Water Column

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Algae: Freshwater Eyesore or Microscopic Masterpieces

~ *Leigh Stevenson*

When most people think of algae, they likely imagine a mat of slimy, odorous green goo that can wreak havoc on the water quality, recreation potential, and aesthetics of our freshwater lakes and reservoirs. Indeed, we often hear of the mighty battles being waged against the negative impacts that algae blooms can present. However, algae are an essential part of all freshwater ecosystems. These microscopic plants, otherwise known as phytoplankton, make up the base of the aquatic food web and are a main source of oxygen to the water column. Besides providing these and many more beneficial functions, algae also encompass a unique beauty that can only be fully appreciated on the microscopic level.

Cyanobacteria (Bluegreen Algae)

This phylum is best known for containing species that are able to produce cyanotoxins, including *Microcystis* (Figure 1a), *Anabaena* (Figure 1b), and *Cylindrospermopsis*. Cyanobacteria can grow as single cells, or in groups as either colonies or filaments. Members of this phylum are excellent competitors, which often makes them difficult to manage. Many species are able to use specialized cells called heterocysts to convert atmospheric nitrogen (N_2) into forms that can be used for plant growth. This gives them a competitive edge over other algae when nutrients are in short supply.

Chlorophyta (Green Algae)

Chlorophyta is the largest and most diverse of all the phytoplankton phyla, and are believed to be the ancestors of all multicellular plants. They are easily identified by their vivid, grass-green coloration, which is the result of large amounts of chlorophyll pigments contained within the cell walls. These pigments, which are also present in terrestrial plants, make green algae excellent photosynthesizers. Chlorophyta, like cyanobacteria, are able to grow as single cells, colonies (Figure 1c and 1d), or filaments.

Cyanobacteria (Golden Algae)

Chrysophyta can be identified by their golden-brown color, which results from the use of carotenoid pigments for photosynthesis. However, in the absence of adequate light, some golden algae are able to feed on dissolved food particles, bacteria, and diatoms. Many species within the phylum Chrysophyta swim using long, whip-like structures called flagella. The most common of the chrysophytes are called *Dinobryon* (Figure 1e), which form large tree-like colonies that often make up a large portion of the total algal biomass within a lake.

Bacillariophyta (Diatoms)

Bacillariophyta are best known for their ornate, glass-like structures. Diatoms produce silica-based cell walls, called frustules, which are able to persist

