

# Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems

## Summary

This fact sheet provides public water systems (PWSs) basic information on human health effects, analysis tools, and the effectiveness of various treatment processes to remove or inactivate four commonly occurring cyanotoxins in water bodies that are a source of drinking water throughout most of the U.S. Cyanotoxins are listed on the EPA's fourth drinking water Candidate Contaminant List and include, but are not limited to, anatoxin-a, cylindrospermopsin, microcystins, and saxitoxin. This fact sheet does not address taste and odor issues caused by the cyanobacteria and will only focus on discussions of anatoxin-a, cylindrospermopsin, microcystins, and saxitoxin.

## Background

The Safe Drinking Water Act (SDWA) protects public health by regulating the nation's public drinking water supply, which relies on sources that include: rivers, lakes, reservoirs, springs, and ground water wells. The SDWA requires the EPA to publish a list of unregulated contaminants that are known or expected to occur in public water systems in the U.S. that may pose a risk in drinking water. This list is known as the Contaminant Candidate List (CCL).

The cyanotoxins included in the most recent CCL are produced by several species of cyanobacteria (cyanobacteria are known as blue-green algae). No federal regulatory guidelines for cyanobacteria or their toxins in drinking water or recreational waters exist at this time. The EPA published drinking water health advisories (HA) for microcystins and cylindrospermopsin in June 2015. The EPA recommends HA levels at or below 0.3 µg/L for microcystins and 0.7 µg/L for

cylindrospermopsin in drinking water for children pre-school age and younger (less than six years old). For school-age children through adults, the recommended HA levels for drinking water are at or below 1.6 µg/L for microcystins and 3.0 µg/L for cylindrospermopsin. Young children are more susceptible than older children and adults as they consume more water relative to their body weight.

There are currently a few states that have established cyanotoxin monitoring guidelines and cyanotoxin threshold levels for public water systems (PWSs). PWSs are responsible for following those guidelines/thresholds and for undertaking any follow-up action required by their state.

## Causes of cyanobacterial harmful algal blooms

Cyanobacteria are photosynthetic bacteria that share some properties with algae and are found naturally in lakes, streams, ponds, and other surface waters. Similar to other types of algae, when conditions are favorable, cyanobacteria can rapidly multiply in surface water and cause "blooms." Several types of cyanobacteria, for example *Dolichospermum* (previously *Anabaena*) *flos-aquae*, have gas-filled cavities that allow them to float to the surface or to different levels below the surface, depending on light conditions and nutrient levels. This can cause the cyanobacteria to concentrate on the water surface, causing a pea-soup green color or blue-green "scum." Some cyanobacteria, such as *Planktothrix agardhii*, can be found in bottom sediments and float to the surface when mobilized

by storm events or other sediment disturbances. Other cyanobacteria blooms may remain dispersed through the water column (such as *Raphidiopsis*, previously *Cylindrospermopsis* sp.) leading to a generalized discoloration of the water.

### Conditions that enhance growth of cyanobacterial harmful algal blooms

Factors that promote cyanobacterial bloom formation and persistence include:

- Extended periods of direct sunlight,
- Elevated nutrient availability (especially phosphorus and nitrogen),
- Elevated water temperature,
- pH changes,
- An increase in precipitation events,
- Calm or stagnant water flow, and water column stability/lack of vertical mixing.

Although bloom conditions in much of the U.S. are more favorable during the late summer, the interrelationship of these factors causes large seasonal and year-to-year fluctuations in the cyanobacteria levels. Some toxin-producing strains can occur early in the summer season while others are only found during late summer.

