Environment and resources

FROM LAKE ERIE TO THE OHIO RIVER: A SUMMARY OF NUTRIENT LOSS IMPACTS IN OHIO

Harold D. Watters, Amanda Douridas, Chris Bruynis
Ohio State University Extension

Chris Bruynis
Bruynis.1@osu.edu
740-702-3200
475 Western Ave, Suite F
Chillicothe, OH 45601

Words in article: 2,414

Academic

This work is all original research carried out by the authors.

FROM LAKE ERIE TO THE OHIO RIVER: A SUMMARY OF NUTRIENT LOSS IMPACTS IN OHIO

Abstract

Ohio residents have been calling for changes in agricultural practices since harmful algal blooms have disrupted recreational use of lakes and drinking water supplies in the Western Lake Erie Basin. These blooms are a result of phosphorus (P) loading into waterways from a number of sources, including agriculture fertilizer and manure use on fields. P loss only accounts for about 0.49 lb/A but equates to roughly 2 million pounds of P each year being dumped into the Basin. Regulations have been put in place to educate farmers on nutrient management and reduce nutrient losses. Three tools have been updated and developed to help farmers reduce P losses: 1.) Updated Tri-State Fertilizer Recommendations, 2.) Updated Ohio Phosphorus Risk Index tool, 3.) Field Application Resource Monitor. These tools address the source, rate and timing of nutrient applications. The cost of implementing these practices varies from farm to farm. Some farms may see no change to their budgets where other farms may see an increase in expenses.

Keywords: phosphorus, nutrients, HABs, management, BMPs

Introduction

The noticeable start of the problem for most people was in 2011. A very wet spring, then warm June led to a massive algal bloom on Lake Erie (Erickson 2013). The truth is a change in public perception had started before that record setting algal bloom on Lake Erie, when Grand Lake St. Marys was designated a distressed watershed in January 2011 after two years of troublesome algae blooms that impacted the lake (Ohio Department of Agriculture 2018). In June 2013 the Ohio EPA published its Nutrient Reduction Strategy to reduce loss of nutrients from point and non-point sources (Ohio EPA, Ohio Department of Agriculture, Ohio Department of Natural Resources 2013); productive agricultural lands and farm fertilizer are implicated in the increasing algal blooms that seem to occur more often. In August of 2014, the city of Toledo in Ohio posted a "Do not drink advisory" when algal blooms floated over the city water intake in Lake Erie (Dungjen and Patch 2014). Do not drink advisories are posted at 20 micrograms/liter (Ohio EPA n.d.). Smaller lakes around the state have been affected too. In 2015 we seemed to hit a high point when more than two dozen sites had Microcystin levels above 20 micrograms/liter (Ohio EPA n.d.) including a harmful algal bloom 1070 km [670 miles] in length on the Ohio River (Youngstrom and Emery n.d). Announced in February 2015, the U.S. EPA's Hypoxia Task Force set an interim target of 20% reduction of nitrogen (N) and phosphorus (P) loading to the Gulf of Mexico by 2025 (Mississippi River Gulf 2014), with a long term goal toward reducing the hypoxia area to less than 5,000 square kilometers by 2035 (EPA 2015). In 2016 the U.S. and Canada came to an agreement to reduce the phosphorus in Lake Erie by 40% in an effort to reduce the size of the HAB and cyanotoxin levels in the water (Factsheet: U.S. 2018).

Material Studied/Area Description

From large scale reports, it appears row-crop agriculture and non-point source pollution is involved in the nutrient loss into Ohio water problems. Kevin King of USDA's Agricultural Research Service in Ohio presented the results of a several year study to determine nutrient loss at the edge of field (King n.d.) At roughly 0.56 kg/ha [0.49 pound per acre], it does not seem like much but adds up when concentrated into a body of water. From some back of envelope estimates for Lake Erie, this 0.56 k/ha [0.49 lb/A] equates to roughly 907 metric tons [2 million lbs] of P each year being dumped into the western basin where the most severe algal blooms occur. This provides enough phosphorus to encourage excessive algal growth.

Farmers have gotten the message from training delivered by Ohio State University Extension (Londo et al 2015); they have also heard the public outcry from media sources, that agriculture is a large part of the problem. As of the end of the preliminary education and certification period in September 2017, approximately 17,500 fertilizer applicators have been trained by Ohio State University personnel across 88 counties in approximately 300 meetings over three years. A training manual was developed for use, along with a slide set for county educators to deliver the message that excess nutrients are polluting Ohio waters and that agriculture is involved. Robyn Wilson, of Ohio State University, reports in her survey report that farmers want to improve the water quality that leaves their farm (Burnett 2015). She also reports that there is great likelihood that farmers will adopt best management practices to reduce nutrient loss.

