Published in final edited form as:
Lake Line. 2012 March ; 32(3): 7–9.

Freshwater Algal Blooms & Public Health

Lorraine C. Backer

Cyanobacteria, or blue-green algae, are ubiquitous in freshwater ecosystems and may form harmful algal blooms (cyanoHABs), dense blooms that are a danger to people, animals, and ecosystems. Cyanobacteria are capable of producing cyanotoxins, a group of structurally diverse compounds that include highly potent neurologic, liver, and kidney toxins, including anatoxin, microcystins, and cylindrospermopsin. People can be exposed acutely (over a short period of time) or chronically (over a long period of time) to cyanotoxins in drinking and recreational waters. For example, occasional drinking water treatment system failures have resulted in cyantoxins entering community water supplies, causing large outbreaks of gastrointestinal distress in the U.S. and Australia. Patients in Brazil received fatal doses of microcystins when kidney dialysis water became contaminated. Anecdotally, people have complained of severe upper respiratory symptoms and hydrogen sulfide odors while near water bodies with intense blooms or with blooms that were scenescing, or dying off. Chronic exposure to low doses of microcysins, toxins produced by *Microcystis aeruginosa*, has been associated with high frequencies of liver cancer in people who drank ditch water in China.

Animals may also be exposed to toxin-producing cyanoHABs. During hot, dry summer months, cyanoHABs flourish in small ponds where domestic animals drink, sometimes causing fatal exposures to cyanotoxins in horses and cattle. Pets, particularly dogs, are at risk for acute fatal poisonings when they swim in or drink from ponds with dense toxin-producing cyanoHABs. In fact, an animal poisoning is often the first indication that a cyanoHAB has formed in a lake or pond. This summer (2012), warmer than average temperatures and drought combined to induce cyanoHABs in many Georgia farm ponds. At least four cows from one ranch died from acute cyanobacteria toxin poisoning after drinking water from one of these ponds (Dacula Patch 2012).

Exposure to Cyanotoxins During Recreational Activities

The most common human exposure to cyanotoxins is during recreational activities on water bodies with ongoing cyanoHABs, simply because many recreational water bodies are used by large numbers of people. Initial studies with people did not find an association between swimming in water with cyanobacterial blooms and self-reported symptoms, such as eye irritation or sore throat. However, later studies found that persons who were exposed to waters with concentrations of cyanobacteria >5,000 cells/mL during recreational activities were more likely to report at least one symptom during the week following exposure than

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were persons exposed to waters that did not contain cyanobacteria. Reported symptoms included itchy skin rashes, hay-fever-like symptoms, gastrointestinal distress, and allergic reactions, as well as more severe symptoms such as headaches, fever, and blistering in the mouth. A more recent study found that people who used personal watercraft on lakes with high cyanobacteria concentrations were twice as likely to report symptoms, particularly respiratory symptoms, than those who used their personal watercraft on lakes with low cyanobacteria concentrations.

We conducted two studies of recreational exposure to microcystins, probably the most commonly occurring types of cyanotoxins, in lakes with ongoing *Microcystis aeruginosa* blooms (Backer et al. 2008 and 2010). In the first study, we recruited 97 people planning recreational activities at a small lake with an ongoing cyanobacterial bloom and seven others who volunteered to recreate in a nearby bloom-free lake (Figure 1). During the study, MC concentrations within the bloom lake water and aerosol samples were very low (<2–5 μg/L and <0.1 ng/m^3, respectively). Study participants' plasma MC concentrations were all below the limit of detection for the assay we used, and they did not report any symptoms after their recreational activities.

In our second study, we recruited 81 children and adults planning recreational activities on one of three reservoirs, two with ongoing blooms of toxin-producing cyanobacteria, including *Microcystis aeruginosa*, which produces microcystins (Bloom Lakes) (Figure 2), and one without an algal bloom (Control Lake). We found low microcystin concentrations in personal air samples and nasal swabs. Microcystin concentrations in all blood samples from study participants were below the limit of detection. Although study participants did not report any health symptoms associated with their activities on the lakes, our findings indicated that recreational activities in the water bodies with toxin-producing cyanoHABs can generate aerosols containing cyanotoxins, making inhalation a potential route of exposure.

