Dr. Ishi Buffam, Assistant Professor in Department of Biological Sciences and Dominic Boccelli, Assistant Professor at the College of Engineering and Applied Science at the University of Cincinnati progressed in completing an Ohio Water Resources Center funded project via joined USGS 104(b) and OWDA subaward. This project titled "**Assessment of a Novel Application of Biochar to Improve Runoff Water Quality from Vegetated Roofs"** aims to improve nutrient retention of vegetated roofs using biochar. Vegetated roofs are becoming increasingly more important as a part of green-engineered solutions for stormwater management in urban areas.

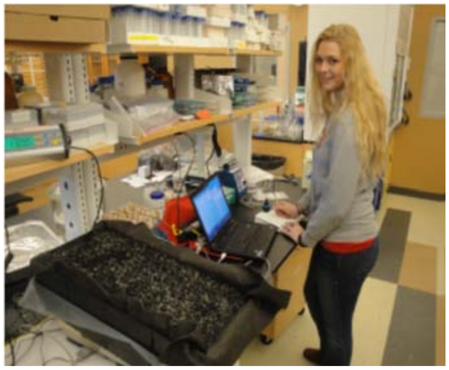

Figure 1 Caitlin Shaw overseeing plot and scale setup for continuous recording of weight changes due to evaporation from biochar-amended vegetated roof substrate.

The integration of biochar is a potential breakthrough in reducing water quality degradation by green roof runoff, but very little is known about the sensitivity to variation in the proportion of the biochar amendment, or the dynamics of sorption kinetics or equilibria. We conducted laboratory column and batch experiments as well as pilot green roof test plots experiments (Figure 1). The laboratory column experiments showed that when averaged over the 5-day experiment, the volume-averaged mean nutrient concentrations (directly proportional to total flux) were reduced in the high-biochar treatment (14 % w/w) by up to 75% for ammonium and 17% for nitrate, while all columns were a slight net source of phosphate regardless of biochar amendment. Furthermore all three different types of biochar substrate (raw, sifted, blended) had about three times higher the water holding capacity when adjusted per mass than traditional green roof substrate. These results are now being tested in the pilot green roof plots and will be incorporated into modeling. Preliminary results show improvements in water retention capacity, but not an impact on the rate of evaporation or length of water retention (Figure 2). The research demonstrates the water quality improvements associated with a biochar-amended green roof, but will also result in a modeling component that can be used within an integrated assessment framework both within and beyond the Ohio River Valley.

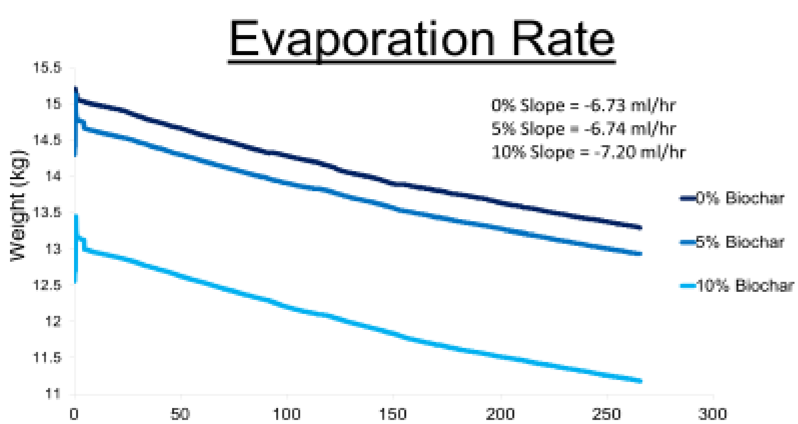

Figure 2 Weight change of each green roof plot (vegetated roof substrate alone, 5% biochar mix, 10% biochar mix) during 11 day incubation period. Evaporation rates were similar for all three treatments.

Researcher Profile: Dr. Ishi Buffam is an ecosystem ecologist and aquatic biochemist. He uses a combination of field vegetation and soil surveys, lab-based water and soil chemistry/biogeochemistry analysis, empirical modeling and GIS-based modeling to evaluate the relationship between landscape/watershed characteristics and surface water chemistry and biotic communities. Many of his current projects are centered on quantifying ecosystem services and potential disservices associated with green (vegetated) roofs, since little is known about the direct biogeochemical functions of green roofs.

Dr. George Bullerjahn, Professor in the Department of Biological Sciences at the Bowling Green State University recently completed his Ohio Water Resources Center funded project via joined USGS 104(b) and OWDA subaward. His project titled "**Source Tracking of *Microcystis* Blooms in Lake Erie and its Tributaries"** is focused on identification of the geographic sources of toxic, bloom-forming cyanobacteria in Lake Erie. The results can affect the lake management, as bloom events that occur in Lake Erie may rely on intervention strategies implemented upstream.

Figure 1. Taylor Tuttle (BGSU), Timothy Davis (NOAA-GLERL) and George Bullerjahn (BGSU) sample Sandusky Bay.

