EPA United States Environmental Protection Agency

US EPA's Guidelines and Other Activities Related to Harmful Algal Blooms

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Tribal Science Webinar

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Presentation Overview

- What are harmful algal blooms?
- Potential routes of exposure and adverse health effects.
- EPA guidelines developed for cyanotoxins in drinking and recreational waters.
- ORD research and other activities related to HABs
- Monitoring techniques.
- Surface water and drinking water treatment practices.
- Public health guidelines.
- Opportunity for Questions.

Disclaimer

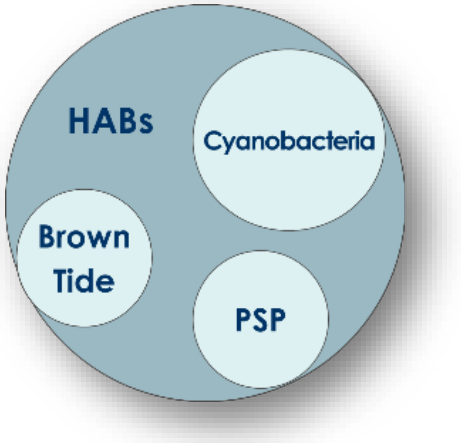
The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

Overview of Harmful Algal Blooms (HABs) and Cyanotoxins

- Algae are natural components of marine and freshwater flora.
- Harmful Algal Blooms (HABs) occur when algae multiply growing in growth forming a scum and affecting aquatic life and water quality.
- Algal blooms could cause :
  - Hypoxia, leading to fish kills.
  - Taste and odor problems in treated drinking water.
  - Toxins at levels that may be of concern for human health.
  - Economic losses from increase in treatment cost in drinking water plants and limiting recreational/fishing uses.
  - Presence in source water and finished drinking water: Toledo, OH (2014), Ohio River (2015), Florida, Utah, Texas, Iowa and New York (2016).

Cyanobacterial Blooms

- In freshwater, cyanobacteria or blue-green algae, are the most common “algae”, some of which produce highly potent cyanotoxins.
- One species can make multiple toxins and different toxins can be produced by a number of different species making visual monitoring difficult.
- Toxins can either reside inside the cell (intracellular) or be released into the water (extracellular).



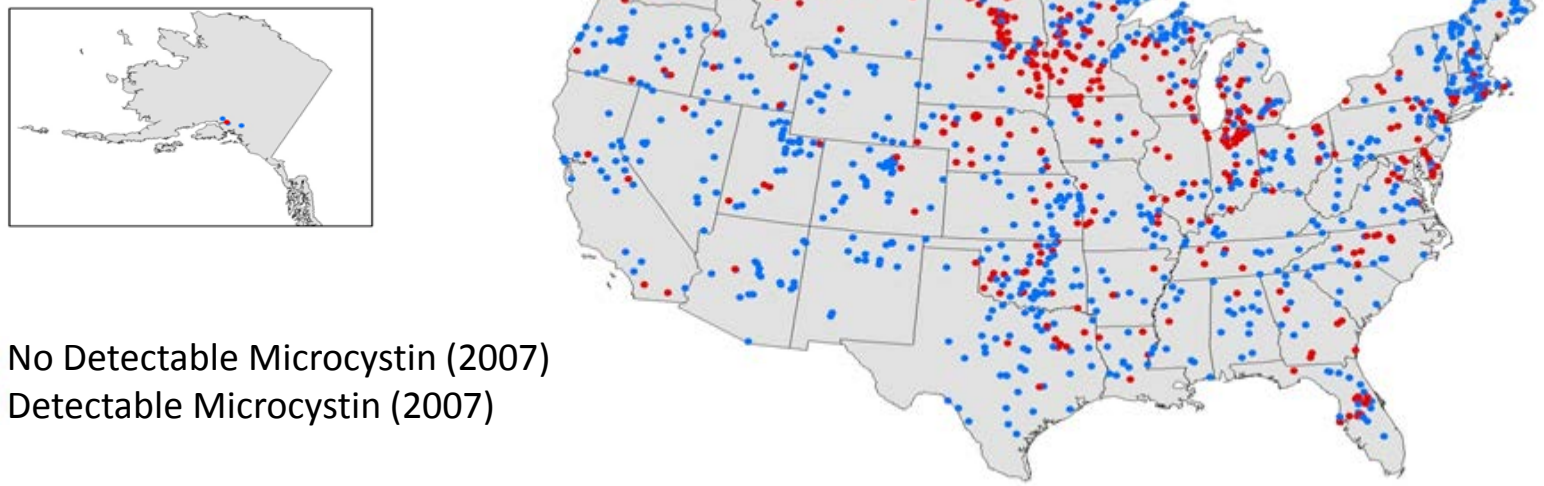
Freshwater Cyanotoxins	Type of Toxin	Causative Organism
Anatoxin-a	Neurotoxin	Anabaena spp.
Anatoxin-a (s)	Neurotoxin	Aphanizomenon spp. Planktothrix spp.
Cylindrospermopsin	Hepatotoxin	Cylindrospermopsis raciborskii, Aphanizomenon ovalisporum
Lyngbyatoxin	Dermal Toxin	Lyngbya spp.
Microcystins	Hepatotoxin	Microcystis aeruginosa Anabaena spp. Planktothrix spp.
Saxitoxins	Neurotoxin	Anabaena circinalis Lyngbya wollei

