2019

HARMFUL ALGAL BLOOM

RESEARCH INITIATIVE

YEAR 4
PROJECT UPDATE

Track Blooms From the Source

Produce Safe Drinking Water

Protect Public Health

Engage Stakeholders



HARMFUL ALGAL BLOOM

RESEARCH INITIATIVE

YEAR 4 PROJECT UPDATE | NOVEMBER 2019

Toledo's drinking water ban in August 2014 was a wake-up call to the state and the nation. Harmful algal blooms, which result from spring storms, summer temperatures and nutrient-rich water flowing into bodies such as Lake Erie, are a persistent and increasing issue that impacts communities all over the world. The challenge is, we still don't know exactly what kind of risks the blooms might present, how to fully prevent them and the best ways to protect people and watersheds. So Ohio's HABRI science teams are on the case: working with front-line health, environmental and agricultural agencies to bring them the answers they need to get the state—and region—out ahead of HABs.

Cover photo by Tom Bridgeman

Introduction

Ohio's Harmful Algal Bloom Research Initiative (HABRI) is a statewide response to the threat of harmful algal blooms. The initiative arose out of the 2014 Toledo drinking water crisis, where elevated levels of the algal toxin microcystin in Lake Erie threatened drinking water for more than 500,000 people in northwest Ohio. To better position the state to prevent and manage future algal water quality issues, the chancellor of Ohio's Department of Higher Education (ODHE) worked with representatives from Ohio's universities to solicit research projects that address critical needs and knowledge gaps identified by state agencies at the front lines of water quality crises.

ODHE, since 2015, has funded applied research at numerous Ohio universities to put answers in the hands of those who need them ahead of future harmful algal blooms. The initiative has launched a new round of agency-directed research each year, with the first round of projects completed in spring 2017. The Ohio Department of Higher Education has funded all research, with matching funds contributed by participating universities.

ROUND	NUMBER OF PROJECTS	TIME SPAN	STATUS	RESULTS	FUNDING AMOUNT (before 1:1 match by universities)	FUNDING SOURCE
Round 1	19	2015-2017	Complete	Final, 2017 report	$2 Million	ODHE
Round 2	14	2016-2018	Complete	Final, this report	$2 Million	ODHE
Round 3	11	2018-2020	In Progress	Preliminary, this report	$2.5 million	ODHE and OEPA
Round 4	10	2018-2020	In Progress	Preliminary, this report	$1.5 Million	ODHE

Rounds 3 and 4 were funded concurrently based on research needs.

We're All Over the Map

Science teams are made up of faculty and students from ten Ohio universities, spanning the state with water monitoring networks, shared sample analysis and collaborative testing of drinking water treatment options. The teams are also all over the map in terms of expertise—from engineering to medicine to economics—and that's by design. Harmful algal blooms (HABs) have many causes, many impacts and many avenues for smart prevention and management.

HABRI Universities

The initiative arose out of the 2014

TOLEDO DRINKING WATER CRISIS

when elevated levels of the algal toxin microcystin in Lake Erie **threatened drinking water for over**

500,000

people in northwest Ohio.

"HABRI research is an essential resource for Ohio EPA as we continue to monitor nutrients and understand the triggers for HABs. The HABRI products and interaction with associated experts are valuable for HAB management and response."

— **Laurie Stevenson**, Director, Ohio EPA

Breaking It Down

High-quality research—even driven by urgent needs—takes time. So HABRI divided the major research questions into bite-sized chunks for science teams to turn around in two years or less. Keeping in mind the four focus areas, the first group of projects, launched in 2015, tackled the entire range of open questions—from upstream nutrient movement in tributaries and algal bloom dynamics to water treatment and public health risks. A third cohort of teams is reporting on their progress this year, building on what we've learned and continuing to drive toward solutions that will better prepare Ohio for the next crisis.

Contributing to the National and Global HABs Dialogue

With HABRI, Ohio has created a research and outreach framework that other states can use to help solve statewide environmental issues. As part of that effort, Ohio's university research teams are also capturing their work in the form of publications for peer review, conference and public presentations, patents and policy briefs. These products, which contribute to efforts such as the World Health Organization developing health guidelines for algal toxins, help to position Ohio as an emerging leader in providing actionable data and systems solutions to this globally relevant threat.

Are We Better Prepared Now?

Unfortunately, harmful algal blooms arise every summer in Lake Erie and in many other lakes, rivers and reservoirs. ODHE launched HABRI to get Ohio ahead of the problem and to prevent another drinking water advisory. HABRI efforts have already yielded results:

- Early warning systems are giving water treatment plants a high-resolution picture of what could be affecting drinking water.
- Researchers are working directly with water treatment plant operators to provide practical guidance on producing safe drinking water. Some have also filed provisional patents on their technologies.
- The Ohio Department of Natural Resources has changed the way they collect information on algal toxin concentrations in sportfish fillets, sampling more frequently during HAB season and from a wider range of Lake Erie locations to better understand how harmful algal blooms affect sportfish.
- OEPA modified its permit procedure to better safeguard Ohioans when HABRI projects showed that farm crops might take in microcystins from water treatment residuals. New HABRI research is now helping OEPA better assess exposure risk from these byproducts of water treatment.
- HABRI has driven information sharing and priority setting between universities and agencies, positioning Ohio to better prevent and manage future crises.

HABRI: What We Do

Fifty-four science teams around the state of Ohio are hard at work getting answers about harmful algal blooms that will directly help state agencies prevent and manage future HABs-related issues and will position Ohio as a leader in understanding this emerging global threat. HABRI teams work under four basic mandates:

FOCUS AREA	CHALLENGE	CRITICAL NEEDS OR KNOWLEDGE GAPS IDENTIFIED BY AGENCIES*
Track Blooms From the Source	Algal blooms are not necessarily "harmful" unless they contain certain algae species and have the right mix of conditions to make toxins such as microcystin. With standard detection methods, public health officials may have to wait for hours or even days to confirm whether blooms are toxic and how they are growing and moving in the water body.	• Rapid determination of whether blooms are toxic and where toxins are moving (even apart from the main algae mass) • Prediction capability for the location and severity of blooms, even months ahead of time • The ability to track nutrients and stormwater upstream and correlate them with particular sources, storm events and algal bloom characteristics • Assessment of bloom and toxin locations within the vertical water column
Produce Safe Drinking Water	When pollutants end up in the water source for a city, water treatment officials need to know what they're dealing with and how best to clear them out of the water. But toxins from harmful algal blooms present a relatively new challenge globally, and the detection and treatment protocols are not mature.	• Laboratory testing of water treatment methods that give treatment facilities effective and cost-efficient options for clearing out algal toxins using their current infrastructure • Development of new, innovative techniques for producing safe drinking water
Protect Public Health	Algal toxins such as microcystin are known to have risks for humans and animals under certain circumstances. But the laboratory studies needed to make public health guidelines have not yet been updated and tailored for the more severe, persistent algal blooms we're seeing in Lake Erie and other freshwater sources around the world.	• New laboratory methods to detect the presence of algal toxins and their byproducts in living tissue such as blood • Laboratory studies on the effects of algal toxins at the cellular level and beyond • Testing of fish from affected water bodies to aid officials in advising anglers
Engage Stakeholders	Effective crisis prevention and management involves many different types of people who need to be connected—ahead of time. The Toledo water quality crisis provided a galvanizing event that revealed the need for closer ties among scientists, agencies, municipalities and landowners.	• Establishment of connections between various land management practices upstream and nutrient flows downstream

**A full list of agency priorities is available at go.osu.edu/habri.*

2019

HARMFUL ALGAL BLOOM
FOCUS AREAS

YEAR 4
PROJECT UPDATE

Track Blooms From the Source

Produce Safe Drinking Water

Protect Public Health

Engage Stakeholders

Track Blooms From the Source

Projects in this focus area aim to improve use of existing technologies, as well as develop new methods to detect, prevent and mitigate harmful algal blooms and their impacts. This will help to ensure drinking water safety and a healthy environment for lakeshore residents by connecting many of the potential causes and effects of harmful algal blooms, from the runoff that fuels them to the toxins that contaminate water supplies, to what makes them produce toxins in the first place.

Monitoring tributaries for nutrients that cause algal blooms

Early warning systems for bloom activity

Understanding blooms better for smarter management

Projects in this Focus Area

Round 3

Expanding the Heidelberg Tributary Loading Program to Assess Future Changes in Nutrient Runoff in the Western Lake Erie Basin
Lead: Heidelberg University

HABSat-1 (Harmful Algae Bloom Satellite-1)
Lead: University of Cincinnati

Investigating the Environmental Drivers of Saxitoxin Production in Recreational and Drinking Source Waters
Lead: Bowling Green State University, The Ohio State University

Round 4

Lake Erie Open Water HAB Impairment Criteria
Lead: The University of Toledo, The Ohio State University

Building a Better Satellite for Harmful Algal Bloom Monitoring

Satellites equipped with sensors that target harmful algal blooms offer early warning systems for drinking water protection, as they allow scientists and water managers to track blooms and their movements on a large scale. However, current satellite monitoring efforts are limited to days without cloud cover and very coarse imagery from a small number of expensive satellites available to researchers.

HABRI scientists are working together with UC CubeCats, an undergraduate engineering student group at the University of Cincinnati, to incorporate a much less expensive system for cyanobacteria detection into a CubeSat, a type of small standardized satellite that the students are designing. This detection system will operate effectively in space, gathering useful imagery from low Earth orbit. The system looks for the presence of phycocyanin, the blue pigment that gives cyanobacteria in some toxic and nontoxic algal blooms their color.