### Effects of cyanobacterial harmful algal blooms

Cyanobacterial blooms can be harmful to the environment, animals, and human health. The bloom decay consumes oxygen, creating hypoxic conditions which result in plant and animal die-off. Under favorable conditions of light and nutrients, some species of cyanobacteria produce toxic secondary metabolites, known as cyanotoxins. Common toxin-producing cyanobacteria are listed in Table 1. The conditions that cause cyanobacteria to produce cyanotoxins are not well understood. Some species with the ability to produce toxins may not produce them under all conditions. These species are often members of the common bloom-forming genera. Both non-toxic and toxic

varieties of most of the common toxin-producing cyanobacteria exist, and it is impossible to tell if a species is toxic or not toxic by looking at it. Also, even when toxin-producing cyanobacteria are present, they may not actually produce toxins. Furthermore, some species of cyanobacteria can produce multiple types and variants of cyanotoxins. Molecular tests are available to determine if the cyanobacteria, *Microcystis* for example, carry the toxin-producing gene. However, quantitative cyanotoxin analysis is needed to determine if the cyanobacteria are producing the toxin. Water contaminated with cyanobacteria can occur without associated taste and odor problems.

In most cases, the cyanobacterial toxins naturally exist intracellularly (in the cytoplasm) and are retained within the cell. Approximately 95% of anatoxin-a and the microcystin variants are found intracellularly during the growth stage of the bloom of certain cyanobacteria species. When the cyanobacteria cell dies or the cell membrane ruptures or is stressed, the toxins are released into the water (called “extracellular” toxins). However, more significant proportions of other cyanotoxins such as cylindrospermopsin, can be naturally released to the water by the live cyanobacterial cell. The reported ratio is about 50% intracellular and 50% extracellular during the growth stage of the bloom. Extracellular toxins may adsorb to clays and organic material in the water column and are generally more difficult to remove than the intracellular toxins.

### Health effects caused from exposure to cyanotoxins

Exposure to cyanobacteria and their toxins could occur by ingestion of drinking water contaminated with cyanotoxins and through direct contact, inhalation and/or ingestion during recreational activities. The acute recreational exposure to cyanobacterial blooms and their cyanotoxins can result in a wide range of symptoms in humans including fever, headaches, muscle and joint pain, blisters, stomach cramps, diarrhea, vomiting, mouth ulcers, and allergic

reactions (see Table 1).

**Table 1. Cyanotoxins on the Contaminant Candidate List (CCL)**

Cyanotoxin	Number of Variants	Primary Organ Affected	Health Effects <sup>1</sup>	Most Common Cyanobacteria Producing Toxin <sup>2</sup>
Microcystins	>100	Liver	Abdominal pain Vomiting and diarrhea Liver inflammation and hemorrhage	<i>Microcystis</i> , <i>Dolichospermum</i> (previously <i>Anabaena</i> ), <i>Nodularia</i> , <i>Planktothrix</i> , <i>Fischerella</i> , <i>Nostoc</i> , <i>Oscillatoria</i> , and <i>Gloeotrichia</i>
Cylindrospermopsin	3	Liver	Acute pneumonia Acute dermatitis Kidney damage Potential tumor growth promotion	<i>Raphidiopsis</i> (previously <i>Cylindrospermopsis</i> ) <i>raciborskii</i> , <i>Aphanizomenon flos-aquae</i> , <i>Aphanizomenon gracile</i> , <i>Aphanizomenon ovalisporum</i> , <i>Umezakia natans</i> , <i>Dolichospermum bergii</i> , <i>Dolichospermum lapponica</i> , <i>Dolichospermum planctonica</i> , <i>Lyngbya wollei</i> , <i>Raphidiopsis curvata</i> , and <i>Raphidiopsis mediterranea</i>
Anatoxin-a group <sup>3</sup>	2-6	Nervous System	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death (symptoms observed in animals)	<i>Chrysoosporum</i> ( <i>Aphanizomenon</i> ) <i>ovalisporum</i> , <i>Cuspidothrix</i> , <i>Raphidiopsis</i> , <i>Cylindrospermum</i> , <i>Dolichospermum</i> , <i>Microcystis</i> , <i>Oscillatoria</i> , <i>Planktothrix</i> , <i>Phormidium</i> , <i>Dolichospermum flos-aquae</i> , <i>A. lemmermannii</i> , <i>Raphidiopsis mediterranea</i> (strain of <i>Raphidiopsis raciborskii</i> ), <i>Tychonema</i> and <i>Woronichinia</i>
Saxitoxin	>50	Nervous System	Tingling, numbness, headaches, dizziness, nausea, vomiting and diarrhoea, temporary blindness, paralysis and death	<i>Aphanizomenon flos-aquae</i> , <i>Dolichospermum circinalis</i> , <i>Lyngbya wollei</i> , <i>Planktothrix spp.</i> and a Brazilian isolate of <i>Raphidiopsis raciborskii</i> .