Exposure and Health Effects

- Potential routes of exposure:
  - Consumption in drinking water and food
  - Ingestion during recreational activities
  - Dermal contact
  - Inhalation of aerosolized toxins
- Health effects related to exposure to cyanotoxins:
  - Hepatotoxic (affects the liver)
    - Microcystins and Cylindrospermopsin
  - Neurotoxic (affects the nervous system)
    - Anatoxin-a and Saxitoxin
  - Dermatoxic (affects the skin)
    - Lipopolysaccharides and Lyngbyatoxin
- Symptoms of acute exposure are irritation to eyes, ears, throat, rashes, and skin lesions.
- Toxicity data (needed to determine thresholds) are not available for manycyanotoxins.

Microcystin Sampling in the 2007 and 2012 EPA National Lakes Assessment

- In 2007, microcystin was detected in 32% of the lakes sampled.
- In 2012, microcystin was detected in 39% of the lakes sampled.



- Less than 1% of lakes are in the high or moderate risk of exposure category, based on the WHO recreational exposure risk guidelines.

https://www.epa.gov/sites/production/files/2016-12/documents/nla_report_dec_2016.pdf

Effects of Cyanotoxins in Animals and Plants

- Pets and livestock can be impacted by cyanotoxins
  - Animals are exposed by drinking water and/or eating algal biomass (surface mats or fur grooming)
  - Rapid onset of symptoms and mortality
- Cyanobacterial cells and toxins can contaminate spray irrigation water and subsequently be associated with crop plants.
  - Low levels of cyanotoxins could be absorbed by roots, migrate to shoots, and then be translocated to grains and or fruits.
  - Cyanotoxins concentration in grains and fruits are very low.
  - Generally, roots accumulated more than the leaves.
  - Cyanotoxins inhibit plant growth causing visible toxic effects on the plant such as leaf discoloration.
- Further investigation is needed to understand the uptake and fate of microcystins and other cyanobacterial toxins by food plants.

Cyanotoxins and Fish

- Cyanotoxins levels in edible fish and shellfish are highly variable depending on trophic level and fish organ or tissues.
  - Concentrations are higher in liver > gut > kidneys and gonads > muscle tissue
  - Concentrations are higher >phytoplanktivorous > omnivorous > carnivorous fish
- More research is needed to quantify the toxicity in fish caused by cyanotoxins and the bioaccumulation in aquatic food webs.
- Rather than biomagnification, biodilution seems to occur in the foodweb with toxins being subject to degradation and excretion at every level.
- One of research needs identified is the need to quantify the total toxicity in fish caused by MCs variants and other secondary metabolites.