The project has already trained a number of undergraduate students who were able to contribute original research on various components of the satellite, including working with suppliers and presenting results at conferences. The research team is now moving into the fabrication stage, as well as testing solar panels and targeting methods for the satellite's sensors. The imaging sensors will be tested on small aircraft during the spring of 2020 to prepare for integrating them into the satellite.

The researchers will use the satellite images to better understand how algal blooms grow and move in the Great Lakes, and to support other early warning systems that help protect drinking and recreational waters for the region's residents. Lessons learned from this satellite development will also inform future monitoring satellite systems.

Once completed and placed in orbit, the satellite will supply imagery of the Great Lakes that allows for the early detection of harmful algal blooms for up to two years. The data will be received by a ground station at the University of Cincinnati, which is currently being upgraded to support this mission.

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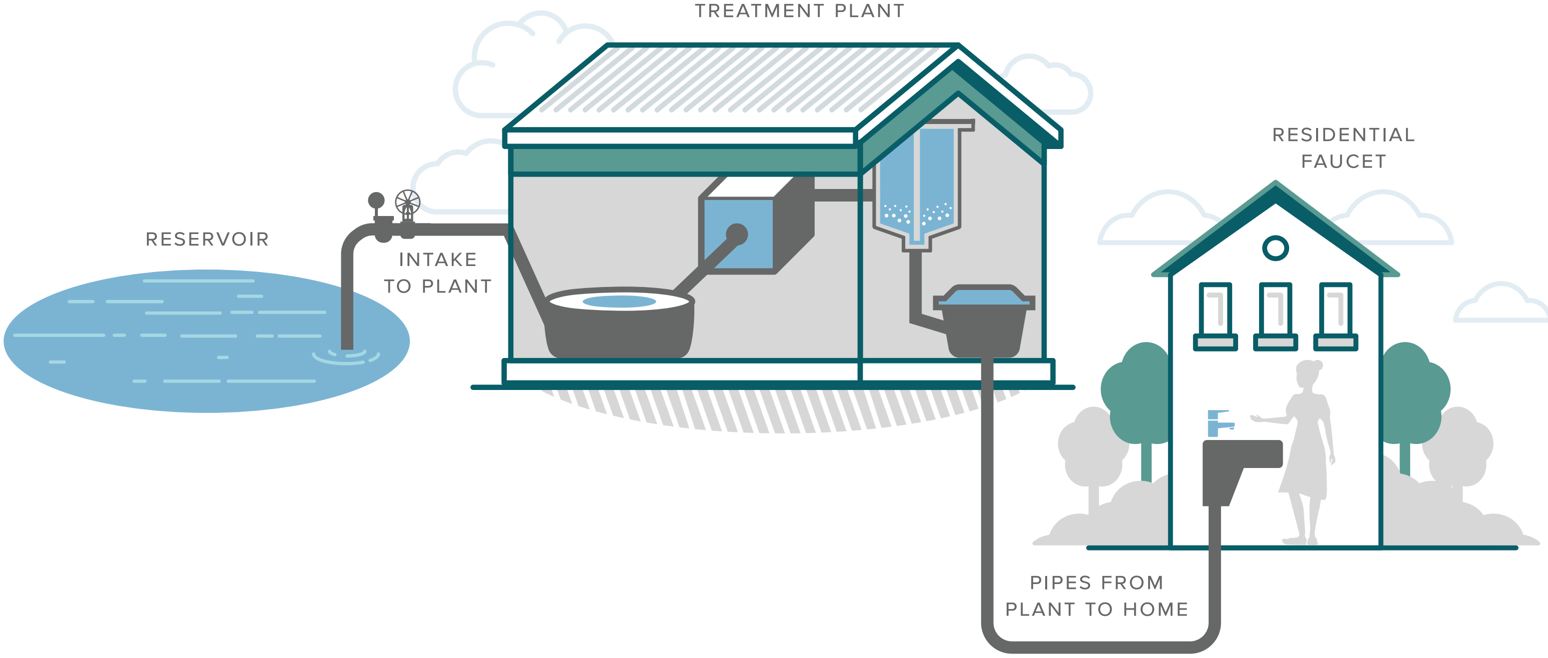
Produce Safe Drinking Water

One of the most direct public impacts of algal blooms was seen in August 2014, when a harmful algal bloom in Toledo caused a “Do Not Drink” order to be issued for more than two days, an impact felt by residents and businesses alike. With direct guidance from state agencies at the front lines of algal drinking water crises like this one, HABRI researchers are developing new treatment methods that will give public health and water treatment professionals the tools they need to make informed decisions when water supplies are threatened by algal blooms.



Projects in this Focus Area

Round 3

Environmental Fate and Persistence of Microcystin in Land Applied Drinking Water Treatment Residuals
Lead: The Ohio State University

GaN ImmunoFET Biosensors for Multiplexing Detection of Cyanotoxins in Water
Lead: The Ohio State University

Optimizing the Use of Powdered Activated Carbon for Saxitoxin Removal
Lead: The Ohio State University

Quantifying Viral Activity Associated with Microcystin-Producing Cyanobacteria to Inform Water Treatment Options for Ohio’s Public Water Systems
Lead: Bowling Green State University

Round 4

Testing and Optimization of Microcystin Detoxifying Water Biofilters
Lead: The University of Toledo

Using Bacteria to Remove Microcystin From Drinking Water

Many Ohio communities draw their drinking water from Lake Erie, so making sure that any harmful algal bloom toxins are removed before the water reaches consumers is essential to maintaining public health. While water treatment plants currently use activated carbon to treat for algal toxins, researchers are developing new approaches that use microcystin-degrading bacteria to remove toxins from their source water.

State agencies like the Ohio EPA and the Ohio Department of Health have expressed a need for new technologies that drinking water plants can use to remove algal toxins from their raw water. In particular, they require ways to effectively treat low levels of toxin without incurring the same cost required to remove higher toxin levels from the water.

HABRI researchers are now exploring biofilters, built by growing bacteria in thin layers called biofilms on solid surfaces, which could potentially purify drinking water that contains low levels of algal toxins. The bacteria they are using occur naturally in freshwater, and have been shown to break down microcystin toxin into non-toxic component parts. The researchers have already filed provisional patents on this technology.

Their current work focuses on determining the right combination of bacteria to grow, to ensure that the largest amount of toxin is removed from the water. In addition, they are scaling up their previous bench-scale laboratory experiments from small filters to a filter size more likely to be used in a water treatment plant.

To make sure the bacteria do not pose a separate threat to human health, the scientists are also working on genetic sequencing for the biofilter bacteria to make sure they won't be able to cause disease in humans. Once the bacterial DNA is sequenced, the researchers hope to also use that information to potentially identify the specific enzymes responsible for breaking down microcystin into non-toxic compounds.

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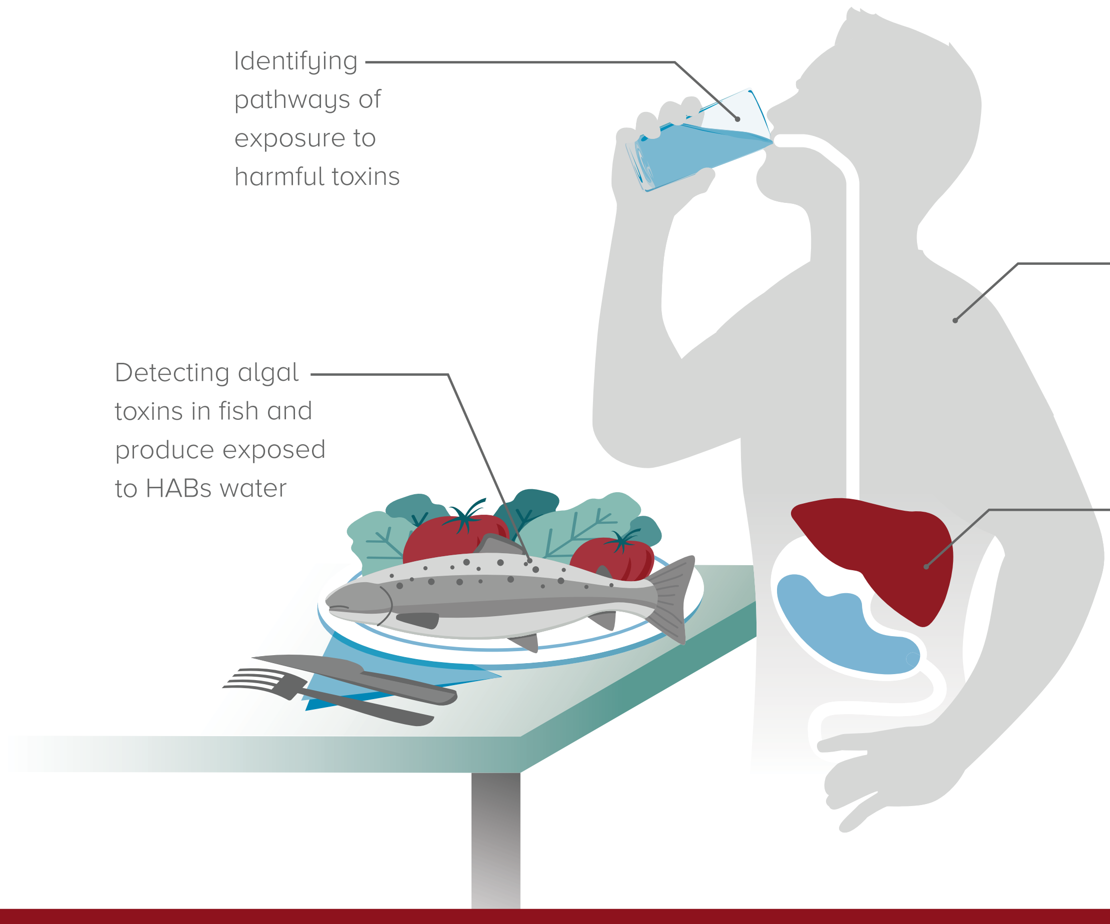
Protect Public Health

While safe drinking water is a major focus for public health officials and researchers, scientists are also working to determine other ways that harmful algal blooms and the associated toxins—in particular microcystin—may impact human health. In this focus area, science teams develop techniques to better detect toxins in biological samples, study the effects of algal toxins on various types of cells and determine the significance of the different ways that people might be exposed to algal toxins—physical contact, eating fish, etc. These studies aim to assist agencies as they develop guidelines for handling harmful algal blooms in coming years.