The funded work is targeting cyanobacteria sampling at Sandusky Bay, the Maumee River and Lake St. Clair, comparing the bloom-forming genera at each site using high-throughput DNA sequencing of diagnostic target genes (Figure 1). It was found that all toxic *Microcystis* strains found in Lake St. Clair clustered with toxic strains found in samples previously collected from Lakes Erie and Ontario, demonstrating extensive genetic connectivity between the three systems and establishing Lake St. Clair as an important immediate and historical source of toxic *Microcystis* to lakes Erie and Ontario (Figure 2). Furtermore *Microcystis* blooms in Lake St. Clair can produce microcystin at levels that could negatively affect human health. Regarding total cyanobacterial diversity, toxic *Planktothrix,* not *Microcystis*, dominates in nearshore environments such as Sandusky Bay. Overall, understanding the physiology of the two different species that respond differently to environmental variables (nitrogen vs. phosphorus, for example) can help determine species-strategies for control and remediation of offshore vs. nearshore bloom events.

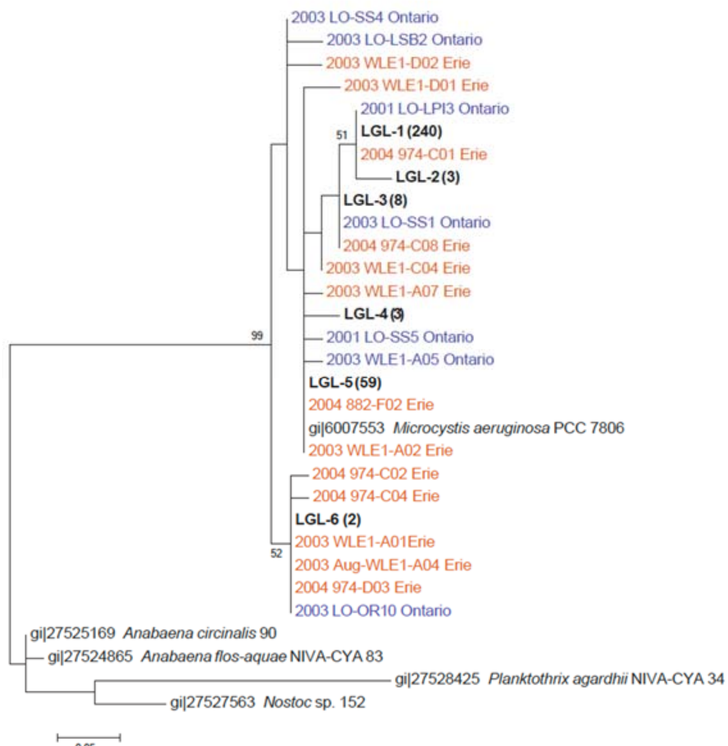

Figure 2. Phylogenetic tree of microcystin synthetase toxin *(mcyA)* gene sequences from Lake St. Clair, compared with environmental sequences from Lakes Erie and Ontario. The Lake St. Clair sequences (LGL) exist as six genotypes that are detected as abundant bloom formers downstream in Lakes Erie (orange) and Ontario (blue).

<u>Researcher Profile:</u> Dr. George Bullerjahn's work is currently focused on enumeration and the physiological performance of phototrophs and ecologically important chemolithotrophs in aquatic systems. His group has identified genes and gene products inducible under nutrient (N, P) limitation and stationary phase conditions, and this work has aided in the development of whole-cell biosensors detecting the bioavailability of nutrients in environmental samples. Additionally, he examines the composition and dynamics of cyanobacterial and nitrifying communities in freshwater environments, focusing primarily on the N and P cycles in the Laurentian Great Lakes.

Dr. Chin-Min Cheng, Senior Research Associate in the Department of Civil, Environmental and Geodetic Engineering at the Ohio State University progressed in completion of an Ohio Water Resources Center funded project via OWDA subaward. The project titled **“Separation of Phosphorus- and Nitrogen-nutrients from Agricultural Degraded Waters Using Pervious Filter Material Developed from Industrial By-products”** aims to evaluate usage of industrial waste materials for nutrient filtration. These developed filter materials would be a low cost alternative for separation of nutrients from agricultural drainage waters. Furthermore these filters might be potentially recycled and reused as soil amendments or fertilizers

Figure 1. Demonstration of Previous Filter Material

In this project, two types of previous filter materials to remove nutrients, i.e., nitrate and phosphate, from agriculture drainage waters (ADW) are being developed and characterized (Figure 1). The P-type filter material contains fly ash, sulfite-rich flue gas desulfurization (FGD) material and quick lime to selectively bind phosphorus. The nitrogen capture materials (N-type filter) are prepared from red mud, fly ash, and stabilized FGD material. The equilibrium concentrations of phosphate and nitrate in the solution after mixing as a function of material dosage are shown in Figure 2. As shown in the figure, over 97% of phosphate was removed by the P-type material with a solid-to liquid (L/S) ratio of 100. With the same L/S ratio, only nearly 4% of nitrate was adsorbed by the N-type material. Furthermore, the absorption isotherms for N and P were developed and expressed as Langmuir isotherm. It is estimated that the maximum phosphate adsorption capacity 20.7 mg/g and 0.18 mg/g for the P – and N-type material, respectively. Although currently the P-type material shows promising adsorption capacity and P removal, to comprehend overall benefits of reusing these by-products, it is vital to understand the leaching properties of the prepared pervious materials under different application scenarios.