Another sure way to attract the attention of farmers is to put laws into effect. Senate Bill 150 of 2014 brought about the first fertilizer application law for Ohio (Ohio Revised Code 2014). This law and the related rules from the Ohio Department of Agriculture that require anyone who applies fertilizer to 20 hectares (50 acres) or more be certified (Ohio Department of Agriculture 2018). This was followed in 2015 with the first law in Ohio to restrict applications of nutrients at certain times of the year and by weather forecast (Ohio Revised Code 2015). In the summer of 2018, Ohio Governor John Kasich, signed an executive order seeking to declare eight watersheds in northwest Ohio to be distressed (Kasich 2018). Designation as a distressed watershed requires specific actions by producers in those designated watersheds, at what is predicted to be a significant cost. It remains to be seen if the request made in the Executive Order is put into place by the Soil and Water Commission and whether the current distressed watershed rules are to be followed (Hall 2018).

Results

Best Management Practices (BMPs) to reduce loss of nutrients are many and can vary from very effective to non-effective. Costs are also wide ranging from soil testing at perhaps $25 USD per hectare up to land construction practices that may cost tens of thousands of dollars. A simple and effective Nutrient Management Plan has a cost range of $500 to $10,000 per farm (LaBarge et al 2018). A summary report of Ohio State University research that will aid in reducing the problem is in final review, but three tools have recently been developed that can quickly be presented to growers and their advisers to begin changes to reduce nutrient loss. They are: 1.) Updated Tri-State Fertilizer Recommendations, 2.) Updated Ohio Phosphorus Risk Index tool, 3.) Field Application Resource Monitor (F.A.R.M.) (FARM n.d.).

One call that came early was the need to update university fertilizer recommendations. One side felt they were too high, allowing excessive nutrients to be applied and the other thought they were too low, bringing risk of yield loss. Since the 2014 field season with grants from Ohio's commodity groups – the Ohio Corn & Wheat Growers, and the Ohio Soybean Council – more than 200 on-farm trials have been conducted (Soil Fertility n.d.). With the associated sampling, replications and multiple analyses, thousands of data points have been generated. Some items that came out of the work were: 1) when soils are in the maintenance range for P & K, meaning above the critical point and below the application cut-off point, it is rare to have a yield loss due to nutrient availability, 2) crop removal rates are lower than predicted with the 1995 Tri-State Fertilizer Recommendations (Vitosh 1995). The updated Tri-State Fertilizer Recommendations will address these changes.

The next concern for nutrient loss was the need to update the Ohio Phosphorus Risk Index (P-Index). The P-Index gives an approximation of the risk from any specific field for phosphorus movement (On-Field Ohio! n.d.). The update is based on research work conducted across Ohio at 29 paired field locations. The update uses real data and provides a quantitative estimate of that nutrient loss. Scenarios across management practices can be compared for P loss, however, no economic risk information is shared with the tool. While there is a goal to reduce P losses by 40% or more, some expect an unbearable economic cost to producers while commodity prices are at their lowest in several years.

Last but not least is the weather impact that can occur when applications are made into significant weather events – specifically, high rainfall amounts of short duration (Ohio EPA 2010). With this influence on rain events and risk on nutrient movement, the law and regulations specify conditions under which you may not apply fertilizer or manure (Ohio Revised Code 2015). Along with those regulations came a requirement to record a 48-hour weather forecast along with the application records. Educators suggested farmers get this forecast from the National Weather Service, and several saw that the development of an application may make finding that forecast and keeping those records easier. One application that is field-specific and provides a forecast is the Field Application Resource Monitor (F.A.R.M.) (FARM n.d.). The application can also provide a forecast from the past for those who may have been a bit rushed when applying their fertilizer or manure, but forgot to print the forecast.

Discussion

Together these three tools can help make and document management changes that can reduce the nutrient loss problems. But what are the costs?

For fertilizer applications, when soil tests are in the maintenance range, we recommend application at crop removal rates of P_2O_5 and K_2O. A comparison of the newly determined crop removal rates, compared to the 1995 removal rates show we can reduce fertilizer costs (or manure application rates). Table 1 shows comparisons at yield goals of 12.55 metric tons per hectare [200 bushels per acre corn], 4.2 t/ha [67 bu/A] soybean and 6.68 t/ha [100 bu/A] of wheat in a three-crop rotation.

Table 1. Crop removal replacement rates kg/ha [pounds/acre] for corn, soybean, and wheat for Ohio.