<sup>1</sup> Sources: *Health Effects Support Documents (HESD) for microcystins, cylindrospermopsin and anatoxin-a (US EPA c,d,e) and Testai et al., 2016*

<sup>2</sup> Not all species of the listed genera produce toxin; in addition, listed genera are not equally as important in producing cyanotoxins.

<sup>3</sup> The anatoxin-a group does not include the organophosphate toxin anatoxin-a(S) as it is a separate group. In the US, the most common member is thought to be anatoxin-a, and thus this toxin is listed specifically.

Such effects can occur within minutes to days after exposure. In severe cases, seizures, liver failure, respiratory arrest, and (rarely) death may occur. The cyanotoxins include neurotoxins (which affect the nervous system), hepatotoxins (which affect the liver), and dermatotoxins (which affect the skin). However, there have been new studies of effects in other systems, including hematological, kidney, cardiac, reproductive, and gastrointestinal effects. There is evidence that long-term exposure to low levels of microcystins and cylindrospermopsin may promote cell proliferation and the growth of tumors. However, more information is needed to determine the carcinogenicity of both microcystins and cylindrospermopsin.

There have been many documented reports of dog, bird and livestock deaths throughout the world as the result of consumption of surface water with cyanobacterial blooms. In 1996, 116 patients at a renal dialysis clinic in Caruaru, Brazil experienced headache, eye pain, blurred vision, nausea and vomiting when they were exposed intravenously to water containing a mixture of microcystin and cylindrospermopsin (Carmichael et al., 2001). Subsequently, 100 of the affected patients developed acute liver failure and, of these, 76 died. Analyses of blood, sera, and liver samples from the patients revealed only the microcystin toxin.

## Analytical Methods

Table 2 describes the methods available for cyanotoxin measurement in freshwater. For drinking water, the EPA developed [Method 544](#), a liquid chromatography/tandem mass spectrometry (LC/MS/MS) method for microcystins and nodularin (combined intracellular and extracellular), [Method 545](#), a LC-ESI/MS/MS method for the determination of cylindrospermopsin and anatoxin-a, and [Method 546](#), an ADDA-ELISA method.

Commercially available Enzyme-Linked Immunosorbent Assay (ELISA) test kits are one of the more commonly utilized cyanotoxin testing methods, since they do not require expensive equipment or extensive training to run. Semi-quantitative field screening ELISA kits are

available for the presence or absence of cyanotoxins. If cyanotoxins are detected by a field screening kit, repeat analysis is recommended using either a quantitative ELISA test or one of the other analytical methods identified in Table 2. More precise, quantitative ELISA test kits are available for microcystins/nodularins (including ADDA-ELISA), saxitoxin, anatoxin-a, and cylindrospermopsin. Although they provide rapid results, ELISA kits generally have limitations in selectivity and are not congener specific and recognizing different congeners can vary quantitatively due to different cross-reactivities.