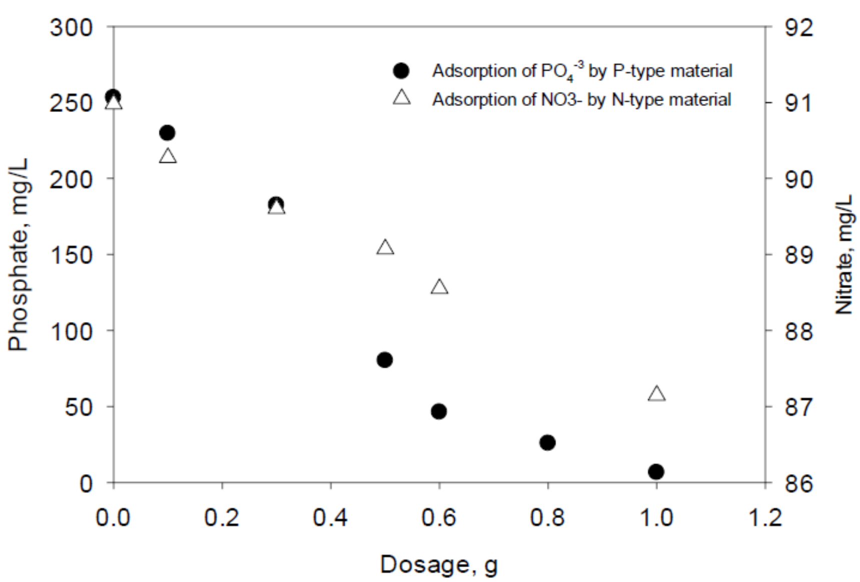

Figure 2 The equilibrium concentrations of phosphate and nitrate in the solution as a function of material dosage

Researcher Profile: Dr. Chin-Min Cheng’s work is to seek approaches to better manage by-products produced from industrial processes and agricultural operations, which consequently improves the sustainability of our society by reducing the consumption of natural resources and associated environmental impacts.

Dr. Isabel Escobar, Professor in Chemical and Environmental Engineering at the University of Toledo recently completed her Ohio Water Resources Center funded project via OWDA subaward. Her project titled **"High-performance Biologically Inspired Membranes for Water Treatment"** relied on the idea of combining the ultra-efficient functioning of biological molecules with the productivity of synthetic membranes. These biomimetic membranes with structure and function similar to the membranes of living organisms may offer the ultimate breakthrough for low-energy desalination.

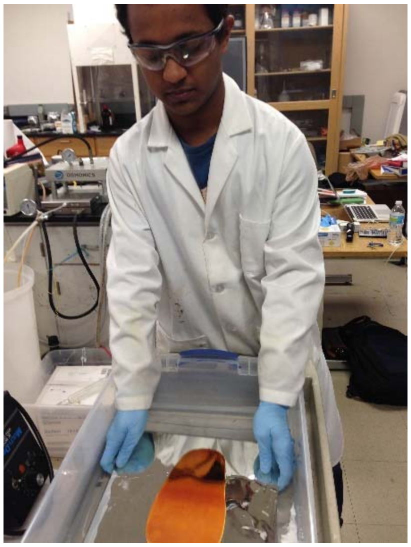

Figure 1 Membrane preparation

The objective of the project was to make a new class of biomimetic nanofiltration membranes by modifying their surface and making them chemically and mechanically stable (Figure 1). In short, aquaporins were treated with polysaccharides to protect them, and then were embedded in amphiphilic polyvinyl alcohol with alkyl side chains (PVA-alkyl) matrix. This PVA alkyl with embedded aquaporins will be used as the nanofiltration membrane active layer on the surface of a polybenzimidizole (PBI) membrane (Figure 1 shows a PBI membrane being cast). While initial flux values of aquaporins modified membranes were lower than unmodified membranes, final flux values after 140 hours of experiment were consistently higher for the modified membranes. Furthermore, aquaporins-modified membranes showed higher flux recoveries possible due to the fact that aquaporins are bidirectional; hence, backwash was more efficient. In addition, membranes modified with aquaporins showed higher selectivities, as measured by salt rejections (Figure 2) and protein rejections, as compared to unmodified synthetic membranes and may offer ultimate breakthrough for low energy desalination.

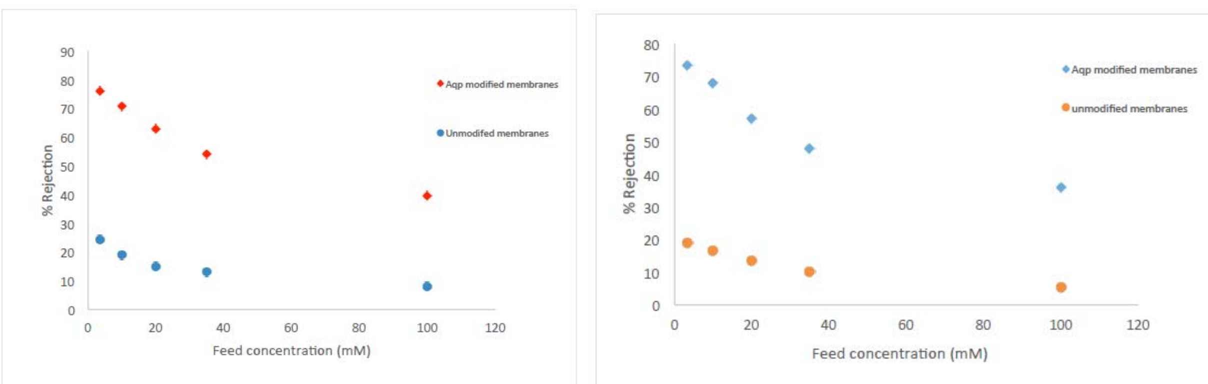

Figure 2 Calcium (left) and sodium (right) chloride filtration rejection by aquaporins modified (red diamonds) and unmodified (blue diamonds) membranes

