Cyanobacteria (Blue-Green Algae) Harmful Algal Blooms

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When ponds and lakes become overgrown with algae, the body of water can become unattractive for recreation and have foul tastes or odors that restrict the use of the water as a drinking supply. Some types of algae also produce compounds that are toxic to other organisms. Besides impacting people, algae can also cause problems for fish and other aquatic life. Large abundances of algae that cause adverse effects are called **harmful algal blooms (HABs)**. Reports of livestock and pet (Backer et al. 2013) illnesses and deaths due to drinking toxic water are known. Although documented reports of human illnesses are infrequent (Carmichael 2008), there is a growing concern the safety of fresh water across the United States. (Resource Media and NWF2013). The increased frequency of algal blooms in small lakes as well as in large lakes (including lakes Erie, Ontario and Michigan) in numerous states has led to drinking water and recreational contact bans around the United States (Downing 2013, KVAL 2013).

Harmful Algal Blooms (HABs)

Algae, or phytoplankton, are microscopic organisms that are a normal and important part of ponds, streams, rivers, lakes, oceans and other aquatic habitats. They form the base of the aquatic food web, providing food for invertebrates and fish. They get their energy through photosynthesis, much like plants, and in the process produce a significant amount of the oxygen we breathe every day. In healthy aquatic habitats, algae are usually present in low numbers and the water appears clear.

When your pond turns green ...

Under certain conditions, algae can grow excessively, resulting in an **algal bloom**: a visible, dense buildup of algae (Figure 1). Blooms can turn a clear pond cloudy, forming foams, mats or scums on the surface of the water. Some blooms have unpleasant tastes and odors.

Figure 1. A* Microcystis *bloom. *Photo S Wilhelm*

Blooms are most common in still, nutrient-rich waters during warm weather. One of the main causes of algal blooms is excessive nutrients. Just like land plants, algae require nutrients (such as nitrogen and phosphorus) to grow. Runoff from land can carry nutrients from fertilizers, animal manure, sewage treatment plants, failing septic tanks, and other sources. When these extra nutrients end up in a pond or lake, they stimulate the growth of algae, causing an algal bloom.

Algal blooms can cause a variety of problems. Blooms causing detriment to human or animal health or to the environment are referred to as **harmful algal blooms (HABs)**, as shown in Figure 2. Thick blooms block light from reaching to the bottom of the pond and macrophytes (pond plants rooted to the bottom, such as water lilies or cattails) can die back due to the lack of light. Blooms also can lead to reduced oxygen levels in the water. When the algae dies, bacteria decompose the dead cells, using up oxygen in the process. The low oxygen (hypoxic) **"dead zones"** kill fish and other aquatic species. Recurring dead zones have become a major problem in some of our large water bodies, including Lake Erie, the Chesapeake Bay, and the Gulf of Mexico. In many cases, those dead zones are linked to algal overgrowth.

Figure 2. An algal bloom on Lake Erie. *Photo: S Wilhelm*

Toxic cyanobacteria

There are many types of freshwater algae; the most common groups are diatoms, green algae and **cyanobacteria** (also known as blue-green algae). Under some conditions, cyanobacteria produce compounds that are toxic to animals and humans. The most common cyanobacteria toxins include the microcystins, cylindrospermopsins, anatoxins and saxitoxins. Microcystins are hepatotoxins (affecting the liver), and anatoxins and saxitoxins are neurotoxins (affecting the nervous system).

Cyanobacteria do not actively excrete the toxin. Instead, most of the toxin is released from a cyanobacterial cell when it is consumed by another organism or dies and ruptures. When a large cyanobacterial bloom dies, the water may look clear, but the algal-produced toxin may still persist until sunlight or bacteria break the toxin down to a nontoxic form.

There are currently about 3,000 known species of cyanobacteria, and some estimate that the total number of species is twice that number. However, toxin formation is confined to a relatively small (less than 100) number of cyanobacteria species. Some of the more common toxin-producing cyanobacteria include *Microcystis*, *Anabaena*, *Planktothrix* and *Lyngbya*. Very few of these toxins affect fish, and why cyanobacteria make toxins is still not well understood. Species with the capability of toxin production do not always make toxin. Some species produce a single toxin, others produce multiple toxins. Even within a single species bloom, some cells will make toxin while others will not. The reason for toxin formation remains a mystery that scientists are still working to understand.

