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Water Quality and Nutrient Management Extension Programs in Ohio

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Abstract: Extension has a long history of conducting educational programs for agricultural producers on a wide array of issues, including water quality. In Ohio, the focus of these educational efforts has grown to include best management practices for nutrient management. The need for education in nutrient management began in earnest in the 1970s due to the presence of harmful algal blooms (HAB) in the Western Lake Erie Basin. International actions taken during that time all but eliminated the HABs from the lake until they made a resurgence in the 1990s. Twenty years later, the HAB threat in Lake Erie is still present and has major implications for commerce, tourism, and human and environmental health. The HAB threat has spurred outcries from the general public, resulting in the creation of new laws by the Ohio Legislature, and an expanded and enhanced focus area for Ohio State University Extension (OSUE) programming. In this paper, we describe the conditions that have led to the development of the HAB in Lake Erie, the legislative action that has been taken in attempts to curb the problem, and the educational programs developed by OSUE in partnership with state agencies, non-government organizations, and other interested parties to address these water quality issues with Ohio agricultural producers and the general public.

Keywords: *Lake Erie, Harmful Algal Blooms (HAB), microcsystin, phosphorus, nitrogen, Ohio, extension*

Lake Erie is the shallowest, smallest by volume, and southernmost of the Laurentian Great Lakes (Millie et al. 2009). The lake is bounded by the Canadian Province of Ontario to the north and the US States of Michigan to the west, and Ohio, Pennsylvania and New York to the south and east. As with all the Great Lakes, Lake Erie is a vital source of drinking water, international and interstate commerce, recreation, tourism, and industry for the nearly 12 million residents living near the lake. Because of its relatively small size and shallow depth, Lake Erie is more susceptible to disturbance due to natural and human influences than the other Great Lakes (Millie et al. 2009).

The lake has experienced significant nutrient loading, especially phosphorus, from a number of point and non-point sources for most of the 20th century. Excessive loading of nutrients in agricultural run-off has long been associated with a myriad of water quality issues around the world, including the Great Lakes region (Makarewicz 1993). In the Great Lakes region, Lake Erie has consistently been the most affected by excessive nutrient loading (Baker 1985) with excessive phosphorus and nitrogen in run-off waters cited as the most damaging (Forster and Rausch, 2002; Richards et al. 2013). Since phosphorus is the primary limiting nutrient for harmful algal bloom (HAB) development, the cumulative addition of phosphorus over time has enhanced the development of HABs and significantly impaired the water quality of the lake (Bertram 1993; Taft 1945). HABs create taste and odor problems

within the water, degrade overall environmental quality, and make the lake less aesthetically pleasing. In addition, certain HAB species release toxins in the water, which pose a significant health hazard to humans and wildlife (Dove and Chapra 2015).

To address these issues, an international commission was formed in the 1970s to develop and implement strategies for reducing nutrient loading in the lake. These strategies included upgrading municipal water treatment systems, reducing the phosphorus content of soaps, detergents, and lawn fertilizers, and promoting agricultural practices that reduced tillage and increased residue cover. These actions resulted in a decrease in phosphorus runoff into Lake Erie, and for a time, a cessation of HAB formation (Chesters et al. 1980).

HABs appeared again in Lake Erie in the 1990s. Causes cited for this resurgence included increased nutrient loading from point and non-point sources, and a warming of the lake (Baker 1992; Millie et al. 2009). Zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*) were also found in Lake Erie during this time. These mussels are non-native invasive species brought into Lake Erie through the ballast of ocean going ships. These invasive mussels have caused numerous environmental problems in the Lake, including changes in the trophic structure of the lake and a clarification of the water column (Holland 1993). This clarification is allowing sunlight to penetrate deeper, and is believed to be contributing to the resurgence of HABs (Wynne et al. 2010).