Methods that utilize liquid chromatography combined with mass spectrometry (LC/MS) can precisely and accurately identify specific microcystin congeners for which standards are available. LC/MS methods have also been designed to minimize matrix interference. Currently, a few standards for a limited number of the known microcystin congeners are available. If congener-specific information is needed, an LC/MS (ion-trap, tandem mass spectrometry, TOF) method should be considered. Although HPLC-PDA methods are less selective than LC/MS methods and the quantitation is more problematic due to sample matrix interference, they could provide a measure of resolution of the congeners present. You may also consult the [EPA Frequently Asked Questions: Laboratory Analysis for Microcystins in Drinking Water](#) for more information.

## Sample handling considerations

Samples must be handled properly to ensure reliable results. Detailed procedures are typically specified in the particular analytical methods/SOPs. Water systems should obtain and follow sample collection and handling procedures established by the laboratory performing the analysis. Laboratories establishing such procedures should adhere to analytical method defined protocols but may also consult the USGS sampling protocol [Guidelines for design and sampling for cyanobacterial toxin and taste-and-odor studies in lakes and reservoirs \(2008\)](#).

**Table 2. Methods Available for Freshwater Cyanotoxin Detection**

Methods	Anatoxins	Cylindrospermopsin	Microcystins	Saxitoxin
<b>Biological Assays</b>				
Mouse	Yes	Yes	Yes	
Protein Phosphatase Inhibition Assays (PPIA)	No	No	Yes	
Neurochemical	Yes	No	No	
Enzyme-Linked Immunosorbent Assays (ELISA)	Yes	Yes	Yes	Yes
<b>Chromatographic Methods</b>				
<b>Gas Chromatography</b>				
Gas Chromatography with Flame Ionization Detection (GC/FID)	Yes	No	No	No
Gas Chromatography with Mass Spectrometry (GC/MS)	Yes	No	No	No
<b>Liquid Chromatography</b>				
Liquid Chromatography / Ultraviolet - Visible Detection (LC/UV or LC/PDA)	Yes	Yes	Yes	Yes
Liquid Chromatography/ Fluorescence (LC/FL)	Yes	No	No	Yes
<b>Liquid Chromatography Combined with Mass Spectrometry</b>				
Liquid Chromatography Ion Trap Mass Spectrometry (LC/IT MS)	Yes	Yes	Yes	Yes
Liquid Chromatography Time-of-Flight Mass Spectrometry (LC/TOF MS)	Yes	Yes	Yes	Yes
Liquid Chromatography Single Quadrupole Mass Spectrometry (LC/MS)	Yes	Yes	Yes	Yes
Liquid Chromatography Triple Quadrupole Mass Spectrometry (LC/MS/MS)	Yes	Yes	Yes	Yes

Among the most important sample handling considerations are the following:

- *Collection* – Bottle type, volume, and preservative used depend on the laboratory doing the analysis. Generally, samples should be collected and stored in amber glass containers to avoid potential cyanotoxin adsorption associated with plastic containers and to minimize exposure to sunlight.
- *Quenching* – samples (particularly “finished” drinking water samples) that include

a residual disinfectant, e.g., chlorine, should be quenched immediately upon sampling. Sodium thiosulfate or ascorbic acid are commonly used as quenching agents and their appropriateness can be specific to the analytical method selected to meet the monitoring data quality objectives. For example, EPA Method 544, an LC/MS/MS technique for measuring six microcystin congeners and nodularin in drinking water, specifies the use of ascorbic acid, along with other sample preservation reagents. On the other hand, EPA Method 546



(an ELISA technique for measuring “total microcystins” and nodularin in drinking water), exclusively specifies the use of sodium thiosulfate and prohibits the use of ascorbic acid. The different approaches are deliberate and designed to meet method performance goals that include established criteria for sample hold times.

- *Chilling* – samples should be cooled immediately after collection, during shipping, and pending analysis at the laboratory. Depending on the analytical method being used, sample freezing may be appropriate to extend holding times, taking precautions to avoid breakage.