Current Guidelines for Cyanotoxins in Drinking and Recreational Waters

EPA's Drinking Water Health Advisories (HA)

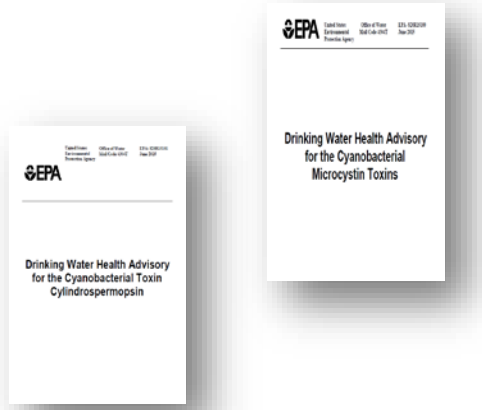
- Informal technical guidance for unregulated drinking water contaminants to assist federal, state and local officials, and managers of public or community water systems in protecting public health during emergency situations.
- HAs are **non-regulatory** concentrations in drinking water that is not expected to cause adverse non carcinogenic effects for a specific exposure period.
  - Acute (one-day) and Short (10-day) term exposures for infants (0 – 12 months).
  - Chronic (lifetime) exposures for adults.
  - Carcinogenic

Development of EPA's Drinking Water Health Advisories

- Joint effort with Health Canada.

- 2014/15 - Health Effects Support Document for microcystins, cylindrospermopsin and anatoxin-a
  - Data inadequate to develop an HA for anatoxin-a.

- 2015 – Development of Health Advisories for microcystins and cylindrospermopsin
  - June 17th, 2015 – HAs Published



HAs for Microcystins and Cylindrospermopsin

- EPA published Drinking Water Health Advisories (HAs) for microcystins and cylindrospermopsin
  - MC-LR is considered a surrogate for all microcystins
  - Short term exposure is more consistent with expected exposure pattern.
  - No lifetime or carcinogenic value derived

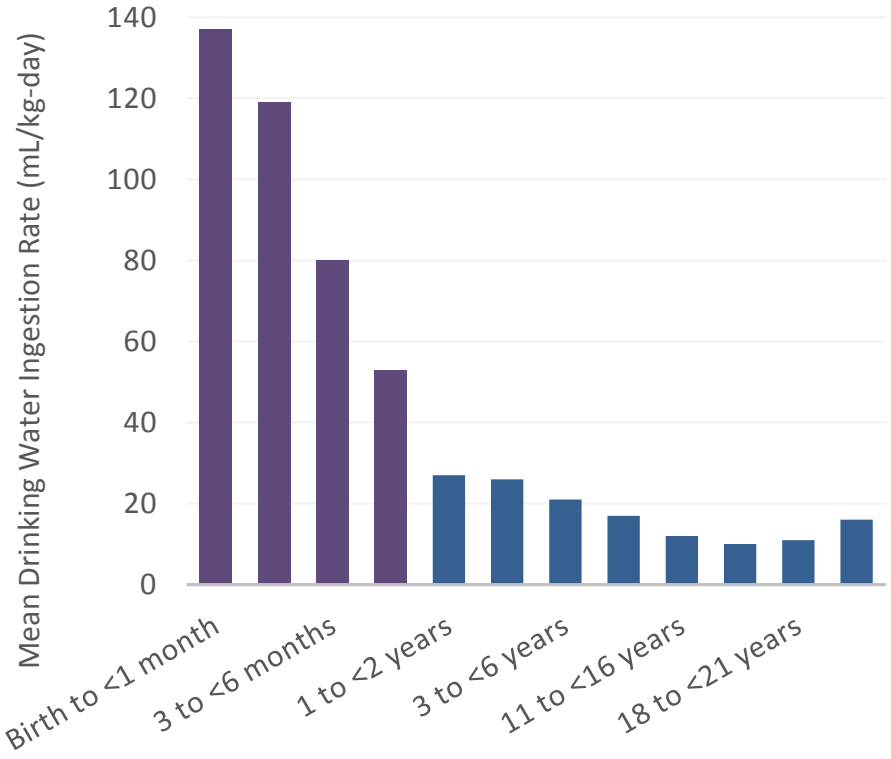
Toxin	10-day Health Advisory	
	Bottle-fed infants and pre-school children	School-age children and adults
Microcystins	0.3 µg/L	1.6 µg/L
Cylindrospermopsin	0.7 µg/L	3 µg/L

http://water.epa.gov/drink/standards/hascience.cfm#micro

Children's Exposure to Cyanotoxins

- Bottle-fed infants consume large amounts of drinking water compared to their body weight.
- At six years and older, exposure on a body-weight basis is similar to that of an adult.
- Infant-specific exposure factors are available from U.S. EPA's Exposure Factors Handbook (2011).

