The Iowa Policy Project

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Scum in Iowa's Water
Dealing with the Impact of Excess Nutrients

By Andrea Heffernan and Teresa Galluzzo

Iowa is home to approximately 93,000 farms, comprising 86 percent of Iowa's total land area. Like many farming states, Iowa has seen a significant shift in population from rural areas to urban areas. This shift, as well as a number of farm policy changes, has resulted in a substantial increase in the average number of acres per farm. Most Iowa farms produce one or two crops, often with little or no crop rotation. The current trend is to plant two years of corn followed by one year of soybeans. Both crops, especially corn, use large amounts of synthetic fertilizers and herbicides, some of which runs off into Iowa waters and eventually the Mississippi River.

In addition to the consolidation of farms producing commodity crops, large-scale concentrated animal feeding operations have become commonplace in the last several years. Large-scale livestock operations produce substantial amounts of animal waste, which is often used as fertilizer on farm fields. Animal feed is phosphorous-rich, and as a result, waste generated by the animals contains high levels of this nutrient.[1] When animal manure is applied to agricultural fields as fertilizer and runoff occurs, some of the excess phosphorus ends up in our waterways.

Excess phosphorus also enters Iowa's waterways from lawn fertilizer use. When lawn fertilizer containing phosphorus is over-applied or applied to lawns that are already rich in phosphorus, the excess phosphorus will eventually run off into storm sewers that empty into waterways. Effluent from wastewater treatment plants is also a source of excess phosphorus in Iowa waters.

One result of excess nutrients entering waterways is the proliferation of cyanobacteria. Often referred to as blue-green algae, cyanobacteria, are a form of bacteria present in various aquatic environments. When conditions are favorable for them, cyanobacteria can quickly multiply into high-density blooms; this is particularly true when they encounter water that is high in nutrients, and especially high in phosphorus. Some blooms will produce and release toxins resulting in impaired waterbodies. These toxins are harmful to wildlife and humans coming into direct contact with contaminated waters. They can also cause difficulties in water treatment when source water is contaminated.

This report will examine the effects on water quality from cyanobacteria and their toxins. We discuss the health effects of cyanobacteria, where the organisms are found in Iowa waterways, how drinking water treatment must be adjusted and what can be done to monitor and prevent cyanobacteria.

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What are Cyanobacteria?

Cyanobacteria are one of the largest and most important groups of bacteria on earth. They are estimated to have evolved 3.5 billion years ago, at which time their primary effect on the developing Earth was to add oxygen to the low-oxygen atmosphere.[2] By adding oxygen, the chemistry of the planet began to change, allowing new life forms to evolve.[3] Cyanobacteria are aquatic and photosynthetic, meaning they live in the water and can manufacture their own food by utilizing sunlight.[4]

Cyanobacteria can live in fresh, brackish, or marine water. They are often referred to as blue-green algae or pond scum. Under the right conditions – abundant nutritional sources, adequate sunlight and temperature – cyanobacteria can reproduce rapidly and form a bloom.[5] The blooms can remain either under water or float to the surface, producing an unsightly mass of pond scum.

Nitrogen and phosphorus serve as the primary nutritional sources for cyanobacteria. These nutrients enter waterways through agricultural runoff, wastewater treatment plant effluent and runoff from lawn fertilization. Aquatic ecosystems react to excess nutrients by producing more vegetation than other species can consume.[6] Dense algae blooms can block sunlight and use up oxygen in the water resulting in a decrease in diversity, food supply and the destruction of other organisms and their habitats.[7] Reduced stability of ecosystems due to excess nutrient inputs is a process known as eutrophication.

Not all cyanobacterial blooms are toxic. One form of cyanobacterium, spirulina, has long been valued as a high protein food source and is easily cultivated in ponds. On the other hand, some blooms produce toxins that can be harmful to humans, animals and the environment; these blooms are referred to as cyanobacterial harmful algae blooms.

The Environmental Protection Agency (EPA) has added cyanobacteria and their toxins to all three versions of its Drinking Water Contaminant Candidate List (issued in 1998, 2005 and 2008). The EPA compiles drinking water contaminant lists to prioritize research on contaminants to determine whether regulations are needed. However cyanobacteria and their toxins are currently unregulated by existing national drinking water regulations.[8]

Environmental and Public Health Effects

While there are thousands of blue-green algae species, only a few produce substances that are known to be toxic, called cyanotoxins. The various cyanobacteria genera that produce toxic compounds include *Microcystis*, *Cylindrospermopsis*, *Anabaena*, *Nodularia*, *Oscillatoria* and *Aphanizomenon*.[9] In Iowa, the most common toxin-producing genera are *Microcystis*, *Anabaena* and *Oscillatoria*.[10]

Reports of poisonings associated with cyanobacterial harmful algae blooms (HABs) date back to the late 1800s.[11] Laboratory animal research has shown that cyanobacterial toxins can cause a range of adverse health effects, yet few studies have explored the links between cyanobacterial HABs and human health.[12]

People and animals can be exposed to harmful cyanobacteria by swimming through a bloom or drinking untreated, contaminated water. Those engaging in recreational water activities can be exposed to the harmful toxins through inhalation of water droplets with high levels of bloom-related toxins; farm workers can also be exposed if untreated water is used for irrigation.[13]

It is not possible to tell whether a bloom contains cyanotoxins just by looking at it. It is natural to avoid cyanobacterial blooms that have risen to the surface as they tend to look unpleasant and have a foul smell. However, because some blooms will remain below the water's surface, it is not always possible to tell where harmful algae blooms are located.

