHEDS IN THE NORTHERN MISSISSIPPI EMBAYMENT

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Researchers from the University of Kentucky College of Agriculture, Food and Environment, and the Kentucky Geological Survey are partnering with the U.S. Department of Agriculture Natural Resources Conservation Service to conduct a wetland edge-of-field monitoring program, formally named Blue Water Farms. The goal of this program is to evaluate the effectiveness of conservation practices related to nutrient and sediment losses from agriculture row-crop fields converted to wetlands in the northern Mississippi Embayment. Rain generated surface runoff samples will be collected from six small (< 10 acre) wetland watersheds identified using LIDAR. The watersheds will be in one of three stages of wetland vegetative growth; 1) final soybean crop and tree planting, 2) intermediate herbaceous growth approximately 5 to 7 years after tree planting, and 3) mature timber stand. The outlet of each watershed will be 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 will be analyzed for nutrients (ammonium, nitrate, total Kjeldahl nitrogen, orthophosphate, and total phosphorus) and total suspended solids at the University of Kentucky Lexington campus. In addition, surface water discharge and precipitation measurements will be recorded. Fifty-four months of runoff data will be collected. The surface water quality and quantity data from these wetland watersheds will aid in determining the effectiveness of wetland conservation practices on nutrient and sediment losses in the northern Mississippi Embayment.

12. BLUE WATER FARMS: EDGE-OF-FIELD MONITORING OF NUTRIENT AND SEDIMENT LOSS FROM NO-TILL CORN AND SOYBEAN FIELDS IN THE LOWER GREEN RIVER WATERSHED

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Researchers from the University of Kentucky College of Agriculture, Food and Environment, and the Kentucky Geological Survey are partnering with the U.S. Department of Agriculture Natural Resources Conservation Service, Kentucky Soybean Promotion Board and western Kentucky row-crop producers to conduct an edge-of-field monitoring program, formally named Blue Water Farms. The goal of Blue Water Farms is to evaluate the effectiveness of conservation practices related to nutrient and sediment losses from active agriculture row-crop fields in the lower Green River basin. Runoff from no-till corn/soybean fields will be sampled for nutrients (ammonium, nitrate and nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus) and total suspended solids. In addition, surface water discharge and precipitation measurements will be recorded. Data will be collected between 8 and 10 years, which will include two years of baseline data and 6 to 8 years of control/treatment data. The control conservation practice is broadcast poultry litter and the treatment is poultry litter injection. Data collected from paired field-scale watersheds will aid in determining the effectiveness of surface amendment of litter to the injection of litter on nutrient and sediment loss in western Kentucky.

Six paired watersheds in two no-till corn/soybean rotation fields have been identified in the lower Green River basin. LIDAR and survey data were used to subdivide the fields into three control watersheds and three treatment watersheds ranging in size from 4, 5 and 10 acres. We anticipate that in the spring of 2018, six monitoring stations will be instrumented with a flume, an ultrasonic flow meter, an automated composite water sampler, and a rain gauge. We anticipate baseline sample collection will begin shortly after the stations are instrumented in late winter 2018. Nutrient and sediment samples will be analyzed at the University of Kentucky Lexington campus.

In fall 2018, we anticipate Blue Water Farms to expand with 12 additional watershed monitoring stations: six in no-till, corn-soybean rotation, tile-drained fields in the lower Green River watershed, and six in the Pennyryle focusing on cover crop best management practices. These sites will be instrumented, sampled and analyzed using the same protocol described above.

13. EDGE-OF-FIELD MODELING TO QUANTIFY THE CONTRIBUTION OF MACROPORE FLOW INTO NITROGEN LOADING FOR POORLY DRAINED AGRICULTURAL FIELDS

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Farmers have extensively utilized artificial drainage systems to drain excess water from agricultural fields to enhance crop yield. Tile drainage system consists of a network of perforated plastic pipes, typically 60 to 120 cm below the surface, to direct the drained flow into a pond or surface water channel. The implementation of tile drainage systems across the midwestern US have been reported to be a significant exporter of nutrients to the Western Lake Erie Basin and Gulf of Mexico. The USDA-ARS has established a series of edge-of-field (EOF) monitoring stations on privately owned farmlands to collect water samples from the surface and subsurface of agricultural fields. In the planning level, computer models can be utilized as powerful tools to simulate the surface and subsurface hydrology and water quality and subsequently inform recommendations for BMPs. In this work, the Agricultural Policy Environmental eXtender (APEX) 1501, and a modified version which simulates macropore flow, will be applied to an artificially drained field. Previous application of the macropore model focused on quantifying the impact of macropore flow on dissolved reactive P loads in tile and highlighted improvement of hydrologic and dissolved phosphorus simulations. In this study, we will modify the nitrogen routine of the model to examine how macropores are transporting dissolved nitrogen (DN) to stream channel. We expect the results to show that the effluent from subsurface through macropores is one of the major fluxes of DN loading into waterbodies. We will also compare the results of the two models to examine how the modified model improves the simulation capability of DN into tile. The modified model can be used to conduct scenario analysis for water quality management purposes.

