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CD Summary

Contact: 971-673-1111 | cd.summary@state.or.us | www.healthoregon.org/cdsummary

MOOD INDIGO: MAKING SENSE OF THE CYANOTOXIN BLUES

Given the excitement (consternation?) around the drinking water advisory in Salem earlier this summer, harmful algal blooms (HABs) are likely on the minds of many. As Oregon weather continues on its hot streak, and the season for recreational use advisories on water bodies is in full swing, HABs will continue to make the news. This *CD Summary* reviews what we know about cyanobacteria, the organisms that make up HABs, and what health care providers need to know to protect their patients and assist Oregon Health Authority (OHA) in tracking cyanotoxin-related illness.

WHAT ARE HABS?

Cyanobacteria* are an ancient phylum of photosynthetic bacteria (Figure 1) that have been around for about 3.5 billion years. Their industrious efforts at photosynthesis are largely responsible for development of Earth's oxygen-rich atmosphere that allowed for the evolution of oxygen-dependent life.[1†] Cyanobacteria are found globally in marine and fresh water, and although beneficial, under certain environmental conditions these organisms proliferate into visible colonies, or blooms. These blooms may appear as bright green, bluish-green, white, or reddish-brown scum, streaks, or cloudy patches, and often have the appearance of spilled paint or pea soup (Figure 2). Conditions contributing to blooms include: warm temperature, increased nutrients (often from agricultural run-off), and decreased water flow.

WHAT ARE CYANOTOXINS?

For reasons that aren't well understood, some cyanobacteria produce metabolic byproducts that are acutely toxic to mammals (including humans) and other vertebrates. Cyanotoxins are varied in form and target organ. The four cyanotoxins found most often in Oregon's fresh waters [2] are: 1) anatoxin-a;[3] 2) cylindrospermopsin; 3) microcystins; and 4) saxitoxins. Anatoxin-a and saxitoxins are potent neurotoxins. Microcystins and cylindrospermopsin target the liver[4,5] and were the cyanotoxins driving the City of Salem's drinking water advisory for vulnerable populations. In addition to the liver, cylindrospermopsin can also damage the kidneys.

Figure 1. Micrograph of *Microcystis aeruginosa*.

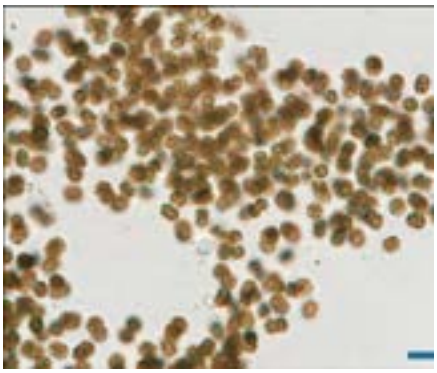

Photo credit: United States Geologic Survey,

ROUTES OF EXPOSURE

People and animals can be exposed to HABs through three main routes: skin contact (e.g., through swimming); inhalation (by breathing cyanotoxin-contaminated mist or water droplets); and ingestion (of food or water contaminated with cyanotoxins). Symptoms depend on the specific toxin, as well as the route and duration of exposure. Direct contact with skin or mucus membranes can lead to irritation of the exposed tissue or rash. Similarly, inhalation primarily leads to respiratory tract irritation.

Figure 2. Cyanobacterial bloom on Lemolo Lake, Oregon, 2018.

The most concerning exposure is ingestion, which can result in the symptoms outlined above for each toxin type. Systemic exposure has led to severe illness in both animals and humans. Livestock and other animal deaths attributable to drinking water containing cyanobacteria have been recorded for more than 100 years.

HUMAN ILLNESS OUTBREAKS

The most severe outbreak of microcystin-associated illness was in 1996 in Caruaru, Brazil; 130 dialysis patients received dialysate made from microcystin-contaminated water. Of those exposed, 100 developed acute liver failure, and 76 died.[4]

The most severe outbreak of cylindrospermopsin-related illness was in 1979 at Palm Island, Australia. A group of people, mostly children, drank directly from a reservoir affected by a bloom of cyanobacteria known to produce cylindrospermopsin. Patients presented with fever, headache, vomiting, bloody diarrhea, hepatomegaly and kidney damage with loss of water, electrolytes and protein; most required hospitalization.[5]

U.S. AND OREGON CASES

No systematic nationwide surveillance for cyanotoxin-related illness exists. The best available data on cyanotoxin-associated human illnesses are from the CDC's Harmful Algal Bloom-related Illness Surveillance System (HABISS). From 2007–2011 nation-

* Often erroneously called "blue green algae". We're hoping to "deep six" that term.
† Ironic that organisms which may have been responsible for life on Earth now make life miserable for many.

wide, HABISS counted 176 suspect, probable, or confirmed cases of human illness related to cyanotoxin exposure during recreational activities in bodies of fresh water.[6] Since 2008, the Oregon Public Health Division (PHD) has recorded 21 suspect and 3 confirmed cases of human illness associated with exposure to cyanobacterial blooms during recreational activities on fresh water bodies in Oregon; none were fatal. Since cyanotoxin poisoning is not a mandated reportable condition in Oregon, we assume these case counts underrepresent the burden of disease.

