

Cyanobacterial Harmful Algal Blooms (HABs) and Cyanotoxins: Recreational Exposure, Health Effects and Guidance Levels

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What are Cyanobacteria and Cyanotoxins?

Cyanobacteria are a type of bacteria capable of photosynthesis. Although they are not true algae, they were often historically referred to as “blue-green algae”. A cyanobacterial harmful algal bloom (HAB) is an excessive growth, or “bloom”, of cyanobacteria, some of which can produce one or more types of potentially harmful toxins (cyanotoxins). HABs normally occur under suitable environmental conditions of light, temperature, nutrients, and calm water. These blooms can result in a thick coating or mat on the surface of a waterbody, often in late-summer or early fall. People, pets, livestock and/or wildlife can be exposed to HABs by coming in contact with or ingesting water where a HAB is present. If a HAB is suspected in a waterbody, people, pets and livestock should avoid contact with the water, and water or fish from the affected waterbody should not be consumed. This fact sheet provides detailed information on HAB recreational exposures, health effects, and the NJ recreational advisory guidance levels. An additional fact sheet providing general information about HABs is available at: www.state.nj.us/dep/wms/bfbm/CyanoHAB-Home.html.

What are the potential human health impacts from recreational exposure to cyanobacteria and the toxins that they may produce?

During recreational activities (e.g., swimming, wading, and watersport activities including jet skiing, kayaking, wind surfing, and paddleboarding), exposure to cyanobacteria and the toxic chemicals (cyanotoxins) that they produce can occur. Recreational exposure can occur from accidental or deliberate ingestion of water, direct skin contact, or inhalation of water droplets. Inhalation exposures to cyanotoxins from breathing air near a waterbody with a HAB are much lower than exposures that can occur from contact during recreational activities such as swimming.

Health effects from HABs can result from contact with cyanobacteria cells themselves or from the cyanotoxins and other harmful substances that can be produced by the cyanobacterial cells. Exposure to cyanobacterial cells can cause a range of health effects, including allergic-like reactions (e.g., rhinitis, asthma, eczema, and conjunctivitis), flu-like symptoms, gastroenteritis,

The Primary Cyanotoxins and their Health Effects

(More specific information about species can be found in Meriluoto, Jussi, Spoof, and Codd, eds. Handbook of cyanobacterial monitoring and cyanotoxin analysis. John Wiley & Sons, 2017.)

Cyanotoxin	Health Effects in Humans	Common Cyanotoxin Producing Taxa
Microcystins	Abdominal pain, headache, sore throat, nausea and vomiting, dry cough, diarrhea, blistering around the mouth, pneumonia, liver toxicity	<i>Microcystis</i> , <i>Aphanizomenon/Cuspidothrix</i> , <i>Dolichospermum/Anabaena</i> , <i>Nodularia</i> , <i>Planktothrix</i> , <i>Phormidium</i> , <i>Fischerella</i> , <i>Nostoc</i> , <i>Oscillatoria</i> , and <i>Gloeotrichia</i>
Cylindrospermopsins	Fever, headache, vomiting, bloody diarrhea, liver and kidney toxicity	<i>Cylindrospermopsis</i> , <i>Aphanizomenon</i> , <i>Umezakia</i> , <i>Anabaena</i> , <i>Lyngbya</i> , and <i>Raphidiopsis</i>
Anatoxin-a group	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death, neurotoxin	<i>Aphanizomenon/Cuspidothrix</i> , <i>Cylindrospermopsis</i> , <i>Cylindrospermum</i> , <i>Dolichospermum/Anabaena</i> , <i>Microcystis</i> , <i>Oscillatoria</i> , <i>Planktothrix</i> , <i>Phormidium</i> , <i>Raphidiopsis</i> , <i>Tychonema</i> and <i>Woronichinia</i>
Saxitoxins	Tingling, burning, numbness of the oral mucosa, gastrointestinal distress, muscle weakness, respiratory paralysis leading to death, neurotoxin	<i>Aphanizomenon/Cuspidothrix</i> , <i>Cylindrospermopsis</i> , <i>Cylindrospermum</i> , <i>Dolichospermum/Anabaena</i> , <i>Lyngbya</i> , <i>Phormidium</i> , and <i>Raphidiopsis</i>

respiratory irritation, skin rashes, and eye irritation. Additionally, HABs may begin to produce cyanotoxins at any time. Exposure to a HAB which is actively producing cyanotoxins may result in more serious health effects, including liver toxicity and neurological effects. Cyanotoxins are not classified as carcinogens by USEPA, although studies in laboratory animals and cultured cells suggest that some cyanotoxins can cause liver tumors and promote the growth of existing liver tumors. The table above summarizes the health effects caused by the most common cyanotoxins and the species of cyanobacteria that are capable of producing them.

