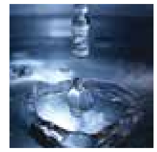
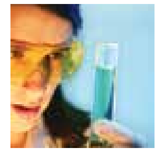
CARUS
WATER





Permanganate: An Initial Barrier for Extracellular Cyanotoxins

CAIROX® POTASSIUM PERMANGANATE
CARUSOL® LIQUID PERMANGANATE
TECHNICAL BRIEF

TECHNICAL SUMMARY

Cyanobacteria (blue-green algae) have become a growing concern in the drinking water world. Greater nutrient loading and warmer weather have led to an increase in the occurrence and magnitude of harmful algae blooms in the Great Lakes and throughout North America. Often these blooms can release toxic compounds (cyanotoxins) into the environment, which can have damaging health effects on people, pets, and wildlife. These toxic compounds can be either located within the cell (intracellular) or dissolved in the water (extracellular). The toxin ratio will change as the bloom grows and dies.

There has been significant focus on improving the industy's ability to predict the occurrence of cyanobacterial blooms. While not technically algae, cyanobacteria often seem to behave much like them. Blooms appear to develop when there is increased light, available nutrients, higher water temperatures, increasing pH and more precipitation, but they can occur at any time.

Figure 1: Photograph from NASA/NOAA

The occurrence of blue-green algae in drinking water sources can lead to water quality and safety impacts, requiring removal by conventional drinking water treatment processes prior to public use. Specifically, three cyanotoxins that can be produced during algae blooms are on the draft Contaminant Candidate List 4 (CCL4) for potential regulation through the Safe Drinking Water Act (SDWA). Microcystin-LR, cylindrospermopsin, and anatoxin-a have significant potential health effects, which can include damage to the liver (hepatotoxin) and central nervous system (neurotoxin). To ensure public safety, the U.S. Environmental Protection Agency (USEPA) has issued 10-day drinking water Health Advisories for microcystin and cylindrospermopsin. Additionally, many state agencies have set regulatory limits on the concentration of cyanotoxins in finished drinking water.

Treating for these toxins while meeting other Safe Drinking Water Regulations can be challenging. Knowing which treatment methods are effective, and what other benefits they may bring to the conventional water treatment process, is critical to achieving regulatory compliance. Knowing both the type of toxin and whether it is located inside the algae cell (i.e. intracellular) or dissolved in the source water outside the algae cell (i.e. extracellular) will help determine the most effective and lowest risk treatment approach.

Chemical oxidation can be a very effective option for treating cyanotoxins dissolved in source water. At the chemical oxidant concentrations commonly used for pretreatment, it can be a valuable first barrier to reduce the risk of toxin breakthrough during drinking water treatment. The table below, adapted from the CyanoTOX Calculator, Ver. 1.0*, lists different oxidants and their ability to oxidize extracellular toxins.

Half Life - Selected Cyanotoxins at 1 mg/L Dose, pH 6.8

	Permanganate	Chlorine	Chloramine	Ozone	Chlorine Dioxide
Microcystin-LR	5.2 min	24.8 min	>14 hours	0.08 sec	13.1 hours
Anatoxin	4.8 sec	>14 hours	>14 hours	0.52 sec	Non-Reactive
Cylindrospermopsin	4.2 days	1.7 min	>14 hours	0.10 sec	14.4 hours

* American Water Works Association (AWWA), Utah State University, Hazen and Sawyer

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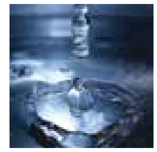

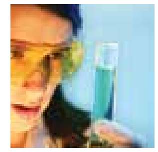

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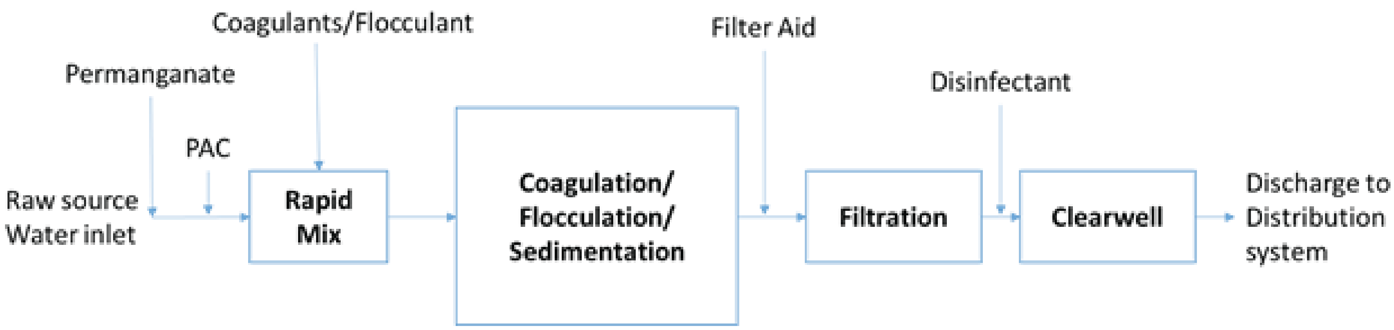
Permanganate is effective for oxidizing microcystin-LR and anatoxins. Since permanganate is often added to raw water to control inorganics (iron and manganese), taste and odor, or disinfection by products it provides an initial barrier for extracellular toxins. Permanganate is typically fed in levels of 1-3 mg/L depending on background demand and treatment needs. Because a significant amount of toxins will be located within the cell, it is recommended that treatment of algae-impacted water does not contribute to the breaking down of the cell and subsequent release of toxins. There has been a substantial amount of research conducted globally on the reactions of permanganate with microcystin and anatoxin. Technical articles report the application of permanganate at low doses (e.g. less than 3 mg/L) did not result in significant cell lysis and did not increase extracellular cyanotoxins. In addition, there may be improvements in the settleability of the algae cells.

It is important for operators to understand the benefits of feeding permanganate early in a process, and the consequences of discontinuing its use. A conventional surface water treatment process has multiple steps and barriers to inhibit the breakthrough of algal toxins. Pretreatment with permanganate followed by powdered activated carbon is a common approach to water treatment. This combination provides two barriers that are effective for microcystin and anatoxin. Disinfection with hypochlorite or chlorine after filtration provides an additional barrier that is effective for microcystin and cylindrospermopsin.



Controlling algal toxins is one in a long list of regulatory challenges facing water operators. Balancing the treatment plant process to achieve the greatest benefits while avoiding unintended consequences is the ultimate goal. CAIROX® potassium permanganate and CARUSOL® liquid permanganate can provide positive benefits as an additional barrier for algal toxins, while helping to control other regulated compounds.

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