### Sample analysis considerations

When measuring both intracellular and extracellular toxins, rupturing cyanobacterial cells (lysing) is generally employed to break the cell wall and release the toxins into solution. Freeze/thaw cycling, traditionally carried out over three or more cycles, is the most common lysing technique, though some analytical methods rely on other approaches. Lysing is particularly important for samples collected prior to the PWS filter effluent. For a well-designed, well-operated PWS, lysing would not be expected to have a significant impact on finished water (post-filtration) samples as cyanobacteria cells should not be present at significant levels in the finished water. However, laboratories must carefully follow the requirements of the analytical methods and mandated monitoring programs, which may require lysing for all samples. Some analysts elect to confirm the effectiveness of raw-water lysing (or to judge the need for finished-water lysing) using microscopic examination for intact algal cells.

### Cyanotoxin treatment and bloom management

Once cyanobacteria and/or their cyanotoxins are detected in the surface water supplying the water system, the treatment system operators can act to

remove or inactivate them in several ways. Some treatment options are effective for some cyanotoxins, but not for others. Effective management strategies depend on understanding the growth patterns and species of cyanobacteria that dominates the bloom, the properties of the cyanotoxins (i.e., intracellular or extracellular), and appropriate treatment processes. For example, oxidation of microcystin depends on the chlorine dose, pH and the temperature of the water. Applying the wrong treatment process at a specific state in treatment could damage cells and result in the release rather than removal of cyanotoxins.

Table 3 summarizes the effectiveness of different types of water treatment to remove intact cyanobacteria cells and treatment processes that are effective in removing extracellular dissolved toxins of several of the most important cyanobacteria. You may also consult the EPA [\*Water Treatment Optimization for Cyanotoxins\*](#) document for more information.

To avoid the release of cyanotoxins into the water, drinking water treatment operators can undertake different management strategies to deal with cyanobacteria blooms. For example, those drinking water utilities that have access to more than one intake can switch to an alternate source that is not as severely impacted by the bloom. Another management alternative is to adjust intake depth to avoid drawing contaminated water and cells into the treatment plant.

Pretreatment oxidation at the intake poses several concerns with respect to lysing cells and releasing toxins. Copper sulfate and ozone at the intake are not recommended because of the risk of lysing algal cells. Chlorination, in addition to lysing the cells, has the potential to produce disinfection by-products during water treatment. If pretreatment oxidation is needed, it is important to carefully evaluate the influent, as successful pre-oxidation depends on the algal species, oxidant and dose.

**Table 3. Cyanotoxin Treatment Processes and Relative Effectiveness**

Treatment Process	Relative Effectiveness
<b><i>Intracellular Cyanotoxins Removal (Intact Cells)</i></b>	
Pre-treatment oxidation	Oxidation often stresses or lyses cyanobacteria cells releasing the cyanotoxin to the water. If oxidation is required to meet other treatment objectives, consider using lower doses of an oxidant less likely to lyse cells. If oxidation at higher doses must be used, sufficiently high doses should be used to not only lyse cells but also destroy total toxins present (see extracellular cyanotoxin removal).
Coagulation/ Sedimentation/ Filtration	Effective for the removal of intracellular toxins (cyanobacteria cells). Ensure that captured cells accumulated in sludge are removed frequently so as not to release toxins. Ensure that sludge supernatant is not returned to the supply after sludge separation.
Membranes	Effective for removal of intracellular cyanotoxins (cyanobacteria cells). Microfiltration and ultrafiltration are effective when cells are not allowed to accumulate on membranes for long periods of time. More frequent cleaning may be required during a HAB.
Flotation	Flotation processes, such as Dissolved Air Flotation (DAF), are effective for removal of intracellular cyanotoxins since many of the toxin-forming cyanobacteria are buoyant.
<b><i>Extracellular (Dissolved) Cyanotoxins Removal</i></b>	
Membranes	Depends on the type of cyanotoxin, membrane material, membrane pore size distribution, and influent water quality. Nanofiltration is generally effective in removing extracellular microcystins. Reverse osmosis filtration is generally applicable for removal of microcystins and cylindrospermopsin. Cell lysis is highly likely. Further research is needed to characterize performance.
Potassium Permanganate	Effective for oxidizing microcystins and anatoxins. Further research is needed for cylindrospermopsin. Not effective for oxidizing saxitoxin.
Ozone	Very effective for oxidizing microcystins, anatoxin-a, and cylindrospermopsin. Not effective for oxidizing saxitoxin.
Chloramines	Not effective.
Chlorine dioxide	Not effective at doses typically used in drinking water treatment.
Free Chlorine	Effective for oxidizing microcystins as long as the pH is below 8. Effective for oxidizing cylindrospermopsin and saxitoxin. Not effective for oxidizing anatoxin-a.
UV Radiation	UV radiation alone is not effective at oxidizing microcystins and cylindrospermopsin at doses typically used in drinking water treatment. When UV radiation is coupled with ozone or hydrogen peroxide (called “advanced oxidation”), the process is effective at oxidizing anatoxin-a, cylindrospermopsin, and with high UV doses, microcystins.

