United States Environmental Protection Agency

EPA Tools and Resources Webinar: Harmful Algal Blooms

May 18, 2016

3:00 – 4:00 PM ET

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EPA's Research on the Control of Cyanobacterial Toxins

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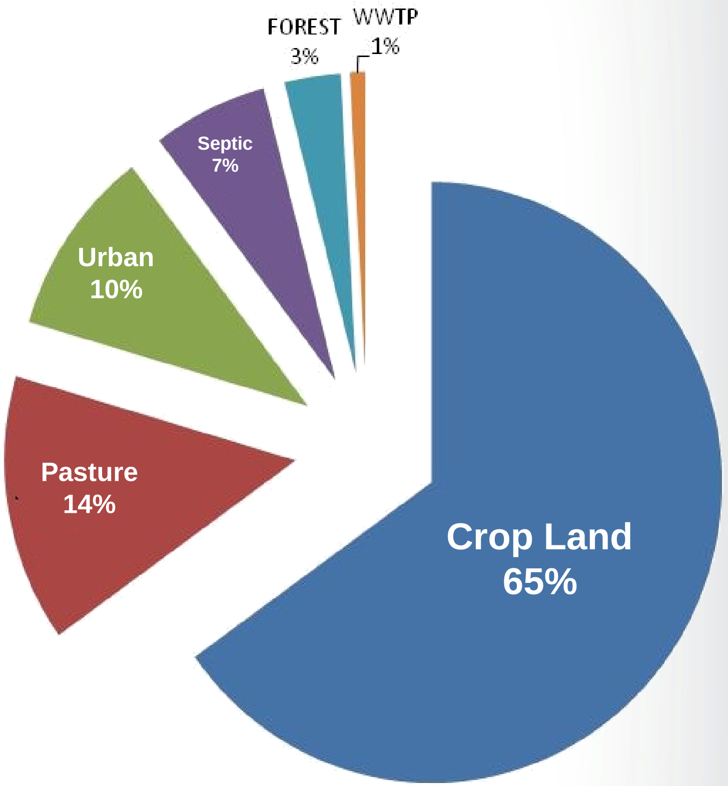
Background

Complex Issue:

- Excessive nitrogen and phosphorous levels can cause harmful algal blooms
- Different algal/cyanobacteria strains bloom under different conditions, at different times, and have spatial variability (horizontal and vertical)
- Different strains produce different toxins at varying amounts
- Different analytical methods tell different pictures of what is going on
- Toxins can be intracellular (within algae itself) or extracellular (dissolved in the water)
- Drinking water treatment is a balancing act between processes



Nitrogen Load Source Distribution to Harsha Lake in Ohio

Cyanobacteria Strains & Associated Toxins

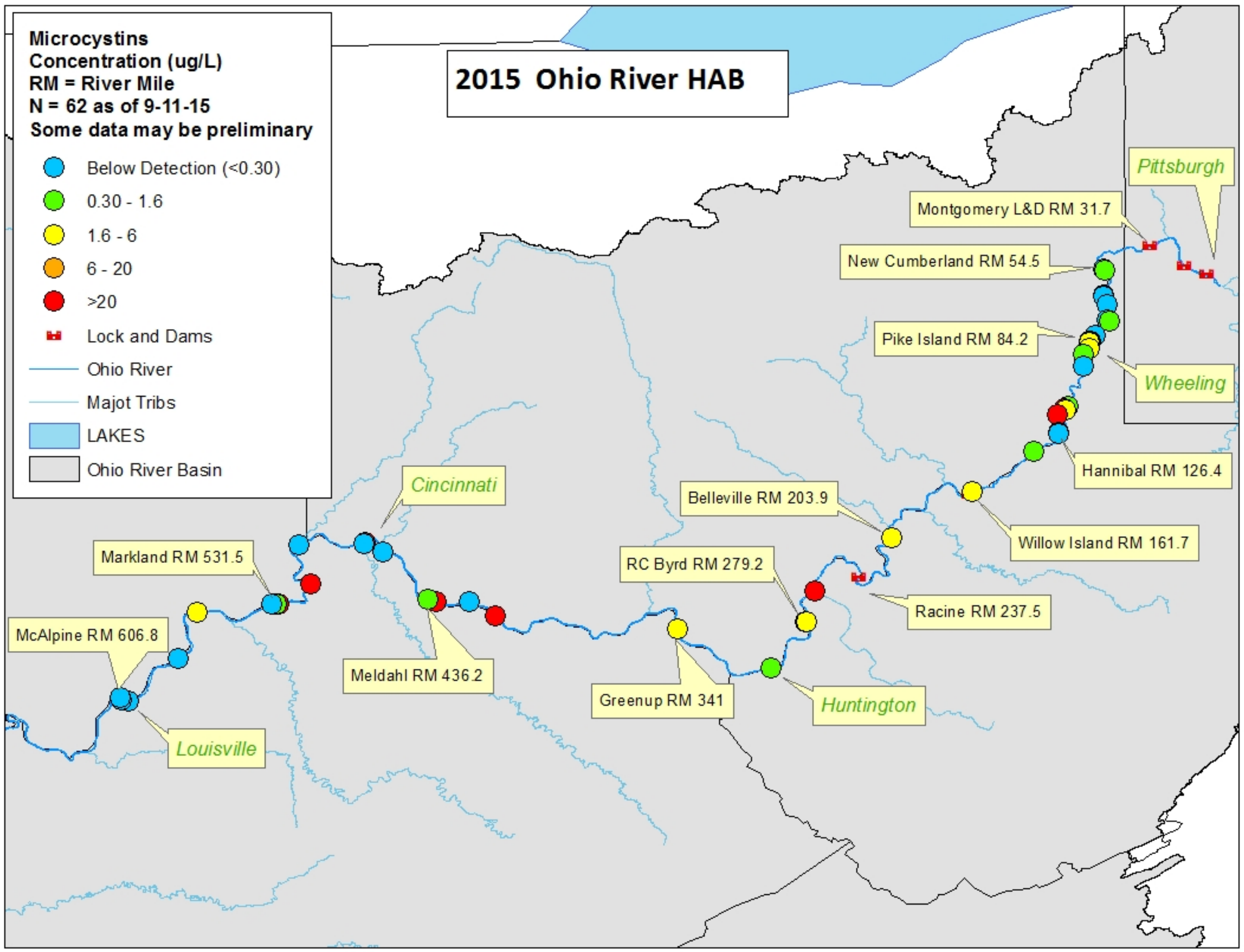
- Strains produce different toxins at different amounts
- Toxins can have multiple variants

