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

Annual Technical Report
2019

FY2019 Annual USGS Ohio Water Resources Center Report

Products

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Murugesan, B. 2019. Phosphorus Recovery From Municipal Wastewater Using Anoxic/Aerobic Membrane Bioreactors And Magnesium Carbonate Pellets. Master's thesis, University of Cincinnati, OhioLink, ucin1563272593809462

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Patterson, M.E. 2020. Developing Design Standards To Enable The Use Of Innovative Technology In Ohio Public Water Systems. Master's thesis, The Ohio State University, OhioLink, osu1578013204387712

Information Transfer Program

The Ohio WRC distributes a monthly electronic newsletter that contains sections that spotlight Ohio WRC research and inform readers about upcoming policy changes related to water, requests

for proposals, events, news, and other water relevant information. The newsletter is distributed to 498 individuals, including academic researchers (70%), water organizations and state agency representatives (11%), and legislators (17%). The current open rate is 46%, which is 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, water professionals, 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, the publication of project reports and one page summaries from projects that are distributed to a broad audience.

Student Support

Total students supported: 6 undergraduate, 18 graduate, and 1 post doc.

Student Internship Program:

- one supported student works as NOAA-GLERL Pathways Student Intern (student employment during degree program)
- one supported student received NOAA Davidson Graduate Student Fellowship

Notable Achievements and Awards

Dr. Gil Bohrer's project received a follow up contract from the Ohio Department of Natural Resources (ODNR) for the project titled "Hydrological modeling of Old Woman Creek" ($37,000). Duration: 1/2020-6/2021.

Dr. Gil Bohrer's project received follow up support from the National Oceanic and Atmospheric Administration (NOAA) through Old Woman Creek National Estuarine Research Reserve (OWC-NERR) (administered by Ohio Department of Natural Resources (ODNR)), project title "Hydrological modeling of Old Woman Creek" ($34,517, total grant $37,965). Duration: 2020-2021.

Dr. Gil Bohrer's project received follow up support from the US Department of Energy for the project titled "Functional-type modeling approach and data-driven parameterization of methane emissions in wetlands" ($395,743, total grant $808,246). Duration: 2020-2023.

Dr. David Costello's project received the follow up NSF CAREER award for the project titled "Beyond N and P: How trace metal limitation influences stream ecosystem function" ($650,711). Duration: 9/2020-8/2025.

Ohio Water Resources Center (PI Bohrerova and Weavers) received support for research project from the Ohio Water Development Authority for the project titled "Developing Design Standards

to Enable the Use of Innovative Technology in Ohio Public Water Systems" ($144,762). Duration: 01/2018 – 12/2019.

Ohio Water Resources Center received 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 Weavers and Bohrerova) received follow on funding from Ohio Water Development Authority for the project titled "Developing Second Design Standard to Enable the Use of Innovative Technology in Ohio Public Water Systems" ($192,561). Duration: 1/2020-12/2021.

Ohio Water Resources Center (PI Bohrerova) received Coronavirus Relief Fund from Ohio Environmental Protection Agency (Ohio EPA) for the project titled "State of Ohio Wastewater SARS-CoV-2 Surveillance" ($2,224,340). Duration: 7/2020-6/2021.

Ohio Water Resources Center (PI Bohrerova) received support from the Ohio Department of Health (ODH) for the project titled "Dormitory Wastewater Monitoring of SARS-CoV-2 at Universities and Colleges in the State of Ohio" ($4,130,622). Duration: 12/2020-6/2021.

Capillary Trapping Of Buoyant Particles By Cylindrical Collectors And Its Application In Transport Of Floating Fertilizers In Overland Flow

Project Type: Annual Base Grant
Project ID: 2019OH214B

Project Impact:

Surface water pollution from nutrient fertilizers is a long-standing problem in many US states, including Ohio. Controlled-release fertilizers (CRFs) have been recognized as a promising way to increase the utilization efficiency of nutrients, while also reducing nutrient pollution from over-fertilization. However, unique polymers and film coatings used with some CRFs make them buoyant during surface runoff. This poses challenges in predicting their mobility in the field. Dr. Wu's team hypothesize that properties (size and density) of CRFs exert primary control on their mobility in overland flow through vegetative systems. To test this hypothesis, the team determined collision efficiency of buoyant particles by cylindrical collectors and investigated the key factors which govern the capillary attraction between floating particles and collectors in a modeled vegetation system. The results show that the collision efficiency remains constant when bulk flow velocity is smaller than particle escape velocity. The collision efficiency decreased drastically with the increase of the bulk flow velocity. In addition to flow velocity, particle size has a non-trivial effect on the decrease of collision efficiency. With increased flow velocity, the collision efficiency decreases exponentially for both particles with different densities. A modified collision equation which accounts for attraction capacity of the floating particle attached to the stem was developed and validated with experimental observations. The team expects this study to shed useful insights on optimization of CRF size and density as well as their applications in green infrastructure systems (e.g. vegetative filter strips, rain garden, bioswales, and planter boxes).

