Ohio Water Resources Center
Department of Civil, Environmental and Geodetic Engineering

Annual Technical Report
2018

General Information

Products

Silliman, B. A. and Toman, E. M. 2019. Production of sediment from the running surface of unbound aggregate roads in southeast Ohio, USA. International Journal of Forest Engineering, 30(2):99-108.

Liu, D., Toman, E., Fuller, Z., Chen, G., Londo, A., Zhang, X. and Zhao, K. 2018. Integration of historical map and aerial imagery to characterize long-term land-use change and landscape dynamics: An object-based analysis via Random Forests. Ecological Indicators, 95:595–605. https://doi.org/10.1016/j.ecolind.2018.08.004

Chaffin, J.D., Kane, D.D., Stanislawczyk, K. and Parker, E.M. 2018. Accuracy of data buoys for measurement of cyanobacteria, chlorophyll, and turbidity in a large lake (Lake Erie, North America): implications for estimation of cyanobacterial bloom parameters from water quality sonde measurements. Environmental Science and Pollution Research, 25:25175–25189. 10.1007/s11356-018-2612-z

Singer, D.M., Jefferson, A.J., Traub, E.L. and Perdrial, N. 2018. Mineralogical and geochemical variation in stream sediments impacted by acid mine drainage is related to hydro-geomorphic setting. Elementa Science of the Anthropocene, 6:31. DOI: https://doi.org/10.1525/elementa.286

Wang, Y. and Bielicki, J.M. 2018, Acclimation and the response of hourly electricity loads to meteorological variables, Energy, 142: 473-485, https://doi.org/10.1016/j.energy.2017.10.037

Chen, J. and Boccelli, D. L. 2018. Forecasting hourly water demands with seasonal autoregressive models for real-time application. Water Resources Research, 54:879–894. https://doi.org/10.1002/2017WR022007

Burkey, M. F. 2018. A REVIEW OF IRON SULFIDES AND OXIDES IN COAL MINE WASTE, HUFF RUN WATERSHED, OHIO. Undergraduate thesis, Kent State University, OhioLink, ksuhonors1525905282950671

Wang, Y. 2018. Climate Change and Its Effects on the Energy-Water Nexus. PhD thesis, Ohio State University, OhioLink, osu1534307556870925

Slater, J. 2018. Historical Land Use Changes and Hydrochemical Gradients In Ohio’s Sphagnum-Dominated Peatlands. Master’s thesis, Ohio State University, OhioLink, osu1543647650696665

Liu, D. 2018. Quantifying and Valuating Radiative Forcing of Land-use Changes from Potential Forestry Activities across the Globe. Master’s thesis, Ohio State University, OhioLink, osu1524066498953157

Douglas, C. 2019. Instantaneous Water Demand Estimates for Buildings with Efficient Fixtures. Master’s thesis, University of Cincinnati, OhioLink, ucin1561996040464642

Shaw, M.E. 2018. Concentration-discharge behavior of contaminants in a stream impacted by acid mine drainage. Master’s thesis, Kent State University, OhioLink, kent1529320351379744

Information Transfer Program

Since January 2019, the Ohio WRC distributes a monthly electronic newsletter that contains sections that spotlight Ohio WRC research, inform readers about upcoming policy changes related to water, requests for proposals, events, news and other water relevant information. The newsletter is distributed to 478 academic researchers (73%), water organizations and state agencies representatives (9%) and legislators (19%) with a current open rate of 44% (above industry averages). The official Web site of the Ohio Water Resources Center, hosted by The Ohio State University, appears at http://wrc.osu.edu/. We continue to co-organize quarterly luncheon seminars with the Water Management Association of Ohio (WMAO) that are attended by State agency professionals, other water professionals in the State, students, and academic researchers. Other examples of information transfer programs we participate in include: annual WMAO conference sponsorship and participation, sponsorship of breakfast meetings of the Environmental

Professional Network at OSU, publication of project reports and one page summaries from projects that are distributed to a broad audience.