To date, no confirmed cases of human illness in the U.S. have been attributed to cyanotoxin exposure to water from a treated drinking water system. However, microcystin and cylindrospermopsin (the two cyanotoxins that most commonly affect drinking water systems) can cause non-specific gastrointestinal symptoms that could easily be confused with foodborne or infectious illness.

MAN'S BEST FRIEND SUSCEPTIBLE, TOO

Dogs, given their penchant for flinging themselves into bodies of water, consuming large quantities of cyanobacterial scum, and licking cells and toxins from their fur, are a good sentinel species for cyanotoxin exposure. One study counted 367 suspected or confirmed cases of canine cyanotoxin poisoning in the U.S. between the late 1920s and 2012.[7] More than half of these poisonings were fatal; and, in most cases, the exposure was to cyanotoxins in fresh bodies of water.

While reporting of canine cyanotoxin poisoning to OHA is voluntary, we have recorded 10 possible, 1 probable and 2 confirmed cases of canine cyanotoxicity from 2008–2018. Most were fatalities. Again, we assume many canine cases are under-reported.

SYMPTOMS

The symptoms of cyanotoxin exposure depend on the type and concentration of cyanotoxin and the route of exposure.

Anatoxin-a intoxication in animals results in rapid onset (within minutes of exposure) loss of coordination, and, in severe intoxications, seizures and respiratory paralysis: however, information on illness in humans is sparse.

Saxitoxin-associated illness has been linked to ingestion of contaminated shellfish, and, within minutes, can lead to paresthesia, vomiting, weakness, and, with high levels of intoxication, respiratory failure.[8]

Microcystin intoxication also has a rapid onset,[9] within one hour, and can manifest as gastrointestinal symptoms or liver injury.

Cylindrospermopsin intoxication presents similarly, and can also lead to kidney injury. People and pets swimming in or near a cyanobacterial bloom might also develop rash or itching due to direct irritation from compounds found within the cell walls of the bacteria.

ADVISORY LEVELS

The Environmental Protection Agency (EPA) has established health advisory levels for microcystin and cylindrospermopsin for drinking water and recreational waters.[4] Several groups are considered at higher risk, including the medically fragile, children age ≤5 years, the elderly, pregnant women, nursing mothers (or, more accurately, the infants they're nursing), and those with underlying liver or renal disease. For recreational waters, protective levels were developed based on the amount of water children 6–11 years (the most exposed age group) typically ingest while swimming.

The OHA has adopted these EPA levels and used the same methods to develop levels for anatoxin-a and saxitoxin. Drinking water systems use the health advisory levels to issue do-not-drink advisories that trigger recommendations for sensitive groups and the general public, as necessary. OHA uses the values to issue recreational use health advisories when fresh water bodies are affected by a bloom.

TREATMENT

There are no specific antidotes for cyanotoxins; if illness develops due to exposure, treatment is supportive. Vomiting and diarrhea are typically self-limited, and the goal is to avoid dehydration or electrolyte disturbance. For patients with known liver or kidney disease who report cyanotoxin exposure and become symptomatic, further evaluation is prudent.

INVESTIGATING SOURCES

Though reporting of cyanotoxin-related illness is not mandatory, OHA encourages reporting and performs passive surveillance and follow-up interviews when possible. If you think something's brewing, or if you're thinking about cyanotoxins at all, please give us a call at 971-673-0440 (OHA's Harmful Algae Bloom Surveillance Program), or email us at hab.health@state.or.us.

Cyanobacterial blooms can develop in any water body, so asking patients or pet owners about water body conditions at the time of exposure is helpful in determining if the illness was potentially cyanotoxin-related.

Characterizing the nature of exposure is important in classifying cyanotoxin-associated illness. Availability of toxin testing data from an implicated water body can make the difference between a probable, suspect, or confirmed case. This testing is typically done by the agency or entity that manages a given body of water. OHA's HABS program provides guidance to partners on best monitoring and sampling practices.‡ Ultimately, though, entities managing local water bodies have discretion as to whether and how closely to follow OHA guidance, or to sample at all.

PREVENTION

For the most part, limiting the risk of illness involves minimizing exposure to affected recreational waters until the bloom disappears. Specifically, encourage people to avoid swimming and or splashing in affected water, and to keep pets from swimming in or drinking the water. Upstream prevention of blooms may not be altogether possible, but reducing nutrient pollution from agricultural and urban runoff may be helpful.

FOR MORE INFORMATION

HAB advisories, general information about HABs, photos depicting cyanobacterial blooms, advisory guidance for partner agencies and information about how cyanotoxin recreational guideline values were developed can be found at:
www.healthoregon.org/hab.

Information for providers related to HABs in drinking water can be found here:
www.oregon.gov/oha/PH/HealthyEnvironments/DrinkingWater/Operations/Treatment/Pages/algae.aspx.

The Centers for Disease Control and Prevention (CDC) has extensive information on their website: Harmful Algal bloom (HAB)-Associated Illness: www.cdc.gov/habs/index.html.

‡ www.healthoregon.org/hab

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