Treatment Process	Relative Effectiveness
Activated Carbon Adsorption	<p><u>Powdered activated carbon (PAC)</u>: Effectiveness of PAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as NOM concentration. Wood-based activated carbons are generally the most effective at microcystins adsorption. More research is needed to evaluate PAC's effectiveness at adsorbing cylindrospermopsin, anatoxin-a, and saxitoxin, however the limited research has demonstrated promising results. Doses in excess of 20mg/L may be needed for complete toxin removal, especially if NOM concentrations are high.</p> <p><u>Granular activated carbon (GAC)</u>: Effectiveness of GAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as NOM concentration. GAC is effective for microcystins, and likely effective for cylindrospermopsin, anatoxin-a and saxitoxin. The condition of the carbon is an important factor in determining GAC's effectiveness for cyanotoxin removal. GAC may need to be regenerated more frequently to ensure adequate adsorption capacity for HAB season.</p>

In-line application of powdered activated carbon (PAC) could also be used to remove any toxins that may have been released.

### Intracellular cyanotoxin removal

The conventional drinking water treatment processes (coagulation, flocculation, sedimentation and filtration) can be effective in removing intracellular cyanotoxins (cyanobacteria cells). Coagulation, flocculation and dissolved air flotation (DAF) are more effective than sedimentation. Microfiltration and ultrafiltration are highly effective at removing intact cyanobacterial cells. During an active bloom, operators may need to alter process parameters to account for the increased loading of cyanobacteria. It may be necessary to backwash filters more frequently to prevent retained cells from releasing intracellular toxins.

### Physical removal of extracellular cyanotoxins

Common treatment techniques for the removal of extracellular toxins include adsorption by

activated carbon, membrane filtration and chemical inactivation (disinfectants and oxidants). Both powdered activated carbon (PAC) and granular activated carbon (GAC) have been effective in adsorbing microcystins and cylindrospermopsin, although microcystin variants may have different adsorption efficiencies. The performance of activated carbon depends on the concentration of the toxin, influent water quality (i.e., NOM concentration), PAC dose, and type of activated carbon. Jar tests are recommended to test the effectiveness of various PAC types and doses, with the implementation of the carbon with the greatest capacity for removal of the target contaminants. GAC filters are effective in removing microcystins if they are properly regenerated to ensure adequate adsorption capacity is maintained. Nanofiltration and reverse osmosis may be effective in removing cylindrospermopsin and microcystin. However, site specific tests are recommended as removal efficiency depends on the membrane pore size distribution and water quality.