Health effects of HAB toxin exposure

The most common routes of exposure to cyanobacteria and their toxins are skin contact, swallowing water while swimming, eating contaminated fish, and, in the case of animals, licking water or algae off of fur after swimming. When animals are exposed to or ingest HAB toxins in large quantities, there can be adverse health effects. Some humans are very sensitive to the algal cell material, leading to an allergic response. Direct contact with high levels of algal cells or their toxins can cause irritation of skin, eyes, nose and throat and inflammation of the respiratory tract. Ingestion can cause nausea, vomiting and diarrhea. In humans, toxins have been linked to liver disease and neurological effects. The effects of long-term, chronic exposure to cyanobacterial toxins are not yet understood; however, links between algal toxins and increased rates of liver cancer have been suggested (Grosse 2006). For this reason, health departments routinely caution that you should avoid contact with all blooms, toxic or not.

Toxic cyanobacterial blooms have caused the death of wildlife, livestock and pets. Dogs are especially susceptible, as they are not repulsed by unsightly or smelly blooms. Dogs tend to wade or drink in shallow areas of ponds and lakes where algal mats can concentrate. They may also eat algal materials washed up on shore, or lick their fur after swimming through a bloom. Treatments for illnesses from cyanobacteria toxins are limited as there are no known antidotes to the toxin.

Identifying Harmful Algal Blooms

Not all algal blooms produce toxins, and you cannot visually distinguish if a bloom is toxic, even under a microscope. In general, freshwater diatoms and green algae do not make toxins, though they can cause harm through water fouling or hypoxia. Small aquatic plants also can grow to high densities and cover the surface of fresh water bodies but are not harmful. Unpleasant tastes and odors are not good indicators of toxins: a bloom that has taste and odor problems is not necessarily toxic; likewise a toxic bloom does not necessarily have unpleasant taste and odor. Laboratory analysis is required to detect these toxic compounds in a water sample. But since most harmful algal blooms in freshwaters are caused by cyanobacteria, the best precaution is to determine if you have cyanobacteria (potentially toxic) or some other type of green algae or aquatic plant (harmless).

Nontoxic algae and plants

Duckweed (*Lemna spp*). This tiny aquatic plant actually is not an alga. It is common throughout North America and is harmless. It looks like tiny lobed leaves on the surface of the pond, similar to a miniature clover or lily pads, with roots extending down into the water.

Photo credit A. Ludwig

Wikipedia.org

aquaplant.tamu.edu/plant-identification /alphabetical-index/common-duckweed

Green algae. This is a broad group of species. Green algae can look like filaments, strings or hairs. They can form mats on the surface and sometimes air bubbles are apparent. There is a rough texture like fabric or carpet. When you dip a stick into the pond, algae will cling to it. These blooms are typically not toxic.

Photo credit A. Ludwig

Photo credit A. Ludwig

1aquaplant.tamu.edu/plant-identification/alphabetical-index/filamentous-algae

Ahrens, Sara. img_1353.jpg. August 2010. Pics4Learning. 17 Apr 2015 <pics.tech4learning.com>

Photo credit A. Ludwig

Photo credit A. Ludwig

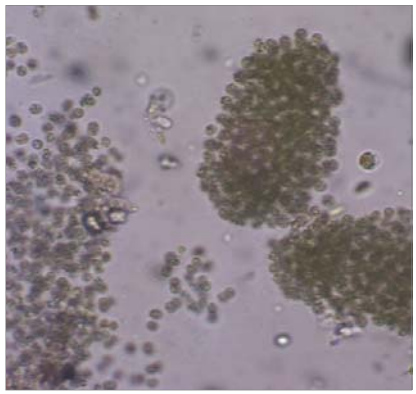
Potentially toxic cyanobacteria

Cyanobacteria blooms look like green paint or pea soup. The texture is smooth. When you dip a stick into it, the green does not cling to the stick. Some cyanobacteria blooms can be toxic. Some common types of potentially toxic cyanobacteria are **Microcystis, Anabaena, Planktothrix and Lyngbya**.

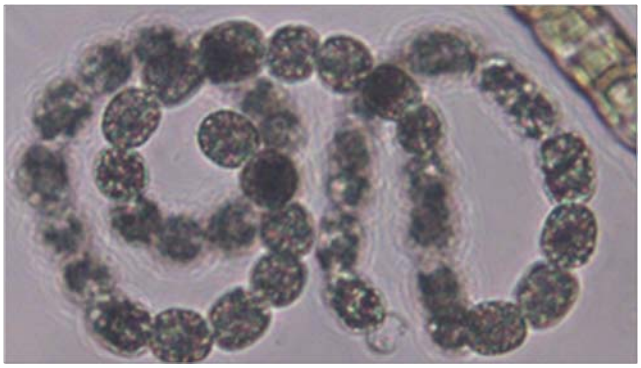
Microcystis. Blooms are green, thick and paint-like, sometimes with a granular texture. At their onset individual colonies can be sometimes seen with the naked eye — they look somewhat like snowflakes in the water.