<u>Researcher Profile:</u> Dr. Escobar's research focuses on developing and/or improving polymeric membrane materials for water/wastewater treatment and water reuse operations through membrane post-synthesis modifications, the use of dynamic membranes, and process modifications.

Dr. Kristin Jaeger, Assistant Professor, and Dr. Mažeika Sullivan, Associate Professor, both in the School of Environment and Natural Resources at the Ohio State University are working on an Ohio Water Resources Center funded project via a USGS 104(b) award. Their project, entitled “**Linked geomorphic and ecological responses to river restoration: Influence of dam removal on river channel structure and fish assemblages**,” aims to investigate linked short-term response of the Olentangy River following the removal of low-head dam, with a focus on fish community assemblages in both actively and passively restored river reaches. Recreational fishing is a major revenue generator within the state. Therefore, how fish assemblages respond to dam removal reflects a critical knowledge gap in the burgeoning dam removal and river restoration research.

Figure 1. Student Ellen Comes uses McNiel sampler on the Olentangy River to characterize riverbed sediment.

Dr. Sullivan’s ongoing work in the Olentangy River system over the last four years serves as a rare baseline ecological data set that both researchers can build on to quantitatively evaluate river channel geomorphic change (the physical shape of the river) and changes in the ecological fish community as a consequence of the removal of the 5th Avenue Dam on the Olentangy River (Figure 1). In the short term, geomorphic response upstream of the dam following its removal included decreased cross-sectional area in the former impoundment, increased and more varied streamflow velocity and channel incision into the reservoir sediment, which has generally flushed finer sediments from the previously impounded, unrestored portion of the river and resulted in coarsening of riverbed sediments at this reach. These geomorphic changes translate to habitat changes for fish. Upstream of the removed dam (at the actively restored reach), fish assemblage composition shifted significantly and was accompanied by a significant decrease in species richness and diversity. These changes represented changes in the relative abundance of taxa. Between year 1 and year 2 post-dam removal, diversity increased significantly at the upstream restored and downstream reaches (Figure 2).

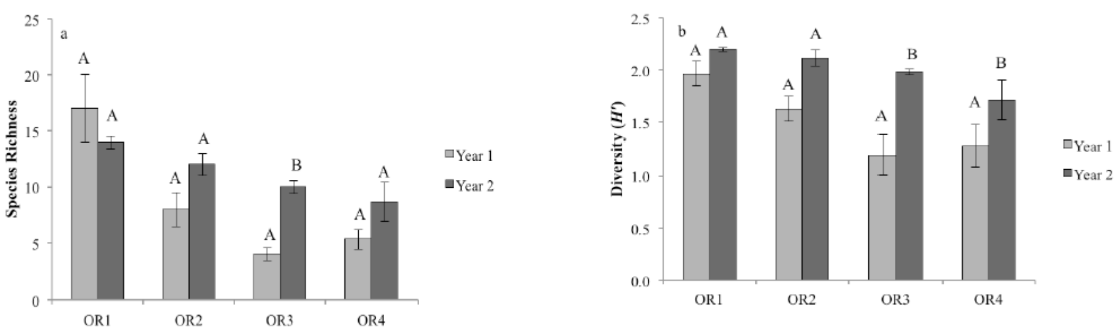

Figure 2. Fish assemblage (a) species richness and (b) diversity (*H*’) in years 1 & 2 following dam removal of the Olentangy River study reaches. OR1 is the upstream of an existing dam control reach; OR2 is the upstream of the removed dam, unmanipulated experimental reach; OR3 is the upstream of the removed dam, restored experimental reach; and OR 4 is the downstream of the removed dam experimental reach. Significant differences based on *t*-tests are indicated by different letters ($p < 0.05$). Error bars represent +1 SE from the mean. From Dorobek, Sullivan, and Kautza (In press).

<u>Researcher Profile:</u> Dr. Kristin Jaeger works across a range of spatial scales including reach to network scale and headwaters to large mainstem rivers. Her research interests focus on how stream channel morphology and flow regimes adjust to perturbations, either natural or anthropogenic. Her ongoing projects include work on geomorphic response to surface mining, large wood dynamics in mountain channels, and characterizing spatiotemporal patterns of streamflow permanence in dryland systems.

Dr. Anne Jefferson, Assistant Professor in the Department of Geology at the Kent State University progressed in completing an Ohio Water Resources Center project via USGS 104(b) subaward. The overall objective of her project titled **"Characterizing stream restoration's water quality improvement potential through hyporheic exchange enhancement"** is to evaluate how stream restoration affects hyporheic exchange, and therefore water chemistry. Such understanding is crucial for deciding where stream restoration is appropriate to meet management objectives, designing restoration projects to meet those objectives, and evaluating whether restorations are successful.