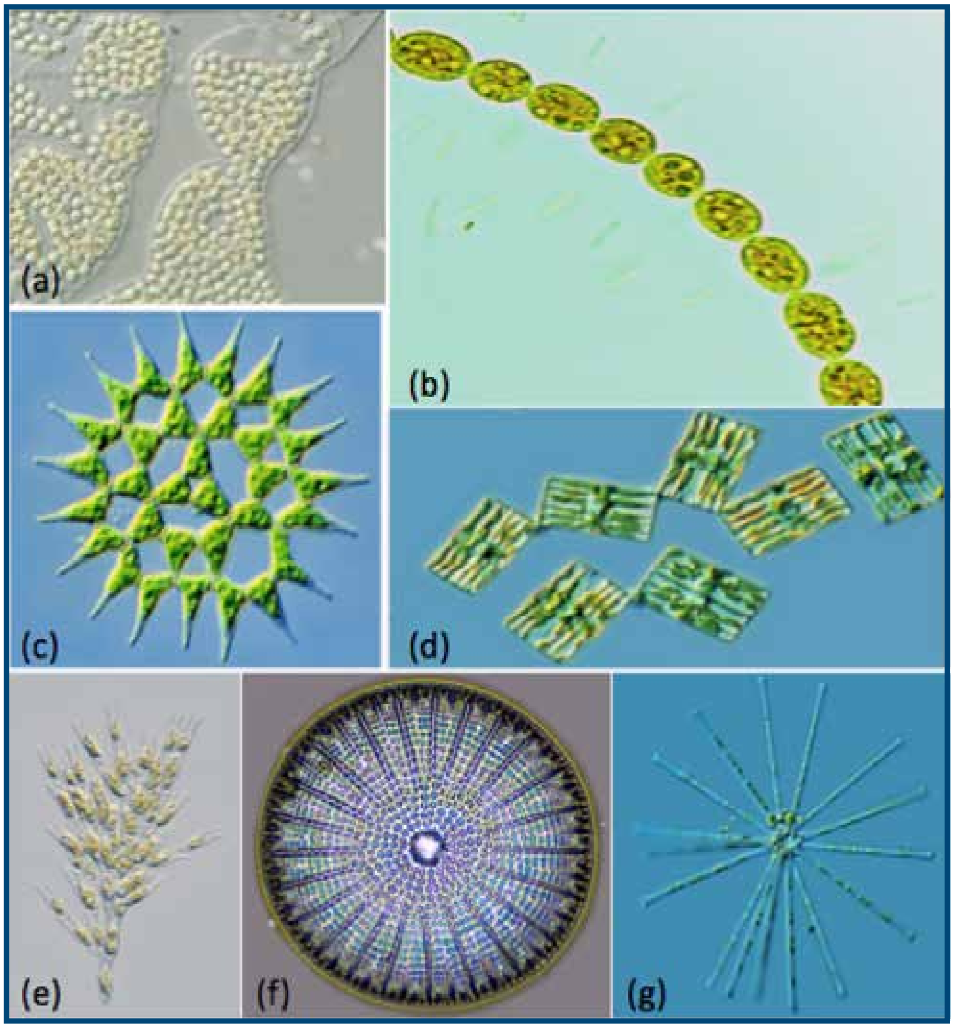

Figure 1. *Cyanobacteria:* (a) *Microcystis ehrenbergii*; (b) *Anabaena, Chlorophyta*; (c) *Pediastrum clathratum*; (d) *Tabellaria flocculosa, Chrysophyta*; (e) *Dinobryon divergens and Bacillariophyta*; (f) *Arachnoidiscus*; (g) *Asterionella formosa*

for thousands of years after the organism has died. As such, diatoms are often used to piece together the ancient history of a lake. Once the organism dies, the frustules settle to the bottom creating a vertical timeline as sediment builds. This profile can be interpreted by paleolimnologists to determine the past environmental conditions of the water body. Diatoms come in a variety of shapes and sizes and can grow as individual cells (Figure 1f) or in colonies (Figure 1g).

Cyanobacteria Background

~U.S. EPA

What are Cyanobacteria and Cyanotoxins?

Cyanobacteria, commonly referred to as blue-green algae, are photosynthetic bacteria that occur naturally in waters used for primary contact recreation, such as swimming and waterskiing. Under certain conditions, cyanobacteria may grow rapidly to form dense accumulations known as cyanobacterial blooms. When the bloom is formed by a toxin-producing bacteria, it is generally referred to as a harmful algal bloom (HAB).

These blooms are considered harmful due to the production of irritants and/or toxins, called cyanotoxins (e.g., microcystins and cylindrospermopsin), which can pose health risks to humans and animals. More information can be found on the U.S. EPA website.

Animals such as pets, livestock, and wildlife may also be exposed to cyanotoxins if they drink water from toxin-contaminated water bodies, lick their fur after swimming in such waters, or consume toxin-containing algal scum or mats. Health effects from cyanotoxin exposure in animals can include vomiting, diarrhea, seizures, and death.

What Causes Cyanobacterial Blooms?

Certain environmental conditions, such as elevated levels of nutrients from human activities (e.g., nitrogen and phosphorus), warmer temperatures, still water, and plentiful sunlight can promote the growth of cyanobacteria to higher densities, forming cyanobacterial blooms. Such blooms may result in a higher risk to human or animal health due to the production of cyanotoxins and other cyanobacteria-associated irritants. Although the presence of cyanobacteria does not necessarily mean that cyanotoxins are being produced, it is important to note that cyanotoxins may be present both before and after cyanobacteria are observed.

What Are Some Visual Signs of a Cyanobacterial Bloom?

Visual signs of a bloom include: surface water discoloration (e.g., a green, white, brown, red, or blue tint); reduced transparency (e.g., water that looks like pea soup or lets limited light through); or, thick, mat-like accumulations of scum on the shoreline and surface. Cyanobacteria are also associated with unfavorable taste-and-odor compounds in lakes and reservoirs. The following photos show visual signs of cyanobacterial blooms, including surface water discolorations, scum, or, mat-like accumulations along the surface (Figure 2).

As discussed under "What Causes Cyanobacterial Blooms?" above, it is important to note that a cyanobacterial bloom may be present without producing cyanotoxins, and conversely, cyanotoxins can be present both before and after blooms are visible. Therefore, it is recommended that cyanotoxin levels be confirmed through laboratory testing of the water. Microscopic phytoplankton identification can provide information when blooms are present and not visually apparent.