Crop	New 2018 Recommendations		1995 Tri-State Recommendations	
	P_2O_5	K_2O	P_2O_5	K_2O
Corn – 12.55 t/ha [200 bu/A]	78.46 [70]	44.83 [40]	82.94 [74]	60.53 [54]
Soybean - 4.2 t/ha [67 bu/A]	59.41 [53]	85.18 [76]	60.53 [54]	105.39 [94]
Wheat - 6.68 t/ha [100 bu/A]	48.2 [43]	23.54 [21]	75.1 [67]	41.47 [37]
Three-year rotation needs Percent reduction (%)	186.06 [166] 15%	153.56 [137] 26%	218.57 [195]	207.36 [185]

The reduction of 15% and 26% for P_2O_5 and K_2O in fertilizer replacement may help offset the anticipated increase in costs to change management practices and equipment.

Utilizing the P-Index tool, comparisons between nutrient and soil loss can be made directly between cropping systems. Economic comparisons can then be made to understand savings or expenses associated with practices involved. A comparison between two crop management systems (CMS) is provided as an example (Dayton n.d.). CMS A conducts fall chisel, spring disk operations and runs the field cultivator ahead of planting corn, then planting soybeans in no-till. CMS B is a strictly no-till system. On a Blount Silt Loam with a 3% slope, erosion is reduced by 80.5% when moving from CMS A to CMS B. The cost of erosion in the U.S. was estimated at $2.11-12.58 USD per metric ton of eroded soil in 2004 (Tegtmeier and Duffy 2004). With a potential reduction in soil erosion from 4.94 t/ha/yr [2.2 US tons/A/yr] to 0.96 t/ha/yr [0.43 US ton/A/yr], this could be reduction in impact of $10.37-61.16 USD/ha [$4.20-24.76/A USD].

Runoff of P was reduced by 71% when going from CMS A to CMS B. According to the 2012 United States Department of Agriculture (USDA) Census, there were 979,972 hectares [2,421,563 acres] under conventional tillage practices in Ohio (USDA n.d.). This category most closely matches our CMS A. If we make a conservative assumption that these acres fall within the 15 mg/kg soil test P category and lose 1.23 kg/ha [1.1 lb/A] P through surface runoff, a 71% reduction in runoff through those acres converting to CMS B would result in an almost 858 metric tons [1.9 million pounds] reduction in P runoff.

The farm economics of CMS A and CMS B vary widely depending on the field. In 2016, Ibendahl found that no-till farmers had higher machinery and fertilizer expenses than tillage farmers but they also had higher profits. In another study, yields under no-till were found to drop in the first two years after implementation (Pittelkow et al 2015). These negative effects decreased over time for all crops in the study except corn which saw a 7.6% yield decrease over conventional tillage where legumes (soybeans) saw no difference. Taking the 2017 state yield of 11.10 t/ha [177 bu/A] (Great Lakes Region 2018) and decreasing it by 7.6% would result in a 0.85 t/ha [13.5 bu/ac] loss. At $3.50USD corn, that is a reduction in profit of $116.71/ha [$47.25/A]. In some cases, implementing no-till would decrease farm profitability.

Going from a soil test level of 15 mg/kg to 150 mg/kg, there is a 9-fold increase in surface dissolved P runoff. Reducing or eliminating P applications to soils above recommended rates will have a cost savings for farmers and decrease P runoff. This may be offset somewhat by the expense of soil sampling. Soil sampling in Ohio averages $15.85USD/ha [$6.40 per acre] (Ward and Barker 2018). In the 2017 Ohio Farm Business Summary, of the 20 farms analyzed, the average fertilizer expense was $308.63/ha [$124.95/A]. This includes all fertilizer sources. In the 2019 Corn Production Budget (Ward 2018), $284.96/ha [$115.37/A] was budgeted for fertilizer at an expected yield of 10.48 t/ha [167 bu/A] with $78.32/ha [$31.71/A] of that being specifically for P_2O_5. Costs will vary depending on current farm practices. Some may see no additional expenses while others may need to change their entire farming system approach leading to the purchase of new equipment.

Since 1951, the city of Toledo saw a 41% increase in the heaviest 1% of precipitation events (Climate Center 2016). About 80-90% of phosphorus loading into waters occurs during heavy rain storms (Ohio Sea Grant n.d.). If nutrient applicators are able to utilize the F.A.R.M. application to better predict when runoff events are likely to occur, nutrient applications ahead of those events can be reduced. This, in turn, will reduce phosphorus loading.