Drinking Water Ingestion Rates by Age



Supplemental Documents and other efforts in support of the HAs

- Analytical methods development (April 2015/2016)
  - 544 (microcystins and nodularin-R)
  - 545 (anatoxin-a and cylindrospermopsin)
  - 546 (Adda ELISA Method for microcystins and nodularins).
- Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water (June 2015)
- Cyanotoxin Management Plan Template and Example Plans (November 2016)
- Water Treatment Optimization for Cyanotoxins Document (November 2016)
- Drinking Water Cyanotoxin Risk Communication Toolbox (November 2016)

Draft Recreational Criteria/Swimming Advisories Summary

- On December 2016 EPA published draft values for microcystins (MCs) and cylindrospermopsin (CYL).
  - Consider MCs, CYL, and cyanobacterial cells as stressors.
  - Focus on fresh waters, but consider potential effects at the estuarine interface.
  - Focus on oral ingestion, but consider dermal and inhalation exposure routes.
  - Evaluate exposure for different age groups.
  - Use peer-reviewed data to develop recommended values for MCs and CYL in recreational waters. Evaluate science describing health effects from exposure to cyanobacteria cells.
  - Use Agency-recommended recreational exposure values in a scenario which includes immersion and incidental ingestion of ambient water.
  - Characterize effects that are not quantified.

EPA's Draft Advisory Values for Recreational Exposures

Application	Draft Recreational Advisory Values	
	Microcystins	Cylindrospermopsin
	4 µg/L	8 µg/L
Swimming Advisory	Not to be exceeded on any day.	
Recreational Criteria for Waterbody Assessment	Not to be exceeded more than 10% of days per recreational season up to 1 calendar year.	

- Status:
  - Draft published in the FR for public comments for (until March 20th).
  - To be published in 2017.
  - For more information contact John Ravenscroft (Ravenscroft.john@epa.gov)

https://www.epa.gov/sites/production/files/2016-12/documents/draft-hh-rec-ambient-water-swimming-document.pdf

ORD's Research Areas and Research Studies

- Characterization of Environmental Strains of Cyanobacteria and Their Corresponding Toxic and Allergenic Components
- Adverse Mammalian Health Effects of Algal Toxins: Bioaccumulation, Bloom Extract Toxicity, and Basic Mechanisms

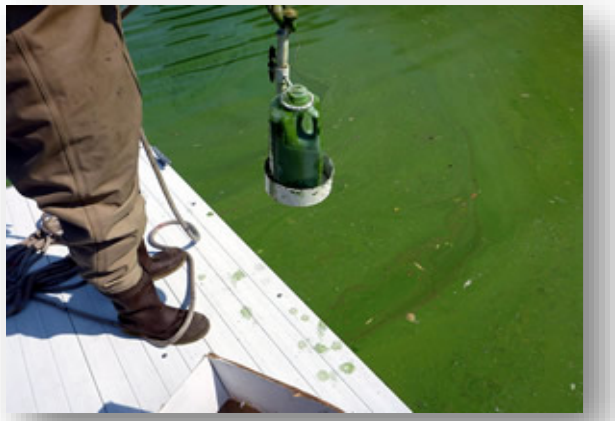
- HAB related water quality trading research
- Watershed/Source water HAB risk mitigation