Example: Over 80 known microcystin variants

Toxins analyzed by USEPA (544 and 545)

Adapted from : Paerl and Otten 2013. Harmful Cyanobacterial Blooms: Causes, Consequences, and Controls. Microbial Ecology 65:4 995–1010	Cyanobacteria Taxa											
Toxin	Anabaena	Aphanizomenon	Aphanocapsa	Chroococcus	Cylindrospermopsis	Limnothrix	Merismopedia	Microcystis	Planktolyngbya	Planktothrix	Pseudanabaena	Nodularia
Aeruginosin								X		X		
Anatoxin-a/homoanatoxin-a	X	X			X				X	X		
Anatoxin-a(S)	X											
Aplysiatoxins									X			
BMAA	X	X			X			X	X	X		
Cyanopeptolin	X							X		X		
Cylindrospermopsin	X	X			X							
Jamaicamides									X			
Lyngbyatoxin									X			
Microcystin	X	X	X		X	X	X	X		X	X	
Nodularin												X
Saxitoxin	X	X			X					X		

Spatial Issues: 2015 Ohio River Bloom

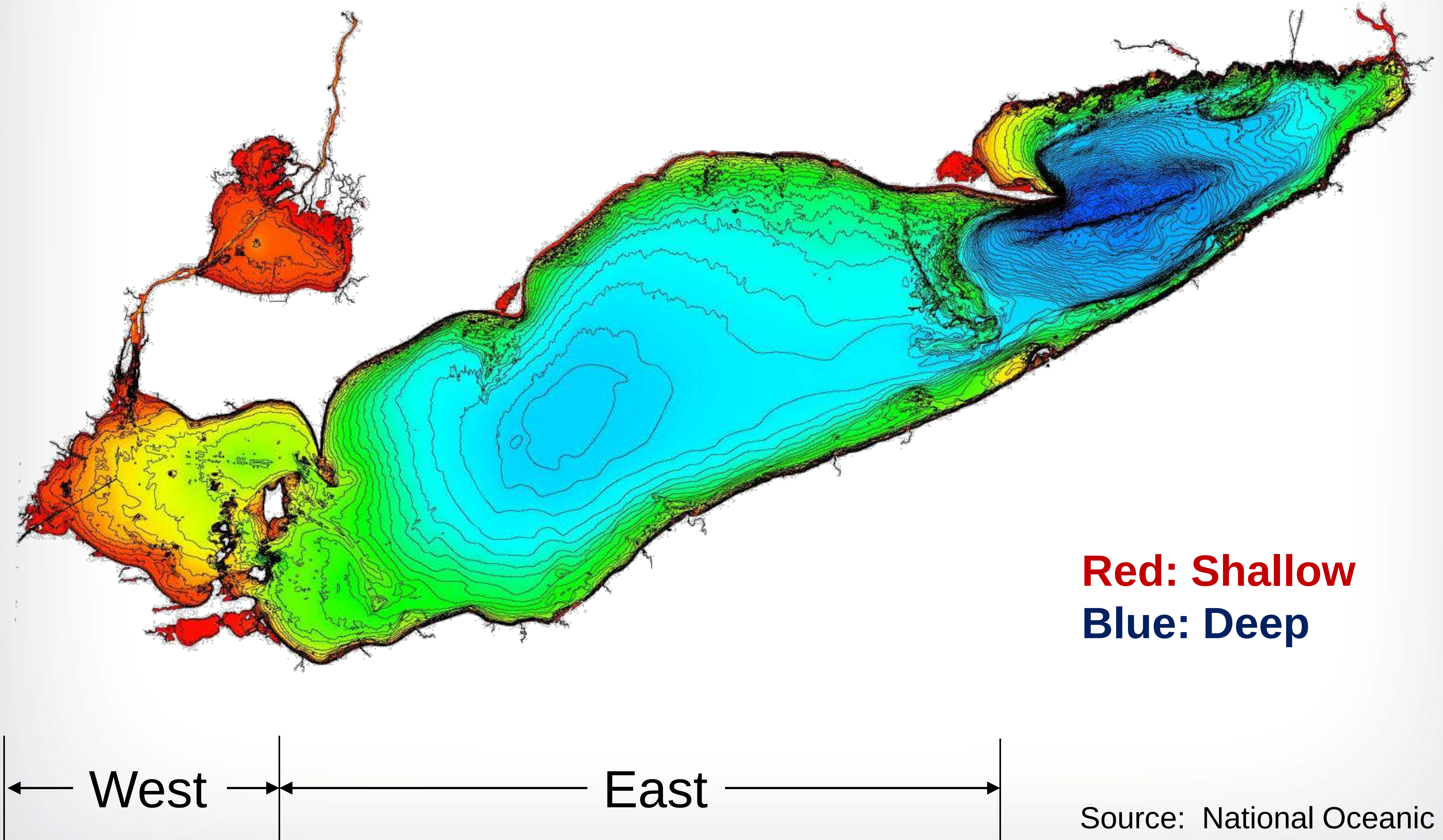


Source: Ohio River Sanitation Commission

Little consistency over small or large scale

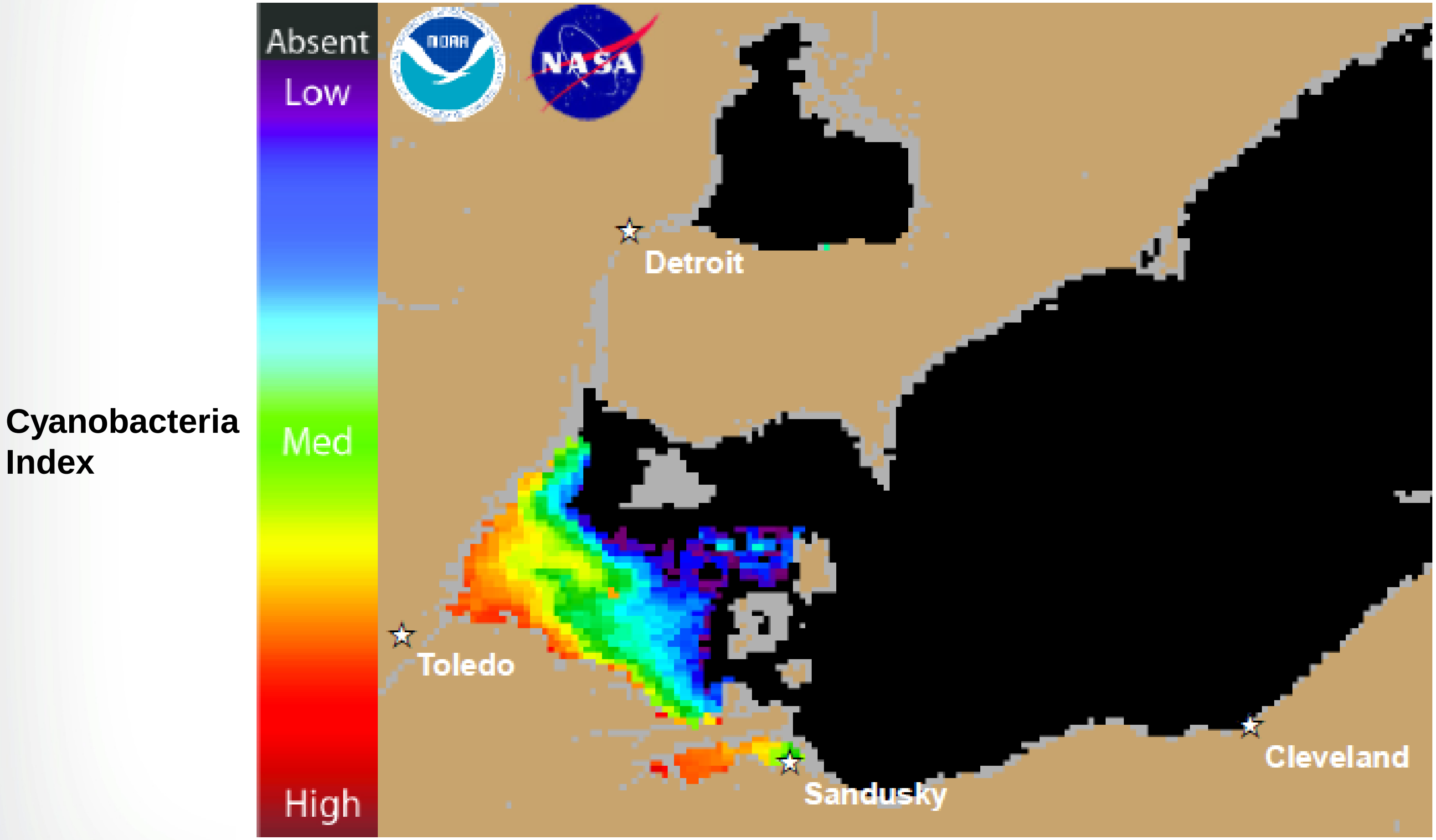
Spatial Issues: 2015 Ohio River Bloom

Lake Erie Depth



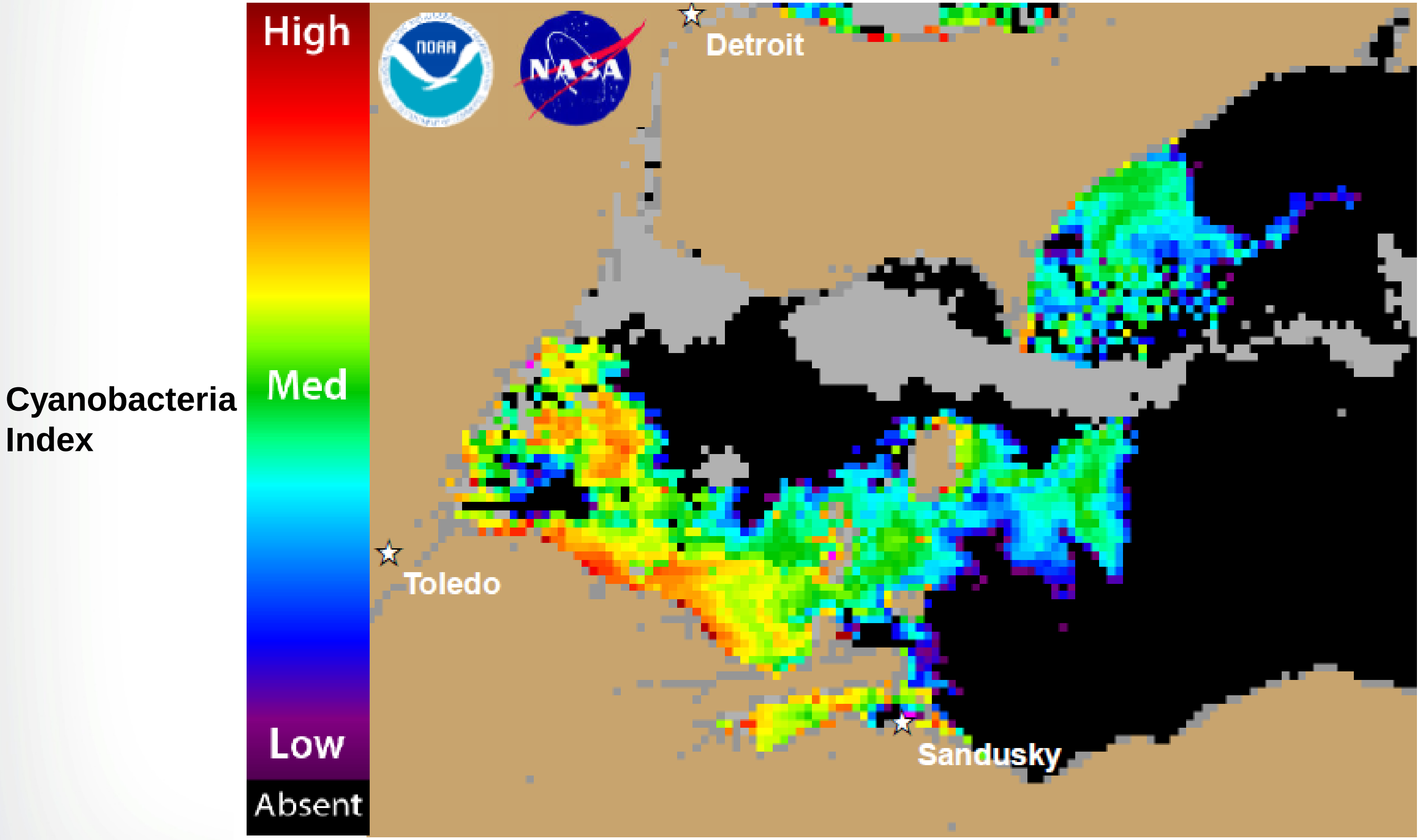
Source: National Oceanic and Atmospheric Administration