What recreational HAB guidance levels are available?

From 2014-2017, the Bureau of Freshwater and Biological Monitoring of the NJ Department of Environmental Protection (DEP), with assistance from the Division of Science and Research (DSR), developed the laboratory capability needed for HAB response. This capability included methods to identify and count cyanobacterial cells and to measure levels of three of the most toxic, commonly observed cyanobacterial toxins in NJ's freshwaters, namely microcystins (suite of microcystin congeners), cylindrospermopsins, and the anatoxin-a group. The Department has also now developed the ability to measure at least one other toxin, saxitoxin, and is exploring other HAB lab techniques, such as genetic methods to measure the potential for toxin production.

In order to assess HAB test results, respond to these blooms and protect human and animal health, a number of states, as well as the World Health Organization (WHO), derived their own "action levels" or health advisory guidelines based on cyanobacteria cell counts and/or concentrations of the more toxic, commonly-occurring cyanotoxins. In 2017, DSR reviewed the cyanotoxin guidance values developed by WHO and various other states, as well as relevant scientific publications, and developed guidance values based on cyanobacterial cell counts and for three toxins (see below) which are applicable to recreational exposure. These values are used by NJ to provide advice on recreational activities in response to HABs. The basis for these guidance values can be found in the Cyanobacterial Harmful Algal Blooms (HABs) Freshwater Recreational Response Strategy (<https://www.state.nj.us/dep/wms/bfbm/download/NJHABResponseStrategy.pdf>).

Until 2019, recommended HAB criteria or guidelines were unavailable from USEPA. In 2019, USEPA released its recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. The USEPA (2019) criteria/advisories for these two cyanotoxins were not available when DEP developed its guidance values. DEP scientists continue to review NJ's guidance levels to ensure that they are based on the most up-to-date science, including evaluation of the USEPA (2019) recommended criteria/advisories.

What are the health advisory guidance levels for New Jersey waters?

Health advisory guidance levels based on cyanobacterial cell counts

As mentioned above, exposure to cyanobacterial cells may cause allergenic and/or irritant effects in a portion of an exposed popu-

lation. These effects are caused by endotoxins



(components of the cyanobacterial cell wall) that are present in the cells regardless of whether or not they are producing cyanotoxins. Therefore, Alerts should be posted for freshwater lakes or ponds in which cyanobacterial blooms are suspected through visual or other screenings, until confirmation analysis is performed.

If the cyanobacterial cell count equals or exceeds 80,000 cells/ml in an area where primary recreational contact is likely to occur, advisory signs indicating the confirmation of a HAB should be posted. This recommendation is based on the WHO (2003a) guidance (i.e. $\geq 20,000 - 100,000$ cells/ml is categorized as moderate risk), as described in the NJ Response Strategy (<https://www.state.nj.us/dep/wms/bfbm/download/NJHABResponseStrategy.pdf>). Blooms of cyanobacteria may produce a variety of toxins at any time.

Health advisory guidance levels for individual cyanotoxins

The following guidance levels are recommended for recreational exposure to toxins. The bases for these values is provided in the NJ Action Level section and Appendix F within the overall Response Strategy (<https://www.state.nj.us/dep/wms/bfbm/download/NJHABResponseStrategy.pdf>).

- Microcystins (as total including –LR and other detectable congeners): 3 µg/L
- Cylindrospermopsins: 8 µg/L
- Anatoxin-a group: 27 µg/L

These concentrations are intended to be protective for children's swimming exposures during cyanobacteria harmful algal bloom (HAB) events, since children are the sensitive sub-population for swimming exposures. In New Jersey, HABs may persist for several months during the swimming season, and the recreational advisories are intended to protect for repeated daily exposures during the duration of a HAB event. The uncertainties in the risk

estimates underlying the development of these values, as well as the inherent uncertainty in the time course and location of the toxins in any given water- body, should be considered when providing advice to the public regarding recreation in affected waterbodies. As described above, inhalation (breathing) exposures to cyanotoxins that may be present in the air near a waterbody with a HAB are much lower than exposures that can occur during recreational activities such as swimming.

