The first real snapshot of algal bloom toxins in Lake Erie

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Credit: Justin Chaffin

Remote-sensing technology produces detailed images of the size and

density of the harmful algal bloom (HAB) in Lake Erie's western basin each year, but determining the bloom's toxicity relies on research that—literally—tests the waters.

An initiative called the "HABS Grab," conducted by an international team of researchers, has provided the most accurate estimates to date of where and how much of the liver toxin microcystin might be present during a seasonal bloom.

The 100 and 172 water samples "grabbed" in one-day outings a year apart suggested there were about 12 tons of microcystins—the toxins that can be produced by cyanobacteria—in the lake on a single day in 2018, and over 30 tons in the western basin on one day in 2019.

Beyond reaching those estimates, the team found that the concentration of the toxins fluctuated over short distances, and less than a quarter of all of the Microcystis, the most common cyanobacteria genus in Lake Erie, were actually capable of toxin production. In addition, findings suggested using chlorophyll as a proxy measure for the presence of microcystin may not be as reliable as previously thought.

"Those issues can only be overcome with more frequent data collection," said Justin Chaffin, senior researcher and research coordinator at The Ohio State University's Stone Laboratory and lead author of the study.

"We have good biomass data from satellites, so we can see where the bloom is and how thick it is, but there's never a direct link between bloom biomass and how much toxin there is in the water. To measure the toxin you have to be out on a boat grabbing a sample."

The research is published online in the journal *Harmful Algae*.

The HABS Grab principal funder, the National Oceanic and

Atmospheric Administration (NOAA), annually forecasts the summer harmful algal bloom in Lake Erie, basing predictions on data derived from high-quality satellite imagery.

Microcystis is the main type of cyanobacteria that compose the HAB in Lake Erie, and it can produce high amounts of microcystins, which can pose risks to human and wildlife health. A dangerously high concentration of the toxin overwhelmed a Lake Erie water treatment plant in 2014, leading to the three-day Toledo drinking water crisis.

Lake Erie supplies drinking water to an estimated 11 million people in the United States and Canada—and for that reason alone, not to mention the lake's recreational uses and economic benefits—it's important to have a better handle on the toxicity of the annual bloom, Chaffin said.

"Obviously, we don't want toxins in there," he said. "Stepping further away, we're understanding how blooms occur in lakes and their spatial distribution, and the physiology that causes cyanobacteria to produce microcystins.

"We wanted to take the HABS Grab approach to quantify microcystins in a way that might help us eventually estimate its concentrations from day to day or week to week."

The two grabs took place on Aug. 9, 2018, and Aug. 7, 2019. On each of those days, 40 or so scientists—a U.S. team in 2018 and a joint U.S.-Canadian effort in 2019—boarded boats to collect water samples across the western basin, covering roughly 880 square miles. Back in their labs, researchers analyzed the samples' contents for nutrients, toxins, pigments and cyanobacterial DNA.

In 2018, the highest detected microcystin concentrations of between 2 to 5 micrograms per liter were found in water hugging the Ohio shoreline

and surrounding the Bass Islands. In contrast, the highest concentrations of between 15 and 50 micrograms per liter were measured in Maumee Bay in 2019—but in the same year, microcystins were below detectable levels near the Detroit River outflow and around the Bass Islands.

According to Ohio Environmental Protection Agency standards, treated drinking water should contain no more than 1.6 micrograms of microcystin per liter for adults and 0.3 micrograms per liter of the toxin for children. Water treatment plants monitor for microcystins, but Chaffin said that in an ideal scenario, scientists could tell plant operators when and at what concentration microcystins will be present in advance of the bloom reaching their intake.

The authors noted that the 12- and 30-ton biomass estimates of toxins in the blooms are largely a function of how big the western basin is. They estimated the basin-wide average concentration of microcystins at 0.52 and 1.38 micrograms per liter in 2018 and 2019, respectively, and noted that the concentrations detected in the HABS Grab samples varied by nearly two orders of magnitude over very short distances.

Less helpful was the finding that the microcystin-to-chlorophyll ratio varied widely throughout the western basin, indicating that incorrect water treatment decisions could be made if they rely solely on chlorophyll.

There are even potential bright spots, Chaffin said: The location of the toxins aligned with water currents, indicating that water currents can be used to forecast where those toxins will be transported, and the microcystin-to-chlorophyll ratio increased with nitrogen concentrations, suggesting nitrogen affects how much toxin a cyanobacteria cell can produce.

"We really needed a high-spatial-resolution toxin dataset so we can

compare it to the satellites and see, within one day, what the relationship is between toxins and bloom biomass," Chaffin said. "What we found is that the relationship between toxins and biomass even on one day is not consistent across the lake."

The HABS Grab was an enormous undertaking and hasn't been repeated since 2019. But the team hopes this study lays the groundwork for future data collection to broaden understanding of how toxins circulate during the annual harmful algal bloom and to bolster work to reduce related health risks.

"In order to be sure we implement the right strategies to protect the public and ecosystem health, we need to know as much information as we can, and one of the key pieces of information comes from this kind of sampling," said Felix Martinez, a program manager for the NOAA National Centers for Coastal Ocean Science. "If a really comprehensive dataset could be developed, taking a snapshot at different points in time over the bloom season, that might give us a better idea of how to predict conditions for a given year."

In the meantime, the researchers are continuing to analyze the samples for purposes ranging from characterizing microbial communities in the water to ecosystem modeling.

More information: Justin D. Chaffin et al, The Lake Erie HABs Grab: A binational collaboration to characterize the western basin cyanobacterial harmful algal blooms at an unprecedented high-resolution spatial scale, *Harmful Algae* (2021). DOI: 10.1016/j.hal.2021.102080

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