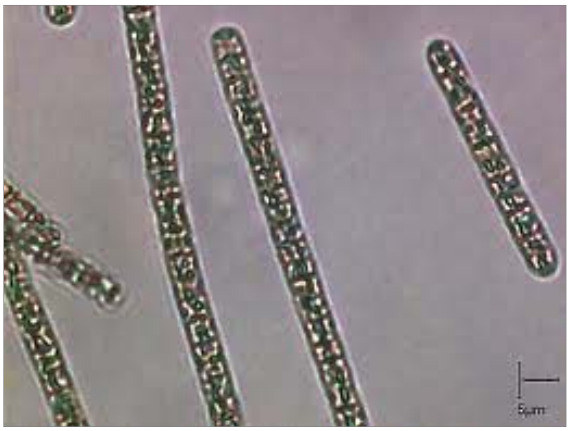


Anabaena. Like Microcystis, populations of this cyanobacterium are found worldwide. The blooms also look similar. However, the Anabaena cells form long filaments visible under a microscope and often contain specialized cells that convert nitrogen gas directly to ammonia by the process of nitrogen fixation.

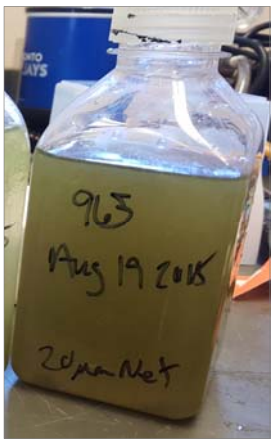


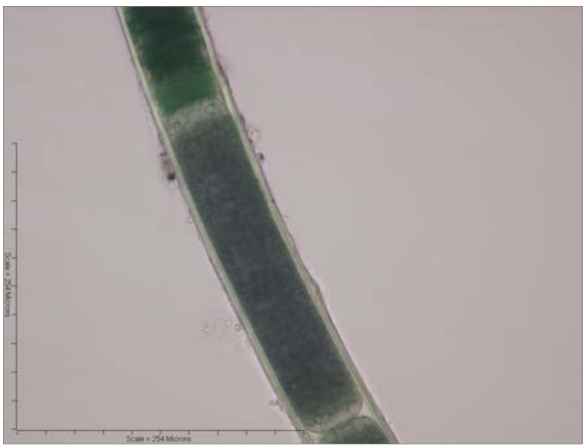
Planktothrix. This organism forms long, slender, straight filaments that will form dense suspensions both in the water column and on sediments. It is common in both Europe and North America and can be found in high abundances in agriculturally impacted bodies of water.



Lyngbya. This horse-hair like cyanobacterium can form large dense mats on the bottom of water bodies, sometimes washing up on shore to create unsightly mounds of algae. One of the best studied species, *Lyngbya wollei*, was first isolated from the TVA Guntersville Reservoir.

Image from www.outdooralabama.com





For additional photos of algal blooms and photomicrographs of the various types of algae, please see the following:

- Bloom Characterization Guide, Ohio EPA epa.ohio.gov/portals/28/Documents/HAB/BloomCharacterizationGuide-DRAFT.pdf
- Algal Plates, Ohio EPA epa.ohio.gov/portals/35/inland_lakes/10000%20Algae%20Plates_1.pdf
- Photo Gallery of Green and Blue-green Algae, New York DEC www.dec.ny.gov/chemical/81962.html
- Cyanosite, Purdue University www-cyanosite.bio.purdue.edu/images/images.html

I Think I Have a Cyanobacteria Bloom. What Should I Do?

It is important to remember that not all cyanobacteria blooms are toxic. But to be safe, if you think you have a cyanobacteria bloom, you should take the following precautions:

- Do not let livestock, pets or people come in contact with water with visible cyanobacteria blooms. If you do come into contact, rinse thoroughly with clean water.
- As a general rule, never drink untreated surface waters, even if algal blooms are not visible. Untreated water can contain bacteria and other parasites that can cause illness.
- Do not allow people, pets or livestock to drink water when a bloom is visible, even if it has been treated. Boiling, chlorine disinfection, UV treatments and water filtration will **not** remove algal toxins.
- Do not use toxin-contaminated water for food crop irrigation.
- Do not use algaecides such as copper sulfate to treat the blooms; this will cause the cells to rupture and cause a substantial release of toxins into the water, greatly increasing the risk of toxin exposure. Copper is also toxic to other aquatic wildlife. Most blooms will die off on their own.
- Be cautious of eating fish collected from contaminated waters. Concentration of the toxins in fish flesh is highly variable. You may get a fish with a very high concentration of toxins.
- If you come in contact with water that has visible cyanobacteria blooms and experience any of the symptoms listed above, seek medical attention.