Student Support

Number of Students directly or indirectly supported:
12 Undergraduate
16 Graduate
1 Post Doc

Notable Achievements and Awards

Dr. Bhavik Bakshi's project received follow up support from the National Science Foundation (NSF) program on Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) for the project titled \Dynamic regional INFEWS/T1: Impacts of deglobalization on the sustainability of regional food, energy, water systems" ($1.7 million). Duration: 09/2017 - 08/2020

Dr. Soryong Chae's project received follow up support from University of Cincinnati Research Council for project titled "Efficient Control of Legionella using a Self-Cleaning Carbon Nanotube Membrane for Health Care Water Systems" ($50,000). Duration: 04/2017 - 06/2018

Dr. Gouma submitted an invention disclosure titled "Amyloid Fibers from Wheat Flour" to the Ohio State University in 08/2018

Ohio Water Resources Center received a research and administrative support from the Ohio Water Development Authority titled "The Ohio Water Resources Center: Amendment of Cooperative Agreement" ($200,000). Duration: 01/2019 – 12/2020

Ohio Water Resources Center (PI Bohrerova and Weavers) received a support for research project from the Ohio Water Development Authority for project titled "Developing Design Standards to Enable the Use of Innovative Technology in Ohio Public Water Systems" ($144,762). Duration: 01/2018 – 12/2019

Projects

Remediation of Hydraulic Fracturing Flowback Fluids by Trace Element Extraction

Project Type: Coordination Grant **Project ID:** 2017OH569O

Project Impact: Hydraulic fracturing of unconventional shale gas plays generates brines with complex chemistries that are mainly viewed as hazardous waste. Among the constituents in such brines are trace metals that, if concentrated to economic proportions, could be rendered valuable resources. The goal of this project was to understand the evolution of the major and trace element composition of flowback/produced fluids (FP fluids) and investigate strategies to actively remove potentially toxic or economically important elements. Dr. Welch's team amended FP fluids with solutions of dilute HCl (control), sodium carbonate (pH increase) and phosphate and sulfate rich solutions to induce precipitation. The results showed that carbonate addition removed Ca as calcium carbonate, as well as other trace metals, but only small amounts (~ 10s %) of Sr and Ba were removed. Addition of sulfuric acid resulted in the formation of barite-celestite and gypsum phases, and removal of Ba, Sr and Ca from solution; however, mineralogy depended on the concentration of sulfate added. Low levels of sulfate resulted in the formation of small barite roses without significant Sr removal from solution. Intermediate levels of sulfate resulted in the precipitation of euhedral Sr-bearing barite crystals, as well as celestite with elongate crystal habit. The highest level of sulfate addition resulted in the precipitation of abundant gypsum interspersed with elongate celestite; and although barite was not observed in the precipitates, barium was removed from solution.

Addressing the Water-Energy Nexus of Fossil Power Generation by Considering Technological, Agro-Ecological, and Economic Options in the Muskingum Watershed

Project Type: Annual Base Grant **Project ID:** 2017OH540B

Project Impact: The objectives of this work were to identify ecological overshoots for activities in the Muskingum River Watershed (MRW), investigate various alternative scenarios to understand the trade-offs between energy, water, and CO2 flows, and suggest better watershed management solutions that could be "win-win" in terms of multiple objectives for watershed sustainability. Dr. Bakshi's team employed a holistic TES (Techno-Ecological Synergy) assessment approach to examine watershed sustainability. The results showed that the amount of water supply in the MRW is larger than the amount of water demand, which implies that the reduction in water quantity indicator may not be a huge concern since the TES metric for water supply is still positive. However, TES metrics for other ecosystem goods and services, such as natural gas, CO2, and air and water pollutants, show negative values, which indicate unsustainable conditions of activities in the MRW. It was identified that TES sustainability metrics for carbon sequestration and air quality regulation services can be improved by employing NGCC (Natural Gas-Fired Combined Cycle) power plants with recirculating cooling system and CO2 conversion to formic acid that uses electricity from wind power generation. The synergistic solution that includes both technological and agroecological alternatives could produce "win-win" outcomes in terms of multiple objectives.