HABs are scums of green algae which form on the surface to a depth of 2-3 feet and can produce the toxin microcsystin. When present in large enough quantities, microcsystin can cause significant human and environmental health problems (Millie et al. 2009). HABs are considered to be one of the most significant issues threatening water quality in the Great Lakes Basin, and Lake Erie in particular (Dove and Chapra 2015). The potential damage HABs can cause was highlighted on August 4, 2014. On this date, the close proximity of HABs to the city of Toledo water intake facilities resulted in microcsystin levels exceeding the 1 ppm threshold for safe drinking water set by the U.S. Environmental Protection Agency. This threshold, combined with the outdated city water intake and treatment system, shutdown Toledo's water supply to over 400,000 residents. This shutdown lasted for 50 hours, and drew the world's attention to the water quality problems in Lake Erie, and by extension the entire Great Lakes basin, like no other event. Public outcry concerning the presence of HABs and their perceived causes have been increasing over time, and reached a crescendo with the Toledo water crisis (Richards et al. 2002).

Legislative Response

The Ohio Legislature, in response to increased pressure from the public and the federal government, passed legislation in 2014 and 2015 in an attempt to reduce the causes and subsequent severity of the HABs.

In the fall of 2013, legislation was crafted to reduce nutrient inputs into Ohio's waterways. Senate Bill 150 was passed in the spring of 2014, and went into effect on August 22 of the same year. The bill mandates that agricultural producers who apply fertilizer to 50 or more acres of agricultural crop production be certified and keep records of all fertilizer applications. The law created a fertilizer applicator certification program to educate producers on the time, place, form, amount, handling and application of fertilizer along with the impact of nutrient loss on water quality. The bill serves as a component of a state level nutrient reduction strategy addressing all sources of relevant nutrients, and supports generally practical and economically feasible best management practices. The goal of this certification is to provide agricultural producers with a fundamental understanding of soil and fertilizer interactions and related best management practices to help them apply fertilizers in a more judicious manner.

The Ohio Department of Agriculture (ODA) was tasked by the legislature with implementing SB 150. ODA in turn contracted with OSUE to develop what has become Fertilizer Applicator Certification Training (FACT). FACT was scheduled to begin in December of 2014 in conjunction with Pesticide Applicator Training (PAT). Producers will have until September 30, 2017 to obtain certification. After the initial

certification, producers will be required to attend a two-hour recertification program every three years. OSUE will be the exclusive provider of certification training through the first three-year cycle. As per SB 150, this first round of FACT training will be conducted at no cost to those attending.

The Ohio Legislature in 2015 passed additional legislation in the form of Senate Bill 1. The intent of this legislation is to control algae production in the Western Lake Erie Basin through the regulation of phosphorus and nitrogen fertilizer along with manure applications. Under this law, a person may not apply fertilizer under the following conditions: 1) on snow-covered or frozen soil; 2) When the top two inches of soil are saturated from precipitation; or 3) when the local weather forecast for the application area contains greater than a 50% chance of precipitation exceeding one inch in a twelve-hour period. These rules don't apply if the fertilizer is injected into the ground, incorporated into the soil within 24 hours of application, or applied onto a growing crop. For manure applications, items one and two above apply. However, manure should not be applied when the 24-hour weather forecast exceeds 0.5 inches of rain in the application area. The law also requires that anyone applying manure from an ODA permitted animal facility to more than 50 acres in agricultural production be certified through the FACT program, or through the ODA Certified Livestock Manager Program. The effective date of this new law was July 3, 2015.

OSU Response

Extension has a long history of conducting educational programs in the areas of nutrient management and water quality (Laughlin et al. 2004; Londo 2004; Vaughn 1989). Since one of the major land uses in Ohio is in agricultural production, it is appropriate that these educational programs have been focused on best management practices for nutrient management, soil drainage, and erosion reduction on agricultural lands (Christianson & Tyndall 2011; Richards et al. 2002). However, the current issues in Lake Erie have gone beyond traditional extension and research activities. To address the complex legislative, environmental, and general public concerns associated with Lake Erie, OSU developed an innovative and more comprehensive approach.