Projects in this Focus Area

Round 3

HAB-Associated Health Effects and Airborne Microcystin Levels Among Recreational Lake Users
Lead: The University of Toledo

ImmunoFET Sensors for Detection of Microcystins in Human Biological Samples
Lead: The Ohio State University

Round 4

Effects of Inflammatory Bowel Disease on Susceptibility to Microcystin-LR
Lead: The University of Toledo

High-Throughput Analysis of Human Toxicity and Therapeutics Targets of Cyanotoxins Across Organ Systems in Health and Disease
Lead: The University of Toledo

Metabolomic Biomarkers of Acute and Chronic Cyanotoxin Exposure During the Promotion of Hepatic Carcinogenesis
Lead: The Ohio State University

Novel Therapies for Microcystin-Induced Hepatotoxicity in Pre-Existing Liver Disease
Lead: The University of Toledo

How Does Microcystin Affect Liver Cancer Development?

Harmful algal blooms can release toxins that affect the liver, kidneys and heart, as well as the digestive and nervous system in people and animals. Exposure from drinking contaminated water is most common, and can be either chronic, such as from drinking water that contains minute amounts of toxin daily over a long period, or acute, such as swallowing water with high levels of toxin just once while swimming in a contaminated lake.

In some cases, long-term and high doses of algal toxins can lead to an increased risk for liver cancer, but researchers don't really know how dosage and chronic or acute exposure affect that risk. HABRI scientists are now working to better understand the mechanisms of algal toxin damage, as well as whether dosage and timing of exposure changes those mechanisms.

Microcystins, the toxins that most Lake Erie harmful algal blooms produce, cause tissue damage in liver cells, which can turn into liver cancer with prolonged or concentrated exposure. This damage can exacerbate problems in patients with pre-existing liver disease such as non-alcoholic fatty liver disease, one of the most common pre-existing liver conditions. The researchers are using mice to mimic both short-term concentrated exposure to algal toxins, such as would happen on a weeklong vacation to a contaminated beach, and long-term exposure to levels generally considered safe to drink.

Results showed that liver damage in mice exposed to high doses of microcystin was higher the more toxin they had ingested. Other systems like kidneys and reproductive organs were also affected. Unexpectedly, three of four mice that died early in the study were female, suggesting that although liver cancer is more common in males, acute impacts of algal toxins may be more severe in females.

The mice exposed to low levels of microcystins developed more pre-cancerous and liver tumors than control mice, especially in high-risk individuals with pre-existing liver disease. So while microcystin alone or in healthy individuals may not pose a significant health risk at low doses, exposure in high-risk populations can promote damaged liver cells to become cancer cells.

The researchers continue to study the mechanisms involved in producing this liver damage, in the hopes of eventually finding biomarkers that let them predict who may be at greatest risk for toxin-induced liver cancer before it develops.

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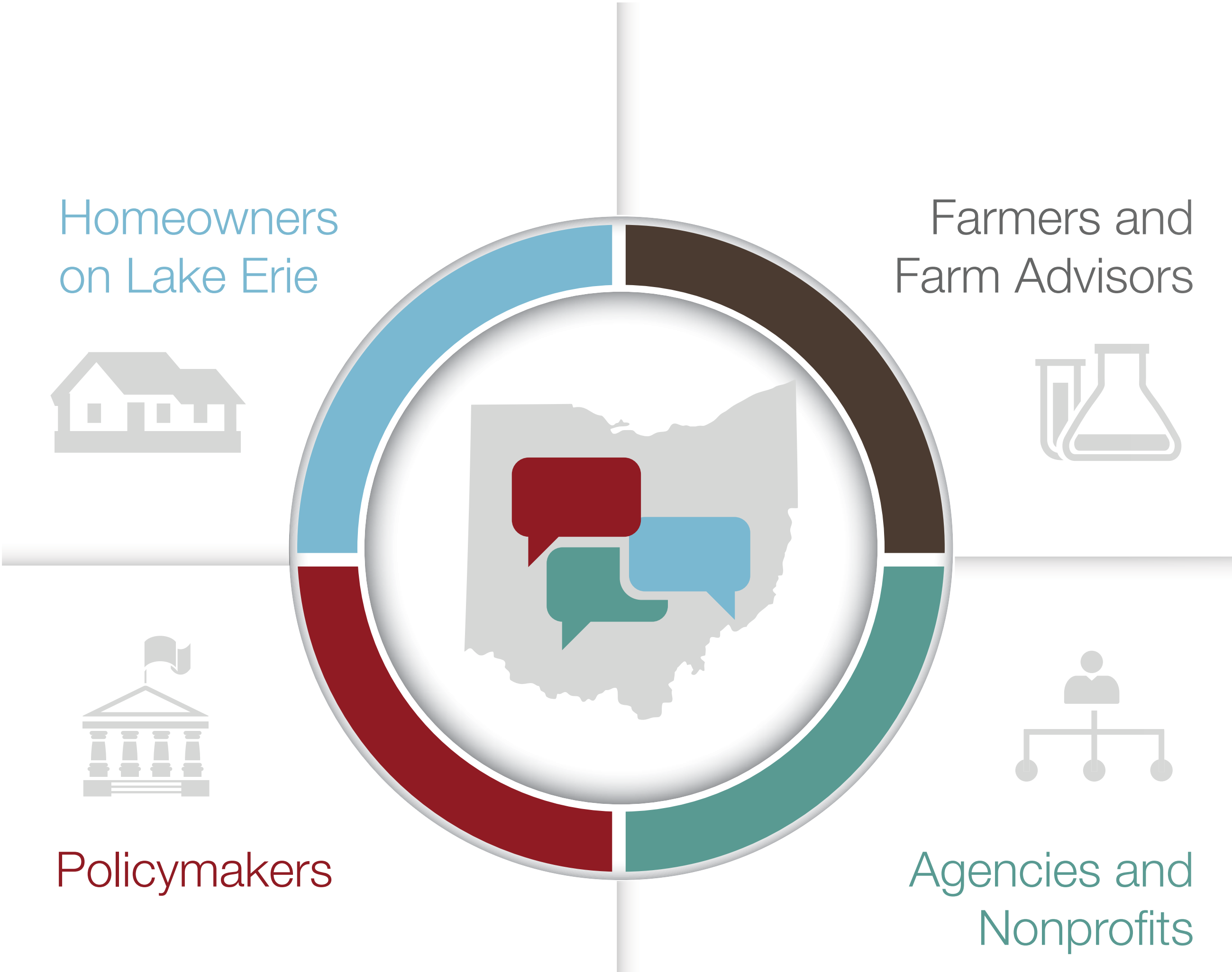
Engage Stakeholders

Complex issues like harmful algal blooms have many causes and many impacts—which means many different people have perspectives and roles to play in finding solutions. Researchers in this focus area are figuring out how information moves through existing networks of people and how to best use those networks—such as OSU Extension and farmer partnerships—to create effective collaborations to tackle harmful algal blooms.



Projects in this Focus Area

Round 3

Critical Model Improvements for Simulating Promising Conservation Actions for Tile-Drained Fields in the Maumee River Watershed
Lead: The Ohio State University

Physiological, Growth and Survival Response of Age-0 Yellow Perch and Walleye to Toxic Cyanobacteria
Lead: The Ohio State University

Round 4

Effectiveness in Implementation: Mapping Agricultural Management Practices, Farmer Perceptions and Outcomes
Lead: The University of Toledo

Evaluation of the Effects of Changing On-Farm Manure Management Practices on Reduction of Dissolved Phosphorus Runoff
Lead: The Ohio State University

Spatial Distribution Model for Manure from Permitted Livestock Facilities (CAFOs/CAFFs) in the Lake Erie Western Basin and Maumee Watershed, Ohio
Lead: The University of Toledo

Tracking and Attenuating Nutrient Loads from Manure Fertilization
Lead: Bowling Green State University

Developing a Better Manure Fertilizer

Manure from concentrated animal feeding operations (CAFOs) can negatively impact water quality. If too much is applied to too little land, this can lead to relatively large amounts of nutrients in field runoff. The same manure can also be used as a beneficial agricultural fertilizer, but the cost of transporting it to fields is often high relative to its fertilizer value because of the high water content.

HABRI researchers are developing a low-cost treatment for manure from concentrated animal feeding operations, focused on separating manure nutrients from wastewater and producing a dry product that could reduce transportation cost by 20 to 40 times. That dry product would also release nutrients more slowly into the soil, thus enhancing crop yield and improving water quality.

In the past year, they treated 3000 gallons of liquid manure from a dairy CAFO with a wastewater treatment coagulant that allowed them to separate solid and liquid manure components and ensure that nutrients remained in the solid portion. They compared this treated manure to raw manure by placing it on experimental farm fields, tilling the fields to incorporate the fertilizer and then planting soybeans. During this pilot test, water samples were collected during rain events and analyzed for agricultural nutrients.

Results show higher phosphate concentrations in runoff from plots fertilized with raw manure, compared to plots that received the treated manure solids. Crop yields from both field types were similar, suggesting that plants can absorb nutrients from the treated manure just as well as from the raw manure. Overall, the treated manure seemed to have a positive impact on reducing agricultural nutrients in runoff from farm fields.

