Water Column

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Invasive Blue-Green Alga Found in Indiana Lakes

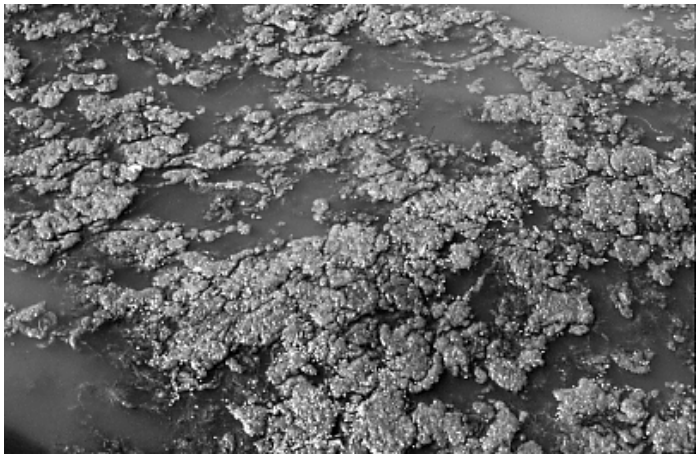
[*Editor's note*: We devote this entire issue to an emerging issue of importance in Indiana lakes. Our intent, as always, is to inform and educate. *Water Column* will report on new information as it becomes available.]

Among the usual visitors to Indiana lakes this past summer was a new and unwanted one—a blue-green alga called *Cylindrospermopsis raciborskii*. This species, which had never before been identified in Indiana, was first identified in Ball Lake, a 75-acre natural lake in Steuben County. It was later found in several Indiana reservoirs.

The occurrence of *Cylindrospermopsis*, particularly in Ball Lake, caused quite a stir because these organisms are known to produce toxins. In this article, we will describe this alga, its toxins, and what the state is doing about them.

What Kind of Algae is This?

Cylindrospermopsis is a member of the group of algae called "Cyanobacteria" or "blue-green algae". Blue-greens are the algae most commonly associated with summertime blooms in nutrient-enriched lakes, reservoirs, and ponds around Indiana. Symptoms of a typical blue-green algae bloom are all too common—green scum on the surface, green color to the water, foul odors.



A nasty surface scum.

Blue-green algae are single-celled organisms closely related to bacteria. Unlike bacteria, however, they are capable of photosynthesis—just like green plants. Blue-greens have a number of adaptations that allow them to dominate the summertime algae in nutrient-enriched lakes. For example:

- some contain *gas vacuoles*, which allow them to control their own buoyancy so they can stay in the lighted zone (*photic zone*) of lakes;
- some have specialized structures called *heterocysts*, which they use to make their own nutrients in a process called "nitrogen fixation" (in the same way that pea and bean plants are nitrogen-fixers);
- many taste badly or are too large for small herbivorous zooplankton to eat;
- some can out-compete more desirable groups of algae for necessary carbon and phosphorus;
- many blue-greens, including *Cylindrospermopsis*, produce toxins.

Where Did This Alga Come From?

Cylindrospermopsis was first identified in India in the early 1900s. It was found decades later in Australia. The first confirmation in the United States was in Florida in the early 1990s. Since then, it has moved as far north as Michigan and as far west as Oklahoma, Nevada, and Texas, and is likely in California as well.

How Did It Get Here?

No one knows for certain how this invasive species arrived in Indiana. It may have arrived in the bilge water or cooling water of trailered motorboats, a process known to spread other more common lake invaders such as zebra mussels. It may have hitched a ride on waterfowl feathers.

What Does Cylindrospermopsis *Look Like?*

Cylindrospermopsis occurs as either straight or curled filaments. It is very small in size, generally 2-4 microns wide and 10-80 microns long. This is small enough that these organisms can pass through collecting nets usually used to sample algae. Filaments may contain from 5 to 10 cells. The end cells are often pointed. Heterocysts, if present, occur as end cells.

Subtropical, it does well in high nutrient (especially high-phosphorus) high-temperature waters. Unlike other blue-greens, *Cylindrospermopsis* tends not to form surface scums. Instead, the densest numbers of cells, as high as hundreds of thousands per milliliter, often occur 2-6 feet below the surface. Because of this, it can be difficult to recognize when a bloom occurs.

What Toxins Do Algae Produce?

Blue-green algae produce a variety of toxins. Common species of *Anabaena*, *Aphanizomenon*, and *Microcystis* most often produce toxins when stressed—during bloom conditions. Algal toxins are generally of two types: neurotoxins (affect nerves) and hepatotoxins (affect liver) (see box). *Cylindrospermopsis* produces three different toxins: cylindrospermopsin (a hepatotoxin), anatoxin-a (a neurotoxin), and saxitoxin (a neurotoxin). Recent studies have found cylindrospermopsin to be carcinogenic and genotoxic.