Assessing Ultrasound as a Source Water Reservoir Management Strategy to Control Cyanobacteria Blooms

Project Type: Coordination Grant **Project ID:** NA_Weavers

Project Impact: In Ohio, seasonal harmful algal blooms (HABs) have increased in frequency and intensity. These blooms have greatly affected many water resources in Ohio, including drinking water reservoirs. Reservoir management strategies are typically broken into three categories: physical, chemical and biological. Ultrasound is a physical method that may be an important bloom prevention and mitigation strategy. Compared to other physical strategies and use of algaecides, ultrasound has the advantage of low energy, no chemical addition, and the possibility that cell lysis and release of toxin does not occur. Using a bacterial surrogate and cyanobacterial mixture, we evaluated the effect of ultrasound deployed in pond on aerotops (gas vesicles) and other viability and stress markers in these microorganisms. Series of experiments showed that gas vesicles of both bacteria surrogate and two algal species (Microcystis and Anabaena/Dolichospermum) were unaffected by ultrasound. Other indicators (live/dead ratio, colony sizes, ATPase concentrations) might suggest that ultrasound causes changes in algae, but

the work is still ongoing.

Bog HELPR: Bog History, Ecosystem status and Land-use for Peatland Restoration in Ohio

Project Type: Annual Base Grant **Project ID:** 2017OH534B

Project Impact: The goal of the project was to collate detailed data on the current and historic spatial distribution of peat bogs in Ohio and combine these data with a ground survey to assess the bogs ecological condition. The research evaluated four methods in their usefulness to peatland restoration in Ohio: using history mapping for classification, peat bog hydrochemistry, vegetation community composition, and soil microbial community composition. Dr. Davies with his students evaluated a total of 70 potential bog sites, and developed bog classification maps. These maps will provide an invaluable resource that catalogues areas where peatland cover has been lost and that should be a priority for ground survey to assess restoration potential. Using hydrochemical analysis, the researcher concluded that Ohio's peat bogs can most likely be identified as poor fen systems. This conclusion was supported by the high electrical conductivity (EC) with a wide range (33-597 µs/cm). In assessing the vegetative and microbial communities within the peat bogs, the research showed that bryophytes can be used as indicators of peatland hydrochemical status. Additionally, carbon stock estimate confirmed that regardless of their small size and total area, peat bogs are a critical store of ancient carbon.

Characterizing the Link between Algal Bloom Biomass and Methane Production in Ohio Reservoirs

Project Type: Annual Base Grant **Project ID:** 2017OH532B

Project Impact: Dr. Buffam's team took samples from Harsha Lake in Ohio and determined CH4 production rates, composition of organic matter in sediment and genetic composition of methanogens. The results indicated that quantity of organic matter but also source (terrestrial versus algae derived) were both important for methane production rates in the reservoir. For Harsha Lake, areal CH4 production rates were highest in the riverine portion of the reservoir, even when rates were normalized to organic matter quantity (OM). This suggests that not only was OM more abundant in the riverine zone, it was also more readily utilized by methanogens. Additionally, this zone was the shallowest, as opposed to other tested location with much deeper water profile. Based on our results that show high degree of spatial variation in CH4 production rates, studies of reservoirs as well as natural lakes with substantial riverine inputs should take a spatially-aware sampling approach to determine CH4 production and emissions, rather than sampling only at a single deep location.

Design of a Self-Cleaning Membrane-Assisted Bioreactor for Enhanced Removal of Nutrients from Wastewater

Project Type: Coordination Grant **Project ID:** 2017OH570O

Project Impact: The main objective of this project was to fabricate a self-cleaning membrane for the efficient removal of nutrients from municipal wastewater. A bench-scale membrane bioreactor (MBR, treatment capacity = 10 L/day) was developed and optimized for simultaneous removal of nitrogen and phosphorus and combined with self-cleaning carbon nanotube (CNT) membrane. The bench-scale MBR system showed good performance in removing organic matter and nutrients from synthetic wastewater. Typical removal efficiencies of COD, TN, and TP by the MBR were 95~96%, 83~84%, and 63~65%, respectively. The CNT composite membrane was able to treat wastewater for 9-10 days without cleaning and the membrane was effectively recovered from fouling using electric heating. It was found that the CNT composite membrane has an anti-fouling function and electric heating is a sustainable method to clean the CNT membrane after fouling. The results allow for development of novel engineering solutions for the mitigation of membrane fouling and/or recovery from membrane fouling that eventually increase performance of MBR systems.