August 2014 Lake Erie Bloom



Sources: National Oceanic and Atmospheric Administration; National Aeronautics and Space Administration

August 2015 Lake Erie Bloom

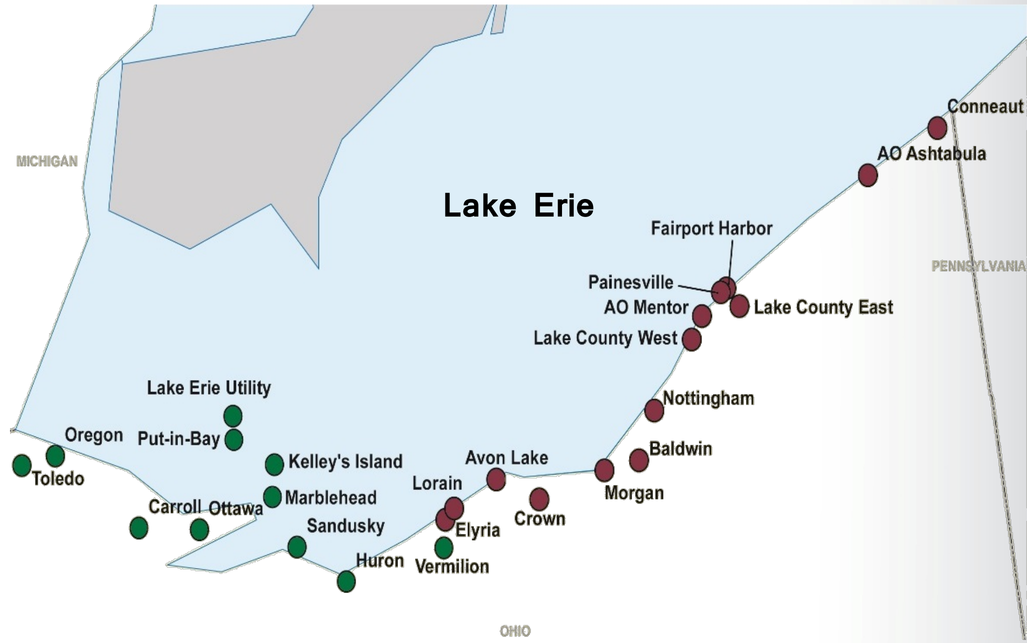


Sources: National Oceanic and Atmospheric Administration; National Aeronautics and Space Administration

Lake Erie DW Treatment Plant Study

Field Studies

- Monitoring cyanobacteria toxins through numerous treatment plants on Lake Erie
- Parameters *(not inclusive)*
    - $NO_3/NO_2/NH_3$
    - PO_4
    - TOC/Total N
    - Total alkalinity
    - Trace metals by ICP
    - Toxins (Microcystins, Cylindrospermopsin, Anatoxin, Saxitoxin)



Bench- and Pilot-Scale Studies

- Bench-scale permanganate, ozone, and activated carbon trials
- Pilot installation in Toledo, OH

Analytical Methods

ELISA

- ❖ Broad-based method (measures 80+ toxin congeners/variants)
- ❖ Can give both internal and external toxin levels
- ❖ Easy and relatively inexpensive
- ❖ Relatively quick

LC-MS/MS

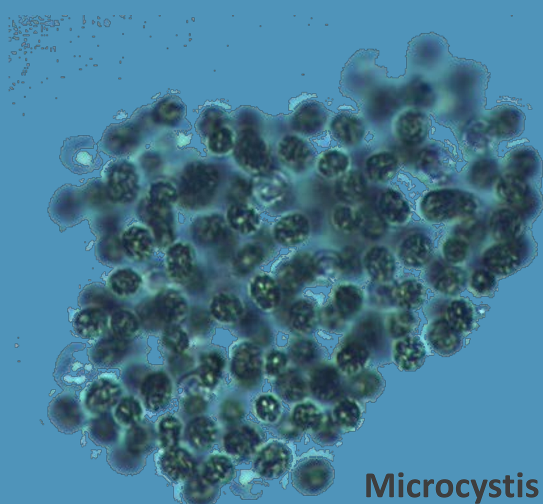
- ❖ EPA research methods typically tests for 13 microcystin congeners/variants (over 80 known)
- ❖ Can give both internal and external toxin levels
- ❖ Requires significant expertise and analytical equipment
- ❖ Takes time

Treatment for Cyanobacteria Toxins

Toxin within the cell and those that are dissolved require different treatment processes

Particulates (toxin in cell)

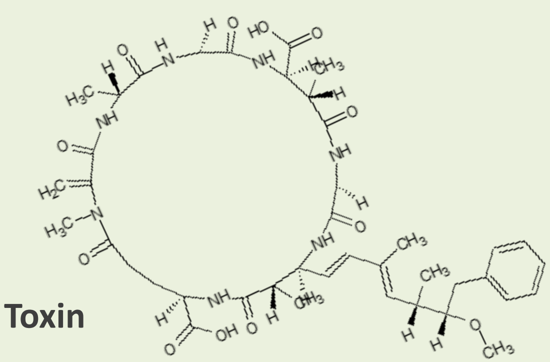
- Solids removal processes effective



Microcystis (cells)

