Researchers seek to characterize harmful algal bloom development in the Iowa Great Lakes

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Why this research was needed

There are thousands of lakes and reservoirs used as drinking water sources across Iowa and the Midwest. Agricultural runoff and flooding often put these sources at risk from excess nutrients and contaminants. One major risk is the presence of harmful algal blooms within public water resources. Harmful algal blooms are caused by toxic-producing cyanobacteria, often called "blue-green algae". Cyanobacteria is a naturally occurring phenomenon that is often aggravated due to excessive phosphorus and nitrogen present in the water, along with increasingly warm water temperature and a greater presence of sunlight.

A major challenge for water managers is the detection and management of harmful algal blooms to protect human and other animal life. The presence of harmful algal blooms can lead to beach closures, degraded aquatic ecosystems and associated impacts on fish populations, and limit the availability of access to safe drinking water. Researchers in this study seek to improve the understanding of lake conditions that lead to the development of harmful algal blooms.

How was it done?

The area of study for this project included West Okoboji, East Okoboji, and Big Spirit Lake, known as the Iowa Great Lakes and located in northwest Iowa. A new water quality buoy was installed on Big Spirit Lake, similar to the one installed on West Okoboji a few years ago. The buoys collect information about water quality variables, including temperature and dissolved oxygen. The buoys also record meteorologic data, including wind speed, temperature, precipitation, and solar radiation at the lake. Temperature and dissolved oxygen measurements are collected every 10 minutes, at regular intervals from the surface to the bottom of the lake.

Samples of water were collected every week at multiple locations and analyzed at the State Hygienic Laboratory at the Iowa Lakeside Laboratory in Milford, Iowa. Samples were analyzed for pH, dissolved oxygen, nutrients, chlorophyl (a measure of algal abundance), and microcystin (a toxin produced by cyanobacteria). Measures of pH indicates the level of acidity or alkalinity of lake water, which needs to be within a normal range for aquatic life to thrive. Dissolved oxygen (DO) levels are a measure of the oxygen available to living aquatic organisms. Low DO can lead to fish kills and release of stored nutrients from lake sediments. Samples were analyzed for total phosphorus, orthophosphorus, and total nitrogen. These nutrients are essential for aquatic plants, including rooted macrophytes and phytoplankton, and can be carried into lakes by runoff from their watersheds. Phosphorus can also be carried in from dust blown to the lake and released from lake sediment under anoxic conditions. Nutrients can also enter the lake from ground water. High levels of nutrients in lakes can lead to dense rooted aquatic

Image of Harmful Algal Blooms

plant growth and harmful algal blooms.

Harmful algal blooms are either densely growing green algae, or they can be comprised of cyanobacteria. Whether a nutrient enriched lake is dominated by rooted plants or algal blooms partially depends on light availability at the lake bottom. In many shallow lakes, like East Okoboji, an invasive plant, Curly-leaf pondweed (CLPW), has an advantage in that it begins growing early in the growing season, even before ice has left the lake. CLPW can outcompete other plants to form dense weed beds that sprawl across the lake surface. The plants die back in early to mid-summer and decompose at the bottom of the lake, leading to low oxygen levels and release of nutrients into the water. This along with long hot and dry summer days can provide conditions ideal for algal bloom formation. Unlike East Okoboji, which is sheltered from the wind due to its smaller size, shape, and being surrounded by trees, Spirit Lake has large open water that is exposed to the wind. It is also a relatively shallow lake, and wind can generate waves and currents that disturb the lake sediments. Weeds have been less of an issue on the lake, but nutrient levels are high and algal blooms are becoming more common.

Heating of the lake surface from the sun along with wind mixing leads to vertical stratification with layers of warm water over cooler water at depth. Although temporary periods of stratification can occur on Spirit and East Okoboji, the much deeper West Okoboji experiences long periods of stratification, often lasting through the summer. Stratification limits oxygen mixing down into the deeper waters of lakes and low oxygen levels can occur. Nutrient and light conditions caused resulting from stratification can provide ideal regions below the surface waters where harmful algal blooms can form, undetectable at the surface. Continuous temperature and water quality monitoring at buoys located in West Okoboji and Big Spirit lakes are used to monitor these conditions. The data is transmitted in real time to a server at the Lakeside Laboratory. This information is available on the Lakeside Laboratory website to the public. Results of water sampling are available to the public from the DNR AQuIA program, and from the Cooperative Lakes Area Monitoring Project (CLAMP), a volunteer program organized by the Iowa Lakeside Lab and Friends of Lakeside Lab.

In this study, characterizing the amount of nutrients, temperature, and other parameters at the lake surface and below helped to quantify the factors associated with nutrient recycling and is used to identify conditions leading to early development of harmful algal blooms. Other factors considered were wind and nutrient runoff events into the lakes, variation in ice-off records, as well as data on coverage of dense rooted plants and when die-off occurred. This information, along with water quality and weather data, was used to evaluate the frequency and long-term trends of algal bloom events later in the summer.