Nutrient Management for Water Quality Signature Program

Signature programs are a cornerstone of the OSUE strategic plan. They are interdisciplinary in nature, including participation of all extension programming areas, are supported by focused marketing and promotion, and are replicable across the state. The Nutrient Stewardship for Cleaner Water Signature Program is designed to improve water quality by helping agricultural producers efficiently use nitrogen and phosphorus. By keeping more of these nutrients on the field, producers should experience increased crop yields, farm profits, and cleaner water. The signature program team is composed of county extension educators, field specialists, state specialists, and program coordinators from across OSUE. The programs conducted under the signature program include Fertilizer Applicator Certification Training (FACT), on-farm research, Certified Crop Adviser (CCA) training, and the manure science review. OSUE has also been part of a regional group that has developed a voluntary third party audit process for Nutrient Service Providers resulting in 4R Nutrient Stewardship Certified Facilities. Nutrient service providers are those that provide soil sampling, recommendation and application services to farmers. We just completed the first year of the signature program with another 2.5 years remaining. Evaluation of the program as a whole will be done through the summarization of the impacts of the component programs with a final report submitted to OSUE administration.

FACT Training

Beginning in late spring of 2014, OSUE state and field specialists started developing the curriculum for the three-hour FACT training with significant input from county educators as well as OSUE pesticide safety educators. The FACT training was developed to meet the requirements set forth in Senate Bill 150. Given past experience in developing certification training programs, the pesticide safety education program was selected

to administer the FACT training program.

The curriculum modules are focused on four areas: understanding the certification process, water quality effects of N & P from agriculture, phosphorus management, and nitrogen management. In addition, yield response and cost information were tied together with water quality impacts to ensure agricultural sustainability. FACT products included presentations which were shared with county educators and program staff, plus a workbook for program participants containing exercises and material that could be reviewed at home. An evaluation tool and the Agricultural Fertilizer Applicator Certification Manual were developed to be used in training programs. The evaluation asked a number of typical extension program evaluation questions used for reporting purposes. In addition, there were also questions about producer awareness of the role of agriculture in the state's water quality issues. During 2014-2015, nearly 7,000 participants attended the FACT training programs held across the state.

Since FACT was conducted at the county level, a full-day in-service for OSUE county Agriculture and Natural Resources (ANR) educators was held in November of 2014. A goal of this in-service was to introduce the FACT curriculum, manual, and evaluation tool to the educators. In addition, the in-service provided an opportunity to ensure that county educators had the basic knowledge of soil science, fertility, and agronomy needed to conduct the training.

A de-centralized approach was taken to planning the FACT programs, with educators in each of the nine OSUE Extension Education and Research Areas (EERA) determining the number and timing of certification meetings for their area. The EERAs are geographically similar areas of the state containing 8-10 counties each. ANR Educators within each EERA work together to conduct a wide variety of training programs, including FACT. FACT programs were scheduled to begin in December of 2014; however, in response to the August water crisis in Toledo, trainings in the Western Lake Erie Basin started in September of 2014, three months ahead of schedule.

This training was provided on a county by county basis by local ANR educators and state and field specialists in agronomy and soil fertility. FACT training was conducted in conjunction with the annual Pesticide Applicator Training (PAT) held in each county. PAT is a three hour program, typically conducted in a county extension office. The cost for the three hour PAT training is $35 per person. Due to some similarities in training material, those who were renewing their PAT certification could take the FACT training for an additional two hours at no cost. Those without PAT certification were required to attend a three hour stand-alone session. Again, there was no charge for the 3 hour stand-alone programs. Funds to cover costs associated with conducting the FACT trainings were provided by the Ohio Department of Agriculture (ODA) and the Ohio Farm Bureau. Participant certification is provided by the ODA and is based on completion of the program only, no exam is required. Certification is valid for three years. Recertification requires two additional hours of approved continuing education credits obtained every three years. It is anticipated that recertification will also be free of charge.

First year results of the training from September 2014 through April 2015 show a total of 6,985 individuals were trained at 110 events held across Ohio. The largest concentration of participants was from NW Ohio counties in the Lake Erie Basin. Of all attendees, 2,074 program evaluations were collected immediately following the training, representing a 30% return rate. Most respondents reported they understood that most of the phosphorus entering the Lake Erie Basin is from agricultural operations, and that they need to be part of the solution. Future surveys will be distributed via email to determine longer term results of the FACT training. Of particular interest is a measure of behavior change in farmers. We want to know what steps have they taken, as a result of the training, to reduce nutrient loss from their land and the economic effects of those changes.