A number of health effects are associated with exposure to harmful cyanobacteria for both people and animals. Recreational exposure to cyanobacterial HABs can result in a rash, hives, or skin blisters. Inhalation of water droplets through irrigation or recreational activities can cause itchy, watery eyes and nose, a sore throat, asthma-like symptoms and/or allergic reactions. Drinking contaminated water can lead to gastroenteritis (including diarrhea and vomiting), liver toxicity, kidney toxicity and neurotoxicity. These effects occur on different time frames with varying degrees of severity. Liver toxicity may take hours or days to show up in people or animals; symptoms include abdominal pain, diarrhea and vomiting.[14] Neurotoxicity symptoms can appear within 15 to 20 minutes after exposure. Symptoms in dogs can include weakness, staggering, difficulty breathing, convulsions and even death; symptoms in humans include numb lips, tingling fingers and toes and dizziness.[15]

Chronic exposure occurs when people consume low levels of cyanobacterial toxins over many years in drinking water, or possibly in food such as fish and shellfish. The long-term chronic effects of low-level exposure are still under investigation but some studies have shown a correlation between liver cancer and drinking water contaminated with cyanobacterial toxins.[16]

Cyanobacteria Around the World

Cyanobacteria are found worldwide. Health-related issues stemming from contact with cyanobacterial HABs have been reported from Australia to the United States. The international examples provided below were compiled from a report by the World Health Organization, "Toxic Cyanobacteria in Water: A Guide to their Public Health Consequences, Monitoring, and Management."

The earliest reported cases of gastroenteritis from cyanobacteria occurred in a series of towns along the Ohio River in 1931. Low rainfall had caused the water in a side branch of the river to develop a cyanobacterial bloom, which was then washed into the main river. As the water moved downstream a series of outbreaks were reported.

A water reservoir in Harare, Zimbabwe, was reported having a natural bloom of *Microcystis* decay in the reservoir at the same time every year. Children living in the area of the city that drew its water from this reservoir developed symptoms of gastroenteritis each year during the time of the harmful algal bloom.

Brazil has seen two of the worst cases of exposure to cyanobacterial HABs, resulting in human deaths in both incidents. Cyanobacterial toxins in drinking water occurred in Bahia, Brazil, in 1988, when a newly flooded dam developed an immense cyanobacterial bloom. Eighty-eight people died, most of them children. In 1996 in Caruaru, Brazil, kidney patients were exposed to cyanobacterial toxins through contaminated dialysis water. Forty-seven deaths were positively attributed to the contaminated water.

Treating Drinking Water Contaminated with Cyanobacteria

The American Water Works Association recommends alternate water sources or treatment processes be used if cyanobacterial cell counts exceed 15,000 cells/ml. This threshold was set in response to toxin concerns and is used as an approximation and not as a maximum level threshold. Even when concentrations of cyanobacteria organisms reach levels of approximately 10,000 cells/ml, water treatment can be complicated. The complications associated with high cyanobacteria levels are:

- Phytoplankton (which includes cyanobacteria) plug sand filters, reducing filter run times;
- Shorter filter runs result in reduced treatment capacity because the filters are being cleaned (backwashed) frequently. The reduced run times also result in increased energy and water consumption, which is ultimately wasted;
- Cyanobacteria cells and cell debris are able to penetrate the sand filters, which increases turbidity.[17] Filter effluent turbidity is a regulated water quality parameter. Particulate matter related to high turbidity enables bacterial growth in the water distribution system. When turbidity is high, a boil order may be mandated;
- Phytoplankton increases the level of dissolved organic matter in raw and treated water. The dissolved organic matter reacts with chlorine to form disinfection byproducts, which are regulated contaminants. This is a chronic operational issue for a water system;
- Dissolved organic matter creates a chlorine demand at the treatment plant and in the water distribution system, which makes maintaining adequate disinfectant more difficult;
- Dissolved organic matter may cause objectionable tastes and odors.[18]