Protecting Health

In the United States, there are no federal regulations defining acceptable levels of cyanotoxins in drinking or recreational waters. To manage these water bodies, most states rely on guidelines published by the World Health Organization (WHO) or on risk assessments based on the WHO data (WHO 2003). However, these guidelines were based on cell concentrations rather than on cyanotoxin concentrations, and not all cyanobacterial blooms produce toxins. Resource managers and public health officials are often left with the difficult choice between protecting public health by closing a water body with a significant algal bloom that may not be producing toxins, and protecting the local tourism economy by keeping a water body with a visible, aesthetically unappealing bloom open for use.

In addition to using the WHO guidance, some states have done their own risk assessments to develop guidelines to support public health decision making, such as posting advisories or closing water bodies (see Graham et al. 2009). For example, the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency issued guidance on six cyanotoxins in 2012 (Butler et al. 2012). The guidance provides calculated action levels that may be applied by local, regional, state, or tribal entities to reduce or eliminate exposure of people and animals to algal toxins.

Oklahoma was the first state in the U.S. to pass legislation limiting exposure to freshwater algae (the bill can be viewed at: http://legiscan.com/gaits/view/366438). The new law requires the Oklahoma Tourism and Recreation Department to maintain a public website (www.checkmyoklake.com) that provides information about cyanoHABs to the public, including monitoring data collected by the Oklahoma Department of Environmental Quality, the U.S. Army Corps of Engineers, and municipal authorities. It also requires any agency with authority to manage recreational waters to post signs directing people to the website for information. The legislation also formalizes the responsibility for warning people about cyanobacteria and cyanoHABs blooms and sets the health-related warning thresholds: tourism officials will warn lake users if algae cell counts exceed 100,000 cells/mL and microcystin concentrations exceed 20 μg/L. These levels are controversial, even within Oklahoma, because WHO considers cell concentrations of 100,000 cells/mL to be associated with a high probability of health effects.

Kansas has taken a mutlti-faceted approach to reducing exposure to cyanoHABs that includes a website where people can get information and report potential blooms (http://www.kdheks.gov/algae-illness/index.htm). The state has also developed an extensive outreach and education campaign that includes social media communication.

Each Monday, Odin, the Olde English Bulldogge, has a new message on the Kansas Department of Environmental Health (KDEH) Facebook© page (Figure 3). Since Odin began starring in these messages, the number of KDEH Facebook© friends increased from 29 to nearly 400 (personal communication, Dr. Janet Neff, KDEH, June 27, 2012). For more information about Kansas' innovative website and about the veterinary perspective from this state, please see the articles by Ed Carney and Deon van der Merwe on pages 19 and 23 of this issue.

Summary

Ideally, data from epidemiologic studies designed to carefully evaluate the associations among environmental toxin concentrations, exposure routes, and related health symptoms are needed to develop environmental contaminant exposure guidelines for both people and animals. However, if these data are limited, agencies tasked with protecting public health may use alternative approaches to protect citizens, including using available guidelines, developing legislation, or creating public education campaigns.

Biography

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Lorraine Backer is an environmental epidemiologist with the National Center for Environmental Health, Centers for Disease Control and Prevention in Atlanta, Georgia. Her research includes assessing human exposures to cyanobacterial toxins and contaminants in drinking water. She is the PI for the Private Well Initiative, a project that seeks to understand the public health impacts from private well water.

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Figure 1.
Microcystis bloom in a recreational lake where we conducted our first study of human exposure to cyanotoxins.

Figure 2.

Microcystis bloom in a reservoir where we conducted our second study of human exposure to cyanotoxins.