## Oxidation of extracellular cyanotoxins

Ultraviolet (UV) radiation is not effective at typical water treatment plant doses. Much higher doses are required to photolytically destroy microcystin, anatoxin-a, and cylindrospermopsin. For example, UV inactivation dose for *Cryptosporidium parvum* is about 40 mJ/cm<sup>2</sup>, while the photolytic destruction dose for microcystin, cylindrospermopsin, anatoxin-a and saxitoxin ranges between 1530 to 20,000 mJ/cm<sup>2</sup>. UV has been used along with a catalyst (e.g., ozone, hydrogen peroxide, or titanium dioxide) to oxidatively decompose the toxins (this is typically called advanced oxidation). However, the effectiveness of this process is largely dependent on the organic content of the water.

Oxidants such as free chlorine, ozone and permanganate can be used to inactivate microcystins but free chlorine's effectiveness is pH-dependent (ideal range is 6-8). Anatoxin-a is resistant to oxidation by free chlorine. Ozone is an effective oxidant for microcystins, but its efficacy may be affected by the presence of organic matter. Ozone can also be used as an oxidant for anatoxin-a and cylindrospermopsin; however, ozone is pH-dependent for the oxidation of anatoxin-a (pH 7 to 10) and for cylindrospermopsin (4 and 10). Ozone is not effective for oxidizing saxitoxin. Permanganate is effective in oxidizing microcystin and anatoxin-a (from pH 6 to 8), but is not effective for cylindrospermopsin. Chloramines and chlorine dioxide are not effective treatments for microcystin, anatoxin-a or cylindrospermopsin.

Formation of disinfection by-products is another potential problem with the use of ozone, copper sulfate, and chlorine when there are high bromide concentrations in the water. However, results from studies on the impact of chlorination of cell-bound toxins and resulting disinfection by-products formation are contradictory. Most of the findings suggest that pre-chlorination should ideally be avoided during blooms, unless

adequate CT<sup>1</sup> values can be guaranteed to ensure efficient oxidation of lysed cyanobacteria and the resulting extracellular cyanotoxins.

Drinking water operators are encouraged to monitor the treated water to confirm the removal of cyanotoxins.

## Developing a Risk Management Plan

Water supply managers should consider developing a risk management plan for cyanobacterial bloom occurrence, especially those systems with source waters that are susceptible to HABs. Elements of such a plan should include monitoring, treatment and communication components. The plan could include a monitoring program to determine sampling locations and schedule; sample volume; whether to sample for cyanobacterial cells or specific cyanotoxins or both; which analytical screening test to use; and conditions when it is necessary to send sample(s) to an identified laboratory for confirmation. The EPA published Recommended Recreational Ambient Water Quality Criteria or Swimming Advisories for two Cyanotoxins, Microcystins and Cylindrospermopsin, that public water systems could use as part of the monitoring program during a severe bloom event with high levels of cyanobacteria and cyanotoxins in a surface water used for recreation and as a supply for drinking water treatment facilities. As part of the management plan, water supply managers should also develop strategies for effective treatment approaches to reduce the potential of cyanotoxins in the finished water. Additionally, as part of the plan, water supply managers should develop a communication plan that identifies the required communication steps to coordinate with the agencies involved, the appropriate actions that must be taken, and the steps to inform consumers and the public. The following are potential EPA resources for developing a management plan:

<sup>1</sup> A CT value is used in the calculation of disinfectant dosage for chlorination of drinking water. A CT value, the product of the concentration of a drinking water disinfectant and the contact

time with the water being disinfected (typically expressed in units of mg-min/L).

- [Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water](#)
- [Cyanotoxin Management Plan Template and Example Plans](#)
- [Drinking Water Cyanotoxin Risk Communication Toolbox](#)

## For more information

Additional information on cyanobacteria and cyanotoxins is available on the **EPA's Cyanobacteria Harmful Algal Blooms (CyanoHABs) in Water website**: <https://www.epa.gov/cyanoHABs>

Additional information and resources about cyanotoxins in drinking water is available on the **EPA's Cyanotoxins in Drinking Water web page**: <https://www.epa.gov/ground-water-and-drinking-water/cyanotoxins-drinking-water>

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