Cyanobacteria in Iowa

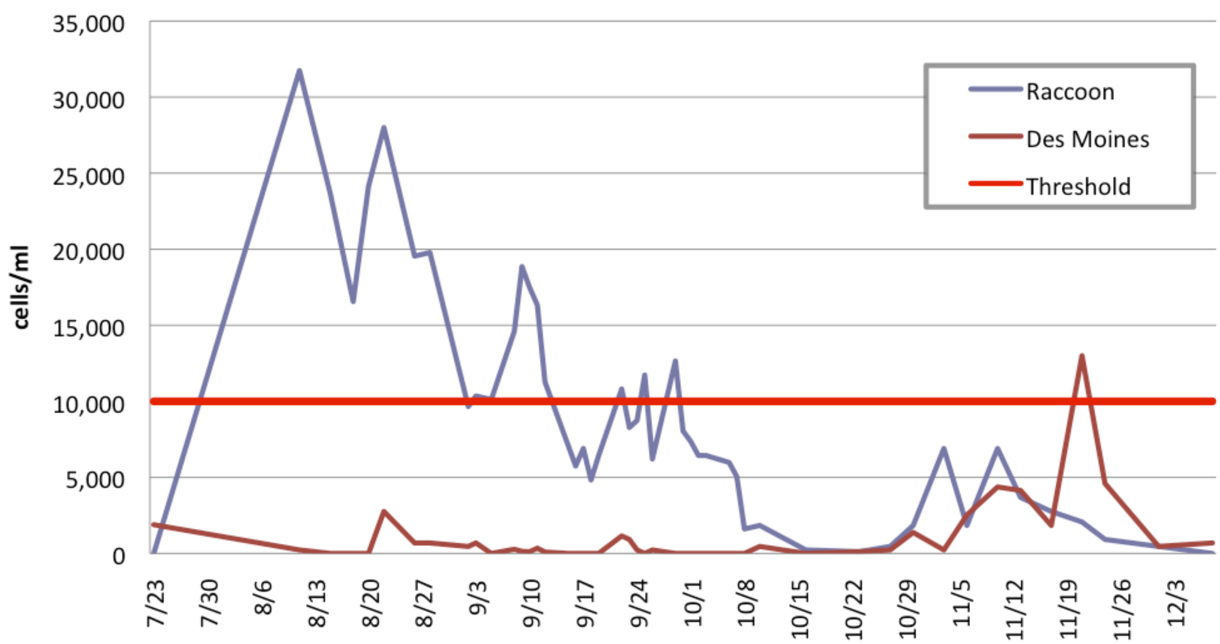
Cyanobacteria are being found in several Iowa waterways. During the summer of 2004, high levels of cyanobacteria and cyanotoxins (microcystin) were revealed in Carter Lake, near Council Bluffs, after testing was prompted by a series of indicators pointing to the possibility of a cyanobacterial bloom.[19] These indictors consisted of swimmers complaining of rashes and the characteristic green water often observed during harmful algae blooms.[20]

Cyanobacteria have also been found in Iowa's drinking-source waterways. A water utility company, which asked to remain anonymous, has reported cyanobacteria in its source waters in the past. The utility draws its water from a lake/river system. Both the lake and the river had increased levels of cyanobacteria during the last week of July through the first half of August of 2009. Water treatment processes were complicated for a number of days and alternate treatment steps had to be taken in order to address the turbidity spikes caused by the cyanobacteria. Cyanobacteria have also been found in this lake in the past.

An Iowa town in the south-central part of the state that uses lake water as its source supply also experienced cyanobacteria blooms this year that were as bad as residents have experienced in some time.[21]

High levels of cyanobacteria have recently been observed in the Des Moines and Raccoon rivers, source waterways for Des Moines Water Works, which serves the largest number of water customers in Iowa. In 2008, the Raccoon River was recorded having well over 10,000 cyanobacterial cells/ml[22] from late-July through late-August, with an increase again in mid-September. The Des Moines River had very low levels of cyanobacteria through most of 2008, however, in mid-November, cyanobacteria levels surged above 10,000 cells/ml for a few days. Figure 1 shows the levels of cyanobacteria in the Des Moines and Raccoon Rivers for five months in 2008.

Figure 1. Des Moines and Raccoon River Cyanobacteria, 2008



Source: Des Moines Water Works

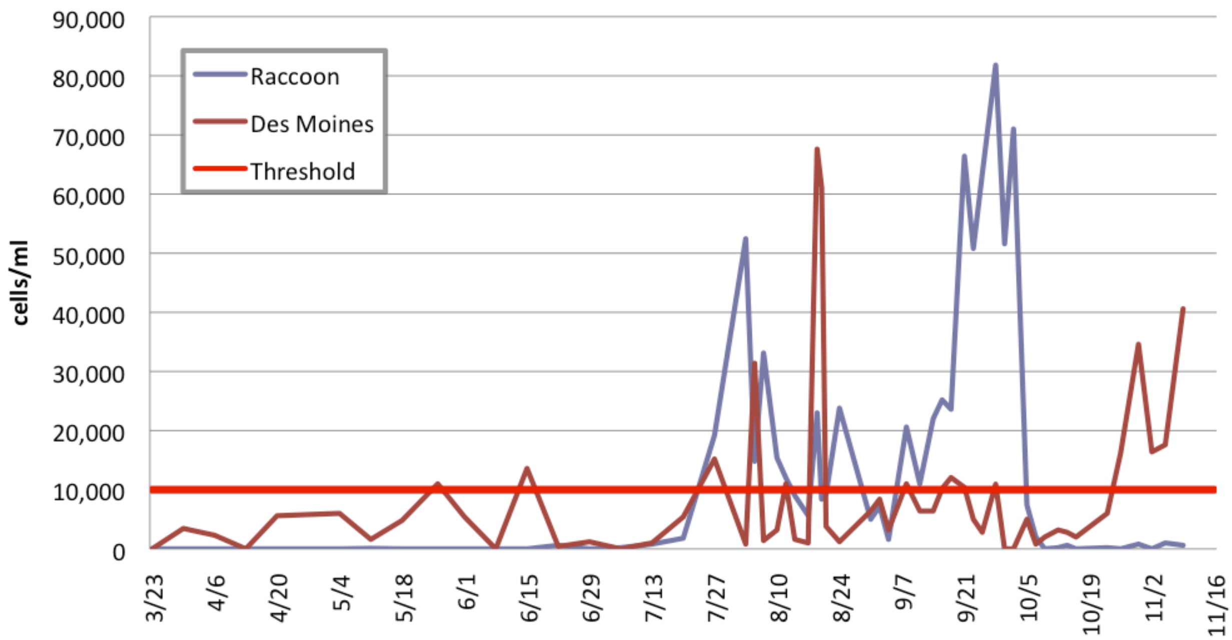
In 2009, on an even greater number of days, Des Moines Water Works source water reached levels of cyanobacteria above the 10,000 cells/ml threshold, including days when both the Des Moines and Raccoon were above the threshold. (See Figure 2.) In particular for the Des Moines River:

- In late-May, mid-June and late-July, cyanobacteria levels in the Des Moines River spiked just above 10,000 cells/ml
- August 5 saw an increase of cyanobacteria to 31,400 cells/ml
- A sharp increase in cyanobacteria August 19 and 20, boosted levels to almost 70,000 cells/ml
- Increases of cyanobacteria occurred in late October when levels reached 16,400 cells/ml on October 26 and further increased to 34,600 cells/ml on October 30
- Levels remained high through early November, peaking on November 9 to over 40,000 cells/ml

The Raccoon River, DMWW's other water source, also had several measurements well above the AWWA's recommended maximum during 2009, shown by Figure 2.

- In early-August, cyanobacteria levels surged to 52,440 cells/ml
- Levels fluctuated between 5,000 cells/ml to over 30,000 cells/ml through late-August
- A sample taken on September 21 found the highest levels of cyanobacteria ever measured by the DMWW laboratory for the Raccoon River — a count of 66,400 cells/ml
- A sample taken on September 28 surpassed the week-old record, with levels of 81,800 cells/ml
- Cyanobacteria levels remained in the range of 50,000 to 70,000 cells/ml through October 5, when cyanobacteria levels fell below 10,000 cells/ml

Figure 2. Des Moines and Raccoon River Cyanobacteria, 2009



Source: Des Moines Water Works

The high levels of cyanobacteria in the Des Moines and Raccoon Rivers required the Des Moines Water Works to alter their water treatment processes. Altering water treatment processes results in increased energy and water consumption, as well as an overall increase in operating costs. Capacity is reduced during times when levels of cyanobacteria are above the 10,000 cells/ml threshold as well. It is likely the issues regarding water treatment processes caused by increased levels of cyanobacteria are not unique to DMWW. However, many utility managers are unsure how to proceed or what information to communicate to customers when there are water quality problems with the source supply.[23] And because cyanobacteria are not regulated, there is no requirement that any notice be given to customers. DMWW has, however, been proactive in addressing these issues with customers and the public at-large in an effort to build a consensus that will work toward improving water quality conditions in the Des Moines and Raccoon Rivers.

Monitoring and Reporting of Cyanobacteria

The Iowa Water Quality (WQ) Standards have no numeric criteria established for cyanobacteria. Thus, the Iowa Department of Natural Resources (DNR) has not developed an assessment/listing methodology specific to cyanobacteria. Ideally, a methodology for adding a waterway to Iowa's Section 303(d)[24] list of impaired waters due to cyanobacteria levels would be based on an appropriate criterion in the Iowa WQ Standards, such as some threshold level of the most common cyanotoxin, microcystin.[25]

However, DNR has no plans to add such a criterion to Iowa WQ Standards.[26] Without a better tie-in with Iowa WQ Standards, and without a generally accepted methodology of measuring levels of cyanobacterial toxins, data for cyanobacteria and their toxins will likely not be specifically used to identify impaired waters in Iowa.[27]

The Iowa DNR, however, does consider high levels of cyanobacteria in waterbodies a potentially serious water quality issue and utilizes the narrative WQ criterion protecting against "nuisance aquatic life" to rank cyanobacteria levels in lakes.[28] In 2002-06 Iowa State University and University Hygienic Laboratory (UHL) surveyed and ranked 132 waterbodies according to the levels of cyanobacteria detected. Those ranked in the highest 25 percent of all lakes sampled were identified as "potentially impaired" in the Iowa DNR's assessment database.