Figure 1 *Dr. Jefferson's student collecting samples*

Overall this study has discovered a dynamic environment in the hyporheic zone of restored streams, with changing hydraulic conductivity and strong chemical gradients. In the stream where sediment inputs were restricted by an upstream dam, hydraulic conductivity did not change at the reach scale over a 5 month period, as opposed to a stream with unresticted sediment input where hydraulics conductivity declined over 15 months following restoration. Despite these dynamics, neither restored reach effected a change in surface water chemistry, as measured by baseflow grab samples analyzed for nitrate and other anions. Pore water collected from piezometers (Figure 1) revealed one important trend. Manganese concentrations were greatest in the head or upstream end of riffle 2 and 3, and in the middle of riffle 1, in each case as much as ten times higher than the surface water (Figure 2). These results suggest that redox chemistry is active within the constructed riffles in the restoration and is likely caused by dissolved oxygen gradients along flowpaths through these structures.

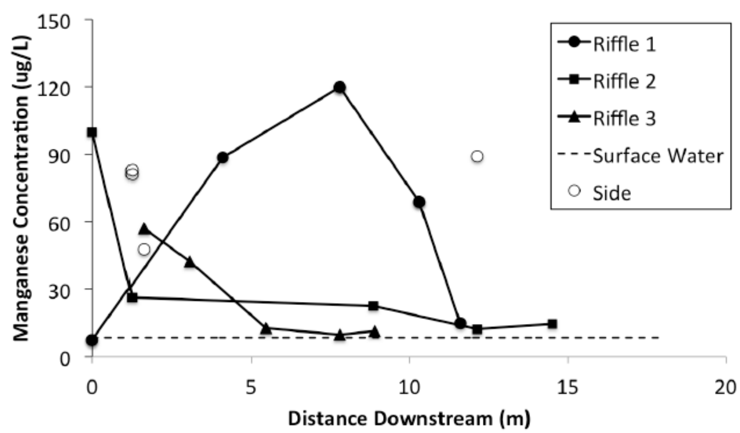

Figure 2 *Manganese concentrations from pore water 15---30 cm below the streambed surface at Kelsey Creek.*

In summary, hyporheic exchange was not significant enough to modify the water quality signal resulting from upstream land use and geology. This could be either be the result of insufficient hydraulic conductivity; the observed weak upwelling and downwelling; or short restored reach length. While the study was limited to two sites and approximately one year of data, the results suggest that stream restoration practices may not induce sufficient hyporheic exchange to improve downstream water quality.

<u>Researcher Profile:</u> Dr. Anne Jefferson's lab works on watershed hydrology, groundwater-surface water interactions, and landscape evolution in human-altered landscapes. Current projects focus on green infrastructure, stormwater management, and stream restoration. Much of her research is field-based, but her group also makes use of stable isotope analyses, geographic information systems (GIS), and hydrologic modeling.

Paula Mouser, Assistant Professor at Civil, Environmental and Geodetic Engineering at the Ohio State University and Mary Ann Thomas, researcher from USGS completed an Ohio Water Resources Center funded project via OWDA subaward. Their project titled "**Characterizing Methane in Geologic Formations of Ohio; Phase 1: Seed Grant to Investigate Natural Biogenic Methane from Domestic Wells Unaffected by Oil and Gas Production"** will serve as a starting point for compiling information about "baseline" methane in Ohio subsurface formations. This information could ultimately be used to assist investigations of stray gas complaints.

Figure 1 Groundwater Sampling

Eleven domestic wells in southwestern and central Ohio unaffected by shale gas development were sampled (Figure 1) and methane was detected in all raw water samples. The volume percent of methane was 0.03-0.7 % for 7 samples and 61-92 % for 4 samples. The isotopic signature of methane was determined for the 4 samples with higher methane concentrations, and results were consistent with biogenic methane. During 2014, further DNA analysis and sequencing were conducted. The number of species (richness) identified within samples ranged from 33-97 when subsampled to 250. The PR_239 site was the most unusual from all other sites as it was dominated by the presence of OTUs within the *Firmicutes* (Figure 2). All other sites were dominated by various *Proteobacteria* (orange in Fig 1). Other dominant phyla include the *Nitrospirae* (nitrifyers), *Actinobacteria*, and candidate phylum OP3. The presence of certain *Euryarchaeota* was notable across the PR sites, while contributing on average less than 0.2% of the other sites. This group contains the methanogenic orders of microorganisms.

