Toxic Compounds Derived from Cyanobacteria Blooms in Drinking Water

Deteriorating drinking water quality, including the presence of taste and odor-causing compounds derived from cyanobacteria ("algae") blooms, continues to be a major concern for municipal drinking water suppliers. The same blooms that produce taste and odor compounds can also produce toxins that are known to cause chronic and/or acute health effects in humans and animals. This fact sheet discusses the sources and types of algal toxins, related regulations, and available treatment options.

SOURCES OF ALGAL TOXINS

Cyanobacteria are photosynthetic bacteria that produce algal toxins. Due to their common blue-green color, cyanobacteria are known by several other names, including "blue-green algae," "blue greens," and "cyanophyta." Cyanobacteria are most commonly found in eutrophic waters (waters with high levels of nutrients) and shallow reservoirs, and can occur as surface scum, benthic (bottom) mats, and on aquatic weeds (Hoehn, 2002).

Cyanobacteria naturally produce chemicals inside their cells. These chemicals range from physiologically harmless taste and odor-causing compounds such as geosmin (trans-1, 10-dimethyl-trans-9-decalol) and MIB (2-methylisoborneol) to certain toxic compounds. When large numbers of algae and bacteria flourish in a water body (an "algae bloom"), the concentration of compounds produced as intracellular by-products of cyanobacteria begins to increase as cells die.

REGULATIONS

Cyanotoxins (algal toxins) can be present wherever blooms occur. Research in the U.S. and Canada has shown that a high percentage of raw water taken from water supplies undergoing a cyanobacteria bloom contained cyanotoxins, in addition to other taste and odor-causing chemicals (Carmichael, 2001). In fact, toxic cyanobacteria are indistinguishable from non-toxic cyanobacteria under a microscope. As a result, a number of regulating agencies worldwide have issued guidance regulations. In the U.S., the USEPA has listed freshwater cyanobacteria and their toxins on the Contaminant Candidate List. In addition, New Zealand, Germany, and the World Health Organization have established microcystin guidelines of 1.0 parts per billion (ppb), while Canada has established a 1.5 ppb guideline.

COMMON ALGAL TOXINS

Often, algal toxins are classified by their effects on humans and animals. There are several types of toxins (AwwaRF, 2002):

Hepatotoxins
The best known and most widely regulated cyanotoxins, microcystin-LR and microcystin-LA, are hepatotoxins. Hepatotoxins affect the body's ability to produce proteins and ultimately result in liver damage. Microcystin and other hepatotoxins can also result in tumor promotion.

Neurotoxins
Examples of neurotoxins are the anatoxins and saxitoxins. This type of toxin affects the communication between the brain and muscles, and can result in muscle spasms, altered respiration, and can ultimately result in asphyxiation. The effects of this class of toxins are acute (i.e. the effects are observed quickly) versus the long-term, chronic effects produced by the hepatotoxins.

Cytotoxins
Cylindrospermopsin is an example of a general cytotoxin. This type of toxin can also inhibit productions of proteins, eventually effecting kidney and liver function. There is also some evidence to suggest that this type may be carcinogenic.

Endotoxins
Endotoxins often act externally and can result in skin irritation. Ingestion can result in gastrointestinal upsets. The effects of this type of toxin are generally milder than the previously-listed types. Examples of this type are the lipopolysaccharides.

TREATMENT ALTERNATIVES

Various technologies have exhibited degrees of success in treating cyanotoxins. For example, while ozone has been demonstrated to be effective for the treatment of microcystin, granular activated carbon (GAC) has been shown to have limited effectiveness (i.e. rapid breakthrough). Biologically-active GAC has shown promise although the process is not well understood nor easily replicated. The saxitoxins are not well removed by ozone (AwwaRF, 2002) and ozonation is also expensive, complex to operate, and can form bromate, a harmful by-product.

Alternatively, UV-oxidation using UV light and hydrogen peroxide is a cost-effective alternative for treating a wide variety of taste and odor problems and algal toxins. MIB, geosmin, MTBE, phenols, VOCs, and many other contaminants can be treated with UV-oxidation. This technology involves the photolysis of hydrogen peroxide with UV light to generate hydroxyl radicals. The hydroxyl radical is one of the most powerful oxidizing agents known and reacts rapidly with organic constituents in the water, including cyanotoxin compounds.

Trojan's UV-photolysis and UV-oxidation reactors provide a reliable barrier to taste and odor compounds and algal toxins and do not form bromate. In addition, the same UV system used for algal toxin control simultaneously performs disinfection.

TROJANUV - TREATING MULTIPLE CONTAMINANTS WITH ONE UV SYSTEM

As a further benefit to algal toxin control and microbial disinfection, the Trojan UV system will disinfect *Cryptosporidium* and *Giardia*. The process will also treat many other dissolved organic compounds present in the water, including endocrine disruptors, nitrosamines (e.g. *N*-nitrosodimethylamine [NDMA]), pesticides, and many pharmaceuticals as needed.

For over 30 years, Trojan has specialized in UV applications for water treatment and wastewater disinfection.

Over 5,000 Trojan UV systems have been installed in municipalities around the world. Tens of thousands of industrial and residential Trojan UV treatment systems are in operation in industries and households worldwide. Now, Trojan offers the industry standard in Environmental Contaminant Treatment (ECT). Trojan's UV-photolysis and UV-oxidation systems are capable of cost-effectively removing environmental contaminants from a variety of water streams.

For more information on treating multiple contaminants with Trojan UV solutions, including algal toxin treatment, please contact Trojan.

References:

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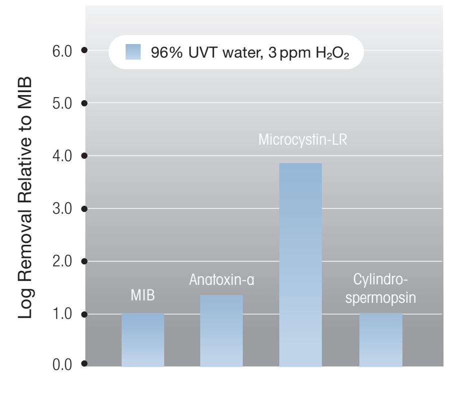

Figure 1. The predicted log removal of contaminants, under identical conditions, is illustrated above. Removal of taste and odor compounds such as MIB by UV-oxidation also results in removal of algal toxins such as Microcystin.

Figure 2. The City of Cornwall, Ontario, Canada currently uses the TrojanUVSwift™ECT to provide year-round primary disinfection and taste and odor removal during intermittent T&O events with a design flowrate of 26.4 MGD (4,164 m^3/hr).

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