Lakes with the highest levels of cyanobacteria are already Section 303(d) impaired due to trophic state index[29] values for chlorophyll-*a* that suggest impairment. Chlorophyll-*a* (an indicator that algae is present, possibly including cyanobacteria) monitoring data is used by Iowa DNR to infer the relative size of algal populations in Iowa lakes. Lakes with very high levels of chlorophyll-*a*, and thus very large algal populations, are assessed as violating Iowa's narrative water quality standard protecting against "aesthetically objectionable conditions" that can limit use of the lake for swimming, boating and other beneficial uses.[30] Such lakes are added to Iowa's Section 303(d) list of impaired waters and are identified as needing a total maximum daily load (TMDL). The goal of the TMDL, also called a "water quality improvement plan," for these algae-impaired lakes is to identify strategies to reduce levels of nutrients in the water and consequently reduce levels of all algae populations, including populations of cyanobacteria.[31]

However, being assigned a TMDL does not necessarily result in action. A TMDL specifies the maximum amounts of particular pollutants that can enter the water body in one day in order for it to still meet Iowa's water quality standards. Unlike violation of a National Ambient Air Quality Standard, which would limit development in an offending air shed, the DNR is limited in improving an impaired river. As stated on the DNR website:

> For any real improvement to be made on a stream or lake that has a water quality improvement plan, it is up to local communities and landowners to put the plan into action. By organizing a watershed improvement group, locals can apply for funding from the DNR and other agencies to help landowners and others install conservation practices.[32]

An assessment of cyanobacteria in lakes is an important step in monitoring cyanobacteria and their toxins, however, assessments are not being completed for other types of waterbodies, such as rivers, the source of many water utility companies' drinking water. Part of this inconsistency is due to the more common occurrence of algal problems in lakes.[33] While lakes provide the ideal habitat for cyanobacteria to thrive, lakes can overflow into moving bodies of water, such as stream segments and rivers, potentially impacting subsequent waterways.

The EPA has also not established formal guidelines or regulation mechanisms for cyanobacterial toxins.[34] With no formal guidelines or regulations for cyanobacteria or cyanotoxins, no standardized detection method has been established. In addition, no best available technology has emerged for removing the toxins from drinking water.[35] However, with cyanobacteria and their toxins being listed under the EPA's "Drinking Water Contaminant Candidate List," innovation in treatment technologies is being pursued. A report in the Journal of Environmental Engineering discussed the current treatment methodologies researchers are testing for the removal of cyanobacteria and their toxins for their overall effectiveness in regard to safety, efficiency and cost. Many of the technologies explored revealed promising results, though all the technologies have their own advantages and limitations.[36]

In 1998 the World Health Organization set a provisional guideline value of 1.0 microgram per liter (μg/L) for microcystin-LR (MC-LR),[37] the most common cyanotoxin, in potable water. To date, no drinking water regulations exist for cyanobacteria in the United States, however, this is not the case everywhere. Australia, Brazil, Canada, France and New Zealand all have regulatory standards that set the contamination limit of the cyanobacterial toxin microcystin-LR in drinking water. Oregon is the only state in the United States that regulates cyanobacterial toxins, but the regulation only applies to cyanobacterial products — or health food supplements.[38] Table 1 shows the regulatory standards for the above-referenced locations.

Table 1. Current Regulatory Standards for Microcystin in Drinking Water

Location	Microcystin (MC-LR) Limit
Australia	1.3 micrograms per liter (µg/L)
Brazil	1.0 µg/L
Canada	1.5 µg/L
France	1.0 µg/L
New Zealand	1.0 µg/L
United States	No regulatory standard
Oregon	1 part per million for cyanobacterial products
World Health Organization (WHO)	1.0 µg/L – provisional guideline

Cyanobacteria and Global Warming

Global warming is predicted to bring about many changes worldwide. The United States Global Change Research Program has published reports detailing the impacts of climate change that are occurring now and projected to occur in the future. Some changes detailed for the Midwest region include:

- Increases in frequency and intensity of heavy downpours
- Increases in air and water temperatures
- Lengthening of the growing season

These observed changes are predicted to increase as climate change progresses. The changes may have profound effects on cyanobacterial blooms in more ways than one. First, heavy downpours cause significant amounts of runoff as soils are unable to absorb vast amounts of precipitation over a short period of time. Increased runoff will contribute to increased amounts of nutrients in nearby waterways. A study conducted in the United Kingdom assessed the impacts of climate change on indirect human exposure to agricultural chemicals and determined that increased overland flow and flood immersion, due in large part to increased frequency and intensity of precipitation, will expose large nutrient reservoirs found in agricultural soils, further increasing nutrient levels.[39]

Second, water temperatures play a critical role in algal bloom formation. As water temperatures increase, the likelihood of increased bloom formation increases as well. Finally, if growing seasons lengthen, there is potential for increased crop yields. Possibly countering this, however, are potential increases in insects and weeds that are predicted to come with climate change, which could result in greater applications of synthetic chemicals. Increased use of fertilizers, pesticides and herbicides will further exacerbate the amount of chemicals and nutrients entering our waterways.

Litigation

In November 2009, a federal judge in Florida approved a consent decree requiring the EPA to set legal limits for the widespread nutrient contamination that triggers harmful algae blooms in Florida waters.[40] Five environmental groups filed the lawsuit in July 2008, challenging a decade-long delay by the state and federal government in setting limits for nutrient pollution.[41] In June 2008, a water treatment plant serving 30,000 Florida residents was shut down after a toxic cyanobacterial bloom on the Caloosahatchee River threatened the plant's water supply.[42] In the same year, a Department of Environmental Protection (DEP) report concluded that half of Florida's rivers and more than half of its lakes had poor water quality. The consent decree will require the EPA to impose quantifiable and enforceable water quality standards to address nitrogen and phosphorus pollution. The judge rejected arguments made by the polluters who sought to delay cleanup.[43]