14. HIGH RESOLUTION SENSING OF NITROGEN DYNAMICS IN A MIXED-USE APPALACHIAN WATERSHED: INFLUENCES OF A BACKWATER RIPARIAN WETLAND

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Harmful algal bloom proliferation occurring on the Ohio River has generated a renewed interest in nutrient fluxes from Appalachian watersheds. Headwaters of these watersheds often drain steep-gradient hillslopes; however, discharge to the Ohio River occurs in lowland valleys, producing seasonally inundated stream-wetlands. Tributary perirheic mixing with the main-stem, stream hyporheic mixing with a seasonably varied groundwater table, and variable upland concentrations from dynamic source contributions, creates a highly variable nutrient signal, difficult to characterize using traditional monitoring techniques. These watersheds currently lack water quality monitoring infrastructure that can capture these high resolution dynamics. The goal of this study is nutrient dynamic quantification within these wetland landscapes using novel sensing platforms. The site under study is the Fourpole Creek watershed (60km²) draining predominantly forested, urban, and agricultural landscape through a palustrine forested wetland (0.14km²) in West Virginia. Data will be analyzed for the stream-wetland system monitored at the downstream boundary for turbidity, conductivity, pH, dissolved oxygen, fDOM, temperature, flow, and dissolved nitrate/nitrite at 15-minute intervals using a state-of-the-art water quality monitoring platform. Sediment trap samples were collected weekly at upstream and downstream locations for a year, and analyzed for elemental and isotopic compositions. With the aid of this continuous data, results of total nitrogen load estimates, including dissolved and particulate nitrogen, at event to seasonal timescales will be quantified using modeling estimates of flow in a non-uniform and unsteady system. Additionally, we will perform sampling routine scenario analysis to compare traditional grab sampling routines to high-res sensing of Appalachian forested watersheds. Preliminary sensor data results collected at the watershed outlet highlights a noisy timeseries for all parameters that reflect fluctuating contributions from the Ohio River and Fourpole Creek. During stormflows, Fourpole Creek signatures are found to be dominant, highlighting broad fluctuations in dissolved nitrogen and sediment flux parameters over short time-intervals. Elemental measurements from sediment traps display seasonal fluctuations in sediment entering the wetland that is not found at the watershed outlet, suggesting attenuation and transformation of sediment nitrogen within the wetland. Ultimately, this data will be used to inform hydrologic and water quality models that quantify fluxes and apply them for management/scenario analysis.

15. CLIMATE CHANGE IMPACTS ON SEDIMENT TRANSPORT IN KENTUCKY: SENSOR VALIDATION, CONTROLLING PROCESSES, AND FUTURE PROJECTIONS

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The results of global circulation models indicate that the future climate will likely have a substantial effect on hydrological processes of the watershed. However, the literature still has lack of understanding of how climate change will affect the sediment processes in the watershed system. The authors hypothesized that variations in mean and extreme changes, in turn, might impact sediments in depositional and erosional dominance in a manner that may not be obvious to the watershed manager. We, therefore, investigate the inner processes connecting the combined effect of extreme climate change projections on the upland erosion and instream processes to produce changes in sediment redistribution within a lowland watershed system.

The research methods are proposed based upon simulating sediment processes in forecast and hindcast periods. Publicly available climate realizations from several climate factors and the Soil Water Assessment Tool were used to predict hydrologic conditions for the South Elkhorn Watershed in central Kentucky, USA in 2050. The results of the simulated extreme and mean hydrological components are used in simulating upland erosion with the connectivity processes consideration and thereafter used in building the instream erosion and deposition of sediment processes model with the consideration of surface fine grain lamina layer. A new automated sensors platform is being used for numerical model calibration and validation.

Results of climate change impact on the sediment yield suggest that the average annual sediment yield will likely increase when considering the 11% and the 49% increases in the average annual streamflow and in the 100 year event, respectively. A new result unique to our work is the suggestion made by the model that the climate change will likely cause an increase in the deposition to the SFGL in a stream of lowland watersheds. Ongoing research is investigating climate change impacts on longitudinal and lateral sediment connectivity processes.

16. WATER SUPPLY IMPACTED BY ALGAE AND SEDIMENTATION IN KENTUCKY: ADVANCING SENSORS AND NONCONSERVATIVE TRACERS

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Water supply can potentially be impacted by sedimentation and the production of toxic algal blooms. Watershed sedimentation can fill reservoirs reducing their water storage capacity. Excessive nutrient pollution can cause eutrophication within water bodies promoting the growth of algae. Cyanobacteria concomitant with toxic algal blooms can release cyanotoxins that damage fresh water ecosystems and threaten water supply by creating hypoxic dead zones.