Conclusion

Agriculture is under pressure from the public to reduce nutrient loss. The updated Tri-State Fertilizer recommendations and P-Index, along with the F.A.R.M. application are excellent tools to guide farm managers in reducing nutrient runoff from their fields. The costs associated with this will vary widely depending on the specifics of each farm. For most, there are cost effective solutions available that will impact farm budgets minimally or potentially save money. Continued education efforts are needed to increase awareness of nutrient reducing strategies enabling farmers to choose from a range of practices, deciding which works best for their farm. Solving this issue will not happen quickly and more regulation may only add to decreased profitability for farmers.

Reference List

Erickson, J 2013, *Record-breaking 2011 Lake Erie algae bloom may be sign of things to come.* Available from: https://research.noaa.gov/article/ArtMID/587/ArticleID/1529/Record-breaking-2011-Lake-Erie-algae-bloom-may-be-sign-of-things-to-come. [11 November 2018]

Ohio Department of Agriculture 2018, *Grand Lake Saint Marys - Watershed in Distress.* Available from: https://agri.ohio.gov/wps/portal/gov/oda/divisions/soil-and-water-conservation/resources/grand-lake-saint-marys/. [11 November 2018]

Ohio EPA, Ohio Department of Agriculture, Ohio Department of Natural Resources 2013, *Ohio Nutrient Reduction Strategy.* Available from: https://epa.ohio.gov/Portals/35/wqs/ONRS_final_jun13.pdf. [11 November 2018]

Dungjen, T & Patch, D 2014, *Toledo-area water advisory expected to continue through Sunday as leaders await tests; water stations to remain open.* Available from: https://www.toledoblade.com/local/2014/08/02/City-of-Toledo-issues-do-no-drink-water-advisery.html. [11 November 2018]

Ohio EPA n.d., *Harmful Algal Blooms: Public Water System and other Ohio EPA Surface Water Monitoring.* Available from: http://wwwapp.epa.ohio.gov/gis/mapportal/HAB_Monitoring.html. [11 November 2018]

Youngstrom, G & Emery, E n.d., '2015 Ohio River HAB Event' *The Blade,* 2 August. Available from: https://www.epa.gov/sites/production/files/2015-11/documents/ohio-river-hab-2015.pdf. [11 November 2018]

Mississippi River Gulf of Mexico Watershed Nutrient Task Force New Goal Framework 2014. Available from: https://www.epa.gov/sites/production/files/2015-07/documents/htf-goals-framework-2015.pdf. [11 November 2018]

EPA 2015, *Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2015 Report to Congress.* Available from: https://www.epa.gov/sites/production/files/2015-10/documents/htf_report_to_congress_final_-_10.1.15.pdf. [11 November 2018]

Factsheet: U.S. Action Plan for Lake Erie 2018. Available from: https://www.epa.gov/sites/production/files/2018-03/documents/lake_erie_action_plan_fact_sheet_-_march_1_2018.pdf. [11 November 2018]

King, K n.d., *Using Edge of Field Research to Assess Agricultural Management Practices*, PowerPoint Presentation. Available from: https://ncwqr.files.wordpress.com/2017/06/king-heidelberg-3-9-2017-edge-of-field.pdf. [11 November 2018]

Londo, AJ, LaBarge, G, Watters, H, Culman, SW, Rose, MA, Hall, P, Arnold, G, Custer, S, Richer, E, Noggle, S, & Penrose, C 2015, ' Water Quality and Nutrient Management Extension Programs in Ohio,' *Journal of Contemporary Water Research & Education,* vol 156, pp. 48–55.

Burnett, EA, Wilson, RS, Roe, B, Howard, G, Irwin, E, Zhang, W, & Martin, J 2015, *Farmers, Phosphorous and Water Quality: Part II.* Available from: http://ohioseagrant.osu.edu/archive/maumeebay/docs/farmers-phosphorus-and-water-quality-2015-burnett.pdf. [11 November 2018]

Ohio Revised Code 2014, *Chapter 905: Agricultural Additives and Lime; Fertilizer*, 905.321v1, 905.322v1, 905.32v1, 905.323v1. Available from: http://codes.ohio.gov/orc/905.321v1, http://codes.ohio.gov/orc/905.322v1, http://codes.ohio.gov/orc/905.32v1, http://codes.ohio.gov/orc/905.323v1. [11 November 2018]

Ohio Department of Agriculture 2018, *Fertilizer Regulation.* Available from: https://agri.ohio.gov/wps/portal/gov/oda/divisions/plant-health/fertilizers. [11 November 2018]