Electrochemical Sensors For Microbial Activities In Benthic Sediments: A Sentry For Lacustrine P Biogeochemistry

Project Type: Annual Base Grant
Project ID: 2020OH202B

Project Impact:
The goal of Dr. Senko's team is to develop a sensor system to detect microbiological activities. They proposed that zero-resistance ammetry (ZRA) measurements could be used to detect microbiological Fe(III) reduction in aquatic sediments. In ZRA, the team measures electric current that develops between oxic (O2-containing) sediments, where aerobic respiration is occurring, and sediments where Fe(III) reduction is occurring to identify the process. ZRA has the benefit of being a relatively inexpensive and low-power approach to "mapping" microbiological processes at a variety of scales in aquatic sediments. Electrical current measurements using ZRA sensors positioned in lake sediments could serve as an early warning system for harmful algal blooms (HABs) resulting from internal phosphate loading. The team set up experiments where they mimicked different processes in lake sediments by placing sediments from the Old Woman Creek estuary on Lake Erie into separate chambers along with a synthetic Lake Erie water and Fe(III) minerals. One chamber was oxic, while the other chamber was anoxic so only Fe(III) reduction could occur. The water was connected by a salt bridge and two graphite working electrodes (WEs) were inserted into the sediments. These were referred to as WE1 (oxic) and WE2 (anoxic). The team measured the current between WE1 and WE2 and found that electrons were being transferred between the two sediment chambers. These experimental results also indicated that Fe(III) reduction was occurring and that the current developed was due to microbiological activity. Experiments are in process to observe release of phosphate when Fe(III) reduction occurs.

What Role Does Nutrient Cycling By Zooplankton Play In Supporting Hab Production In Western Lake Erie?

Project Type: Annual Base Grant
Project ID: 2020OH143B

Project Impact:
Due to COVID-19, field and laboratory activities for this project were cancelled in 2020. Dr. Hood's team will conduct this work in 2021. During the upcoming field season, the team plans to test components of a hypothesis arguing that nutrient excretion by zooplankton influences the concentration and ratio of dissolved nitrogen and phosphorus and, therefore, mediates the extent and toxicity of harmful algal blooms (HABs) in western Lake Erie. The measurements will provide critical information about the controls on nutrient dynamics in western Lake Erie. These controls are poorly understood, but influence key aspects of HABs, including the timing, severity, and toxicity of bloom events. Improving our mechanistic understanding of the factors controlling HABs in western Lake Erie via nutrient availability measurements will benefit lake and HAB forecast models as well as managers and policymakers seeking to improve water quality, fisheries, and ecosystem resilience in Ohio waters.

Microorganisms And Enzymes Driving Glyphosate Degradation In Lake Erie

Project Type: Annual Base Grant
Project ID: 2020OH201B

Project Impact:
The proposed plan for this project was to do the field work in May 2020 in Sandusky Bay. Samples were to be collected and incubations performed exposing natural communities to Glyphosate, its breakdown product, Aminomethylphosphonic acid (AMPA), and several phosphorus (P) and nitrogen (N) combinations. Samples were to be collected for RNA extraction and nucleic acid sequencing. The timing of the sampling was chosen to correspond to the tail end of spring herbicide application. This field work was canceled because of the pandemic and Dr. Saxton's team will be doing this component of the work May 2021. As they were not able to collect as planned in the spring, the team instead performed a separate experiment corresponding to fall herbicide application. This experiment was performed in September 2020 using water from Acton Lake in Preble and Butler counties. The experimental set-up was the same as was proposed and will be performed using Sandusky Bay water in May 2021. Instead of the transcriptomic analysis that will be performed in May, the team instead extracted DNA from the collected samples and will perform 16S rRNA gene amplicon sequencing. These samples will be sequenced in early 2021 using separate funds. This experiment does not impact our ability to perform the Sandusky Bay experiment in May. It will provide us with information on how a natural microbial community responds to glyphosate and associated chemicals and will help guide the Sandusky Bay experiment.