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The researchers are also working on a way to trace nutrient runoff back to its source based on organic nitrogen and phosphorus compounds that are specific to where the runoff came from. They are identifying specific compounds present in each type of manure treatment, along with contaminants like hormones and antibiotics potentially present in manure from large animal operations in order to determine whether the treatment process can help prevent problems from these substances.

Future funding will hopefully expand their experiments to manure from swine facilities, and to testing new polymers they have developed in the lab that offer performance advantages and possible cost savings.

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HARMFUL ALGAL BLOOM RESEARCH PROJECTS

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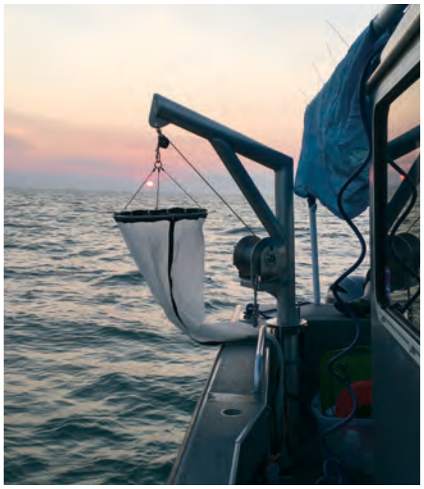
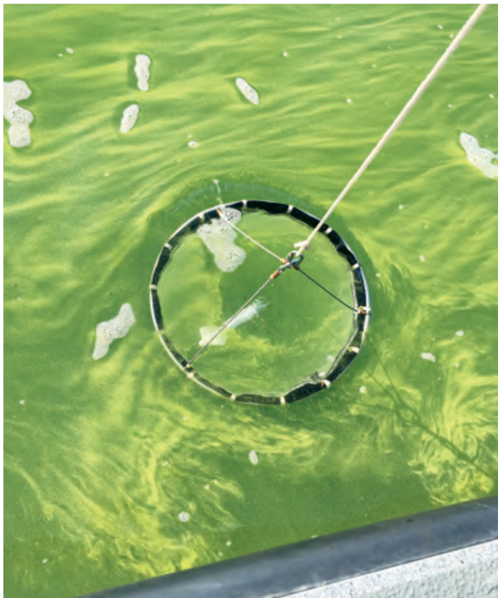
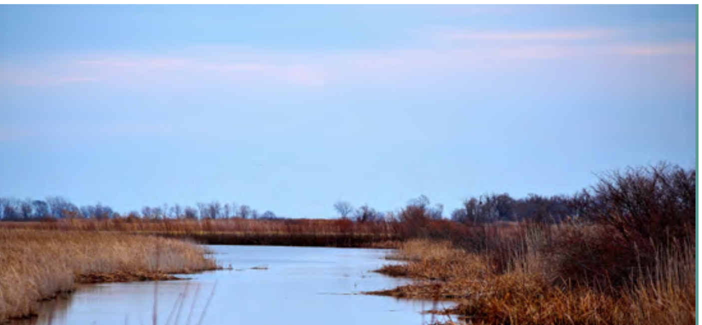
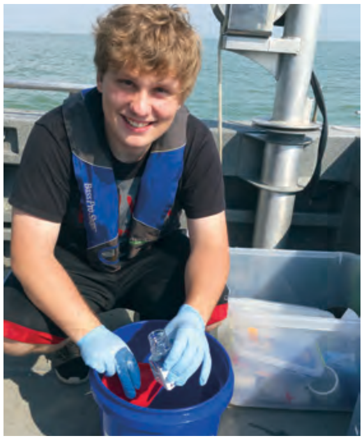








Developing Impairment Criteria for Western Lake Erie

RESEARCH PROJECT TITLE:

Lake Erie open water HAB impairment criteria

Principal Investigator: Thomas Bridgeman, The University of Toledo

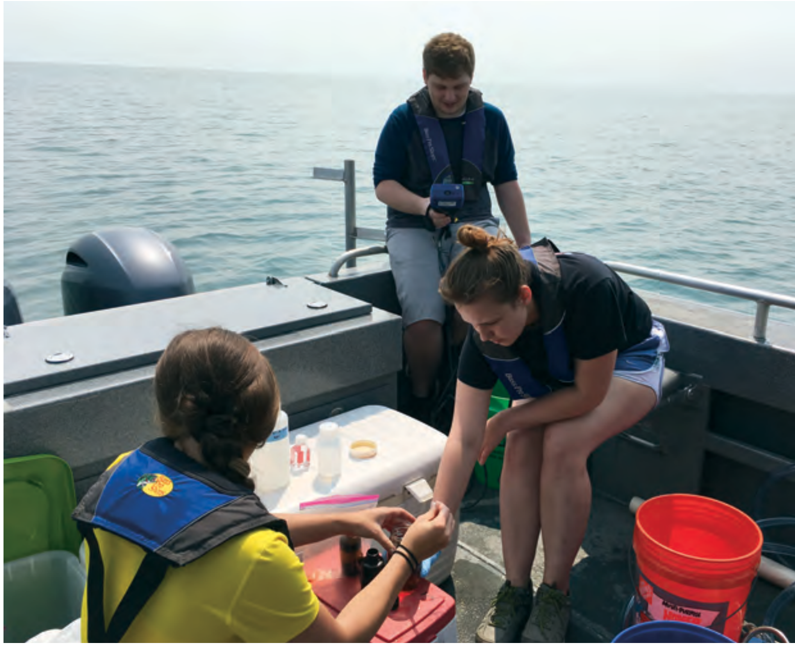
Partners: Bowling Green State University, The Ohio State University

PROJECT SUMMARY

Researchers are working with the Ohio EPA to determine effective methods of evaluating harmful algal blooms in western Lake Erie and Sandusky Bay. The outcome of their project will form the basis of future decisions on whether to declare the open waters of western Lake Erie as impaired due to HABs.

The scientists are also investigating methods of quickly and easily measuring surface scum, which can confound HABs measurements both from boats and via satellites.

So far, the researchers have conducted weekly sampling trips during the harmful algal bloom season (June-October) in the open waters of Lake Erie, and biweekly in Sandusky Bay. The samples and related water quality data were analyzed in Ohio EPA laboratories.



THE BOTTOM LINE

Researchers are working directly with state agencies to develop science-based criteria for informed management decisions around harmful algal blooms and recreational lake use in Lake Erie's western basin.

Pictured: During harmful algal bloom season, researchers are sampling water in Lake Erie and Sandusky Bay to determine effective methods of evaluating HABs for the Ohio EPA.

When New Toxins Present Themselves, Forecast Them

RESEARCH PROJECT TITLE:

Investigating the environmental drivers of saxitoxin production in recreational and drinking source waters

Principal Investigator: Timothy Davis, Bowling Green State University

Partners: The Ohio State University, Ohio Environmental Protection Agency, Defiance College, Kent State University, NOAA National Ocean Service, Cawthron Institute

PROJECT SUMMARY

Since the 2014 Toledo water advisory, a lot of attention has focused on harmful algal bloom toxins. An emerging toxin of concern in Ohio is saxitoxin, a potent neurotoxin that has been found for decades in marine environments, but has recently been detected in freshwater as well. In Ohio, saxitoxin distribution is fairly widespread, but little is known about what triggers toxin production in natural waters, many of which provide drinking water to Ohio communities.

In collaboration with Ohio EPA, the researchers monitored Ohio lakes for potential saxitoxin-producing blooms. Once a bloom was identified, a rapid response team sampled water and took environmental measurements to help understand the causes of toxin production. In addition, the researchers are developing a new method to detect saxitoxins in freshwater, as most current methods are meant for marine environments or detection in shellfish.

Complementary laboratory experiments used isolated harmful algae strains (both floating cyanobacteria and those growing on the lake bottom) under different nutrient levels and temperatures to see how the organism reacts under controlled conditions. To do these experiments, they developed a temperature gradient chamber that allows them to grow different cyanobacterial strains at different temperatures under the same light conditions. This lets the researchers identify the optimal temperature for algal toxin production, as well as develop the beginnings of a toxicity forecast for these harmful algal blooms.

To date, the researchers have found that the Maumee River contains populations of cyanobacteria that produce cylindrospermopsin, another algal toxin. Previously, it was thought that Maumee River blooms only produce microcystin, the most commonly found algal toxin in Ohio. This discovery has changed how these waters are monitored, and further study will determine if the algal populations potentially change in type over the course of a field season.

THE BOTTOM LINE

Researchers are expanding knowledge of harmful algal bloom toxins from microcystin, the most commonly found toxin in Ohio waters, to other emerging toxins of concern. Understanding what drives the production of saxitoxin, a potent neurotoxin, as well as cylindrospermopsin, another type of liver toxin that was recently found in Maumee River blooms, has changed how blooms in the river are monitored and represents the first steps in developing a toxicity forecast for harmful algal blooms in the state.

Expanded River Monitoring Program Will Inform Science-Based Nutrient Runoff Reduction Efforts

RESEARCH PROJECT TITLE:

Expanding the Heidelberg Tributary Loading Program

Principal Investigator: Laura Johnson, Heidelberg University

PROJECT SUMMARY

The National Center for Water Quality Research at Heidelberg University monitors nutrient loading in Lake Erie tributaries at 24 river locations in Ohio and Michigan, effectively covering about half of Ohio's land area. However, the network of monitoring stations had low representation of smaller watersheds and was missing a station in the priority watershed on the Huron River.

HABRI funding added 3 new stations to monitor smaller watersheds, as well as a station on the Huron River. That station in particular has helped solidify the finding that soil types and physical characteristics of a region are a large driver of nutrient runoff into Lake Erie: the Huron River has higher soil erosion and sediment export but lower nutrient leaching from the soil. This leads to lower dissolved phosphorus transport than the heavy clay soil found commonly in the Maumee, Portage and Sandusky river watersheds.