Developing Design Standards to Enable the Use of Innovative Technology in Ohio Public Water Systems

Project Type: Coordination Grant **Project ID:** NA_Bohrerova

Project Impact: The majority of our nation's drinking water suppliers are small systems serving 25 to 3,300 people. It was recognized by US EPA that to bring these small community systems into satisfactory compliance would necessitate new thinking and flexibility in terms of technology applications. Many technologies that are used in small and large drinking water treatment plants for more than twenty years still require pilot or bench scale testing before plan approval in Ohio. This testing can be cost prohibitive for some treatment plants. Therefore, small and medium public water systems often implement: a) a more costly capital improvement, and/or b) a less appropriate one for meeting water-quality performance criteria and public-health goals. Our project's stakeholders choose to start with low pressure membrane filtration and aims to develop design criteria that will enable plan approval of this technology without pilot scale testing for good and medium water membrane influent quality. We are currently working with membrane manufacturers to develop table of design criteria that contains ranges of water quality conditions (influent to membranes) and recommended membrane fluxes. We anticipate to finalize this table within the next half year and finish writing the design criteria with special conditions. We are working in collaborative way with multiple stakeholders including agencies, manufacturers, design engineers, and treatment plants' engineers and managers.

Effects of Harmful Algal Blooms on Stress and Immune Function in Freshwater Amphibians and Reptiles

Project Type: Annual Base Grant **Project ID:** 2018OH548B

Project Impact: Although the algal toxin microcystin, which is produced during HAB events, is known to be harmful to humans and pets if ingested or inhaled, almost nothing is known about its effects on the aquatic wildlife living in water bodies affected by HABs. Yet, critically, the health of aquatic wildlife is likely a key measure of the health of aquatic systems and the quality of water resources. The purpose of this study was to determine whether amphibians health can be used as an indicator of the quality of water resources. In 2018, Dr. Refsnider's team conducted a laboratory experiment in which they exposed naïve bullfrog tadpoles to microcystin concentrations reflective of Lake Erie Harmful Algal Blooms (HABs). They found that tadpoles exposed to microcystin for 7 days exhibited increased dilation of the intestines compared to control tadpoles, potentially indicating an inflammatory response. Similar to tadpoles, sampled wild turtles during a HAB event in Grand Lake St. Mary's did not exhibit increased stress levels compared to control turtles, but microcystin-exposed turtles had depressed immune functioning compared to turtles from control site at Ottawa National Wildlife Refuge. As of June 2019, Dr. Refsnider's team completed sampling of additional aquatic and wetland-associated species (Northern watersnakes, barn swallows, and red-winged blackbirds) and will compare stress levels and immune function between control and exposed individuals in these species to determine whether the patterns observed in turtles and bullfrogs hold true across broader taxonomic groups.

Impact of filter upset during conventional surface water treatment on UV disinfection efficacy

Project Type: Coordination Grant **Project ID:** NA_Hull

Project Impact: Drinking water treatment plants (DWTPs) do not currently receive inactivation credit for Giardia or Cryptosporidium when the maximum combined filter effluent turbidity exceeds 1 NTU or when the 95th percentile turbidity exceeds 0.3 NTU per §141.551. Although these regulations aim to minimize impacts of particle shielding that can protect microorganisms from UV, studies have shown partial disinfection at turbidities higher than 0.3 and 1 NTU. To quantify the impact of these high turbidity events which may occur during filter upset, we studied UV disinfection of indigenous spores (as more resistant and numerous surrogates for protozoan cysts) in local DWTP flocculated (but not filtered) water. Preliminary results show that spores are loosely associated with flocculated particles, because shaking/swirling samples maximized spore-forming colony counts versus mechanical separation tools (vortex, tissue homogenizer, sonication). Flocculated water exposed to UV showed no difference in log inactivation between stirred and unstirred samples, further supporting that spores are loosely associated because dispersion of flocculated particles and spores had no impact on UV inactivation. A filtrate experiment showed some association between spores and flocculated particles, however, particles larger than 12µm were more reflective than particles smaller than 12µm. This indicates that reflectivity and loose particle associations may counteract spore shielding and that partial inactivation credit may be warranted even during filter upset conditions. Ongoing work will evaluate spores UV log

inactivation curves for flocculated water and compared to control without particles present.