What actions are taken following the report of a possible HAB?

Upon initial reporting of a suspected HAB, one or more of the following field screenings will be performed by a qualified organization to verify whether a potential HAB is present. If field screenings verify that a HAB may be present, a sample will be collected for further confirmatory analysis.

Visual Assessment

A visual assessment is part of the DEP HAB Interactive Map Reporting and Communication System. When public reports are received, the system requests information on size, extent, and visual information using example photos available in the system. When samplers visit the waterbody, additional visual information and measurements are input into the system. Visual assessment may also be in the form of field reports, but typically digital photographs of the bloom are used to help identify the bloom. These photographs or field reports do not provide information on whether cyanotoxins are present in the bloom.

Cyanobacteria Presence

If visual assessment confirms a potential HAB, the presence of cyanobacteria species can be confirmed in two ways if equipment is available: 1. identification and enumeration of individual cyanobacteria may be performed using microscopic equipment; or 2. the presence of phycocyanin pigment (typically unique to cyanobacteria) may be determined using a handheld field fluorometer. The first approach is the method primarily used.

Toxin Presence Screening

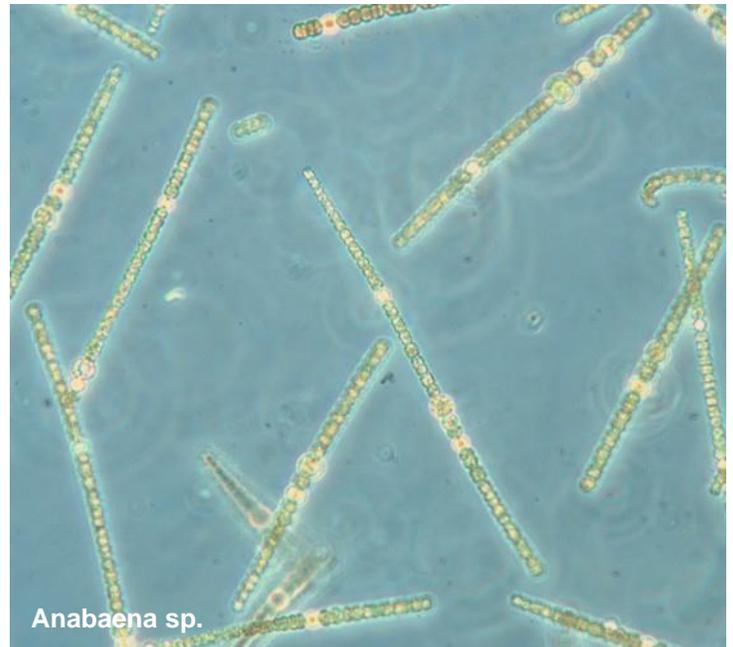
A microcystins field-kit test strip reading can be used generally to identify the presence of microcystins (other toxin test strips are now available; DEP is investigating the feasibility and reliability of various uses of the strip tests). Field-test results should be confirmed using the ELISA or the LC-MS/MS method.

What advisories are provided if a HAB is suspected or confirmed?

NJ health advisory guidance levels are developed for human exposures only. They do not apply to pets, livestock, or other animals, and they do not apply to fish consumption. Contact should be avoided by livestock and pets when evidence of HABs or their toxins are present.

DEP has developed Alert Levels (Watch, Alert, Advisory, Warning and Danger) based on cyanobacterial cell concentrations and cyanotoxin levels in a bloom that can be used to provide tiered advice for recreational exposure to HABs and their toxins. These tiered Alert Levels are based on DSR's evaluation of potential health effects at elevated microcystin concentrations, as well as Warning and Danger (or similar) guidelines from WHO

and other states.



What effects can HABs and cyanotoxins have on pets, livestock and wildlife, such as fish?

Adverse effects of HABs on livestock, wildlife and pets have been documented. Several instances of deaths of cattle, dogs and waterfowl have been attributed to exposure to cyanobacteria and their toxins. Dissolved oxygen can be rapidly deleted from the affected waterbody during a cyanobacterial bloom, leading to fish die offs (fish kills). The accumulation of toxins in fish has been noted, and this issue is being evaluated by DEP, EPA, other regulatory agencies and academia.