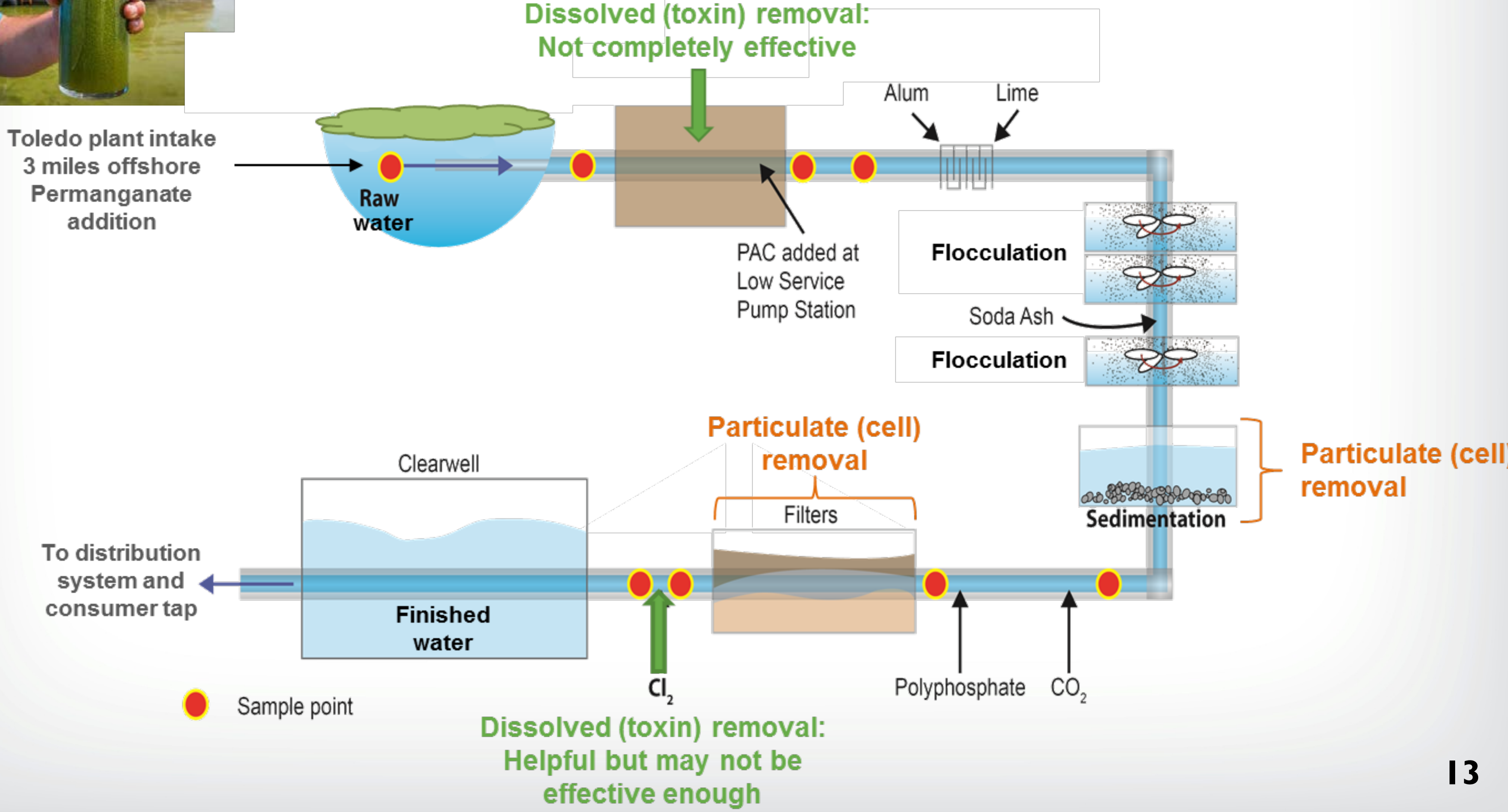
Dissolved (toxin released from cell)

- Solids removal processes ineffective
- Typical disinfectants may not be effective enough (e.g., permanganate, chlorine)
- More effective treatments are expensive and plants typically do not have them in place (e.g., GAC)



Microcystin Toxin

Typical Treatment Train

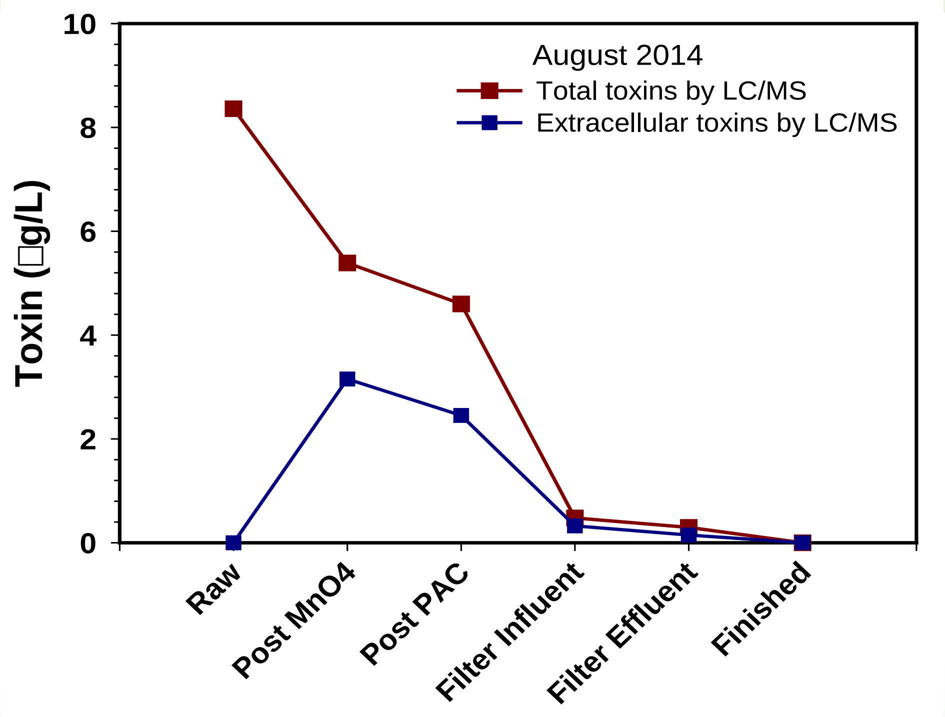


Through Treatment (Toxin)

