

Cyanotoxins in Drinking Water Supplies – Monitoring and Control Strategies

Sunil Kommineni, PhD, PE, BCEE, CWO – Water Quality/Treatment Lead, KIT Professionals, Houston, TX
Djanette Khiari, PhD – Senior Project Manager, Water Research Foundation, Denver, CO

The City of Toledo, OH drinking water crisis this summer brought international attention to an issue that is impacting drinking water supplies – cyanotoxins. Cyanobacteria, also known as blue green algae, are a concern for water purveyors as their presence in water supplies results in water quality issues such as taste and odor (from algal byproducts such as methyl-isoborneol (MIB) and geosmin) and cyanotoxins (or algal toxins). Cyanobacterial blooms occur seasonally and are generally a result of over-enrichment of surface waters by plant nutrients, particularly nitrogen and phosphorus. Human influences such as urbanization, population growth, and agriculture as well as climate change resulting in extreme weather conditions contribute to the rise in number and intensity of cyanobacterial blooms. A recent study conducted by United States Geological Survey (USGS) and Texas Commission on Environmental Quality (TCEQ) has identified a number of Texas reservoirs with potentially harmful cyanobacteria and its by-products (MIB, geosmin and microcystin).

Although cyanotoxins are less frequently found in drinking water supplies compared to taste and odor compounds, their toxicity is of great concern. Cyanotoxins of concern include hepatoxins which affect the liver (e.g., Microcystin-LR, Cylindrospermopsin), neurotoxins which affect the nervous system (e.g., Anatoxin-a), and dermatotoxins which cause skin irritations (e.g., Palytoxin). Presently, there are no United States Environmental Protection Agency (USEPA) regulations for cyanotoxins. The U.S. Environmental Protection Agency (USEPA) recently proposed non-mandatory, 10-day health advisories for Microcystin and Cylindrospermopsin. The USEPA has recognized cyanotoxins as unregulated contaminants that may need to be regulated in the future and included Anatoxin-a, Microcystin-LR, and Cylindrospermopsin in the Contaminant Candidate List 3. More than a dozen countries, including Canada and Australia, have guidelines or regulations for Microcystin-LR in drinking water. The World Health Organization has a provisional guideline value of 1 microgram per liter for Microcystin-LR in finished drinking water. In the US, several states have established drinking water advisory thresholds for cyanotoxins, mainly microcystin LR.

Strategies to mitigate the effects of cyanotoxins need to include both source water and treatment plant monitoring and control measures. Source water monitoring may include visual observations and monitoring of algal surrogates (chlorophyll-a, algal counts), nutrients (N, P) and algal by-products (MIB, geosmin, microcystin) during harmful algal blooms. Source water control measures include aeration/mixing of lakes/reservoirs to prevent stratification, controlling influx of nutrients through watershed programs, designing an intake with the ability to draw water from various depths, and having the ability to draw-on alternate source waters during a bloom. Chemical strategies such as copper sulfate addition to treat algal blooms require careful consideration since it can cause the cells to lyse and potentially release cyanotoxins.

The effectiveness of in-plant treatment processes depends on whether the toxins are contained within the cyanobacterial cell (intracellular) or in the dissolved state (extracellular). Conventional water treatment processes such as coagulation, flocculation, sedimentation and granular media filtration are effective for removing intact cells (or intracellular cyanotoxins). Dissolved air flotation has been shown to be more effective compared to gravity settling for cell removal. Cyanobacteria confined in the sludge may

not lose viability, die and release toxins into the supernatant water. During an algae episode, it is important to isolate sludge and sludge supernatant until the algae bloom has subsided. Microfiltration and ultrafiltration membranes are more effective compared to granular media filtration for intact algal cells removal. During algal blooms, granular media filters and membrane filters need to be backwashed more frequently to avoid clogging / fouling and reduce the risk of toxins release to the water.

Adsorption using granular activated carbon (GAC) and powdered activated carbon (PAC) is effective for removal of cyanotoxins provided there is sufficient contact time. Oxidation using chlorine, ozone and ozone/peroxide have also been shown to remove dissolved some cyanotoxins (e.g., Microcystins) toxins. While ultraviolet (UV) disinfection is not effective for cyanotoxins removal, UV oxidation using higher dosages of UV coupled with hydrogen peroxide can oxidize algal toxins. Ideally, oxidation processes are to be supplemented with biological filtration to optimize toxin removal.

This presentation will discuss the risks associated with algal toxins, occurrence of cyanotoxins in Texas surface waters, development and implementation of source water monitoring programs, and control strategies that water purveyors can consider and implement. This presentation will discuss information and “lessons-learned” by water purveyors that participated in several Water Research Foundation projects. The findings of the presentation will be useful for water utility managers, water treatment plant superintendents, and consultants that are addressing or plan to address water quality issues related to algal blooms.