Harmful Algal Blooms and **Drinking Water Treatment Research**

Darren Lytle and Nick Dugan

In August 2014, half a million people living in and around Toledo, Ohio were issued a water advisory alerting them to avoid all contact with tap water. A cyanobacterial harmful algal bloom (cyanoHAB) in western Lake Erie, Toledo's water source, had produced elevated levels of microcystin toxins from the freshwater cyanobacteria, *Microcystis*. These toxins, which are known to cause gastrointestinal issues, upper respiratory infections, skin irritations, and at high exposure levels, liver damage, had made their way through the water treatment facility (Figure 1).

Toledo's water treatment facility, like much of the water treatment infrastructure in the United States, was designed primarily and built with particulate and microbial contaminant removal in mind. Removal of dissolved organic contaminants, such as cyanobacterial toxins, requires either capital-intensive new construction, or the addition of chemicals or adsorbents such as powdered activated carbon (PAC), which can contribute significantly to the water utility's maintenance and operations budget (Figure 2).

The Toledo, OH, facility represents one example of a facility challenged by a cyanoHAB with high levels of cyanobacterial toxins. EPA has been conducting algal bloom research at multiple facilities around Lake Erie over the past few years to help communities confront the challenge of keeping cyanobacterial toxins from reaching consumers' taps. The first goal of this research is to determine how drinking water providers can optimize their existing facilities to maximize their treatment capabilities for removing cyanobacteria and their toxins.

Figure 1. View from Perry's Victory and International Peace Memorial, located near South Bass Island in Lake Erie's western basin (note the water color).

During the 2013 and 2014 algal bloom seasons, EPA researchers collected monthly samples from seven drinking water treatment facilities distributed along the Ohio shoreline of Lake Erie (see Figure 3, sites not plotted in figure). The samples were collected from six to nine locations (from different parts of the treatment system) at each facility, from May through November. The source water qualities at the facilities ranged from mildly to highly impacted by cyanobacterial blooms. The majority of the observed cyanobacterial activity was confined to the shallow, western end of the lake. Cyanobacterial blooms tend to form in shallow, stable bodies of water that are rich in nutrients, particularly as water warms with rising spring and summer temperatures. All of the samples were analyzed for microcystins, chlorophyll-*a* (which represents the concentration of suspended cyanobacteria), and other chemical markers commonly associated with cyanobacterial bloom events.

One significant finding from these sampling efforts was that the majority of the toxin contamination entering the treatment facilities was contained within the individual cells of the cyanobacteria, *Microcystis* (see Figure 4). As long as the cells remained intact, they and their

Figure 2. Main filter gallery at a well-maintained Lake Erie drinking water treatment facility. Although some of the instrumentation panels are of modern design, the plant itself was constructed in 1940.