Ohio Revised Code 2015, *Chapter 905: Agricultural Additives and Lime; Fertilizer*, 905.326v1, 905.327v1. Available from: http://codes.ohio.gov/orc/905.326v1, http://codes.ohio.gov/orc/905.327v1. [11 November 2018]

Kasich, J 2018, 'Taking Steps to Protect Lake Erie,' *Executive Order 2018-09K.* Available from: https://governor.ohio.gov/Portals/0/executiveorders/Signed%20EO%202018-09K.pdf?ver=2018-07-11-160429-970&timestamp=1531339482234. [11 November 2018]

Hall, PK 2018, 'ODA again revises "watersheds in distress" rule', *Ohio Agriculture Law Blog,* blog post, 26 September. Available from: https://ohioaglaw.wordpress.com/2018/09/26/oda-again-revises-watersheds-in-distress-rule/. [11 November 2018]

LaBarge, GA, et al. 2018, *A Field Guide to Identifying Critical Resource Concerns and Best Management Practices for Implementation: Bulletin 969*. The Ohio State University, College of Food, Agricultural, and Environmental Sciences.

Soil Fertility n.d., *Fertilizer Recommendations,* The Ohio State University. Available from: https://soilfertility.osu.edu/our-research/updating-fertilizer-recommendations. [11 November 2018]

FARM Field Application Resource Monitor n.d., *FARM homepage,* The Ohio State University. Available from: https://farm.bpcrc.osu.edu/.

Vitosh, ML, Johnson, JW & Mengel, DB 1995, *Tri-State fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa*, Extension Bulletin E-2567, Michigan State University, East Lansing.

On-Field Ohio! n.d., *Ohio-Field Ohio! page,* The Ohio State University. Available from: https://nutrientmanagement.osu.edu/field-ohio. [15 November 2018]

Ohio EPA 2010, *Ohio Lake Erie Phosphorus Task Force Final Report Executive Summary*. Available from: https://www.epa.ohio.gov/portals/35/lakeerie/ptaskforce/Task_Force_Final_Executive_Summary_April_2010.pdf. [25 October 2018]

Dayton, Elizabeth n.d., *On-Field Ohio! Management Matters*. Available from: https://nutrientmanagement.osu.edu/sites/pindex/files/imce/On-

Field%20Ohio%21%20Management%20Matters%20bar%207_18.pdf [15 November 2018]

Tegtmeier, EM & Duffy, MD 2004, 'External Costs of Agricultural Production in the United States', *International Journal of Agricultural Sustainability*, vol. 2, no. 1. Available from: https://www.leopold.iastate.edu/files/pubs-and-papers/2004-01-external-costs-agricultural-production-united-states_0.pdf. [14 November 2018]

USDA National Agriculture Statistics Service n.d., *Quick Stats*. Available from: https://quickstats.nass.usda.gov/. [15 November 2018]

Ibendahl, G 2016. *A Cost Comparison of No-Till and Tillage Farms*, Kansas State University. Available from: https://www.agmanager.info/sites/default/files/NoTill-Tillage_Costs_2016.pdf. [15 November 2018]

Pittelkow, CM, Linquist, BA, Lundy, ME, Liang, X, van Groenigen, KJ, Lee, J, van Gestel, N, Six, J, Venterea, RT, van Kessel, C 2015, 'When does no-till yield more? A global meta-analysis', *Field Crop Research*, vol. 183, pp. 156-168. Available from: https://cyberleninka.org/article/n/322035/viewer. [15 November 2018]

Great Lakes Region USDA National Agriculture Statistics Service 2018, *Ohio Corn County Estimates 2017*. Available from: https://www.nass.usda.gov/Statistics_by_State/Ohio/Publications/County_Estimates/2017/2017_OH_corn_CE.pdf. [15 November 2018]

Ward, B, & Barker, FJ 2018, *Ohio Custom Farm Rates*, Ohio State University Extension. Available from: https://farmoffice.osu.edu/sites/aglaw/files/site-library/farmmgtpdf/enterprisebudgets/Ohio%20Farm%20Custom%20Rates%20Final%202018.pdf [15 November 2018]

Ward, B 2018, *Budgets*. Available from: https://farmoffice.osu.edu/farm-management-tools/farm-budgets. [15 November 2018]

Climate Center 2016, *City Fact Sheet: Toledo, Ohio,* University of Michigan. Available from: http://graham.umich.edu/media/files/Climate_Facts-Toldeo_Ohio.pdf. [15 November 2018]

Ohio Sea Grant n.d., *Harmful Algal Blooms Frequently Asked Questions*. Available from: https://ohioseagrant.osu.edu/research/issues/habs/faqs. [15 November 2018]