Figure 2. Cyanobacterial blooms – (a) Sudbury River, MA (photo by Susan Flint), (b) Lake Attitash (photo by Nancy Leland), (c) Monponsett Pond, MA (photo by Edward Broderick)

What Can Be Done to Reduce the Occurrence of Cyanobacterial Blooms?

Addressing nutrient pollution (i.e., nitrogen and phosphorus) can help reduce the occurrence of cyanobacterial blooms. As a long-term strategy, states may consider adopting numeric nutrient criteria and/or numeric interpretations of a narrative nutrient criterion into their water quality standards. The World Health Organization: Guidelines for Safe Recreational Water Environments (PDF)(253 pp, 1 MB) contains a chapter on algae and cyanobacteria in fresh water, which includes short-term and long-term management options with the goal of preventing or reducing the occurrence of cyanobacterial blooms in recreational waters. States may also consider cyanotoxin criteria, in addition to numeric nutrient criteria, and evaluate the need for (and effect of) the criteria and/or advisories in their recreational waters. For the results of a study on how the experimental limitation of nutrient supplies, after a lengthy enrichment period, aided in the diminishing of a cyanobacterial bloom

How Can Recreational Waterbody Managers be Prepared to Respond to a Cyanobacterial Bloom in the Future?

Recreational waterbody managers can take several steps to prepare in the event of a future cyanobacterial bloom. The following actions will help managers protect people, pets and livestock from exposure to HABs:

- *Prioritize recreational waters based on risk.* Recreational managers with limited resources may choose to take a risk management approach toward monitoring the recreational water bodies under their jurisdictions. Such an approach may include prioritizing water bodies based on the likelihood of a HABs event and its relative impact to the public. Prioritization may consider past occurrences of HABs, current environmental conditions (including the levels of nitrogen and phosphorus, temperature, availability of organic matter, light attenuation, and pH), and waterbody use (i.e., type of recreation and the number of users).
- *Develop a response plan.* Some local and state governments have already implemented response guidelines in the event of a cyanobacterial bloom in recreational waters. These include: (1) identifying state-designated recreational water health advisory levels for analyzing the severity of a bloom (as measured by cyanotoxin concentrations or cyanobacteria cell counts), and (2) taking specific actions, such as issuing public advisories, posting warnings, and closing waterways that exceed a predetermined threshold. For a summary of the U.S. states with health advisory values, see Guidelines for Cyanobacteria and Cyanotoxins in Recreational Water. It is also helpful to have a communication plan ready which includes key contacts and ways to notify the public. For a contact list template to help a recreational water manager initially respond to a cyanobacterial bloom, go to Cyanobacteria Bloom Response Contact List(1 pg, 34 K, July 2017, EPA 820-F-17-003) .
- *Develop a monitoring plan.* For information and process steps that a recreational water manager may use to confirm a cyanobacterial bloom event and monitor cyanotoxin levels, including when to post and remove notification signs, go to Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters (PDF)(15 pp, 602 K, June 2017, EPA 820-R-17-001)
- *Develop a control and treatment plan.* Recreational water managers should reduce nutrient pollution and address other underlying factors that can cause cyanobacterial blooms; however, they should also know what technologies are available to control, mitigate and treat cyanobacterial blooms and cyanotoxins in an emergency. For more information, see Control and Treatment – Mitigation Measures for the Presence of HABs in Surface Water. Measures to treat blooms should only be undertaken after consultation with relevant authorities.
- *Develop signage and other communication methods to notify the public.* For information on recommended communication tools, go to Recreational Water Communication Toolbox for Cyanotoxins and HABs. For an interagency toolbox for communicating with stakeholders and the public about water advisories (based upon research and identified practices), see Drinking Water Advisory Communication Toolbox. Although this drinking water advisory toolbox was not designed for recreational waters, the same principles and ideas can easily be adapted for recreational waters.
- *Prepare to respond to media and public inquiries.* See a list of Frequently Asked Questions – Cyanobacterial Blooms and Cyanotoxins (3 pp, 38 K, July 2017, EPA 820-F-17-008) about HABs.

What Should a Recreational Waterbody Manager Do if a Cyanobacterial Bloom is Identified or Suspected?