On-Farm Research

University based recommendations take into consideration production risk, input cost and off site concerns providing a foundation for farmers to invest in utilizing best management practices recommendations on their farm. Extension professionals have traditionally worked with farmers in their communities to adapt statewide

recommendations to local systems. Participating farmers have data they can use directly based on their operation and resources. These data can then be used more broadly to test the statewide recommendations in different environments.

Ohio nutrient recommendations are based on the joint efforts of The Ohio State University, Michigan State University, and Purdue University. The Tri-State Fertilizer Recommendations for Corn, Soybean, Wheat and Alfalfa Production were originally published in 1995. Small, on-farm research projects conducted throughout the years have improved these recommendations. Recent off-site concerns about nutrients, especially phosphorus in Lake Erie and nitrogen in the Gulf of Mexico, along with changes in crop production and weather conditions have led to a three year project beginning in 2015 to evaluate N, P and K recommendations for corn, soybean and wheat production. The project combines both small plot and on-farm evaluations of all three nutrients. Factors examined include application sources and rates, crop productivity, and nutrient content of water leaving these fields. These results will be used to evaluate the economic and environmental impacts of agricultural nutrient additions in the tri-state area. Ultimately, we hope to be able to help farmers better develop specific nutrient management strategies for their farms that maximize productivity and environmental benefits simultaneously. As appropriate, these results will also be used to update the tri-state recommendations.

4R Nutrient Stewardship Certification

The 4R Nutrient Stewardship Certification Program was developed out of discussions between agriculture retailers and non-governmental organizations in Northwest Ohio. The idea of the program was to acknowledge retailers applying best management practices in making nutrient rate, timing, placement, and source recommendations for their clientele. OSUE provided the expertise to ensure the guidelines developed for the 4R program were non-biased and science based, while still meeting the needs of individual farmers.

Through this program retailers prove, by means of a third party audit, that the following are included in recommendations and applications they make:

- Recommendations based on the tri-state nutrient guide.
- Consideration of all nutrient sources being applied to the field whether purchased through the nutrient stewardship program or brought into the operation such as organic materials.
- Recognition of sensitive areas when making recommendations and applications.

A total of 41 criteria are evaluated in the 3 year cycle of initial certification. The program is administered by the Ohio Agribusiness Association, with a governing body made up of the initial organizers. Plans exist to expand the program from the initial target areas of the Western Lake Erie Basin, which includes parts of Ohio, Indiana and Michigan, into the portion of Ohio that includes the Ohio River Watershed. Program criteria can be found at http://4rcertified.org/.

Certified Crop Adviser Training

An additional step OSUE has taken to deliver best management practices for the needs of northwest Ohio producers is to provide non-biased information and training to Certified Crop Advisers (CCA). The CCA program was initiated by the American Society of Agronomy (ASA) in 1992 to ensure that practicing agronomy professionals in the United States and Canada meet the professional standards established by the ASA. Certification requirements include an agronomy-related associate degree with three years of experience, a bachelor's degree in an agronomy-related field with two years of experience, or four years of experience with no degree. Once certified, 40 hours of continuing education every two years are required to maintain the certification.

One example of a CCA continuing education program focusing on nutrient management is the Conservation Tillage Conference (CTC). CTC is a two-day event held every March highlighting nutrient, soil, and water management topics for CCA continuing education credits. CTC is organized and taught by state and field specialists, county ANR educators, and state and federal agency collaborators. Annually, there are approximately 300-400 CCAs in attendance for the two day program. These CCAs consult on approximately 85% of Ohio's 14 million agronomic crop acres.

Evaluations collected at the conclusion of the conference indicate that the CCAs use the information they receive at the conference when developing cropping and fertilizer plans for their clients. Continuing educating programs such as this are essential train-the-trainer type events, allowing OSUE to expand the reach of our training efforts across many more acres than we could have ever done on our own.