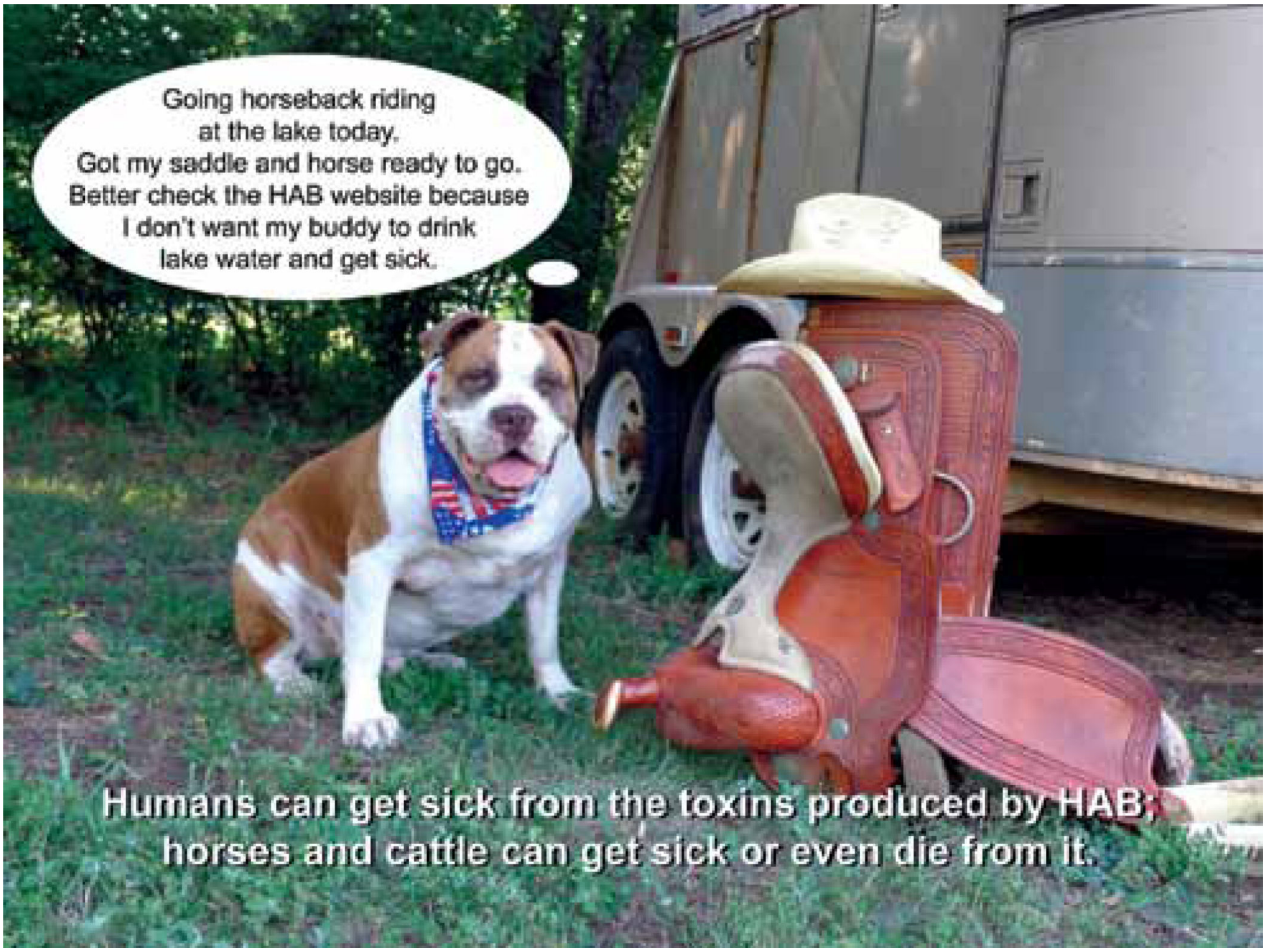

Figure 3.
Odin, the English Bulldogge, with one of his weekly warnings about cyanobacteria and related toxins. Reprinted with permission from the Kansas Department of Environmental Health.