Shortly following the Florida ruling, lawyers for several environmental groups in Wisconsin notified the EPA of its intent to file suit against the agency for failing to protect state water from nitrogen and phosphorus pollution.[44] Wisconsin was selected for the lawsuit because the State Department of Natural Resources has developed a thorough database on phosphorus loadings in the state.[45] The state is also working on regulations that will set an allowable amount of phosphorus in waterbodies.[46]

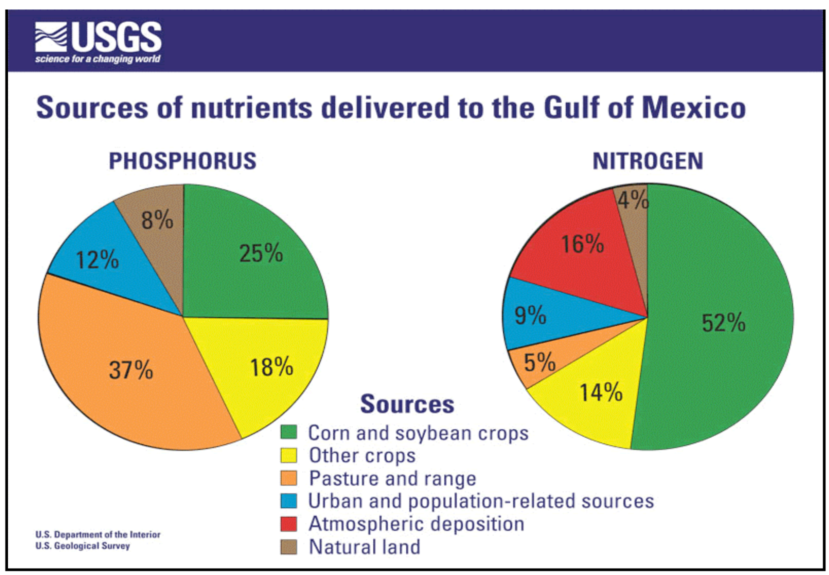
Recommendations

Reducing excess nutrients in our waterways through the reduction of inputs used in agriculture and urban settings is one step toward controlling the proliferation of cyanobacterial blooms. If nutrient overloading is controlled, the eutrophication process can be slowed. The following recommendations suggest various agriculture conservation techniques that can reduce the amount of nutrients entering waterways as well as recommended urban policies and monitoring and reporting policy solutions.

Limits on Nutrient Application

Iowa is one of nine states responsible for contributing over 70 percent of nitrogen and phosphorus pollutants to the Gulf of Mexico.[47] Agriculture sources contribute 80 percent of the total phosphorus and 70 percent of the total nitrogen delivered to the Gulf. (See Figure 3). The most significant contributing factor of phosphorus in the Mississippi River Basin is from animal manure on farmland followed by synthetic fertilizers used on corn and soybean fields. In contrast, urban sources only contribute 12 percent of the total phosphorus delivered to the Gulf of Mexico.

Figure 3. Farms Primary Source of Phosphorus, Nitrogen



Source: United States Geological Survey

Limiting the amount of synthetic fertilizers and manure applications to farm fields will likely have the greatest impact on total reduction of excess nutrients entering Iowa waterways. Voluntary conservation practices structured on incentive-based payments do not ensure an efficient use of resources designated to reduce nutrient loading.[48] So while agricultural conservation practices have benefits, voluntary conservation techniques alone will not adequately address nutrients in Iowa waters. Capping the amount of fertilizer and/or manure that can be applied to agricultural fields to levels appropriate for maximum crop yield will have far-reaching effects on nutrient reduction.

Agricultural Conservation – Nutrient Management

Manure Management

Manure management is a double-faceted approach to controlling excess nutrients. First, it calls for animal feed, which often contains a surplus of phosphorus, to be matched to animal requirements.[49] Matching animal feed inputs to animal nutritional requirements will reduce excess phosphorus in animal waste. Second, a manure management program recommends that phosphorus content of manure and soil be tested before applying manure to crop fields.[50] Soil tests can help farmers identify areas in need of manure-based fertilization as well as areas that need no manure application.

Riparian Buffers

Riparian buffers are a conservation mechanism offering a multi-beneficial approach to control excess nutrients. Buffers play a key role in water quality by separating waterways from adjacent land uses, allowing sediment, nutrients, pesticides and other materials found in surface waters to be intercepted before making it to the waterway.[51] In addition, riparian buffers increase biodiversity by providing habitat for a number of species.

Riparian buffers slow the eutrophication process two ways. First, by impeding nutrients from entering the waterways, the buffers significantly reduce the volume of nutrients in the water. Second, because trees are a primary component of riparian buffers, buffered waterways are predominately shaded. Shaded water results in cooler water temperatures, limiting the ability of cyanobacteria to reproduce rapidly and form large blooms. Without an adequate nutrient source and warm water temperatures, algal bloom formation is hampered.

Precision Farming

Precision farming is a relatively new practice that tailors production inputs to specific plots within a field. Farmers test soils and crop yields of specific plots which allows them to determine the appropriate amount of inputs needed, such as fertilizer, water and other synthetic chemicals.[52] By tailoring the needs of smaller sections of land, overall environmental impacts can be reduced by using only the necessary amount of inputs per plot. Precision farming avoids over application of farm chemicals that can take place when farmers want to guarantee the highest possible yields. When chemical applications are based on need per plot, overall use of fertilizers and chemicals is likely to be reduced, thereby reducing nutrients entering nearby waterways.