Adding monitoring stations in smaller watersheds has been useful to better understand how variable nutrient loads are within larger watersheds and how they scale to the western Lake Erie basin. These smaller watersheds also have the potential to act as pilot regions for large-scale implementation of best management practices that could reduce nutrient runoff. By targeting best management efforts in pilot watersheds with existing monitoring, researchers will be able to assess the effectiveness of different practices by comparing new nutrient data with older data sets. One of the new watersheds is primarily residential, which will also allow researchers to better assess the contribution of nutrients from non-agricultural land.

THE BOTTOM LINE

Data on nutrient runoff across western Ohio watersheds already informs essential management practices, as well as models like NOAA's harmful algal bloom forecast. An expansion of Heidelberg University's Tributary Loading Program will provide information on the impacts of different soil types and surrounding environments, as well as examine the effectiveness of agricultural best management practices in smaller watersheds that can act as pilot locations before larger implementation across the western Lake Erie watershed.

Building a Better Satellite For Harmful Algal Bloom Monitoring

RESEARCH PROJECT TITLE:

HABSat-1 (Harmful Algal Bloom Satellite-1)

Principal Investigator: Catharine McGhan, University of Cincinnati

Partners: University of Alabama, NASA

PROJECT SUMMARY

Harmful algal bloom monitoring via satellite offers early warning systems for drinking water protection, as well as help to determine the causes of HABs in Ohio, but current monitoring efforts are limited by cloud cover and by the small number of expensive satellites available to researchers.

Scientists at the University of Cincinnati have developed a much less expensive image system for cyanobacteria detection, based on the presence of phycocyanin, the pigment that gives harmful algal blooms their color. They are currently testing this imager on aircraft in preparation for integrating it into NASA's CubeSats satellite program.

The project has already trained a number of undergraduate students who were able to contribute original research on various components of the satellite. The research team is now moving into the fabrication stage, as well as testing solar panels and targeting methods for the satellite's sensors. Once completed and placed in orbit, it will supply imagery of the Great Lakes that allow for the early detection of harmful algal blooms for up to two years. The data will be received by a ground station at the University of Cincinnati, which is currently being upgraded to support this mission.

THE BOTTOM LINE

Student researchers are developing a small, relatively inexpensive satellite that will be able to track harmful algal blooms in the Great Lakes from orbit, offering early warning systems for drinking water protection and determining some of the sources of blooms so their origins can be addressed better.

Pictured: Researchers are working with an undergraduate student group to build a small satellite that can track harmful algal blooms in the Great Lakes from space. Once completed, the satellite will be launched as part of NASA's CubeStats program.

What Happens to Algal Toxins in Water Treatment Residuals?

RESEARCH PROJECT TITLE:

Environmental fate and persistence of microcystin in land applied drinking water treatment residuals

Principal Investigator: Nicholas Basta, The Ohio State University

PROJECT SUMMARY

Drinking water treatment residuals (WTR), the solids left behind once water is treated, have beneficial uses. Water-softening WTR are a high-quality lime material that is often applied on land to obtain optimum soil pH for crop production. Alum or Ferric WTR has been used as topsoil replacement or in soil blends. Beneficial use of WTR directs residuals away from landfills, saving communities money and benefiting farmers. However, recent Ohio EPA monitoring found algal toxins like microcystin in some residuals from water treatment plants that are affected by harmful algal blooms. Because toxins in the soil have the potential to be absorbed into growing crops, use of these residuals needs to be evaluated.

Currently, water treatment residuals are not routinely tested for microcystin to determine whether they would be suitable for soil replacement. Researchers are now beginning to develop testing guidelines for residuals, from how best to extract them at the treatment plant to what happens once they are placed on the land. Specifically, they are optimizing analytical lab methods to measure microcystin in the residuals, studying the uptake of microcystin by plants grown in soil that contains residuals, and measuring the persistence of microcystin in soil blends that contain residuals.

Pictured: Residuals from drinking water treatment can be beneficial as agriculture fertilizer, but recent monitoring has found algal toxins in residuals from plants that deal with harmful algal blooms.

Preliminary findings show that microcystin is indeed present in water treatment residuals collected for the project, and that carrots and lettuce take up microcystin when grown in soil that contains residuals. The researchers have also adapted an analytical method used to detect microcystin in water for use in water treatment residuals and soil blends.

THE BOTTOM LINE

Researchers are examining what happens to algal toxins in water treatment residuals once these are mixed into soil blends or placed on the land. They have developed a method to measure microcystin content in residuals and soils, and found that produce grown on these soils can contain algal toxins.

When A Cyanobacteria Virus Is Present In Water

RESEARCH PROJECT TITLE:
Quantifying viral activity associated with cyanobacteria

Principal Investigator: George Bullerjahn, Bowling Green State University

PROJECT SUMMARY

Recent research has demonstrated that viral infections of cyanobacterial blooms can complicate removal of algal toxins like microcystin from drinking water at treatment plants. The infected cells release dissolved toxin directly into the water, while toxin in a virus-free bloom is contained within the cells and sand filtration removes 99 percent of the toxin from the raw water.

The researchers' aim is to detect viruses that may infect *Microcystis* and *Planktothrix*, two cyanobacteria common in western Lake Erie, and to develop a test to determine the level of viral activity in the water. Previous research has linked high viral activity to higher levels of dissolved toxins at water plant intakes.

Using a newly designed PCR-based assay and known genetic information for viruses around the world, the researchers are working to detect viruses in concentrated samples from water sources around Ohio. They are currently focused on *Planktothrix* blooms, which are studied less often, but can detect currently well-known viruses in both *Planktothrix* and *Microcystis* blooms throughout the bloom season.

Once the test is finalized for these viruses, they can expand this method to lesser-known viruses, covering the broad spectrum of potential viral infections in Lake Erie and its embayments such as Sandusky Bay.

THE BOTTOM LINE

Viral infections of cyanobacterial blooms can complicate toxin removal at water treatment plants, as infected cells release toxin directly into the water. Researchers are working on an assay that can detect the presence of viruses in a harmful algal bloom to give water plants advanced warning of the need for additional water treatment.

Pictured: Viral infections can force harmful algae to release toxin into the water, making it more difficult for water treatment plants to remove these toxins. Researchers are now developing a test for some of the most common cyanobacteria viruses to help treatment plants prepare for this situation.

Using Bacteria to Remove Microcystin From Drinking Water

RESEARCH PROJECT TITLE:

Testing and optimizing microcystin detoxifying water filters

Principal Investigator: Jason Huntley, The University of Toledo

PROJECT SUMMARY

Many Ohio communities draw their drinking water from Lake Erie, so making sure that any harmful algal bloom toxins are removed before the water reaches consumers is essential to maintaining public health. While water treatment plants currently use activated carbon to treat for algal toxins, researchers are developing new approaches that use microcystin-degrading bacteria to remove toxins from their source water.

By growing bacteria in thin layers called biofilms on solid surfaces, the researchers developed and tested biofilters that could potentially purify drinking water, and they have filed provisional patents on this technology. Their current work focuses on determining the right combination of bacteria to grow, and scaling up their previous laboratory experiments from small filters to the filter size more likely to be used in a water treatment plant.

The researchers are also working on genetic sequencing for the biofilter bacteria, in large part to ensure that the bacteria are unable to cause disease in humans. Once the bacterial DNA is sequenced, they hope to also use that information to potentially identify the specific enzymes that are responsible for breaking down microcystin into non-toxic parts.

THE BOTTOM LINE

Researchers are developing new methods to remove algal toxins from drinking water, using bacteria that naturally break down microcystin toxin into non-toxic component parts.

Pictured: Researchers are working on novel approaches to remove low levels of algal toxins from drinking water.

When A New Toxin Shows Up in Ohio Waters

RESEARCH PROJECT TITLE:

Optimizing the use of powdered activated carbon for saxitoxin removal

Principal Investigator: John Lenhart, The Ohio State University

PROJECT SUMMARY

The algal toxin saxitoxin was recently found in Ohio waters. Because saxitoxin is primarily associated with marine environments, Ohio utilities lack information they can use when treating freshwater sources that contain this toxin.

Building on previous HABRI research that addressed the toxin microcystin in drinking water, researchers are now developing guidelines for use of powdered activated carbon to remove saxitoxin during water treatment. Activated carbon is commonly used for this purpose, but studies on this approach have produced conflicting results, meaning water plants can't be sure the treatment will be successful.

The researchers are working on laboratory studies with different sources of powdered activated carbon (wood, coconut, coal blend and bituminous coal) to determine which are most effective at removing saxitoxin from a standardized solution that mimics Ohio surface waters.

Preliminary results suggest that competition between natural organic matter and saxitoxin for adsorption by activated carbon is limited. This is counter to what was observed for microcystin and indicates that saxitoxin interactions with activated carbon are quite different than those involving microcystin. However, more testing is planned to assess whether other types of natural organic matter often found in source waters change the effectiveness of any of the carbon types. The results also indicate that wood-based powdered activated carbon performs substantially better than the other carbons tested. This is important to know since many utilities in Ohio are not in the practice of using wood-based carbon. Additional testing is needed to determine whether the wood-based carbon effectively removes taste and odor compounds as well as algal toxins.

Once the baseline ability of the carbons to remove saxitoxin are established under well-controlled conditions, experiments will be repeated using water samples from Ohio surface water sources or with samples amended with organic matter from these sources. As results are collected, scientists involved continue to communicate with local water treatment plants to keep them aware of research progress and to share findings and suggested guidelines.