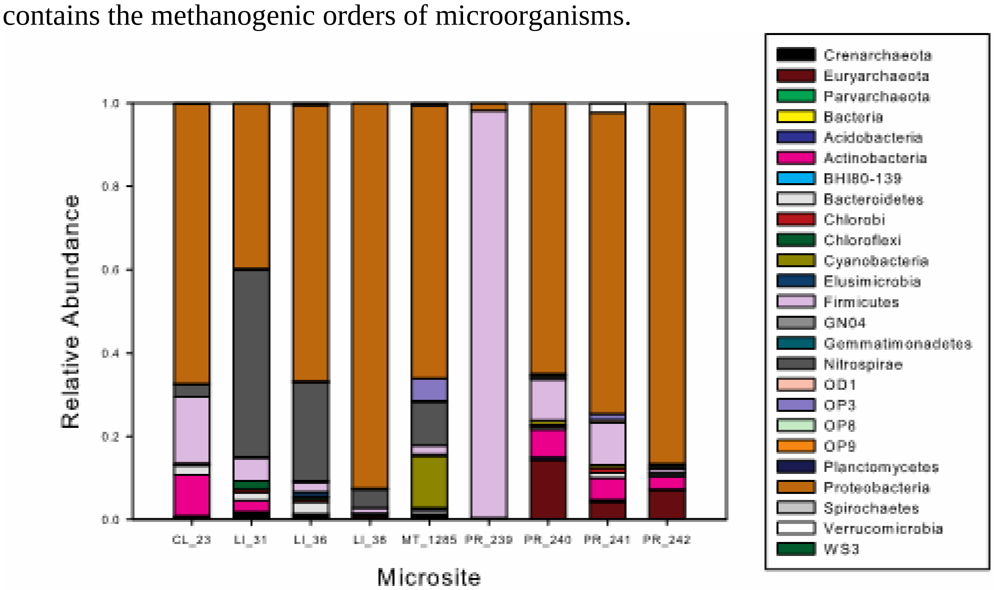

Figure 2 Bar charts of the relative abundance of Phyla OTUs detected in the survey.

Researcher Profile: Dr. Paula Mouser investigates microbial-environmental interactions in engineered subsurface systems ranging from floodplain aquifers and drainage channels to granitic bedrock aquifers and deep hydrocarbon shale. She is also interested in how microorganisms interact with material surfaces, such as membranes used for water treatment and casing used for shale gas wells. Applications of such research include improving detection and remediation strategies for the protection of water resources, and optimizing technologies for water treatment.

Dr. Paula Mouser, Assistant Professor in the Department of Civil, Environmental and Geodetic Engineering at the Ohio State University together with Professors Linda Weavers and Henk Verweij recently completed an Ohio Water Resources Center project jointly funded by the Office of Energy and Environment at OSU and an OWDA subaward to the OWRC. The overall objective of their project titled **"Characterizing the influence of surface chemistry and morphology on biofilm formation of ceramic membranes in wastewater treatment"** is to better characterize biological fouling of membranes used for water and wastewater treatment, and identify innovative cleaning technologies or improvements in membrane sciences to help prevent or reduce the rate of biological fouling.

Experimental results indicate ultrasonic cleaning outperforms conventional cleaning methods (rinsing and air scouring) with post-sonication flux measured as over 30% greater than post-conventional cleaning flux (Figure 1). Characterization of extracellular polymeric substances (EPS) indicated proteins were effectively removed via sonication, whereas polysaccharides were more persistent foulants (Figure 2). Differences in pH affected both the surface charge of the membrane and the structural characteristics of the biological foulants. The highest recovery of membrane flux occurred at the pH closest to the isoelectric point of the ceramic membrane (pH 7), indicating that minimizing the membrane surface charge may be a key parameter for optimizing ultrasonic cleaning.

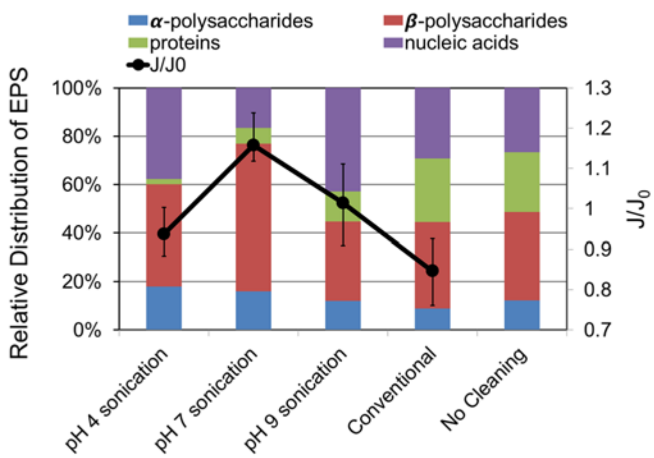

Figure 1. EPS distribution on fouled membrane surfaces and initial flux of cleaned membranes. 'J' is flux measured in first 10 sec of filtration; 'J_0' is virgin membrane flux

The research team, which included PhD student John Krinks, demonstrated the application of ultrasound to be an effective method of recovering flux across ceramic membranes fouled by municipal wastewater. Compared to conventional cleaning, the use of ultrasound results in differing distributions of EPS at the membrane surface and higher flux recovery. Regarding large-scale applicability of ultrasonic cleaning systems for membrane bioreactors, it is not yet considered viable to install transducers in aeration tanks adjacent to the membranes. Rather, such an application is better suited for a small cleaning system in which individual membranes could be removed from service, cleaned via sonication, and returned to the aeration tank.