Conservation Agriculture

Conservation agriculture focuses on three main agricultural principles: reduction in tillage, retention of adequate levels of crop residue and the use of crop rotation.[53] The goal of zero tillage or conservation tillage practices is to leave soil surfaces, typically 20-25 percent, undisturbed.[54] When no tillage or reduced tillage is used, crop residues will be retained on the soil surface. Having an adequate level of crop residue on the soil surface protects the soil from water and wind erosion, runoff and evaporation, improving water productivity and enhancing the physical, chemical and biological properties of soil.[55] Crop rotations are an important component of conservation agriculture as its objective is to employ economically viable, diversified crop rotations to help moderate and mitigate possible weed, disease and pest problems.[56] Conservation agriculture techniques, when done cumulatively, reduce soil loss, enable soils to retain greater quantities of water and reduce the loss of naturally occurring soil nutrients; this results in reduced soil erosion, water runoff, as well as a reduced need for synthetic fertilizers.

Urban Conservation

Nutrients from lawn applications also affect water quality. In the 2009 Iowa legislative session, lawmakers proposed a bill that would allow Iowa cities and towns to regulate the use of chemical lawn fertilizers. The proposed bill, Senate File 343, applied only to residentially zoned property and commercially zoned property used for residential purposes, not to land used for agricultural purposes. This bill was an important step towards giving localities the ability to protect their drinking source waterways. While the bill successfully passed the Senate, it did not pass in the House.

As with agricultural inputs, limiting the use of products containing high levels of nutrients, namely phosphorus, in urban areas is an important step towards controlling the amount of nutrients entering waterways.

Monitoring and Reporting Regulations

Iowa should consider establishing water quality standards in regards to cyanobacteria and their toxins. Once cyanobacteria are named as an impairment to water quality, cyanobacteria levels can be specifically monitored and addressed by all potable water systems. With a monitoring requirement in place, the state would need to set a uniform methodology for measuring cyanobacteria and their toxins in our water. Furthermore, a regulatory limit would need to be set for allowable levels of cyanobacteria in drinking water and in recreation waterways.

With these regulations in place, there would likely be advances in treatment processes for water contaminated with cyanobacteria. This is crucial because there have been elevated levels of cyanobacteria found in Iowa drinking source waterways recently. The two main source waters for the Des Moines Water Works (serving the largest customer base in Iowa), the Raccoon and Des Moines Rivers, had coinciding levels of cyanobacteria above the American Water Works Association's (AWWA) treatment threshold of 15,000 cells/ml. Once cyanobacteria levels surpass 15,000 cells/ml, AWWA recommends using alternate water sources or treatment processes. Cyanobacteria complicate and slow the water treatment process. In addition, cyanobacterial levels in waterways characteristically increase in the summer, when demands for water are at their highest. If water treatment cannot keep up with demand, water customers throughout the state could face shortages in treated water. Iowa needs to become proactive in addressing cyanobacteria to mitigate this threat.

Conclusion

Regulatory standards for cyanobacterial levels should be adopted. However, the real solution for reducing this harmful contaminant is limiting the amount of phosphorus and nitrogen from both agricultural and urban areas that reach Iowa waters. State policy should strike at the source to address cyanobacteria and their negative environmental and health effects. Iowa should take such actions to protect its water and citizens.

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[1] United States Department of Agriculture & Agricultural Research Service. (2003). *Agricultural Phosphorus and Eutrophication* No. ARS-149. Retrieved from http://www.ars.usda.gov/is/np/Phos&Eutro2/agphoseutro2ed.pdf

[2] Perovich, G. e. a. (2008). Cyanobacteria HABs - causes, prevention, and mitigation workgroup report. *Advances in Experimental Medicine and Biology, 619*, 185.

[3] Ibid.

[4] Centers for Disease Control and Prevention. *Harmful algal blooms (HABs).* Retrieved September, 2009, from http://www.cdc.gov/hab/cyanobacteria/facts.htm