Efficient Removal Of Emerging Per- And Poly-Fluoroalkyl Contaminants Using Electrically Heatable Carbon Nanotube Hollow Fiber Membrane Distillation

Project Type: Coordination Grant
Project ID: 2020OHNAO

Project Impact:
Per-and poly-fluoroalkyl substances (PFASs) have a significant impact on drinking water quality, fish and animal habitat, human health as well as ecosystem services in Ohio. The extreme environmental persistence of PFASs, with the increasingly higher aqueous solubility as the chain length shortens, creates increasing difficulty in water treatment by many conventional remediation and treatment technologies. The ongoing, long-term cost of treating PFASs-impacted water (both water and municipal wastewater) using these approaches is anticipated to be substantial. Building on their preliminary research, Dr. Chae's team envisions a new system that will address these challenges by making it possible to treat water and wastewater contaminated with PFASs at low energy demand. In this project, the team proposes to pioneer an innovative engineered system that will make it possible to achieve energy-efficient removal of model PFASs (> 99%) from water, wastewater, and landfill leachates. This study focuses on the incorporation of carbon nanotube (CNT) sheets onto hollow fiber membranes, and the effects of Joule heating on the removal of emerging PFASs via membrane distillation from aquatic environments. Combining electrically heatable CNT layers with hollow fiber membranes has the potential to address the current performance and productivity of MD technology.

State of Ohio Wastewater SARS-CoV-2 Surveillance

Project Type: Coordination Grant
Project ID: 2020OHNOA

Project Impact:
Wastewater monitoring for SARS-CoV-2 ribonucleic acid is a novel surveillance tool that is being developed, in addition to clinical indicators, to monitor trends and changes in the occurrence of COVID-19 in communities. The Ohio Water Resources Center is coordinating an effort to develop a network of analytical laboratories at Ohio's universities and commercial labs to measure SARS-CoV-2 in raw wastewater. This network collaborates with water reclamation facilities that are willing to collect samples for analysis on a regular basis. Samples were collected twice a week and sent to the labs for test to determine the presence of coronavirus ribonucleic acid (RNA) fragments. The goal of the wastewater analysis is to provide an early warning of gene copies increasing in the sewage from communities. This interdisciplinary project involves scientists and researchers from diverse backgrounds in order to support the state in making science-based decisions. Ohio EPA, Ohio Department of Health (ODH) and US EPA are important partners on this project.

Investigating The Extent Of Drinking Water Source Contamination In Southeastern Ohio By Air Emissions Of HFPO-DA From The Chemours Washington Works Facility

Project Type: Coordination Grant
Project ID: 2019OHNAO

Project Impact:
Per- and poly-fluorinated alkyl substances (PFAS) have been in use at the Chemours Washington Works facility near the Ohio/West Virginia border since the 1950's. Replacement chemicals for perfluorooctanoic acid (PFOA) are now in use, including hexafluoropropylene dimer acid, commonly referred to as "GenX". While wastewater discharge into the Ohio River was once thought to be the primary source of PFAS into this environment, the previous work of Dr. May's team suggests that the release of PFAS into the air via exhaust stacks and subsequent deposition to the surface is a potentially important source for the contamination of drinking water sources. Recent modeling work for a similar site in North Carolina suggests that atmospheric deposition rates have the largest effect on risk of groundwater contamination. There are many private wells in southeastern Ohio, so understanding the potential for groundwater contamination due to atmospheric deposition is critical to protecting the health of individuals living within this region. The main goal of the project is to determine the geographic extent to which PFAS can be detected in the air, which will allow the team to infer locations downwind from the facility. In November 2020, Dr May's team deployed passive air samplers to monitor airborne concentrations through select locations ranging from roughly 7.5 to 50 miles downwind from the source. Within each passive air sampler is a foam disk coated with a sorbent to aid in capturing PFAS from the air. The team will collect the samplers and conduct chemical analyses in the laboratory at OSU.