Recreational water managers should take action to confirm the presence of toxin-producing cyanobacteria and/or cyanotoxins, and consider whether to notify

States with HABs, Advisories and/or Beach Closures, Reported in July 2017.

California: Iron Gate Reservoir, Lake Britton, Lake Temescal, Quarry Lakes Silverwood Lake, Castaic Lake
Florida: Doctor's Lake, Lake Okeechobee
Indiana: Cecil; M. Hardin Lake, Brookville Lake, Monroe Lake, Starve Hollow Lake, Hardy Lake, Deam Lake, Mississinewa Lake, Salamonie Lake, Sand Lake, Worster Lake, Whitewater Lake
Idaho: Little Camas Reservoir, Black Lake
Iowa: Black Hawk Beach, Nine Eagles Beach, Lake of Three Fires Beach, Green Valley Beach, Clear Lake, McIntosh Woods Beach, Lake Darling Beach, Lake Anita Beach, Denison Beach (for the presence of MCs)
Kansas: Overbrook City Lake, Sam's Pond, Webster Lake, Marion County Lake, Marion Reservoir, Milford Reservoir (all Zones), Geary, Wolf Pond, Lovells Pond – Barnstable
Maryland: Lake Needwood, Lake Frank
Massachusetts: Mystic River at Blessing of the Bay Boathouse, Lovells Pond, Savery Pond, Lake Siog, Tully Lake, Upper Mystic Lake, West Monponsett Pond
Nebraska: Kirkman's Cove Lake, Swan Creek Lake
New Hampshire: Pelham Town Beach, Long Pond, Silver Lake, Lake Monomonac
New York: Agawan Lake, Allegheny Reservoir, Beaver Lake, Bowne Pond, Burden Third Lake, Chautauqua Lake, Conesus Lake, Indian Lake, Java Lake, Kissena Lake, Lake Carmel, Lake Lacoma, Mill Pond, Mohegan Lake, Lake Montgomery, Morningside Pond, Nassau lake, Nooteeming Lake, Old Town Pond, Oneida Lake, Otisco Lake, Owasko Lake Prospect Park Lake, Red House Lake, Roaring Brook Lake, Roth Pond, Sylvan Beach Smith Pond, The Lake in Central Park, turtle Pond,
North Dakota: Crimmins WPA Lake, Bowman-haley Reservoir, Lake Tschica, Patterson Lake, Channel A -Devis Lake
Ohio: Grand Lake St. Marys, Buckeye Lake - Crystal Beach and Fairfield, Kiser Lake
Oklahoma: Fly Creek, off the Horse Creek Arm of Grand Lake
Oregon: South Umpqua River - Permanent Advisory, Areas of lake Billy Chinook, Drews Reservoir
Rhode Island: Melville Pond
Utah: Utah Lake
Washington: Lone Lake, Rufus Woods Lake, Anderson Lake, Lind Coulee, Spanaway Lake, Waughop Lake

partner agencies and the public, depending on the relative threat to public health. They should follow key steps of an emergency response plan including:

1) Analyze samples from the recreational waters to assess whether the bloom is producing cyanotoxins at levels potentially harmful to human or animal health.

- For more information regarding how to determine whether the suspected bloom is harmful, see **Recom**mendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters (PDF)(15 pp, 602 K, June 2017, EPA 820-R-17-001).
- For a list of laboratories in each state that conduct sample analyses for cyanobacteria and cyanotoxins, see State Resources.
- For testing methods, see Recommendations for Cyanobacteria and Cyanotoxin Monitoring in

Recreational Waters (PDF)(15 pp, 602 K, June 2017, EPA 820-R-17-001) and Detection Methods for Cyanobacteria and Cyanotoxins.

- For an example of guidance from the State of Colorado on handling a harmful algal bloom, see the Colorado Lake and Reservoir Management Association's Guidance Document for Harmful Algal Blooms in Colorado.

2) Notify key partners at the local and state level to coordinate a response.

- For a list of possible partner agencies (such as poison control, veterinary facilities, and public health agencies), see Cyanobacteria Bloom Response Contact List(1 pg, 34 K, July 2017, EPA 820-F-17-003).

3) Issue public notifications (i.e., warnings, advisories, or closures) based on the cyanotoxin level and the risk it presents to human and animal health.

- For examples of public notifications, see Recreational Water Communication Toolbox for Cyanotoxins and HABs.