How are people or animals treated that have been exposed to cyanobacterial blooms?

The Center for Disease Control (CDC) states that if you or your pet comes in contact with a cyanobacteria bloom, wash yourself and your pet thoroughly with fresh water. If you or your pet swallow water from a waterbody where there is a harmful algae bloom, call your doctor, a Poison Center, or a veterinarian. Call a veterinarian if your animal shows any of the following symptoms of cyanobacteria poisoning: loss of appetite, loss of energy, vomiting, stumbling and falling, foaming at the mouth, diarrhea, convulsions, excessive drooling, tremors and seizures, or any other unexplained sickness after being in contact with water. Additional information is available on the CDC website (<http://www.cdc.gov/habs/materials/factsheets.html>).

You can help!

If you observe what you think might be a HAB in a pond, lake, or stream, a suspected Harmful Algal Bloom report can be submitted by smartphone or PC using the [NJDEP HAB Map Reporting and Communication System](#). This system will be used to gather initial information such as: location coordinates, photos, known activities, and extent over the waterbody. This information will be used to inform DEP to

initiate appropriate response actions. Once the DEP completes the investigation of the suspected HAB, results and recommendations for public notices or advisories will be communicated through the HAB System. All information and data will be accessible to the public by clicking the location on the interactive map in the HAB System. If a smart phone or computer are not available, reports may also be submitted to the DEP Hotline at 1-877-WARNDEP (927-6337). You can also contact your local or county Health Department or county 24-hour hotlines (<http://nj.gov/health/lh/directory/lhdselectcounty.shtml>). If reporting by phone, please note the exact location of the suspected HAB along with any details (e.g., date/time, bloom appearance and color, whether a swimming beach is nearby).

Contacts

DEP HAB Reporting and Communication System: [NJDEP HAB Reporting and Communication System](#)

DEP Hotline: 1-877-WARNDEP (1-877-927-6337)

<https://www.state.nj.us/dep/warndep.htm>

DEP Bureau of Freshwater & Biological Monitoring
(609-292-0427)

<https://www.state.nj.us/dep/wms/bfbm/CyanoHABHome.html>

DOH Public Health and Food Protection Program (PHFPP)
(609-826-4935) : <https://nj.gov/health/ceohs/food-drug-safety/>

Local and county Health Departments in New Jersey
<https://www.nj.gov/health/lh/community/index.shtml>

For questions regarding drinking water, please contact your local water supplier or DEP Division of Water Supply and Geoscience (609-292-7219) <http://www.nj.gov/dep/watersupply>

Additional Resources

DEP Harmful Algal Bloom Website: <https://www.nj.gov/dep/hab/>
USEPA's website on HABS: <https://www.epa.gov/cyanohabs>

USEPA (2019) Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin.
<https://www.epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf>

Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report, National Science and Technology Council, Feb. 2016.
https://cdn.coastalscience.noaa.gov/page-attachments/research/FINAL_HABs%20Hypoxia%20Research%20Plan%20and%20Action.pdf

United States Geological Survey (USGS): The Science of Harmful Algal Blooms: <https://www.usgs.gov/news/science-harmful-algae-blooms>

USGS. Graham, J.L., Dubrovsky, N.M., and Eberts, S.M., 2016, Cyanobacterial harmful algal blooms and U.S. Geological Survey science capabilities: U.S. Geological Survey Open-File Report 2016-1174, 12 p., https://www.usgs.gov/mission-areas/water-resources/science/nwqp-research-harmful-algal-blooms-habs?qt-science_center_objects=0#qt-science_center_objects

New Jersey Water Monitoring Council:
<https://www.nj.gov/dep/wms/wmccmeetinginfo.html#2019>

For more information, please visit the NJDEP Harmful Algal Blooms website: www.nj.gov/dep/hab/ For a list of water bodies that are continuing to experience blooms or have experienced blooms earlier this year, visit: www.state.nj.us/dep/wms/bfbm/cyanoHABevents.html

NJ Cyanobacterial HABs Recreational Response Strategy: www.state.nj.us/dep/wms/bfbm/download/NJHABResponseStrategy.pdf