THE BOTTOM LINE

Researchers are developing guidelines for the use of powdered activated carbon in drinking water treatment to remove saxitoxin, an emerging toxin of concern in Ohio waters.

Pictured: Building on research that addressed microcystin toxin in drinking water, researchers are now developing similar guidelines for activated carbon use for saxitoxin contamination.

Developing Handheld Algal Toxin Detection Systems for On-site Water Testing

RESEARCH PROJECT TITLE:

GaN ImmunoFET biosensors for multiplexing detection of cyanotoxins in water

Principal Investigator: Wu Lu, The Ohio State University

PROJECT SUMMARY

The current method for detecting harmful algal bloom (HAB) toxins in water samples is enzyme-linked immunosorbent assay (ELISA), a time- and labor-intensive process that requires specialized laboratory equipment and trained personnel. Researchers at The Ohio State University are working to change that.

They are developing a handheld technology that allows untrained users to test water samples on-site following simple instructions. The sensors would detect microcystin, the most common algal toxin found in Lake Erie, as well as other toxins such as saxitoxin found in places like Sandusky Bay. The overall system would operate similarly to a blood glucose meter, where diabetic patients use disposable test strips to determine glucose levels in their blood sample.

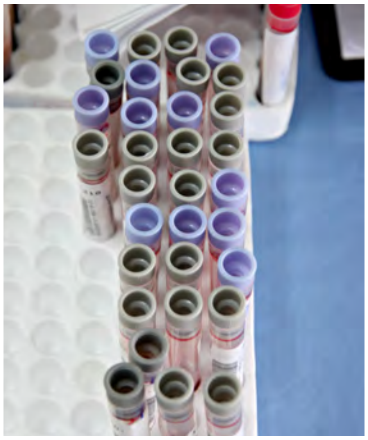
The team designed a sensor based on semiconductor technology that uses a field effect transistor (FET) approach to sense toxins in water samples. This BioFET sensor requires very little water for the sample, and can be integrated into a small handheld reader to make use and storage easy and convenient. Small changes in the surface chemistry of the sensors should also allow it to detect different toxin types, and multiple sensors will eventually work together to detect more than one toxin per sample.

So far, the researchers have produced the different sensor types and used them to detect microcystin-LR, the most common form of this toxin, as well as saxitoxin, anatoxin and cylindrospermopsin in samples of known concentration as well as samples from natural water bodies. The devices detect toxins within the range of the currently used ELISA test, aren't confused by the presence of other biological elements that may remain behind after the samples are filtered, and can even go below ELISA's reported lowest limit of detection.

THE BOTTOM LINE

Researchers are developing a handheld technology that can detect harmful algal bloom toxins on-site, using a system very similar to a diabetic patient's blood glucose meter. They have successfully developed sensors for the four most common algal toxins found in Lake Erie; now they are working on combining multiple sensors to test for more than one toxin at a time in the same water sample.

Pictured: Researchers are designing handheld tests, similar to a glucose meter, that can be used to test water samples on-site with minimal training. Remote locations like the Lake Erie islands could benefit from this approach while they wait for results from off-site testing facilities.



Developing Rapid Algal Toxin Detection Systems for Physician Offices

RESEARCH PROJECT TITLE:

ImmunoFET sensors for detection of microcystins in human biological samples

Principal Investigator: Wu Lu, The Ohio State University

PROJECT SUMMARY

The current method for detecting harmful algal bloom (HAB) toxins in any kind of sample is enzyme-linked immunosorbent assay (ELISA), a time- and labor-intensive process that requires specialized laboratory equipment and trained personnel. Researchers at The Ohio State University are working to change that.

They are developing a handheld technology that allows clinicians in a point-of-care setting like a doctor's office to test blood serum samples on-site following simple instructions. Using this reader, a clinician could determine immediately whether a patient was exposed to microcystins, the most common algal toxin found in Lake Erie, and approximately how much they were exposed to. The overall system would operate similarly to a blood glucose meter, where diabetic patients use disposable test strips to determine glucose levels in their blood sample.

Building on previous work testing for algal toxins in water samples, the team designed a sensor based on semiconductor technology that uses a field effect transistor (FET) approach to sense microcystin-LR, the most common form of this toxin, in blood serum and urine. This BioFET sensor requires very little volume for the sample, and can be integrated into a handheld reader to make use and storage easy and convenient. Small changes in the surface chemistry of the sensors should also allow it to detect other biomolecules, such as the proteins in urine samples that can indicate kidney or liver disease.

The researchers are also investigating using whole blood samples for testing, potentially eliminating a processing step where blood platelets and other clotting factors have to first be removed from the sample. This leaves behind the liquid components of blood, called serum.

So far, the researchers have produced multiple sensor types and used them to detect microcystin-LR, the most common form of this toxin. They also were able to shrink the size of the sensors, making better use of raw materials without compromising performance. The devices detect toxins within the range of the currently used ELISA test, aren't confused by the presence of other biological elements that may be present in the serum, and can even go below that test's reported lowest limit of detection.

THE BOTTOM LINE

Researchers are developing a handheld technology that can detect harmful algal bloom toxins in blood samples, using a system very similar to a diabetic patient's blood glucose meter. They have successfully developed sensors that detect microcystin toxin in blood serum samples; now they are working on refining their method for potential use with whole blood samples and establishing a reliable range in which the sensors can detect the algal toxin.

Surveying the Health of Lake Residents

RESEARCH PROJECT TITLE:

HAB-associated health effects and airborne microcystin levels among recreational lake users

Principal Investigator: April Ames, The University of Toledo

PROJECT SUMMARY

While physical effects from ingesting cyanotoxins are well known – algal toxins like microcystin can cause liver failure – the effects of inhaling water spray that contains microcystin is less well studied. Researchers are improving collection procedures for this potential form of exposure, and surveying lakeshore residents and visitors about their health to better understand the impacts of algal toxins on people near Lake Erie.

Survey invitations were sent to randomly identified users through boater and angler registration lists, as well as to residential addresses within a half mile of the western Lake Erie shoreline in Lucas, Ottawa and Sandusky counties. Respondents detailed where and how they usually use the lake, and what types of health symptoms they may have experienced after exposure to lake water.

During summer 2018, respondents did not report any health symptoms, aside from a few mentions of skin irritation, hay fever symptoms or stomach cramping that would be expected among an unexposed population as well. This could be because the lake did not experience a large bloom during the survey period, or because lake users are taking precautions around potential HAB exposure. Results may be different for the 2019 season due to bloom severity.

The researchers also worked on better sample collection for airborne algal toxins, focusing on variables like sampler position on the boat, the type of boat used, speed and time spent taking the sample. Refining these collection procedures means that this year, they will be sampling microcystin in the air and water on and off shore. In addition, they have designed a pilot study to test a different piece of equipment for the detection of low concentrations of airborne microcystins, which is ongoing.

THE BOTTOM LINE

Researchers are investigating the presence of microcystin in the air, as well as the occurrence of potential effects of algal toxins on the health of lakeshore residents and visitors. While their initial survey did not find an increased incidence of the symptoms commonly associated with algal toxin exposure, they continue to survey water users and sample air and water on and near Lake Erie to determine toxin concentrations for future health research.

Impacts of Microcystin Exposure on Inflammatory Bowel Disease

RESEARCH PROJECT TITLE:

Effects of inflammatory bowel disease on susceptibility to microcystin-LR

Principal Investigator: Steven Haller, The University of Toledo

PROJECT SUMMARY

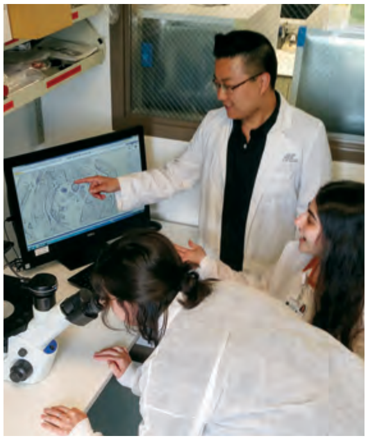
Inflammatory bowel diseases like ulcerative colitis and Crohn's disease have mostly been well-studied, but one gap in the knowledge of environmental factors affecting patients with the disease is the impact of microcystin. These algal toxins are a growing global health concern and have been found at high levels of bioaccumulation within the intestines. Researchers set out to examine the effects of microcystin in healthy mice as well as mice with pre-existing bowel disease.

They found that, while microcystin-LR – the most common form of microcystin in Lake Erie – does not have a significant effect on inflammation and other symptoms alone, it had profound effects in mice with pre-existing colitis. These study groups exhibited weight loss, bloody stools, increased ulcers in the colon, shortened colons and significant elevation in inflammation markers in the bloodstream.

Based on the mice studies, the researchers are currently determining how microcystin causes damage to the intestinal tract so that they can develop targeted therapies for patients with inflammatory bowel disease.

THE BOTTOM LINE

Researchers have found that inflammatory bowel diseases like ulcerative colitis and Crohn's disease can exacerbate the impacts of the algal toxin microcystin in mice. They are currently determining the mechanisms behind these impacts to help develop targeted therapies for patients.



Preventing Negative Effects of Algal Toxins in Patients with Liver Disease

RESEARCH PROJECT TITLE:

Effect of chronic low-dose exposure to microcystin-LR and its susceptibility in populations with pre-existing liver disease

Principal Investigator: David Kennedy, The University of Toledo

PROJECT SUMMARY

Algal toxins like microcystin affect the liver, but studies on specific health effects have been limited to healthy participants and not focused on actual treatment. However, about 30 percent of the population has some form of liver disease, which could be exacerbated by exposure to microcystin. The researchers are focusing on non-alcoholic fatty liver disease, one of the most common forms of pre-existing liver disease, and testing new therapies to prevent or mitigate the damage these algal toxins can cause.