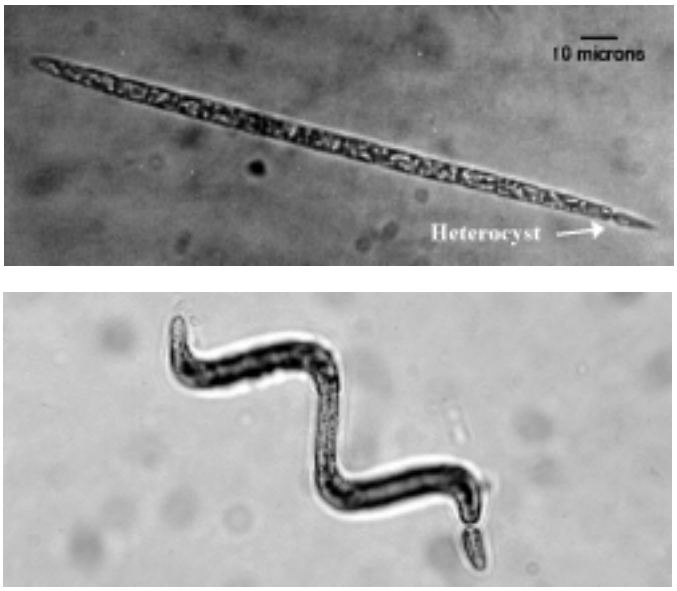
Are The Toxins Harmful to Humans?

No human deaths from blue-green algae, including *Cylindrospermopsis*, have been reported in the United States. People exposed to blue-green algal blooms by swimming in affected lakes or rivers have experienced skin irritations, allergic reactions, gastrointestinal symptoms, and respiratory problems. Nausea, vomiting, and liver failure have been associated with consumption of the blue-green toxins cylindrospermopsin and microcystin in finished drinking water in Australia.

Most of the knowledge about the toxicity of these compounds, including dose-response interactions, comes from animal experiments. Because human toxicity from direct algal exposure has rarely been documented, there is no dose-response data or even experimental data in humans.

There are numerous documented cases of livestock and dog deaths attributed to algal toxins. These were attributed to the animals drinking large quantities of pond water contaminated with algal toxins.

Straight morph with heterocyst (top); curled morph.



Types of Algal Toxins

Hepatotoxins—damage the liver and kill animals by causing blood to pool in the liver. They also promote liver tumor in test animals.

Neurotoxins—interfere with the functioning of the nervous system and often cause death due to paralysis of the respiratory muscles. Symptoms include: diarrhea, shaking, and nasal mucus discharge.

Saxitoxin—a specific neurotoxin that causes paralytic shellfish disease. Symptoms in animals include: tingling and numbness of the mouth, tongue, face, and extremities; nausea and vomiting; dizziness.

Are Fish Caught from These Waters Safe to Eat?

The toxins produced by freshwater blue-green algae do not appear to bioaccumulate in fish and other edible aquatic life in lakes and rivers to the degree that they can in some seafood. Toxic results from consumption of freshwater animals have not been documented. Anglers should always take a common-sense approach to eating fish caught from lakes or

rivers. If the fish looks or smells unhealthy or was dead when you found it, then don't eat it. If an angler is concerned, avoid lakes with heavy algal blooms.

How was Cylindrospermopsis *Identified in Ball Lake?*

The algae were collected and identified by Dr. Ann St. Amand during a routine sampling of Ball Lake in August. Dr. St. Amand, who runs an algal analytical laboratory in Michigan, noticed a dense, green color in the water, but no surface scum. Upon examination of a sample back in her lab, she identified *Cylindrospermopsis*, the first positive identification of this species in Indiana. The concentration of *Cylindrospermopsis* in the sample was 300,000-400,000 cells per milliliter.

How Many Indiana Lakes Contain Cylindrospermopsis*?*

Because the Ball Lake incident occurred only recently, not all Indiana lakes have been tested for the presence of *Cylindrospermopsis*. Additional testing found this alga present in Kokomo, Eagle Creek, and Morse reservoirs at significantly lower concentrations than those found in Ball Lake. Following these discoveries, the U.S. Army Corps of Engineers re-examined algal samples collected during 2000 from its large Indiana reservoirs and found *Cylindrospermopsis* present in samples from four of the eight Corps reservoirs—Monroe, Patoka, Salamonie, and Brookville.

What Concentrations of Cylindrospermopsis *are Considered Dangerous?*

There are no guidelines or standards for *Cylindrospermopsis* or algal toxins in general in the U.S. The World Health Organization has published guidelines for safe practice in managing swimming waters containing toxin-producing blue-green algae.