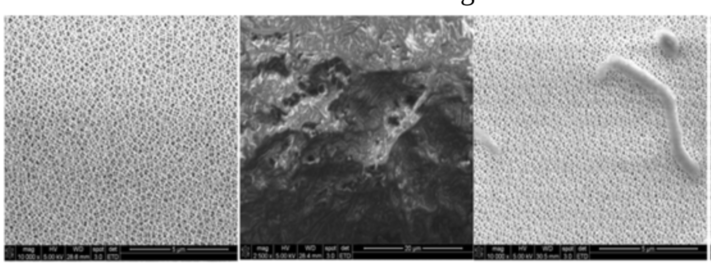

Figure 2. Scanning electron microscope (SEM) images of a clean ceramic membrane surface (left), a fouled membrane after wastewater filtration (middle), and the surface of a ceramic membrane following cleaning with ultrasound at 620 kHz for 30 seconds (right).

Researcher Profile: Dr. Paula Mouser investigates microbial-environmental interactions in engineered subsurface systems ranging from floodplain aquifers and drainage channels to granitic bedrock aquifers and deep hydrocarbon shale. She is also interested in how microorganisms interact with material surfaces, such as membranes used for water treatment and casing used for shale gas wells. Applications of such research include improving detection and remediation strategies for the protection of water resources, and optimizing technologies for water treatment.

Dr. Suresh Sharma, Assistant Professor in the Civil and Environmental Engineering Program at the Youngstown State University continues working on an Ohio Water Resources Center funded project via 104(b) USGS award. The overall objective of his project titled "**Scenario Analysis for the Impact of Hydraulic Fracturing on Stream Low Flows and Water Supplies: A Case Study of Muskingum Watershed in Eastern Ohio**" is to evaluate the capacities of smaller streams for withdrawal permitting and water resources availability at various spatial and temporal scales.

Figure 1. Dr. Sharma's graduate student modeling different scenarios

Soil and Water Assessment Tool (SWAT) was validated on USGS gauged streams and scenarios comparison was done for the Muskingum Watershed (Figure 1). Baseline scenario was based on the realistic conditions of all water use data, excluding hydraulic fracking water use. Similarly, current scenario was based on the real data of water use in the Muskingum watershed including current water withdrawal conditions for hydraulic fracking. The future scenario was modeled using 30 years of generated climate data based on historical precipitation. Seven day minimum monthly flows showed large variability when compared with and without fracking, indicating that flow alteration during low flow period will be more critical than average flow or peak flow period (Figure 2). A significant change in the seven day minimum flows was detected among baseline, current and future scenarios, especially in the first order stream. Furthermore, the future scenario showed that water withdrawal due to hydraulic fracking had localized impact, especially during low flow period. More importantly, the flow alteration due to hydraulic fracking decreased with increase in the drainage area. The modeling results suggests that planners and decision makers should consider water withdrawal for fracking while setting environmental flow criteria in NPDES permitting for this specific region. In addition, climate change data from Climate Model Intercomparison Project 5(CMIP5) data were utilized to evaluate the stream low flows under active hydraulic fracking and climate change. Analysis indicates that basin will experience low flow period for the early 21st century compared to the mid and late century indicating that extended low flow period will be more crucial due to integrated effect of hydraulic fracking and climate change.

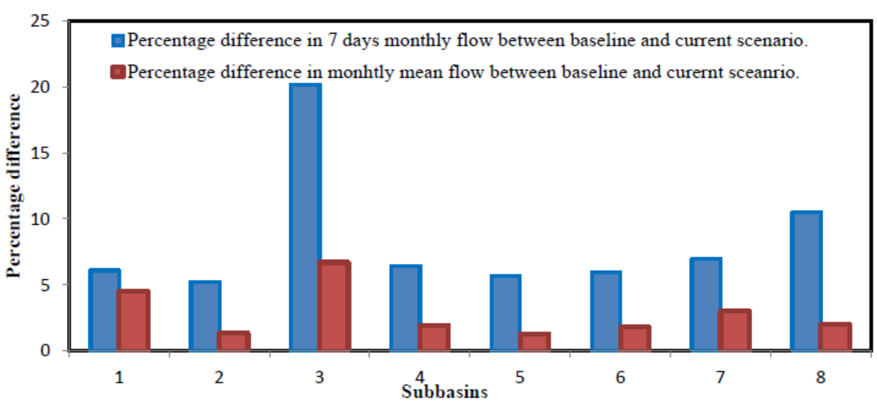

Figure 2. Percentage differences of seven day minimum monthly flow and monthly mean between baseline (without hydraulic fracking) and current scenario on eight subbasins of Muskingum Watershed currently affected by shale gas development.

<u>Researcher Profile:</u> Dr. Suresh Sharma is interested in complex hydrologic and water quality modeling using various types of data driven, conceptual, physically based and distributed and semi-distributed watershed models in climate change/variability context. Currently, Dr. Sharma is working in a research related with hydraulic fracking and its impact on water resources, early flood warning system, and sediment and nutrient loading reduction due to bioenergy crop implementation.

Dr. Christopher Spiese, Assistant Professor in the Department of Chemistry and Biochemistry and Bryan Boulanger from Civil Engineering at the Ohio Northern University completed an Ohio Water Resources Center funded project via joined USGS 104(b) and OWDA grant. His project titled "**Rural On-site Waste Treatment as a Source of Nutrients to a Eutrophic Watershed"** will determine the extent to which residential on-site wastewater treatment in rural watersheds are source of nitrogen and phosphorus. Identification of sources of nutrients into Lake Erie tributaries is critical for understanding how to control these loadings and ultimately maintain a long-term oligotrophic status in the Lake.