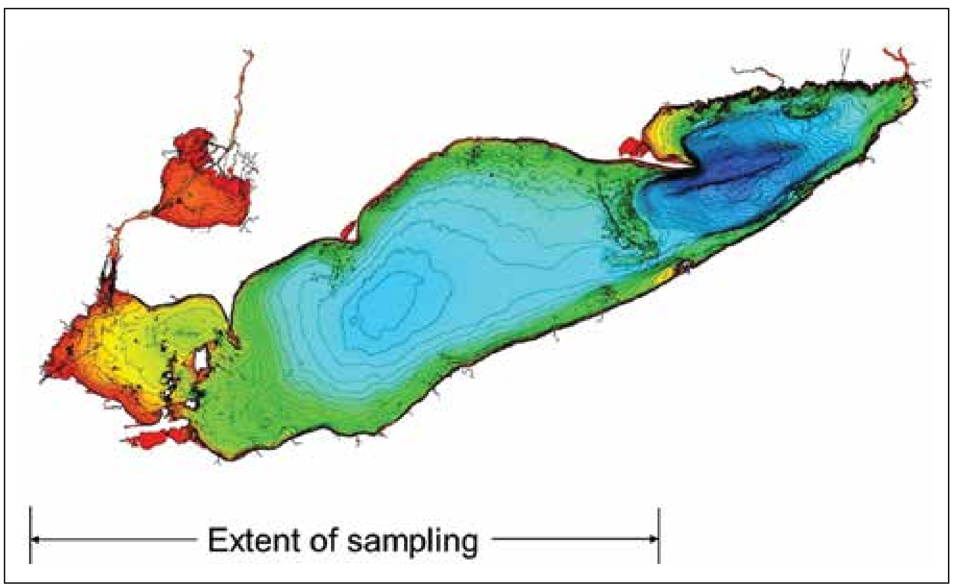

Figure 3. Geographic extent of the EPA's Lake Erie sampling campaign (note: color temperature corresponds to water depth; deeper waters correspond to colder colors (i.e., green to blue).

associated toxins could be removed using the conventional particulate removal processes already in place. As shown in Figure 5, cell removal efficiencies often exceeded four orders of magnitude through the treatment plant.

Data collected during the sampling indicated that EPA could productively focus research efforts on the early stages of treatment processes, where potassium permanganate and PAC are added. The treatment chemical potassium permanganate controls zebra mussels and reduces dissolved organic compounds responsible for bad tastes and odors. Under certain conditions, potassium permanganate also has the potential to stimulate the release of intracellular toxins from cyanobacteria, thus increasing potential downstream risks. EPA's research will provide water utility managers with a better understanding of how treatment processes affect cyanobacterial cells and their toxins. The knowledge gained will help inform drinking water providers in making decisions to optimize the trade-offs between competing treatment goals, human health risk reduction, and costs.

As follow-up for the 2015 bloom season, EPA is planning to provide technical support to the city of Toledo's drinking water treatment facility. Preliminary investigations of cyanobacterial toxins in drinking water treatment plant influents in the western United States will also be performed. The EPA's drinking water engineering research effort is complemented by the development of standard analytical methods to quantify cyanobacterial toxins in different types of water ranging from raw lake water to finished drinking water. All of this work is part of an EPA drinking water research effort that has been in place since the Agency's inception in 1970.

Selected References

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EPA's Harmful Algal Bloom Research Webpage (accessed April 24, 2015:

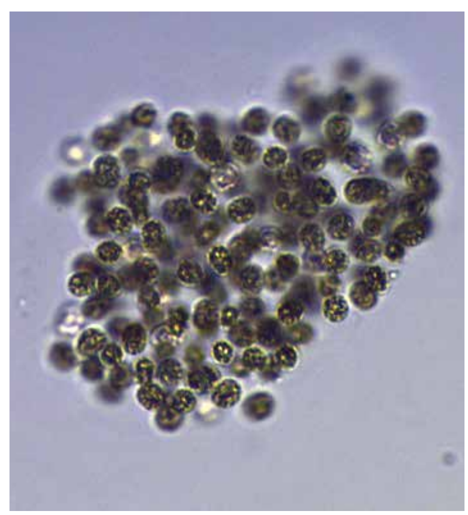

Figure 4. Individual cells of the freshwater cyanobacteria, Microcystis.