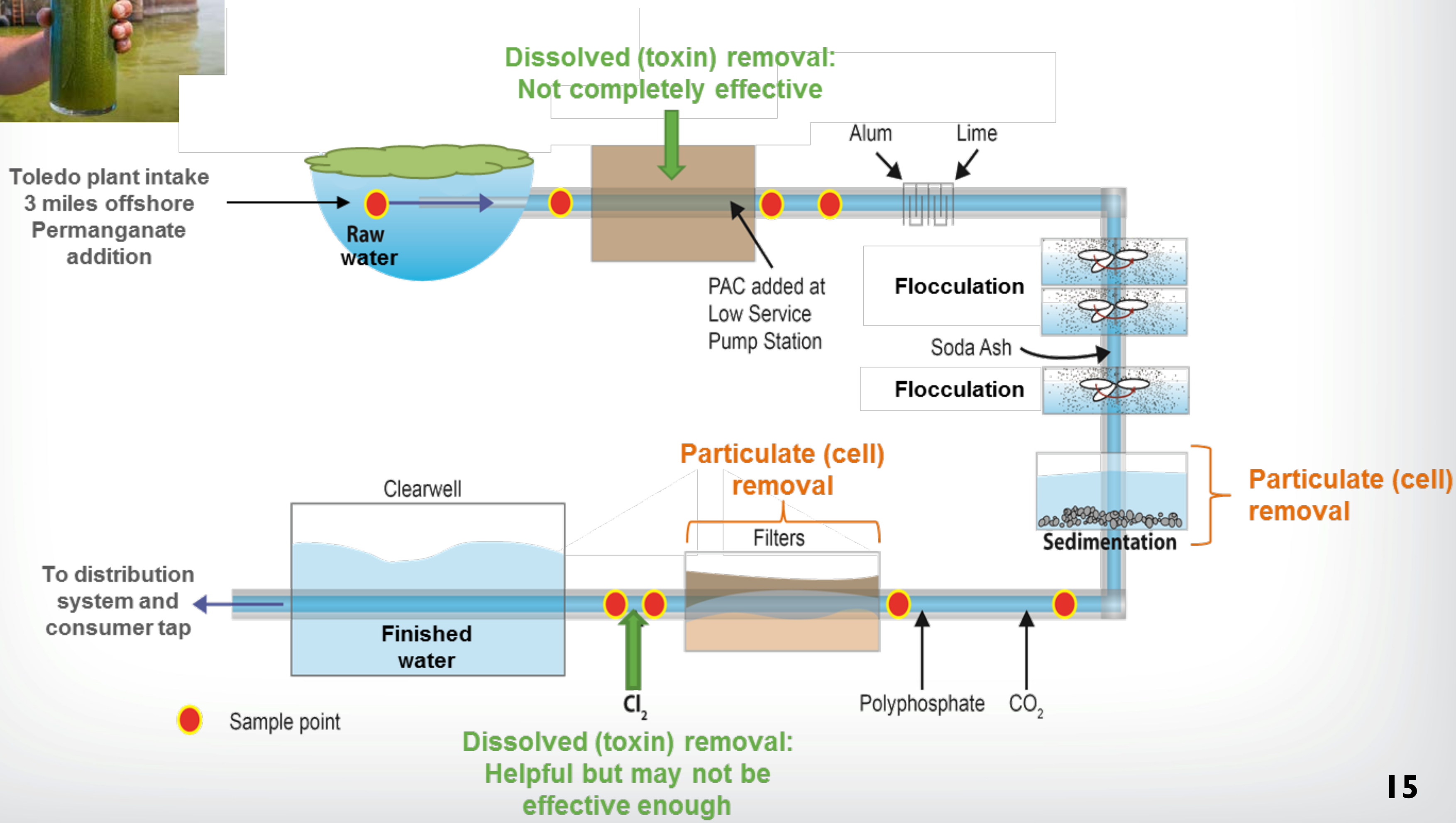
Permanganate reducing total and increasing extracellular toxin

Powdered activated carbon reducing the extracellular toxin

Particulate removal removes the intracellular toxin



Typical Treatment Train

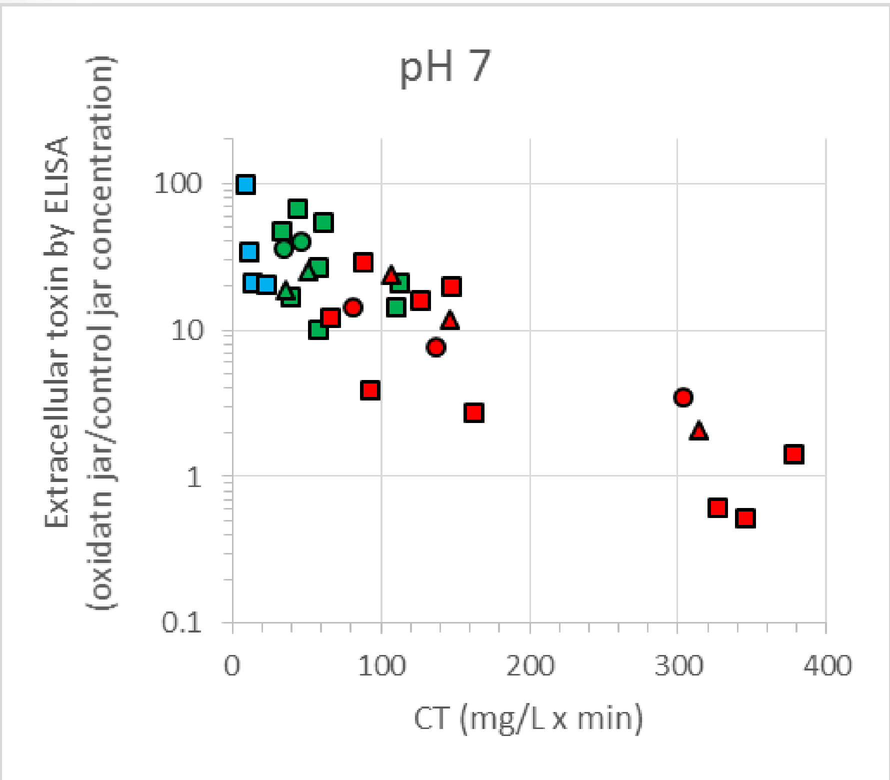


Modeling Permanganate

CT approach can be helpful in understanding degradation

Can be used for predictive purposes

Additional work on different waters and pHs being conducted



1 mg/L $KMnO_4$

2.5 mg/L $KMnO_4$

5 mg/L $KMnO_4$

□ Turbidity = 0.1 NTU

△ Turbidity = 5 NTU

○ Turbidity = 20 NTU

Treatment Conclusions

- If the bulk of the cyanobacterial toxin remains in the cell, particulate control can serve as an effective barrier against toxin exposure
- Common doses of oxidants (permanganate and ozone) can be sufficiently high to damage cells and release toxins, yet potentially too low to completely degrade the released toxin
- The optimal use of oxidants and PAC regarding their points of application and dose should be evaluated for a given plant (bloom dependent)
- Projects are ongoing to further understand and help predict treatment performance

2016 Monthly Webinar Series:

Challenges and Treatment Solutions for Small Drinking Water and Wastewater Systems

Presented by EPA's Office of Research and Development (ORD) and Office of Water (OW)

May 31, 2016, 2:00-3:00 PM EST (Optional Q&A session from 3:00-3:30)

Responding to Harmful Algal Blooms, Optimization Guidelines, and Sampling for Utilities

Nick Dugan (USEPA) / Heather Raymond (Ohio EPA)

Webinar Support Phone Number: 1-800-263-6317

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To Ask a Question: Type question in text box located in the lower section of your screen

A certificate for one continuing education contact hour will be offered for this webinar

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Part 2:

Overview of EPA's Activities to Support Public Water Systems to Manage Cyanotoxins in Drinking Water