Landscape fragmentation and water yield with unconventional shale oil and gas development in Ohio

Project Type: Annual Base Grant **Project ID:** 2018OH567B

Project Impact: Development of unconventional shale oil and gas through hydraulic fracturing has transformed the energy landscape of the United States. However, its environmental impacts remain poorly understood, especially regarding landscape fragmentation and changes to local or regional hydrology. The objective of this study was to identify landscape changes and their effect on surface water flow characteristics with the development of unconventional shale oil and gas in eastern Ohio. Dr. Toman's team focused their research on Yellow Creek watershed in Eastern Ohio. They collected remote sensing data and developed a time series algorithm for detecting landscape disturbances. The results showed that 44 out of 50 well pads showed abrupt changes in land cover vegetation that occurred within two months before or after the well pads have been constructed. The total area disturbed by oil and gas development was 98 ha (less than 0.3% of the total watershed area) of which 66 ha were originally in pasture or cropland and 21 ha were forest. There were no significant changes in storm runoff duration, maximum instantaneous discharge, time to maximum instantaneous discharge, or runoff volume between the storm events before and during oil and gas development. This may be due to the other varied and ongoing anthropogenic land uses within the watershed. Furthermore, the addition of oil and gas development in the studied watershed was likely not large enough to overwhelm the influences of the other land uses occurring in the watershed.

Maumee River Sediments as A Nitrogen Source or Sink To Lake Erie: The Competing Roles of Ammonium Recycling and Denitrification

Project Type: Annual Base Grant **Project ID:** 2018OH564B

Project Impact: The Maumee River has the largest drainage area into the western basin of Lake Erie and is most responsible for high N and P loads to Maumee Bay and the western basin. Many studies evaluating the amount and form of P and phytoplankton in the Maumee River relative to Lake Erie have been conducted, but N studies are comparatively rare. Dr. McCarthy's team selected two up-river sampling locations, at Independence Dam and Mary Jane Thurston State Parks, and two down-river sampling locations, one in the river

Scalable synthesis of Cellulose Acetate and Protein Amyloid Fibers Membranes to Clean up Energy Production Effluents

Project Type: Annual Base Grant **Project ID:** 2018OH568B

Project Impact: The goal of the project was to investigate the synthesis of amyloid fibrils from wheat flour proteins and their use as a membrane material for water purification. Dr. Gouma's team conducted a series of experiments including Amyloid fibrillation, electrospinning, Confocal Microscopy, and Transmission Electron Microscopy. The successful binding of Amyloid fibrils was confirmed by fluorescence imaging. In order to complete the filter, the research team have successfully managed to encapsulate amyloid fibrils into non-woven mats of cellulose acetate via a single step process of electrospinning. This membrane was then preliminary evaluated in its ability to treat fracking flowback water. Due to the affordable nature of the membrane constituents and the potential for it to efficiently remove toxic metals and radionuclides via filtration, this technology could be of significant use in addressing water pollution issues.

Separation of Phosphorus- and Nitrogen-nutrients from Agriculturally Degraded Waters Using Pervious Filter Material Developed from Industrial By-products

Project Type: Coordination Grant **Project ID:** 2013OH436O

Project Impact: The goal of this study was to demonstrate the feasibility of using coal combustion by-products to treat nutrients from agricultural drainage water (ADW). In this study, Dr. Cheng with his students modified

compositions of coal fly ash, stabilized flue gas desulfurization (FGD) materials, and bauxite leaching residual (red mud) in order to improve selective nutrient-adsorbing capabilities of potential end-of-tail filter for ADW. A series of batch and column tests were carried out and the results suggest that the filter material containing red mud did not have the expected adsorption effect on nitrate. However, the pervious filter material made from the coal combustion by-products, i.e., fly ash and stabilized FGD material, was found to be able to effectively remove phosphate and potentially nitrate from ADWs. The reduction of nitrate is unlikely through an adsorption mechanism and other processes might have contributed to the observed nitrate reduction. This study suggests an end-of-tail filtration approach using agricultural and industrial wastes can be developed as an alternative to current BMPs to reduce nutrient discharges from crop lands and produce value-added products containing concentrated phosphate.