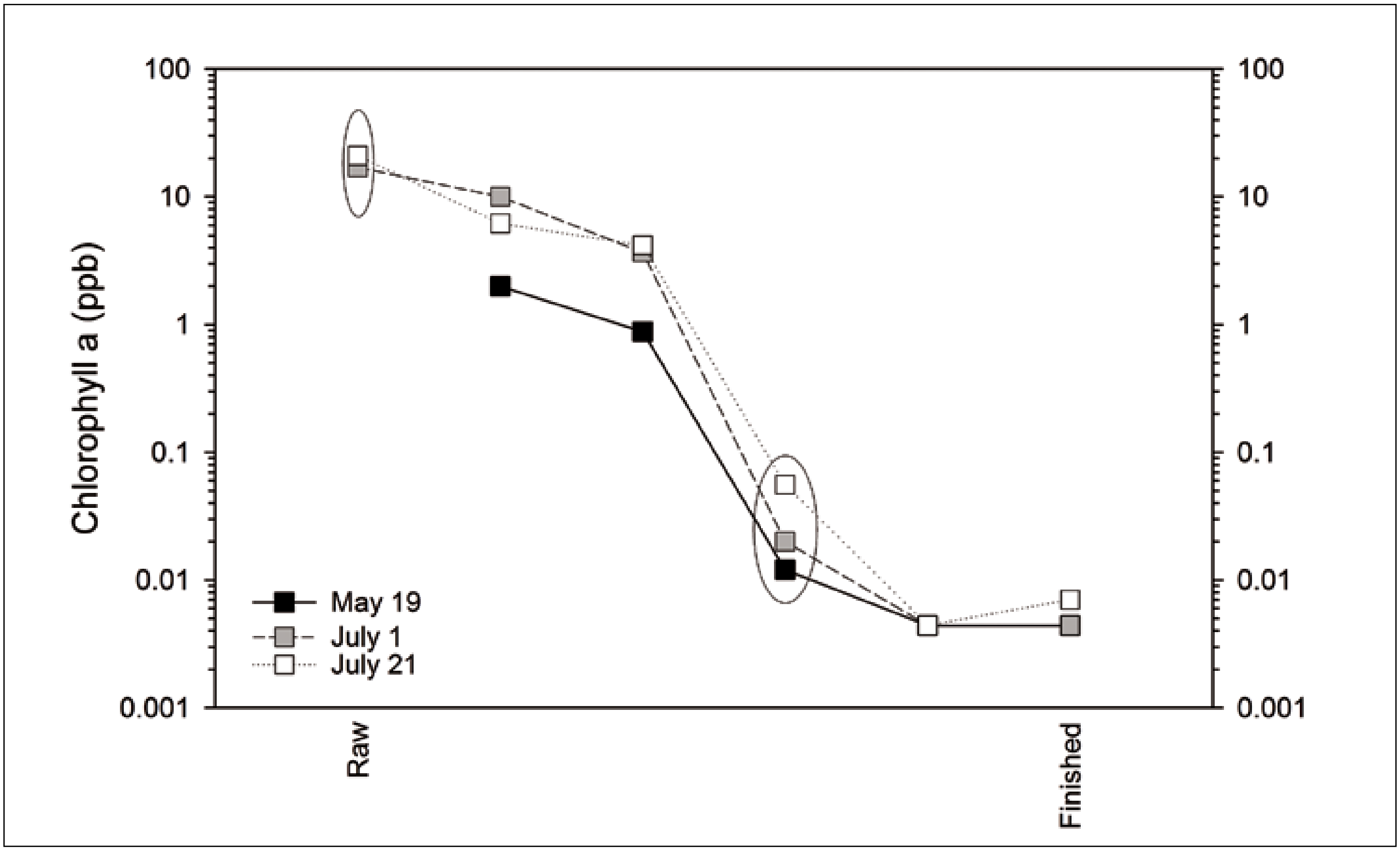

Figure 5. Removal of cyanobacterial cells, using chlorophyll a as a proxy, through treatment at a Lake Erie drinking water treatment facility. Profile data are from three different sampling events during the 2014 bloom season. Differences between circled points represent removal of cells through water treatment stages designed for particulate control.

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Darren Lytle is an environmental engineer who focuses his research on drinking water contaminants and treatment technologies. He investigates corrosion control and water quality; lead and copper corrosion control; and filtration with an emphasis on removal of microbial pathogens. You can reach Darren at Lytle.Darren@epa.gov.

Nick Dugan is an environmental engineer who investigates the removal of organic, inorganic and particulate contaminants through a variety of water treatment processes. Nick can be reached at Dugan.Nicholas@epa.gov.

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