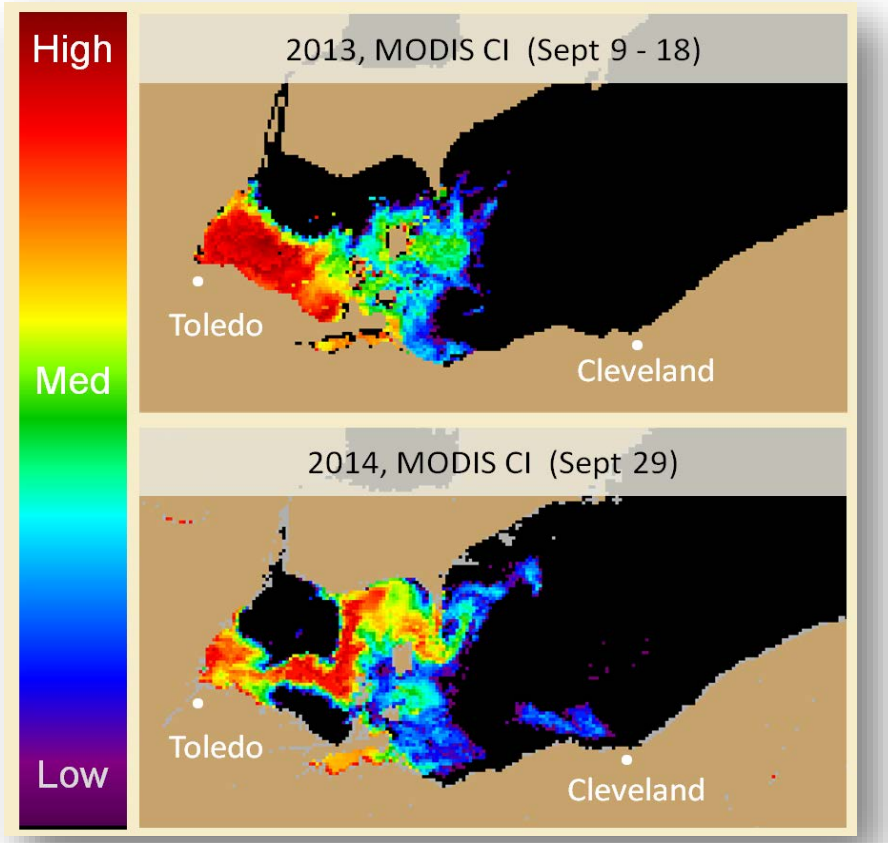
- Satellite Cyanobacteria Assessment Network (CyAN)
- High frequency monitoring of HABs to understand interactions between watershed nutrients and drinking water safety

- Toledo Ohio Pilot-Scale Water Treatment Facility for the 2016 Bloom Season
- Evaluating the Impact of Algicides on a Cyanobacterial Cell's Propensity to Release Toxins during the Early Stages of the Drinking Water Treatment Process

Monitoring for Blooms and Toxins

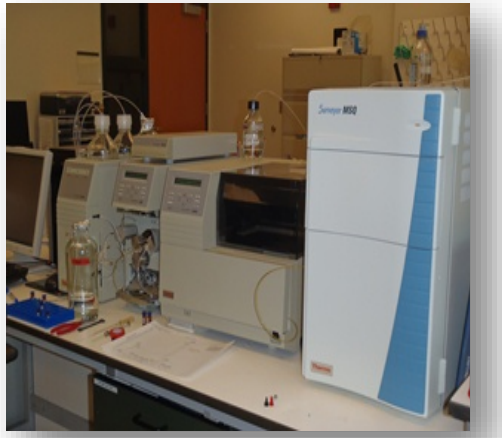
- Visual Monitoring
  - Identifying a bloom
- Forecasting
  - Satellite Imagery
- Sampling





Detection of Cyanobacteria and their Toxins

- Test Strip Kits for field use
- Laboratory Methods
  - Algal Enumeration and Identification
  - Test Strip Kits
  - Analytical Methods
    - Biological (e.g. ELISA)
    - Chromatographic (e.g. GC, LC/MS)