- 20,000 cells/ml = short-term effects (skin irritation, gastrointestinal illness)
- 100,000 cells/ml = potential for long-term illness with some cyanobacterial species; short-term effects (skin irritation, gastrointestinal illness)
- Scum formation = potential for acute poisoning; potential for long-term illness with some cyanobacterial species

The concentrations found during the peak bloom at Ball Lake were significantly higher than these guidelines. The concentrations found in other Indiana surface waters were lower.

What Tests Can Confirm the Presence of This Alga and its Toxins?

Cylindrospermopsis cells can be identified at high magnification by a skilled person with a high-quality microscope. The toxins produced by this alga can be determined by a lengthy and expensive analytical test. At the present time, only research laboratories have the capability to run such tests. A commercial lab in Florida plans to offer these services in the near future. However, because *Cylindrospermopsis* produces toxins all the time, not just when stressed, the presence of cells can be used as a surrogate for the presence of toxins. Preliminary evidence suggests that the curled form produces fewer toxins than the straight form.

What is the State of Indiana Doing about Algal Toxins?

The state responded rapidly to the Ball Lake bloom. A health advisory was issued for the lake and additional samples were collected and taken to a research lab at Wright State University in Ohio for further analysis. The concentration of *Cylindrospermopsis* and its toxin, Cylindrospermopsin were very low in the later samples and the advisory was lifted. Apparently the Ball Lake bloom was short-lived.

A toxic algae work group, coordinated by Jill Hoffman, Lake and River Enhancement (LARE) biologist with IDNR, was formed following the Ball Lake incident. Representatives from IDEM, IDNR, ISDH, U.S. EPA, Purdue University, Indiana University, and several water utilities have participated in the two meetings held thus far. The group is working on protocols for responding rapidly to any future blooms of *Cylindrospermopsis* this coming year. Among the efforts are developing analytical capabilities in Indiana to test for algal toxins. The group will again meet in late winter. In related activities, U.S. EPA has initiated the long process involved in determining whether guidelines or standards are needed for *Cylindrospermopsis*.

Indiana has taken a very proactive position with *Cylindrospermopsis*. Florida is the only other state with a coordinated effort to address these issues.

Can the Growth of Cylindrospermopsis *be Controlled?*

Like any other plant, the growth of blue-green algae requires light, nutrients, and heat to thrive.

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William W. Jones, Editor
Cynthia Mahigian Moorhead, Production Manager

Address all correspondence to:
SPEA 347
1315 E. Tenth Street
Indiana University
Bloomington, IN 47405-1701

Phone: (812) 855–4556 • FAX: (812) 855–7802

The primary nutrient that limits the growth of algae in water is phosphorus. Therefore, we must continue with programs that reduce the misuse of and delivery of this nutrient to streams and lakes. Best management practices that reduce soil erosion and water runoff are important tools in the reduction of phosphorus loading to surface waters.

Algal blooms have traditionally been chemically treated with copper sulfate. However, experience in Australia has shown that while copper sulfate kills *Cylindrospermopsis*, it also causes the release of the toxins into the water.

Algal toxins are difficult to remove from drinking water. It has been reported that conventional water treatment involving flocculation, filtration, and chlorination removes only 10-30% of microcystin-LR from water. More sophisticated treatment using activated carbon or ozonization are much more effective, removing almost 100% of dissolved microcystin-LR from water (Kotak et al. 1994). Florida has detected as much as 90 µg/l of cylindrospermopsin in finished drinking water (USEPA, 2001). Australia has a 1-15 µg/l drinking water guideline.

Prevention of blooms in the first place is still the best long-term toxic algae control strategy.

Sources for this Article and for More Information

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USEPA. 2001. Creating a Cyanotoxin target list for the unregulated contaminant monitoring rule, U.S. Environmental Protection Agency – Technical Service Center, Cincinnati.

Upcoming Meetings

March 9-11, 2002

22nd Annual Midwest Aquatic Plant Management Society Conference. Sheraton Milwaukee-Brookfield, Brookfield, WI. Contact: Bill Kirkpatrick, Phone: (717) 352-9191; e-mail: <aec@epix.net>.

March 18-20, 2002

11th Annual Southeastern Lakes Management Conference Adams Mark Hotel, Winston-Salem, North Carolina. Contact: Barbara Wiggins, Phone: (828) 254-5644; e-mail: <bswiggins@worldnet.att.net>; Web Page: <www.don-anderson.com/senalms2002/>.

April 5-6, 2002

14th Annual Indiana Lakes Management Conference: "The Future of Indiana Lakes". Radisson Hotel, Merrillville, Indiana. Contact: Mark Mongin, Phone: (317) 580-8299; e-mail: <markm@sepro.com>.

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School of Public and Environmental Affairs
Room 347
1315 E. Tenth Street
Indiana University
Bloomington, IN 47405-1701

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