How Can I Prevent Algal Blooms?

It is important to understand that freshwater bodies of water go through a natural aging process, which includes periods of nutrient enrichment called **eutrophication**. Natural aging and eutrophication of lakes generally takes hundreds or thousands of years, but it may be enhanced by human activities on the land. Methods of algae control or removal (e.g., draining the pond, dredging sediment and scooping algal mats, chemical treatments with alum or herbicides) are often expensive and only treat the symptoms of the problems, not the cause. **The best strategy for keeping a body of water clear of algae blooms is to treat the cause of the problem: minimizing the nutrient inputs into your pond**. The primary sources of nutrient runoff from land include:

- Over-application of fertilizer, manure and/or poultry litter.
- Leaking septic systems, drain fields and gray water discharge.
- Animal waste from livestock or migratory birds.
- Shoreline erosion.

Some best management practices to reduce nutrient inputs and the potential for algae blooms include:

- Using grass-lined ditches or swales between fields and pond to redirect nutrient-rich runoff. If your pond needs to be fed by this runoff in order to persist, use small check dams in the channel to slow down the runoff and encourage settling of sediments and absorption of nutrients. Check behind check dams often and remove deposits as needed.
- Ensuring there is a border of thick vegetation around the pond to intercept and filter runoff. A mix of warm- and cool-season grasses works better than groundcover or sparse woody vegetation.
- Keeping a minimum maintenance buffer around the pond of 20 feet. Reduce mowing frequency and do not use fertilizers in this buffer area.

- Planting wetland plants along the perimeter of the pond to help filter runoff and stabilize pond banks. This will help prevent erosion of bank sediments. If left unmowed, wetland plants will usually grow up along the pond perimeter over time naturally. These plants are referred to as volunteers.
- Allowing volunteer plants to come in. These "emergents" will likely fill in shallow areas of up to 18 inches deep and will soak up nutrients from the pond water.
- Adding a means of aeration and circulation to the pond. Adding an aerator or fountain will help remove excess nitrogen in the water and improve the flow of water around the pond.
- Practicing winter draw down and draining the pond, if possible. This practice will help cycle the nutrients as well as freeze the roots of nuisance plants, such as cattails.
- Skimming the surface with rakes or nets and removing the biomass from the pond. Doing so will prevent the additional nutrient load from decaying algal biomass.
- Limiting the light availability to the pond. This practice can be accomplished by planting trees or tall shrubs around the pond or by covering with opaque plastic fabric for an extended period of time.
- Deploying a floating wetland in the middle of the pond to help soak up nutrients. A floating wetland is a floating apparatus that is planted with wetland plants. The wetland plants send roots down into the pond water column and constantly take up nutrients directly from the water. Floating wetlands can be made of foam mats or wooden pallets floated with buoys.

Additional Resources

For more information about harmful algal blooms, and to see more images to help with identification, please see the following websites:

- New York State Department of Environmental Conservation. "Blue-Green Harmful Algal Blooms". www.dec.ny.gov/chemical/77118.html
- Ohio EPA. "Harmful Algal Blooms". epa.ohio.gov/ddagw/HAB.aspx
- US Environmental Protection Agency. "Cyanobacterial Harmful Algal Blooms" www2.epa.gov/nutrient-policy-data/cyanohabs
- Michigan State University Extension. "Pond Management: An in-depth response to frequently asked questions from pond owners and managers." articles.extension.org/sites/default/files/w/1/1d/Pond_Management_and_In-depth_Response_to_FAQs_from_Pond_Owners_and_Managers.pdf

References

(2013) Toxic Algae: Coming soon to a lake near you? A Joint Report by Resource Media and National Wildlife Federation

Backer LC, Landsberg JH, Miller M, Keel M, Taylor TK (2013) Canine Cyanotoxin Poisonings in the United States (1920s–2012): Review of Suspected and Confirmed Cases from Three Data Sources. Toxins 5:1597-1628

Carmichael W (2008) A world overview – one hundred twenty seven years of research on toxic cyanobacteria, Where do we go from here. In: K. H (ed) Cyanobacterial Harmful algal blooms: State of the science and research needs, p 105-125

Downing B (2013) Toxic algae strike Ottawa County water system; threat prevalent across Ohio. Akron Beacon Journal Online

Grosse Y (2006) Carcinogenicity of nitrate, nitrite, and cyanobacterial peptide toxins. The Lancet Oncology 7:628-629

KVAL (2013) State: Don't drink - or touch - this water. KVAL.com http://www.kval.com/news/local/wallowing-or-inhaling-water-droplets-as-well-as-skin-contact-should-be-avoided-214214351.html, Eugene, OR

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