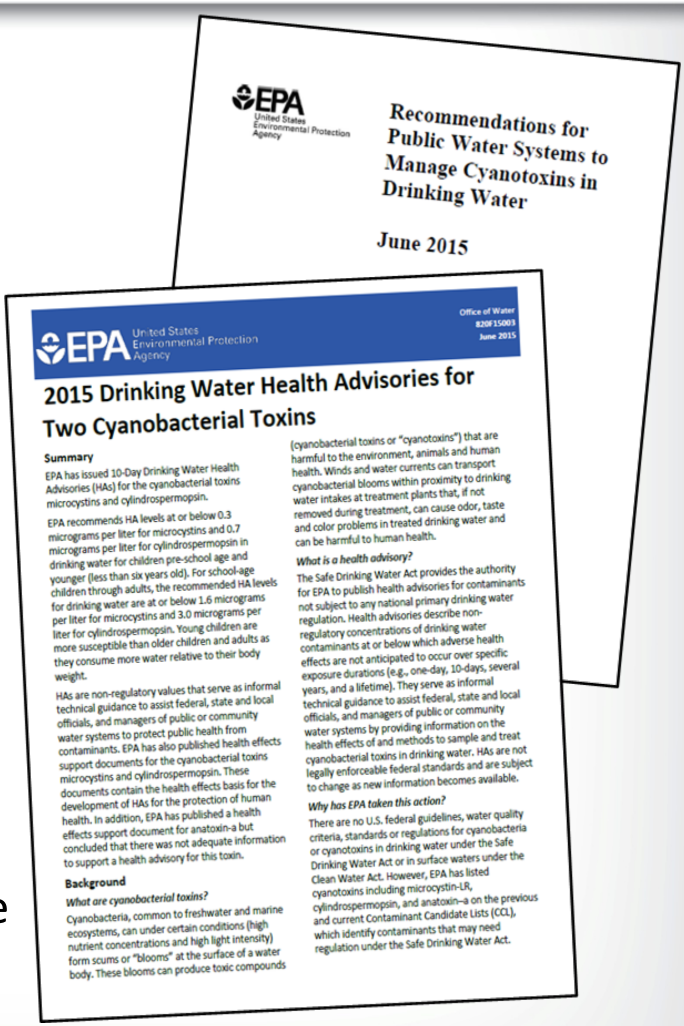
Hannah Holsinger
EPA Office of Ground Water and Drinking Water

Presentation Overview

- Brief overview of past EPA Office of Water (OW) drinking water cyanotoxin management activities
- Discussion of EPA's *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water*
- Overview of H.R. 212, Drinking Water Protection Act
- Brief discussion on EPA OW ongoing drinking water cyanotoxin management activities

Cyanotoxin Activities in EPA's Office of Water

- EPA placed algal toxins on the Safe Drinking Water Act's Contaminant Candidate Lists (CCLs) including draft CCL 4
- 2007 National Lakes Assessment (NLA)
  - 30% of lakes had microcystin detections
  - 1% had detections over 1 µg/L
- Development of analytical methods for cyanotoxins
- Public meeting on April 29th, 2016 to obtain public feedback on cyanotoxin management
- Information on cyanotoxins
  - Cyanobacteria Harmful Algal Blooms Webpage
  - Cyanobacteria/Cyanotoxins Fact Sheet for Drinking Water Systems



EPA United States Environmental Protection Agency

Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

June 2015

EPA United States Environmental Protection Agency

Office of Water
820F15003
June 2015

2015 Drinking Water Health Advisories for Two Cyanobacterial Toxins

Summary

EPA has issued 10-Day Drinking Water Health Advisories (HAs) for the cyanobacterial toxins microcystins and cylindrospermopsin.

EPA recommends HA levels at or below 0.3 micrograms per liter for microcystins and 0.7 micrograms per liter for cylindrospermopsin in drinking water for children pre-school age and younger (less than six years old). For school-age children through adults, the recommended HA levels for drinking water are at or below 1.6 micrograms per liter for microcystins and 3.0 micrograms per liter for cylindrospermopsin. Young children are more susceptible than older children and adults as they consume more water relative to their body weight.

HAs are non-regulatory values that serve as informal technical guidance to assist federal, state and local officials, and managers of public or community water systems to protect public health from contaminants. EPA has also published health effects support documents for the cyanobacterial toxins microcystins and cylindrospermopsin. These documents contain the health effects basis for the development of HAs for the protection of human health. In addition, EPA has published a health effects support document for anatoxin-a but concluded that there was not adequate information to support a health advisory for this toxin.

Background

What are cyanobacterial toxins?

Cyanobacteria, common to freshwater and marine ecosystems, can under certain conditions (high nutrient concentrations and high light intensity) form scums or "blooms" at the surface of a water body. These blooms can produce toxic compounds (cyanobacterial toxins or "cyanotoxins") that are harmful to the environment, animals and human health. Winds and water currents can transport cyanobacterial blooms within proximity to drinking water intakes at treatment plants that, if not removed during treatment, can cause odor, taste and color problems in treated drinking water and can be harmful to human health.

What is a health advisory?

The Safe Drinking Water Act provides the authority for EPA to publish health advisories for contaminants not subject to any national primary drinking water regulation. Health advisories describe non-regulatory concentrations of drinking water contaminants at or below which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one-day, 10-days, several years, and a lifetime). They serve as informal technical guidance to assist federal, state and local officials, and managers of public or community water systems by providing information on the health effects of and methods to sample and treat cyanobacterial toxins in drinking water. HAs are not legally enforceable federal standards and are subject to change as new information becomes available.

Why has EPA taken this action?

There are no U.S. federal guidelines, water quality criteria, standards or regulations for cyanobacteria or cyanotoxins in drinking water under the Safe Drinking Water Act or in surface waters under the Clean Water Act. However, EPA has listed cyanotoxins including microcystin-LR, cylindrospermopsin, and anatoxin-a on the previous and current Contaminant Candidate Lists (CCL), which identify contaminants that may need regulation under the Safe Drinking Water Act.

EPA's Ten-Day Health Advisories for Cyanotoxins

June 2015 EPA released Drinking Water Health Advisories (HA) for cyanotoxins

- **Microcystins**
  - Human data suggest that the liver is the target organ of toxicity. Acute and sub-chronic toxicity studies confirm the liver, kidney and testes as target organs.
  - There is inadequate information to assess the carcinogenic potential of microcystins.
- **Cylindrospermopsin**
  - Human data on oral toxicity of cylindrospermopsin suggests liver and kidney as the target organs. This is confirmed by acute and sub-chronic toxicity studies. Kidney is primarily affected.
  - There is inadequate information to assess the carcinogenic potential of cylindrospermopsin.