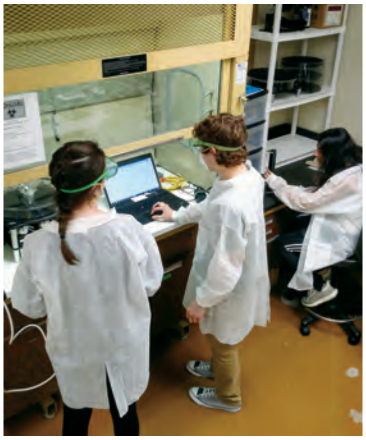
The scientists are using mice bred to exhibit pre-existing liver disease, and testing the effects of chronic microcystin exposure at levels well below those established as safe by the World Health Organization. They are also adding two different methods to block the inflammation and oxidative stress on liver cells that microcystin causes, including the use of a new laboratory-developed peptide. Peptides are small chains of amino acids, which in turn form the basis for larger protein molecules.

When completed, the project aims to define new guidelines for safe microcystin exposure in patients with pre-existing liver conditions, as well as develop new tests that can measure toxin exposure at very low levels. To date, studies of the inhibitor compounds indicate that there may be less damage from oxidative stress on mice treated with the lab-developed peptide. Those results may form the foundation for future research into use of this peptide inhibitor in a clinical setting.

THE BOTTOM LINE

Researchers are investigating the effects of low doses of microcystin on populations with pre-existing liver conditions, which have not been studied much in the past. They are also taking the first steps toward developing a treatment for the negative effects of this algal toxin on liver cells, with promising results in preliminary studies.

Pictured: Researchers are using a mouse model to study the impacts of algal toxins, which negatively affect the liver, on patients with pre-existing liver disease.



Examining Algae Impacts on Human Health

RESEARCH PROJECT TITLE:

High-throughput analysis of human toxicity and therapeutics targets of cyanotoxins across organ systems in health and disease

Principal Investigator: David Kennedy, The University of Toledo

PROJECT SUMMARY

Microcystin, the algal toxin produced by most Lake Erie harmful algal blooms, has been shown to negatively affect multiple organs such as the liver and intestines in humans and animals. However, its specific effects are not well studied, especially when considering that people can inhale these toxins as part of water spray as well as ingest them by drinking contaminated water.

Researchers are using two models to measure the impacts of microcystin: a set of human lung, liver, intestine and kidney cells collected from healthy and diseased patients, and a mouse model. A high-throughput approach to molecular genetics will identify microcystin toxicity in different organ systems, re-evaluate acceptable levels of the toxin in drinking water (currently set at 1.6 micrograms per liter for adults), and identify potential ways in which microcystin affects organs.

Pictured: Researchers are examining the effects of algal toxins on organ systems, along with ways to potentially reduce these negative impacts.

Results so far suggest that pre-existing disease, whether it's inflammatory bowel disease, diabetes or liver disease, can increase the negative effects of microcystin on cells and tissues. The researchers applied natural antioxidant enzymes during some of the experiments, which seemed to reduce cell damage.

Microcystin exposure at low levels also seemed to suppress common liver injury markers, suggesting that new approaches are needed to monitor liver damage in patients with potential exposure to this algal toxin.

The scientists continue to share data with other HABRI researchers, and have updated leadership at the Lucas County Health Department, the Ohio Department of Health and the Ohio EPA on their preliminary findings.

THE BOTTOM LINE

Researchers are examining the impacts of the algal toxin microcystin in human cells directly collected from patients, as well as in mouse models. Their findings so far suggest that pre-existing disease in the organs commonly affected by microcystin worsens the toxin's effects, but that certain antioxidant enzymes can lessen this impact.

How Does Exposure to the Algal Toxin Microcystin Affect the Development of Liver Cancer in Healthy and High-Risk Populations?

RESEARCH PROJECT TITLE:

Metabolomic biomarkers of acute and chronic cyanotoxin exposure during the promotion of hepatic carcinogenesis

Principal Investigator: Thomas Knobloch, The Ohio State University

PROJECT SUMMARY

Harmful algal blooms can release toxins that affect the liver, kidneys and heart, as well as the digestive and nervous system in people and animals. Exposure from drinking contaminated water is most common, and can be either chronic (drinking water that contains minute amounts of toxin daily over a long period) or acute (drinking water with high levels of toxin just once, such as when swimming in a contaminated lake).

In some cases, long-term and high doses of algal toxins can lead to an increased risk for liver cancer, but it's unknown how dosage and chronic or acute exposure affects that risk. Researchers are working to better understand the mechanisms of algal toxin damage, as well as whether dosage and timing of exposure changes those mechanisms.

Microcystins, the toxins produced by most Lake Erie harmful algal blooms, cause tissue damage in liver cells, which can turn into liver cancer with prolonged or concentrated exposure. This damage can exacerbate problems in patients with pre-existing liver disease. The researchers are using mice to mimic both short-term concentrated exposure to algal toxins, such as would happen on a weeklong vacation to a contaminated beach, and long-term exposure to levels generally considered safe to drink.

Results showed that liver damage in mice exposed to high doses of microcystin was higher the more toxin they had ingested. Other organs were also damaged. Unexpectedly, three of four mice that died early in the study were female, suggesting that although liver cancer is more common in men, acute impacts of algal toxins may be more severe in women.

The mice exposed to low levels of microcystins developed more pre-cancerous and liver tumors, especially in high-risk individuals with pre-existing liver disease. So while microcystin alone or in healthy individuals may not pose a significant health risk at low doses, exposure in high-risk populations can promote damaged liver cells to become cancer cells.

The researchers continue to study the mechanisms involved in producing this liver damage, in the hopes of eventually finding biomarkers that let them predict who may be at greatest risk for toxin-induced liver cancer before it develops.

THE BOTTOM LINE

Researchers are examining the impacts of microcystin exposure on the development of liver cancer. Results so far suggest that female mice may be more impacted by high doses of this algal toxin, while mice with pre-existing liver disease are more likely to develop liver cancer after long-term low-level exposure.

Improving Modeling Efforts to Reduce Nutrient Runoff

RESEARCH PROJECT TITLE:

Critical model improvements for simulating promising conservation actions for tile-drained fields in the Maumee River watershed

Principal Investigator: Margaret Kalcic, The Ohio State University

PROJECT SUMMARY

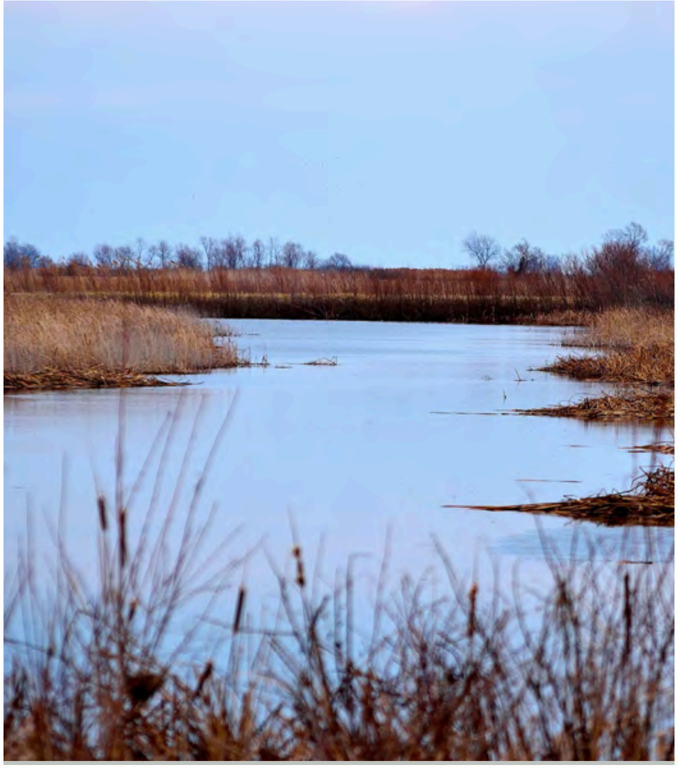
Hydrologic models, which simulate the flow of water throughout a watershed, are often used to inform conservation practices that could reduce nutrient runoff into Lake Erie. However, these models have limitations in how they represent certain aspects of the environment, and researchers are now working to change that.

So far, they have developed an improved method of assessing soil health practices like cover crops and no-till farming to provide a more accurate assessment of how much these practices reduce nutrient runoff into the lake. They have also used soil test phosphorus data to better represent the movement of this particular nutrient throughout the soil.

Once the improved model is finished and validated, it can offer a better picture of which conservation practices in the Lake Erie watershed are most likely to reduce the nutrient runoff that fuels harmful algal blooms, particularly in the western basin.

THE BOTTOM LINE

An improved hydrologic model of the Lake Erie watershed will help inform effective conservation practices that can reduce the nutrient runoff fueling harmful algal blooms.



Pictured: Researchers are developing computer models of water flow in western Lake Erie to help reduce agricultural runoff.

Storage and Treatment of Manure Can Impact Phosphorus Loss from Fertilized Fields

RESEARCH PROJECT TITLE:

Evaluation of the effects of changing on-farm manure management practices on reduction of dissolved phosphorus runoff

Principal Investigator: Harold Keener, The Ohio State University

PROJECT SUMMARY

Using manure as fertilizer on agricultural fields is a common practice, but has the potential to contribute to harmful algal blooms in Lake Erie and other Ohio lakes. These toxic blooms can cause health problems and negatively impact fishing and tourism, making them a concern for many state agencies and local communities.