Manure Science Review

OSUE conducts the Manure Science Review, an annual educational program, to share cutting-edge manure management information with livestock producers, CCAs, and certified livestock managers across Ohio. The event is held in a county location and rotated around the state each year to reach new audiences. The program consists of morning indoor educational sessions and afternoon field demonstrations. New extension research is presented concerning the use of livestock manure as a fertilizer, new manure application equipment, and practical interpretation of recent nutrient management legislation. Annual attendance is approximately 175 participants with training conducted by state and field specialists and county ANR educators. Evaluations for this program are collected at the end of the program.

Field to Faucet

In September of 2014, the Dean of the College of Food, Agriculture, and Environmental Sciences (CFAES) at The Ohio State University announced a water quality initiative called Field to Faucet. This initiative provides funding for research projects, training, and education efforts designed to ensure safe drinking water while also maintaining an economically productive agricultural sector in Ohio. Field to Faucet is a consortium of universities, state and federal agencies, and private companies from across Ohio. Initial funding for this initiative is $5.7 million, provided by CFAES and other partners. To date, there have been 23 research projects covering both applied and more basic water quality research. Some preliminary data generated from these projects has been incorporated in the extension programs discussed earlier. In the future, we look forward to the funding of additional applied research and extension projects through this initiative.

Summary and Conclusions

Degradations in Lake Erie water quality have been occurring for decades. This decline in water quality is due to a number of factors, but nutrient and sediment loading in surface waters driven by agricultural land use is believed to be the main contributor (Christianson & Tyndall 2011). Compliance with existing and new water quality regulations will be one of the major policy and on-the-ground practice challenges faced by agricultural producers in this region for years to come (Welch and Braunworth 2010). More broadly speaking, farmers are also expected to be stewards of our collective natural resource base in the U.S. The dominant land use in Ohio is agriculture, with over 76,000 farms occupying some 14 million acres statewide. Therefore the capacity to prevent and/or mitigate water quality impacts while also addressing other environmental issues of concern is largely dependent on environmentally focused management by the thousands of farmers across the state (Swinton et al. 2007). Assisting farmers in complying with water quality regulations or enacting voluntary measures on farms in order to proactively address water quality impacts will continue to be an important and growing role for Extension (Tyndall and Roesch 2014).

Extension programs have long focused on water issues (Londo 2004). These traditional extension educational programs are no longer sufficient to address the complex legislative and ecological issues surrounding water quality in Lake Erie. OSUE has developed a more comprehensive and unified approach to better addresses these complex issues.

This approach includes the development of a new OSUE signature program which serves as the umbrella program for a number of OSUE water quality programs. These programs are taught by OSUE state and field specialists, county ANR educators, partners from state and federal agencies, and other interested parties in the state. The signature program approach is designed to provide consistency in message and content across all related programs.

On-farm research looking into nutrient best management practices, including fertilizer application rates and water control structures, is being conducted across Ohio. These research results are being incorporated into the educational programs, extension fact sheets, and other outlets. We provide continuing education credits to CCAs in all areas of nutrient management and quality, utilizing the on-farm research results as they become available. This ensures the information CCA students are receiving is non-biased and accurate, and expands the reach of OSUE training by allowing CCAs to apply their newly gained knowledge on the millions of acres they help manage across Ohio.

Lastly, the Field to Faucet initiative is bringing together university, government, and private partners to conduct coordinated research geared towards resolving water quality issues in Lake Erie. Future funding from this initiative will go to supporting existing and developing new and innovative extension nutrient and water quality programs.

The water quality issues plaguing Lake Erie did not occur overnight, and will not be solved overnight. Given that agriculture is the leading land use in the region, it is appropriate that agricultural producers are being targeted for nutrient management education. However, there are millions of non-agricultural acres that are also contributing to the overall nutrient loading in the lake. If we are to truly address the problems in Lake Erie, all stakeholders need to be involved. The OSUE approach to extension water quality education has focused on the agriculture sector, but future additional programming intends to be as comprehensive and inclusive as possible in regards to partners and clientele. The ultimate impact of these programs will be shown through measured improvements in the quality of water entering into, and residing in, Lake Erie.

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