Sediment and nutrient tracer-based fingerprinting coupled with high resolution sensing serves as a means to allocate source contributions of loads and quantify transport rates to reservoirs. However, tracers, and specifically stable isotope tracers, have the potential for being nonconservative, and the fate of the potential tracers requires quantification to justify their usefulness. Further, rarely, if ever, have researchers discriminated in-stream and upland sources from the fate and transport processes using nonconservative tracers and high resolution sensors.

This study was motivated by the need to identify sediment and nutrient sources at the catchment scale to inform watershed erosion and sediment transport models that rely on sensor technology to assess sediment's threat on water supply. The objectives of this study include: (1) investigating the fate and transport of sediment and nutrients in a lowland catchment accounting for the nonconservative nature of biogeochemical tracers, (2) testing new isotope tracers coupled with sensor data streams and sediment connectivity numerical modeling to improve transport models and flux calculations, and (3) analyzing organic carbon and nutrient fate in relationship to stream processes in an experiment to examine mineralization and isotope fractionation.

Lowland stream networks were focused upon in this study due to their efficiency to store sediments that assimilate nutrients due to their low-gradient nature. Moderate and high flows in lowland catchments transport a heterogeneous mixture of upland, bank, and, streambed fine particulate organic matter from autochthonous and terrestrial sources. Additionally, the study lowland watershed's significant occurrence of fine sediment storage in the streambed promotes chemical bonding of nutrients due to the cohesive nature of fine sediment.

Sediments were analyzed for carbon and nitrogen content, applying stable isotopic ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) compositions. These biogeochemical tracers associate with plant cover, land-use, and land management at the sediment sources, including upland and bed sediments. Organic tracers tend to discriminate sediment sources through differences in soil organic matter cycling, the

biogeochemical process by which sediments form their organic signature. A combination of field data collection, laboratory analyses of sediments, and statistical modeling techniques provides a method to distribute applicable tracers to sediment sources within the watershed. The alteration of carbon and nitrogen isotopic compositions during transport were studied in both oxic and anoxic conditions. Once changes during transport occurring to the sediment and tracers are accounted for, the contribution of fluvial sediments from each source can be estimated by coupling with a mass balance un-mixing model.

17. COUPLED HYDRAULIC AND SEDIMENT TRANSPORT MODELING OF A FLUVIAL KARST AQUIFER IN THE BLUEGRASS REGION OF KENTUCKY

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Karst landscapes are solutionally dissolved leading to the development of secondary and tertiary porosity pathways and complex hydraulic, sediment, and nutrient transport dynamics. Although advances in the understanding of transport dynamics in karst have been made, modeling efforts remain insufficient when considering mature surface-subsurface networks. Mature karst systems are characterized by a highly-coupled surface watershed and groundwater basin, a mature soil-covered epikarst, a developed fracture and fissure network, and a primary phreatic conduit that discharges flow to a main spring. The objective of this study was to develop a comprehensive hydraulic, sediment, and nutrient transport model that can be applied to and effectively simulate mature karst systems.

The hydraulic model simultaneously solves conservation of mass, momentum, and energy equations and is comprised of three sub-routines: a hydrologic diffuse flow model, a stream routing model, and a conduit pipe network model. Data inputs to the model include climate, land use, topography, surface tributary sediment concentrations, and conduit bathymetry. The fate and transport of sediment carbon and nitrogen is considered in the model and the stable isotope signatures of carbon-13 and nitrogen-15 are used to constrain model parameterization. To calibrate the sediment model, high frequency turbidity measurements were recorded and TSS samples were collected every seven hours at the spring outlet during the summer of 2017. The model was applied to the coupled Cane Run Creek Watershed and Royal Springs Groundwater Basin located in Fayette and Scott Counties, Kentucky. Royal Springs is the pour point of the groundwater basin and is the drinking water source for Georgetown, Kentucky.

Current manually calibrated hydraulic model results for an event in April 2016 has a Nash-Sutcliffe Efficiency rating of 0.93, which indicates that the model performs well and captures the dynamics of the system. It is anticipated that complete multi-year hydraulic, sediment, and nutrient transport model results will have high performance ratings and improve upon existing models in the same watershed. The results of this study should provide researchers and practitioners a new modeling tool that can be effectively applied to fluvial karst aquifer with flow dominated by a phreatic conduit and has high connectivity to a surface stream. Also, results of this model should further knowledge of hydraulic, sediment, and nutrient dynamics in karst.