[5] Ibid.
[6] Wilkes University – Center for Environmental Quality, Environmental Engineering and Earth Sciences. *Phosphates and water quality.* Retrieved August, 2009, from http://www.water-research.net/phosphate.htm
[7] Ibid.
[8] Environmental Protection Agency. (2009). *Contaminant candidate list 3.* Retrieved September, 2009, from http://www.epa.gov/safewater/ccl/ccl3.html
[9] Woods Hole Oceanographic Institution. (2008). *Cyanobacteria FAQs : Red tide.* Retrieved September, 2009, from http://www.whoi.edu/redtide/page.do?pid=15776&tid=523&cid=27946
[10] University of Northern Iowa. *Bacteria.* Retrieved September, 2009, from http://www.uni.edu/cns/LakeStudy/cyano__enteric_bacteria.htm
[11] Centers for Disease Control and Prevention. *Harmful algal blooms (HABs).* Retrieved September, 2009, from http://www.cdc.gov/hab/cyanobacteria/about.htm
[12] Ibid.
[13] Woods Hole Oceanographic Institution. (2008). *Cyanobacteria FAQs : Red tide.* Retrieved September, 2009, from http://www.whoi.edu/redtide/page.do?pid=15776&tid=523&cid=27946
[14] Centers for Disease Control and Prevention. *Harmful algal blooms (HABs).* Retrieved September, 2009, from http://www.cdc.gov/hab/cyanobacteria/facts.htm.
[15] Ibid.
[16] Woods Hole Oceanographic Institution. (2008). *Cyanobacteria FAQs : Red tide.* Retrieved September, 2009, from http://www.whoi.edu/redtide/page.do?pid=15776&tid=523&cid=27946
[17] Turbidity is a measure of water clarity – how much material suspended in water decreases the passage of light through the water; turbidity can affect the color of the water and can be a useful indicator of the effects of runoff from various sources (EPA).
[18] Jones, Christopher, Des Moines Water Works. 2009. Personal communication October 9.
[19] Iowa Department of Natural Resources, Geological Survey. (2005). *Iowa's Water Ambient Monitoring Program – Cyanobacteria in Iowa Waters*. Water Fact Sheet 2005-5. January. Retrieved from http://www.igsb.uiowa.edu/wqm/publications/fact%20sheets/2005FactSheets/2005-5%2011x17.pdf
[20] Ibid.
[21] Jones, Christopher, Des Moines Water Works. 2009. Personal communication October 28.
[22] Lakes will often experience blooms in excess of one million cells/ml; however in a moving water system such as the Des Moines and Raccoon Rivers, the measured levels of cyanobacteria highlighted in this report were unexpected.
[23] Ibid.
[24] From the Iowa DNR and EPA webpages: Section 303(d) of the Clean Water Act requires states to submit a list of waters for which effluent limits will not be sufficient to meet all state water quality standards. The 303(d) listing for Iowa is composed of lakes, wetlands, streams, rivers, and portions of rivers that do not meet all state water quality standards. States are required to calculate total maximum daily loads (TMDLs) for pollutants causing impairments. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.
[25] Olson, John, Iowa Department of Natural Resources. 2009. Personal communication September 14.
[26] Ibid.
[27] Ibid.
[28] Ibid.
[29] Carlson's trophic state index is an index used by the EPA and Iowa DNR that measures the total weight of biomass in a given body of water.
[30] Olson, John, Iowa Department of Natural Resources. 2009. Personal communication September 14.
[31] Ibid.
[32] Retrieved from http://www.iowadnr.com/water/watershed/tmdl/tmdl.html.
[33] Olson, John, Iowa Department of Natural Resources. 2009. Personal communication November 10.
[34] Antoniou, Maria G., Cruz, Armah A. de la, and Dionysios D. Dionysiou. (2005). Cyanotoxins: New Generation of Water Contaminants. *Journal of Environmental Engineering 131*(9), 1239.
[35] Ibid.
[36] Ibid.
[37] MC-LR is an abbreviation for the hepatoxin microcystin-LR, where L and R stand for leucine and agrinine respectively, which is the most toxic and most commonly found derivative of microcystins in water resources (see Antoniou 2005).
[38] Ibid.
[39] Boxall, Alistair B. A., et. al. (2009). Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture. *Environmental Health Perspectives, 117*(4), 508.
[40] Judge: EPA consent decree for florida waters stands. (2009). *Water & Wastewater News*. November 18. Retrieved from http://www.wwn-online.com/articles/2009/11/18/judge-epa-consent-decree-for-florida-waters-stands.aspx

[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Bergquist, L. (2009). Two pollutants eyed for more regulation. *Milwaukee, Wisconsin Journal Sentinel – JSOnline*. November 23. Retrieved from http://www.jsonline.com/blogs/news/71962717.html
[45] Ibid.
[46] Ibid.
[47] Alexander, R.B., et. al. (2008). Differences in phosphorus and nitrogen delivery to the gulf of mexico from the mississippi river basin. *Environmental Science and Technology, 42*, 822.
[48] National Research Council of the National Academies. (2008). *Mississippi river water quality and the clean water act - progress, challenges, and opportunities*. Washington, DC: The National Academies Press.
[49] United States Department of Agriculture & Agricultural Research Service. (2003). *Agricultural Phosphorus and Eutrophication* No. ARS-149. Retrieved from http://www.ars.usda.gov/is/np/Phos&Eutro2/agphoseutro2ed.pdf
[50] Ibid.
[51] Natural Resources Conservation Service. *Buffer Strips: Common Sense Conservation.* Retrieved from http://www.nrcs.usda.gov/FEATURE/buffers/
[52] Holton, W. C. (2000). Farming from a new perspective: Remote sensing comes down to earth. *Environmental Health Perspectives, 108*(3), A130-A133.
[53] Govaerts, B., Verhulst, N., Castellanos-Navarrete, A., Sayre, K. D., Dixon, J. and Dendooven, L. (2009). Conservation Agriculture and Soil Carbon Sequestration: Between Myth and Farmer Reality. *Critical Reviews in Plant Sciences, 28: 3,* 97 — 122.
[54] Ibid.
[55] Ibid.
[56] Ibid.