Multidimensional Risk Assessment On Riverine Contamination: Case Study Of Cincinnati, OH

Project Type: Coordination Grant
Project ID: 2019OHNAO

Project Impact:
The Greater Cincinnati Water Works (GCWW) public water supply utility relies on the Ohio River for 85% of its source water, with only 2-days of offline storage, making it vulnerable to supply disruptions resulting from river contamination. The simulation models Dr. Ray's team developed enable investment- and policy-informing risk assessment exercises by water utilities along rivers vulnerable to contamination. The team developed the mesh grid of Ohio River bathymetry from Meldahl dam to the GCWW Intake. They have run simulations of the January 2014 Freedom Industries MCMH spill and validated their results against historical observations of MCMH concentrations. Contaminant concentration was tracked at several points along the river reach and compared to previously published results at the Richard Miller Treatment Plant (RMTP). The team ran a stress test on risks of drinking water contamination at RMTP by systematically varying river velocity (streamflow discharge) and spill duration (plume duration at Meldahl), and re-examining contaminant concentration at the RMTP intake. At a contaminant threshold of 0.01 ppb and historical baseline contaminant plume duration, Cincinnati faces critical threats to its drinking water supply if the river is flowing at less than 1.6 m/s. For historical context, that was approximately the flow during the historical event. If the spill happened during low flow velocities or when the flow is held back by locks and dams for navigational purposes, Cincinnati's water supply could be under severe threat by such a spill.

Impact Of Filter Upset During Conventional Surface Water Treatment On UV Disinfection Efficacy

Project Type: Coordination Grant
Project ID: 2019OH610O

Project Impact:
Water utilities can use ultraviolet (UV) light to inactivate protozoan pathogens because it is highly effective, resulting in easy credits for disinfection regulation compliance. Removing or inactivating protozoans is important because they can cause gastrointestinal illness. During filter upset at a water treatment plant (WTP), high turbidity events may negatively impact UV disinfection efficacy due to suspended particles in the water. At high turbidities, Ohio WTPs do not receive disinfection credit for UV. However, studies have shown UV is still partially effective at high turbidities. This research aims to quantify and predict partial UV disinfection in raw surface water, unsettled flocculated water, and unsettled softened water with varying turbidity and particle concentrations. Due to more frequent extreme weather events with climate change and aging infrastructure, more frequent high turbidity events may occur. Results showed that UV disinfection was effective and predictable in each type of water collected from the Dublin Road WTP, even across seasons and widely varied water quality parameters. UV light was reflected more by large particles than by small particles, and microorganisms were only loosely associated with the particles. These characteristics may partially explain why UV treatment was similar even when water conditions varied widely. While UV disinfection of raw surface water and unsettled softened water were similar, UV disinfection of unsettled flocculated water was lower, possibly due to having more particles >20 microns, which increased the effect of tailing in UV disinfection. These results show UV provides predictable partial disinfection during varied turbidity conditions.

Developing Design Standards To Enable The Use Of Innovative Technology In Ohio Public Water Systems

Project Type: Coordination Grant
Project ID: 2019OHNAO

Project Impact:
This project addressed innovation in the water industry in Ohio. This effort provides a case study for the water industry on how to increase access to modern water technologies for small and medium water utilities. The project focused, not on developing new technology, but on the intersection between the regulator that approves the technology, the water utility, and the design engineer—creating design standards for modern technologies with a substantial track record. The current process of requiring pilot studies before design and implementation creates a large barrier, particularly for small and medium water utilities, hindering the use of modern technologies even though these technologies may provide better water quality at lower cost. The first design standard, for low pressure membranes, has been created and is currently under review by the Ohio Environmental Protection Agency for inclusion in their Plan Approval Process for installation of new technologies at a water plant.

Assessing Ultrasound As A Source Water Reservoir Management Strategy To Control Cyanobacteria Blooms

Project Type: Coordination Grant
Project ID: 2015OH482O

Project Impact:
Harmful algal blooms (HABs) are a challenge that utilities across the country face and pose a significant threat in Ohio. Ultrasound is a physical reservoir management strategy that may be an important bloom prevention and mitigation strategy with over 10,000 installations worldwide. Ultrasound is a low energy technology that does not require the use of chemicals, such as algaecides, and potentially could kill cells without releasing their toxins. In this study, Dr. Weaver's team is evaluating the effect of a commercially available ultrasonic device on HABs. This included characterizing the ultrasound during treatment and analyzing bacterial cells. Experiments were performed using a bacteria called Serratia which has been shown to have similar gas vesicles to cyanobacteria. In addition, environmental samples of active algal blooms were collected and tested. The samples were exposed to ultrasound for periods of 0, 1, 3, 7 and 13 days. Each experiment had a control that was not exposed to any ultrasound. Analysis was performed on the samples to investigate gas vesicle collapse and cell life. There was not a statistically significant difference in the number of cells alive or dead between the sample and control. Moreover, both ultrasound exposed and unexposed samples had gas vesicles present. These results indicate that the expected mechanism of ultrasonic control in reservoirs is not active.