18. TEMPORAL VARIATIONS OF HIGH RESOLUTION NUTRIENT CONCENTRATIONS IN MATURE VS IMMATURE KARSTIC WATERSHEDS

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Study of the temporal variations in nutrient concentrations has been limited in the past in terms of the temporal resolution of samples taken. This is primarily due to the time and man-power constraints that exist when conducting grab-sampling regiments in the field. The recent advancements in continuous, *in-situ* nutrient sensors have therefore made high-resolution, high-quality nutrient sampling increasingly possible. The relatively few studies that have been conducted in the United States using such sensors have generally been conducted on very large watersheds, such as the Mississippi River Basin, Columbia River Basin, and the Potomac River Basin. Rarely have such studies been conducted in smaller watersheds such as the South Elkhorn and Cane Run sub-basins ($< 75 \text{ km}^2$), and very rarely have such sensors been used to monitor nutrient levels in mature karst dominated watersheds. The current objective of this study is to use continuous, high-resolution *in-situ* nutrient sensors to monitor the temporal patterns and variations of nutrient concentrations (specifically of nitrogen, most commonly found in natural streams as dissolved nitrate, NO_3^-) in the streams and to analyze the effects of mature vs. immature karst landscape features on the resulting concentrations in similar watersheds.

Nutrient monitoring “platforms”, consisting of the SeaBird-Coastal SUNA V2 nitrate sensor, the SeaBird-Coastal HydroCycle-PO4 phosphate sensor, and various Yellow Springs, Inc. 6-Series Water Quality Sondes (measuring temperature, turbidity, conductivity, dissolved-oxygen, and pH) have been deployed in two watersheds in central Kentucky. The South Elkhorn watershed is a 62 km^2 basin near Lexington, KY and has been defined as a surface-flow dominated, immature karst watershed. The Cane Run watershed is a 98 km^2 basin near Georgetown, KY with a 58 km^2 area made up of a coupled surface-subsurface network. This watershed has been defined as a mature karst watershed with flow occurring both in the surface stream and a sub-surface conduit fed by an extensive series of sink- and swallet-holes in the watershed surface. Data from these “platforms” has been compared using various time-series analysis techniques. Additionally, data for identical parameters, made available by the U.S. Geological Survey, was included in the comparison and analysis of the effects of mature vs. immature karst landscapes for larger watersheds in Kentucky; including the Licking River in northeast Kentucky, the Green River in south-central Kentucky.

Preliminary time-series data analysis has resulted in the identification of pronounced patterns and variations in nitrate concentration diurnally; as well as proceeding, during, and after large hydrologic events. Average nitrate concentrations in karstic systems have been found to be significantly higher consistently compared to average concentrations in surface-water

dominated systems. A specific pattern has been identified during hydrologic events for both mature and immature karstic systems. As the hydrograph for the watershed rises, the nutrient concentrations will generally fall drastically, and then begin to rise again as the hydrograph peaks and begins to fall. Concentrations will generally peak sometime after the hydrograph. This “lagging” concentration peak is assumed to be a function of several factors; including watershed land-use and soil characteristics, hydrologic event magnitude, weather and climate conditions, etc. With an expanding dataset, further analysis and modelling is planned to more comprehensively investigate these phenomena. For example, analyses of hysteresis loops, pre- vs post-extreme events, hydrograph separation, and nutrient decay modeling are ongoing. Relevant findings from this study will help to further understand the nutrient processes in karstic systems and how they compare to surface streams. More specifically, the use of continuous, *in-situ* nutrient sensors in karst systems will help to elucidate the previously understudied field of sub-surface nutrient dynamics.

19. SYNTHESIS OF BIOLOGICALLY-INSPIRED NANOFILTRATION MEMBRANES USING PROTECTED AND MUTATED AQUAPORINS

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Aquaporins are protein water channels present in cells, and they restrict the passage of contaminants and small molecules such as urea and boric acid, without preventing the passage of water. Biomimetic water treatment polymeric membranes attempt to replicate this natural process of high selectivity and efficient transport of different molecules by embedding the polymeric membrane with aquaporins. Therefore, aquaporins have received worldwide attention because of their potential to form biomimetic membranes with high flux and selectivity for water treatment. However, challenges involved in the incorporation of aquaporin proteins in membranes limit their applicability. One of them is to attach aquaporins to the membranes without chemically altering or damaging the aquaporins during the binding to the membrane. The second challenge is to design and prepare an assembly that allows biomimetic membranes with aquaporins to sustain hydraulic water pressure gradients without losing their integrity and performance. The overarching objective of this project was to form a biomimetic membrane made of unaltered aquaporins dispersed in a polymeric membrane selective layer and capable of operation under high hydraulic pressure. Membranes modified with mutated aquaporins showed higher and consistent rejection values for increasing feed concentrations, higher flux recovery and lower flux declines.