4) Consider treatment options, if necessary, to bring cyanotoxins concentrations under control and down to safe levels.

- For more information, see Control and Treatment - Mitigation Measures for the Presence of HABs in Surface Water.

5) Monitor and sample the recreational waters to confirm or modify the notification until cyanotoxins concentrations are at or below safe levels; notifications can be lifted once cyanotoxin concentrations are at or below safe levels.

- For more information on how to determine whether the suspected bloom is harmful, whether to issue a notification based on cyanobacterial cell counts or cyanotoxin levels, and how long the notification should be in place, see Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters (PDF)(15 pp, 602 K, June 2017, EPA 820-R-17-001).
- For an example of a state-level program to assess, monitor, communicate, and manage cyanobacterial blooms and cyanotoxins, see the California Freshwater Harmful Algal Blooms Assessment and Support Strategy

6) EPA recommends that state water recreation managers or appropriate state partners report suspected or confirmed harmful blooms and/or human and animal illnesses associated with cyanobacterial blooms to the One Health Harmful Algal Bloom System (OHHABS). The Centers for Disease Control and Prevention (CDC) developed OHHABS as a voluntary reporting system available to state and territorial public health departments and their designated environmental health or animal health partners.

- For guidance about defining a bloom and how to report health and environmental data, see OHHABS.

Volunteer Corner –

Bruna Oliveira is the volunteer coordinator during the summer of 2017 for the Indiana Clean Lakes Program. She is about to begin her third year as a graduate student at Indiana University's School of Public and Environmental Affairs. Bruna is pursuing master degrees in both public administration and environmental science with a focus in water and policy in hopes of preserving our water bodies for generations to come. She became interested in this work through her undergraduate work with managing invasive zebra mussels and Eurasian milfoil in Northeastern lakes. When she isn't out swimming on one of Indiana's beautiful lakes she enjoys cliff diving and discovering new music. Don't hesitate to contact her with any questions about sampling on your lakes! (Indianaclp@gmail.com)

Have you checked out the Indiana Clean Lakes Program Web page lately? Take a look at www.indiana.edu/~clp/ and see what's new and happening with the program and with Indiana lakes!

Aquatic Invasive Monitoring Plant Highlight

This will be the 18th plant in the plant highlight series. We will be featuring one aquatic plant in each Water Column issue. We will feature both native and invasive plants to improve our plant identification skills.

Duckweeds (*Lemnaceae*), NATIVE

Duckweeds are the smallest of the flowering plants, which consist of tiny, green, rounded, leaflike bodies (fronds) that float on the water's surface. Several duckweed plants can fit easily on a fingertip. They occur singly or connected in groups. They usually reproduce by budding, but do (rarely) produce tiny, simple, male and female flowers. Indiana has species of duckweeds (genus *Lemna*), giant duckweed (*Spirodella*), and watermeal (*Wolffia*).

Each duckweed plant (genus *Lemna*) is a green, leaflike circular or oval frond less than 1/4 inch across, each bearing a single short, hairlike root that dangles into the water. Giant duckweeds grow in clusters of 1-3, with 2-20 roots per frond. Fronds measure to nearly 3/8-inch across, depending on genus.
The watermeal genus includes the smallest flowering plants known;
each plant is about the size of a pinhead and lacks roots; they look like tiny green dots.

Duckweed and watermeal are important foods for wildlife, especially waterfowl. They also provide cover for frogs, turtles, and more. In the presence of excessive nutrients, dense duckweed growth can block out sunlight, shading out oxygen-producing plants below, upsetting a pond's natural balance.

You can find more information about our Invasive Plant Monitoring Program and duckweeds on the Clean Lakes Program website **www.indiana.edu/~clp**. We will be updating the Invasive Plant Monitoring page to include links to several resources and tips on identification guides.

Identification tips:
- Tiny, free floating leaves
- Can cover the entire surface of lake or large areas with a solid green layer
- Some lake observers may confuse a duckweed layer as an algal scum.

WATER COLUMN

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Address all correspondence to:
Melissa Laney, Editor
SPEA 445, 1315 E. Tenth Street
Indiana University
Bloomington, IN 47405-1701

E-mail: mlaney@indiana.edu
Phone: (812) 855-6905
FAX: (812) 855-7802

Perspectives

"Stay close to the serenity of a lake to meet your own peace of mind."

~Munia Khan