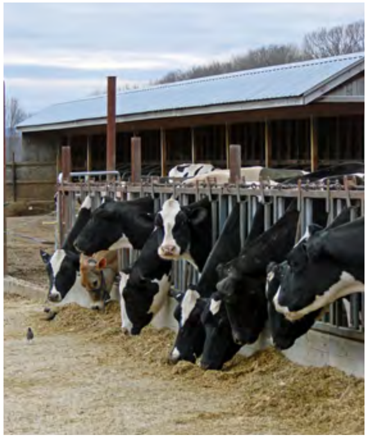
Previous research suggests that changes in manure storage on the farm, before it is applied to fields, affect how much of the nutrient phosphorus can dissolve out of the manure and run off the field unused. The researchers are now working to determine specific management practices that reduce this potential nutrient runoff, ranging from analyzing current manure characteristics at Ohio dairy, swine and poultry farms to modeling the impacts of suggested changes in manure storage and timing of application on phosphorus runoff.

So far, they have studied the effect of storage conditions on phosphorus in liquid dairy and swine manure, as well as in solid poultry manure. They have found that total phosphorus content in their samples decreased significantly from 2004 to 2018, possibly due to changes in animal feed, and that phosphorus concentrations are higher in the solid portion once manure is separated into liquids and solids. They also found that storing manure for 90 days significantly reduced soluble phosphorus in swine manure, and that high storage temperatures generally seem to help with phosphorus reduction.

Once the results are finalized, the scientists will work with farmers to present their findings and evaluate how willing farmers are to adopt new manure management practices.

THE BOTTOM LINE

Researchers are examining the impact of manure storage and application timing on phosphorus runoff from farm fields. The results will inform recommendations for new best management practices that allow farmers to continue to use manure as fertilizer while helping to protect Lake Erie from harmful algal blooms.



Modeling Manure Placement from Livestock Operations to Reduce Nutrient Runoff

RESEARCH PROJECT TITLE:

Spatial distribution model for manure from permitted CAFOs in the Maumee watershed, Ohio

Principal Investigator: Patrick Lawrence, The University of Toledo

PROJECT SUMMARY

Manure from concentrated animal feeding operations (CAFOs) is often used as fertilizer on agricultural fields. Transport from the manure lagoon to the fields is limited by permits, and more information is needed about the impacts of this manure fertilizer on the surrounding environment to determine which fields in the Maumee River watershed are best situated to receive this fertilizer.

Researchers are combining information from those state-issued permits on selected CAFOs with models of how manure is transported to get a better overall picture of where manure could be taken once it leaves the facility, where it is applied on fields, and where potential runoff during rainfall events may occur. This pilot project has potential to expand to other unpermitted livestock operations, including dairy and swine facilities to better understand the total amount of manure from all CAFOs within the Maumee watershed and where application should occur to reduce possible impacts to water systems.

Pictured: Researchers are modeling how manure fertilizer is used near livestock operations to determine how fertilizer could impact nutrient runoff into Lake Erie.

The overall aim of the project is to better inform farmers, management agencies and other stakeholders involved in CAFOs about how much manure is potentially applied on farmland in the Maumee watershed, and how that manure could affect the environment if it is applied in areas where flooding and runoff into streams could be a concern.

So far, the researchers have produced maps of farmland acres within 10 miles of each permitted facility where manure was applied to fields, which ranged from corn and soybean to wheat fields. This information will help with nutrient management in this largely agricultural watershed, which in turn could help reduce harmful algal blooms in Lake Erie that are fueled by nutrient runoff from the land.

THE BOTTOM LINE

Researchers are using computer modeling to simulate how application of manure from concentrated animal feeding operations in the Maumee watershed can impact nutrient runoff from farm fields.

Potential Impacts of Algal Toxins on Juvenile Lake Erie Sportfish

RESEARCH PROJECT TITLE:

Physiological, growth and survival response of age-0 yellow perch and walleye to toxic cyanobacteria

Principal Investigator: Stuart Ludsin, The Ohio State University

PROJECT SUMMARY

Microcystin, a liver toxin produced by many harmful algal blooms in Lake Erie, has been shown to directly affect sportfish like walleye and yellow perch, two important recreational and commercial fisheries in Ohio. Microcystin can impair development and growth in young fish, and ongoing research is now addressing both the indirect impacts of algal blooms on foraging and hunting behavior and the direct impacts of algal toxins on growth and reproduction.

The researchers are conducting laboratory experiments to determine the direct effects of microcystin on the physiology, growth and survival of juvenile walleye under controlled conditions, and combining that approach with measuring microcystin levels, stress markers, endocrine function and growth in wild-caught fish during and after the harmful algal bloom season. By combining these approaches, they can determine if young walleye are affected by naturally occurring cyanobacterial blooms, while ruling out other common natural stressors like food limitations or temperature extremes.

Preliminary results from the lab show that fish can accumulate toxins directly from the water and remove them from their bodies again within two weeks of exposure. Previous research has shown that fish accumulate toxins in the liver, not in muscle tissue, so the fish are safe to eat as long as consumption advisories from the Ohio EPA are followed.

Project findings will likely be used to give Lake Erie fisheries management agencies additional science-based insight into whether harmful algal blooms could be impacting walleye and yellow perch.

Collaborations with the Ohio Department of Natural Resources Division of Wildlife and the Ohio EPA continue from previous HABRI projects, and agency personnel helped procure both fish and water sample data for this study.

THE BOTTOM LINE

Researchers are studying the direct effects of microcystin, the toxin produced by most Lake Erie harmful algal blooms, on walleye and yellow perch. Results will shed additional light on the impacts the blooms have on Ohio's multi-million dollar sportfishing industry.

Developing a Better Kind of Manure Fertilizer

RESEARCH PROJECT TITLE:

Tracking and attenuating nutrient loads from manure fertilization

Principal Investigator: W. Robert Midden, Bowling Green State University
Partner: University of New Hampshire

PROJECT SUMMARY

Manure from concentrated animal feeding operations (CAFOs) can negatively impact water quality. If too much is applied to too little land, this can lead to relatively large amounts of nutrients in field runoff. The same manure can also be used as a beneficial agricultural fertilizer, but the cost of transporting it to fields is often high relative to its fertilizer value. Low-cost treatment systems that separate manure nutrients from wastewater and produce a dry product could reduce transportation cost by 20 to 40 times and create a product that releases nutrients more slowly into the soil, could enhance crop yield and improve water quality.

Researchers are working on developing such a treatment system, along with a way to trace nutrient runoff back to its source based on organic nitrogen and phosphorus compounds that are specific to where the runoff came from.

In the past year, they treated 3000 gallons of liquid manure from a dairy CAFO with a wastewater treatment coagulant that allowed them to separate solid and liquid manure components and ensure that nutrients remained in the solid portion. This treated manure was compared to raw manure by placing it on experimental farm fields, which were tilled to incorporate the fertilizer and then planted with soybeans. During this pilot test, water samples were collected during rain events and analyzed for agricultural nutrients.

Preliminary results show higher nutrient concentrations in runoff from plots fertilized with raw manure, compared to plots treated with the treated manure solids. Crop yields from both field types were similar, suggesting that plants can absorb nutrients from the treated manure as well as the raw manure. Overall, the treated manure seemed to have a positive impact on reducing agricultural nutrients in runoff from farm fields.

The researchers are continuing to study runoff to identify specific compounds present in each type of treatment, along with contaminants like hormones and antibiotics potentially present in manure from large animal operations in order to determine whether the treatment process can help prevent problems from these substances. They are also seeking additional funding to expand their experiments to manure from swine facilities and to test new polymers they have developed in the lab that offer performance advantages and possible cost savings.

THE BOTTOM LINE

Researchers are developing a low-cost treatment for manure from concentrated animal feeding operations to reduce nutrient runoff from fields fertilized with this manure and to improve its value as an agricultural fertilizer.

Photo credit: Bowling Green State University

Combining Technology and Interviews to Better Support Farmers in Managing Nutrient Runoff

RESEARCH PROJECT TITLE:

Effectiveness in implementation – mapping agricultural management practices, farmer perceptions and outcomes

Principal Investigators: Saatvika Rai & Kevin Czajkowski, The University of Toledo

Partner: The Ohio State University

PROJECT SUMMARY

Harmful algal blooms in Lake Erie have been connected to an increase in phosphorus runoff from agricultural fields, and current approaches emphasize best management practices (BMPs) that reduce that runoff. But despite the importance of these practices, understanding of their actual implementation in the field is limited.

Researchers are now implementing the first project of its kind of mapping agricultural practices in the Maumee River watershed, and to link farmer attitudes to BMP implementation. This detailed information could help ensure that resources and support focus on areas where they are likely to have the greatest impact.

Using remote sensing and geographic information systems, the researchers are mapping the location of implemented BMPs, and then comparing this information with survey data collected by researchers on a complementary project. The resulting maps identify concentrated areas of implementation as well as low-adoption areas. In-depth interviews with farmers in areas with few BMPs will help determine the reasons for variation in BMP implementation.

Results are aggregated by zip code to avoid identifying specific farms, but overall BMP implementation seems to be clustered north of Ft. Wayne, Ind., and around Lima, Ohio. County and state differences appear in the maps, suggesting the impact of regional and local policies regarding nutrient runoff.

The researchers are currently in the process of interviewing farmers, and expect more detailed results at the end of the funding period in 2020.

THE BOTTOM LINE

Researchers are using satellite and geographic information systems (GIS) to determine where best management practices to limit nutrient runoff into Lake Erie are concentrated. They will then interview farmers in areas of high and low implementation to determine what forms of support for BMP implementation have been successful, and where more emphasis on addressing problems is needed.

HARMFUL ALGAL BLOOM RESEARCH INITIATIVE

Year 4 Project Update to the
Ohio Department of Higher Education

OHSU-TB-1521

PRODUCED BY

Sea Grant
Ohio Sea Grant College Program

The Ohio State University

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