What the researchers discovered

The goal of the data collection and analysis was to look at the distribution of water quality variables, including oxygen and nutrients, and distribution of invasive aquatic plants, and investigate relationships with timing of weather events and the formation of algal blooms. Algal blooms occur most frequently in East Okoboji and occasionally in Big Spirit Lake, while blooms in West Okoboji are rare. Analysis of water quality parameters from the chain of lakes at the Iowa Great Lakes from 2000 until 2020 revealed trends in water quality and algal bloom events that are related to increased air and water temperatures, and stronger weather events. Significant weather events that had an impact on harmful algal blooms development in the lakes were especially tied to increased spring rain events and late summer drought. Additionally, in East Okoboji Lake, the data showed a correlation between the abundance of invasive species, particularly Curly-leaf pondweed, which covers a significant portion of the lake, and more frequent algal bloom events later in the summer. From 2000–2010 the lake experienced minor bloom events in four years, while from 2011–2020 there were nine bloom events which were significantly more intense. At the same time water clarity declined from about 6.5 feet in the early 2000s to about 3 feet by 2020. As water clarity declines, there may be a shift from rooted aquatic plants dominating the lake in the early part of the growing season to more frequent algal blooms throughout the year in the future.

In this project the results were presented at the Iowa Water Conference, at State water resources planning meetings, and presentations to the Iowa Watershed Approach research seminar. During the project the team also met with members of the Iowa DNR fisheries and lake restoration programs at the Iowa Great Lakes and launched an effort to develop remote sensing tools for detecting and tracking HAB events across Iowa.

What's next?

The long-term vision for this research is to develop a comprehensive lake systems water quality model for the Iowa Great Lakes region to inform stakeholders of the risk of HAB toxins and alert lake visitors and residents of dangerous swimming conditions. The model will also provide drinking water managers with HAB forecasts that could impact water treatment operations. The model will also provide a tool for natural resources managers, and lake managers, to guide lake management and restoration activities. The model can also be used to evaluate the effects on lake health of watershed management applications designed to mitigate runoff and reduce nutrients entering the lakes. The goal is to develop a modeling framework that is informed by monitoring data to guide and evaluate lake restoration activities.

This project has also helped launch a new state-wide initiative funded by the Office of the Vice President for Research at the University of Iowa. The "Iowa Healthy Lakes Initiative: A multidimensional approach to measuring, informing, and solving Iowa's Harmful Algal Bloom Challenge" is lead by a multidisciplinary team of researchers from environmental engineering, sustainability, political science, business, and public health. Over the next year, the team will engage with professionals and the public from across the state who are interested in solving the HAB challenge and improving the health of Iowa's lakes.

For more information about Iowa Water Center sponsored research, please visit iowawatercenter.org.

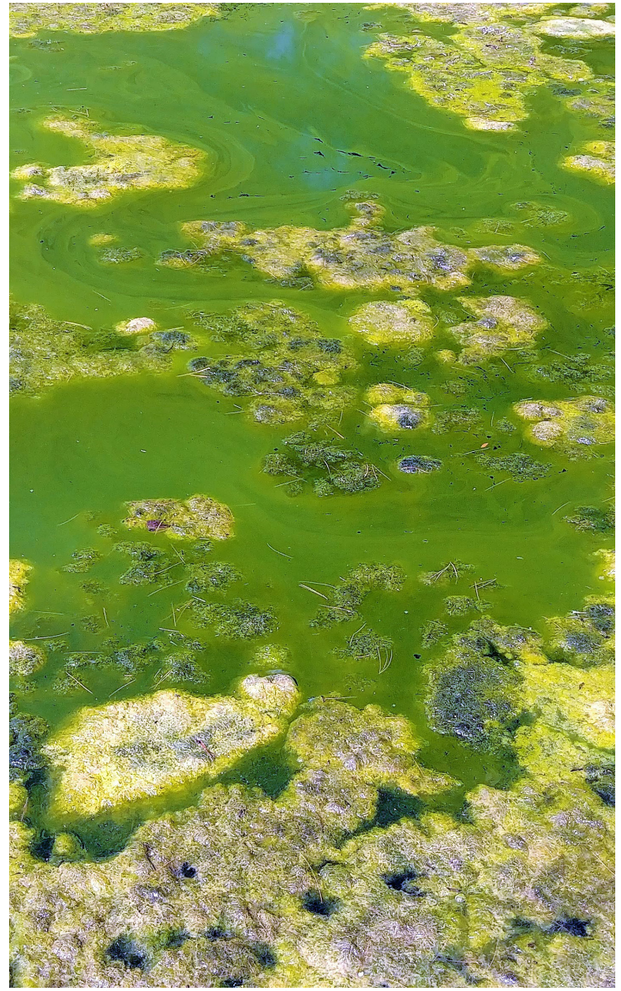

Image of Harmful Algal Blooms.