Overview of Surface and Drinking Water HABs Management Techniques

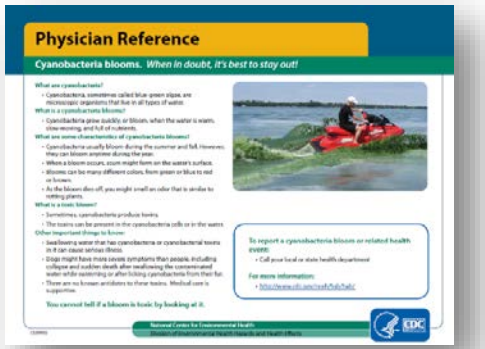
Multi-barrier approach for each toxins

- Surface Water
  - Intracellular Toxins
    - Circulation
    - Aeration
    - Flocculants & oxidizers
    - Floating artificial wetlands
    - Biological manipulations
    - Hydrologic manipulations
  - Extracellular Toxins
    - Awareness and get ready to treat
- Drinking Water (Coagulation/Sedimentation)
  - Intracellular Toxin
    - Oxidants (not often used, afraid of lysing cell)
    - Flocculent aides
  - Extracellular Toxin
    - Activated Carbon
      - Powder (PAC)
      - Granular (GAC)
    - Filtration
      - Conventional
      - Biologically Active

Prevention and Public Health Response

- Source Water Protection
- Monitoring and Detection
- Management and Treatment
- Outreach and Communication

CDC



Washington

Oregon

Iowa

Other HABs-related Activities

Outreach and Communications

EPA CyanoHABs Webpage

- 2012- information on Causes, prevention and mitigation, Human health and ecological effects, Detection methods, Available policies and guidelines, Research and News and a list of States HABs programs and laboratories

EPA Regional Workshops on HABs

- Region 8 (2015), Regions 5 and 10 (2016) and Regions 1, 7 and 9 (2017)

Freshwater HABs Newsletter

- 2014 - Monthly newsletter with news, recently published research, upcoming events, beach closures and Health Advisories, and more.

Inland HABs Discussion Group Webinars

EPA's HABs Listserve: **epacyanohabs@epa.gov**

Partnerships and Collaborations

Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 (HABHRCA)

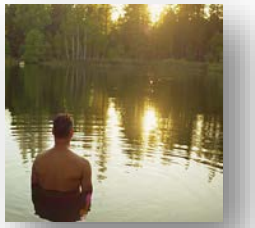
- Give EPA the authority for freshwater HABs.
- Stakeholder engagement and coordinate interagency research agenda.
- Form an Interagency Working Group (IWG).
  - Co-chaired by NOAA and EPA
  - NOAA, EPA, USGS, USDA, Navy, NIEHS, NSF, FDA, NPS, CDC, NASA, USACE, BOEM
  - Develop a Series of mandated reports including a HAB and Hypoxia Comprehensive Research Plan and Action Strategy, Great Lakes and Hypoxia Report Plans, and an Implementation Report for the Strategy
- Several working groups formed, meeting regularly to discuss HABs-related issues.

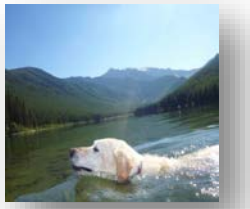
Useful Resources

- Drinking Water
  - US EPA Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems Fact Sheet (PDF)
  - Other resources: EPA's Cyanotoxins in Drinking Water Webpage
- Monitoring and Sampling
  - USGS's Field and laboratory guide to freshwater cyanobacteria harmful algal blooms for Native American and Alaska Native Communities (PDF)
  - USGS' Guidelines for Design and Sampling for Cyanobacterial Toxin and Taste-and-Odor Studies in Lakes and Reservoirs
- Fish
  - US EPA's Fish and Shellfish Newsletter
- States Resources
  - States Monitoring Programs and Information
  - List of State's Laboratories
- Funding Opportunities
  - Fact Sheet: Possible Funding Sources for Managing Cyanobacterial Harmful Algal Blooms and Cyanotoxins in Drinking Water

Summary

- Many cyanobacteria species are capable of producing different toxins but not all cyanobacterial blooms are toxic.
- It is unclear how often toxin-producing blooms occur in drinking water supplies.
- Health effects related to exposure to cyanotoxins vary from irritation to the skin to adverse effects in the liver, kidney and nervous system.
- Research is needed to understand causal factors of bloom formation, acute and chronic health effects for certain toxins, and to determine which conventional drinking water treatment configurations sufficiently reduce algal toxin concentrations.
- A multi-barrier approach for the control and treatment of toxins is needed.





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EPA's Cyanobacteria HABs Website
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