Figure 1. Dr. Spiese ONU sampling tile drainage water.

At six sites across Putnam County, Ohio, tile drainage water was sampled over the course of two years (Figure 1). Caffeine was found at all of the sites with mean ± standard deviation concentrations ranging from non-detect at the control site to 1.2±1.4 μg/L in tile drainage effluents from sites having on-site wastewater treatment (OSWT) systems. Although nitrogen is a large component of human waste, there was no relationship apparent between nitrogen and caffeine. Caffeine and total phosphorus on the other hand had a significant negative correlation (Figure 2a). The study results are interesting, because the observed caffeine-total phosphorous correlation indicates that septic effluents are not significant contributors to nutrient loadings within the rural watershed. Additionally, commonalities in nutrient fingerprints (total and dissolved phosphorous and nitrogen) in groundwater and tile drainage highlight the complex relationships for nutrient and water quality management in irrigation drainage waters. At nearly all sites tested, both fecal coliform bacteria and *E. coli* were detected (Figure 2b). Both microbe types were correlated with caffeine concentration, indicating a common source. In summary, in this agricultural watershed, OSWT systems do not contribute significantly to nutrients, but do appear to be a source of bacteria. These results urge caution when making policy decisions related to nutrient reduction by targeting residential OSWT systems.

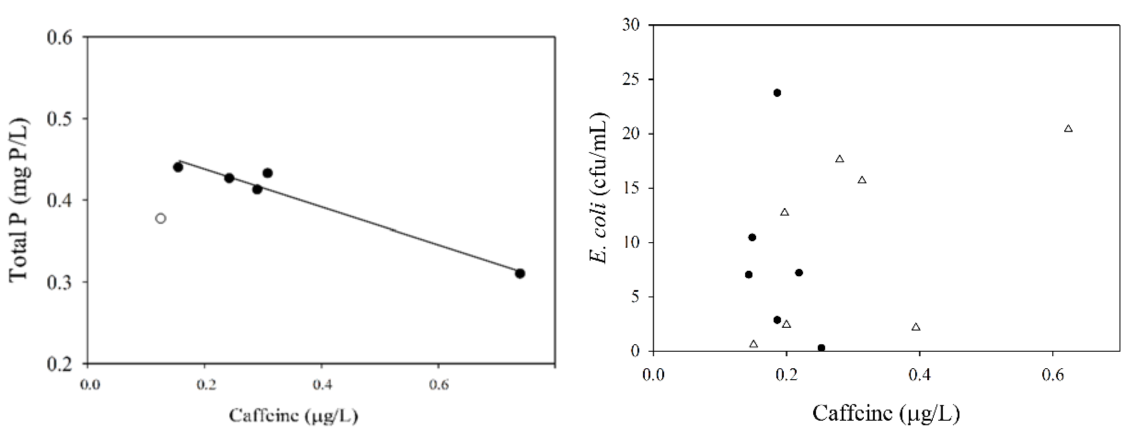

Figure 2 Correlations between caffeine and a) total phosphorus, b) *E. Coli*. Points denote mean of all samples. Correlation coefficients were significant for both.

<u>Researcher Profile:</u> Dr. Christopher Spiese is an environmental chemist and biogeochemist. His research area is a highly interdisciplinary program that incorporates chemistry, biology, geology, and limnology, but his main focus is on physical and analytical chemistry in environmental systems. He currently has projects examining the role of contaminants on membrane transport, the prevalence of microplastics in rivers and the release of bound phosphorus from soils and sediments.

Dr. Elizabeth Myers Toman, Visiting Assistant Professor in the School of Environment and Natural Resources at The Ohio State University together with Dr. Jiyoung Lee progressed in completing an Ohio Water Resources Center project via joined Office of Energy and Environment at OSU subaward. The overall objective of their project titled **"Surface water quality and ecosystem health with shale energy development"** is to characterize the impacts of increased road usage due to natural gas expansion in rural areas on surface waters and ecosystem health.

Beginning in June 2014, equipment that continuously measures and records water quality parameters including temperature, dissolved oxygen, conductivity, pH, and turbidity was installed in streams at the mouth of three small watersheds. Water samples were taken on a monthly basis and analyzed for Total Suspended Solids (TSS) and microbial communities.

Elizabeth Toman's student collecting water samples

Analysis of the data collected has led to the development of a stage to discharge relationship for the streams. Furthermore, we determined a relationship between turbidity and TSS and a positive correlation between stream turbidity and *E. coli* cell counts in the studied streams. These findings provide a foundation for future work at this site regarding water quality, microbial communities and land use. In addition, the results from this research, in conjunction with research at the study location on sediment runoff from road segments, will contribute to the understanding of the quantity of sediment within the stream network that originated from the road surface.

In summary we strive to enhance our understanding of the relationship between suspended sediment concentration and volume of sediment produced by the watershed to the volume of sediment that could be contributed to the streams by the existing road network.

Runoff from the road surface during a natural rain event at the study location.

<u>Researcher Profile:</u> Dr. Elizabeth Myers Toman's research interests lie in the broad areas of forestry, hydrology, and transportation. More specifically she is interested in what occurs when and where these spheres meet. She studies the influence of land management activities such as road construction and use, forest harvesting or vegetation removal, and oil and gas exploration, on stream water quality.