EPA's Ten-Day Health Advisories for Cyanotoxins

- **Exposure pathway**: oral ingestion of drinking water
- **Exposed life stage and population**: children and adults

chemical	10-day 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

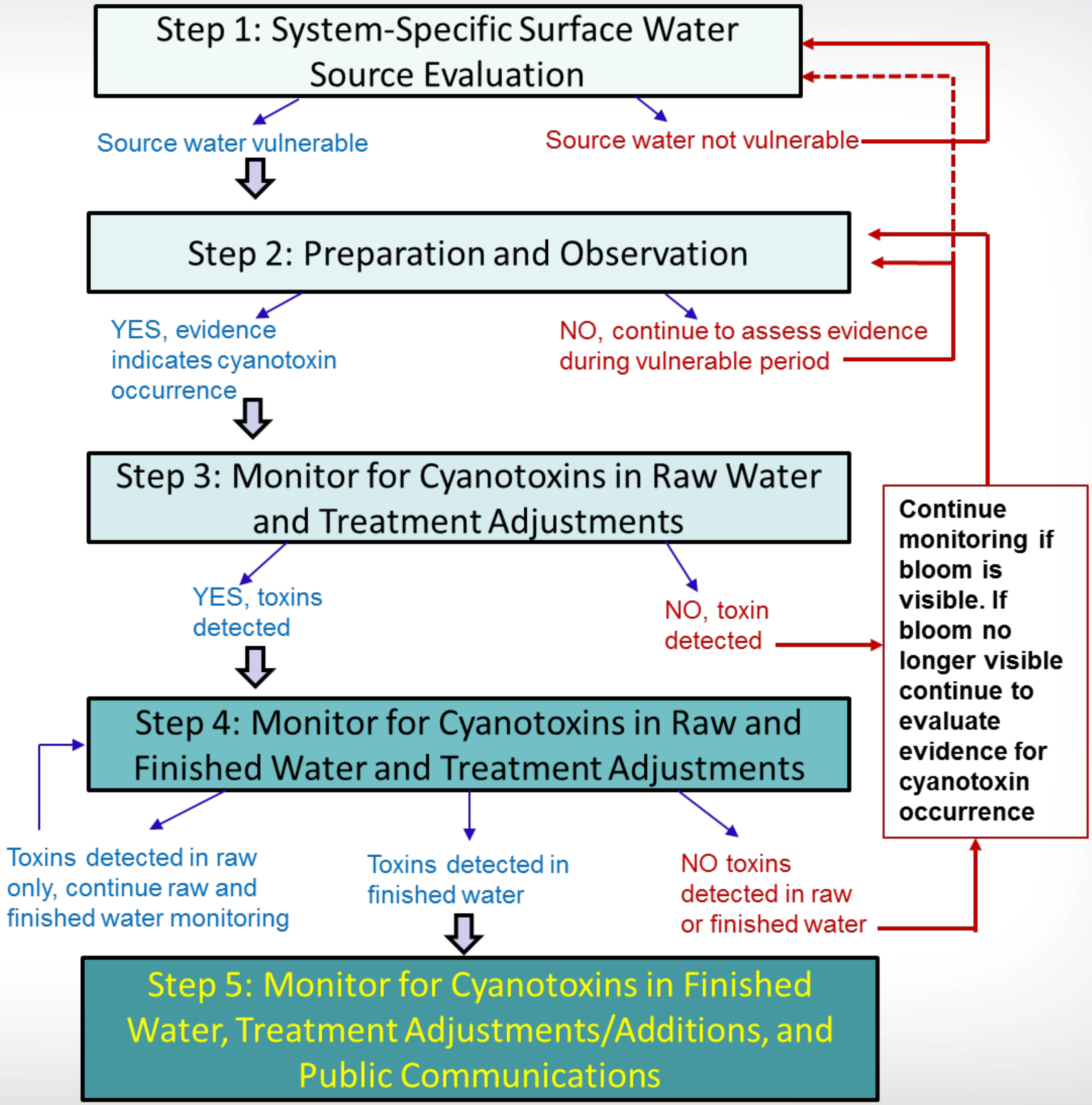
- 10-Day Health Advisory value is considered protective of non-carcinogenic adverse health effects over a 10-day exposure in drinking water.
- Health Advisories are non-enforceable and are intended to provide technical guidance to states and other public health officials on health effects, analytical methods, and treatment technologies.

Managing Cyanotoxins in Drinking Water

- In June 2015, EPA released *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water.*

- This document assists interested states and utilities manage risks from cyanobacterial toxins in drinking water, recognizing the most appropriate course of action will vary on a case by case basis.

Potential Cyanotoxin Management Steps



Step 1: System-Specific Surface Water Source Evaluation

- Key objective: Determine if source water is vulnerable to harmful algal blooms
- Potential information to consider when conducting a system-specific evaluation:
  - Evaluation of source waters at or near the intake:
    - Source Water Characteristics
    - Water Quality Parameters
    - Source Water Assessment Information
    - Climate and Weather Information
    - Land Use
    - Nutrient Levels

Step 2: Preparation and Observation

Preparation

- **Potential actions to consider if a system is determined to be vulnerable in Step 1:**
  - Determine when (e.g., which seasons) systems are most vulnerable to HABs
  - System Evaluation
    - Assess status of treatment plant prior to harmful algal bloom season
      - If source water is vulnerable and existing treatment is not sufficient to remove cyanotoxins from peak blooms, evaluate whether supplemental treatment (e.g., coagulant) might be needed during bloom season, or
      - If source water is vulnerable and existing treatment is frequently challenged by cyanotoxins, consider whether long-term treatment enhancements are needed

Step 2: Preparation and Observation

Preparation (Cont'd)

– Monitoring
  - Prepare for possible future cyanotoxin monitoring by ordering necessary lab materials for screening tests or setting up contracts with outside labs

– Communication
  - Establish partnerships with primacy agencies, state, and local public health officials

Step 2: Preparation and Observation

Observation

- Key observation objective: Identify potential cyanotoxin occurrence in source and raw water
- 3 Key Potential Observations:
  1. Visual: Visually confirm the presence of a bloom at intake structure or confirm public reports of blooms near raw water intake
  2. System effects: Track changes in treatment plant operations, water quality parameters, etc.
  3. Indicators: Indicator occurrence in source water and raw water at intake

Steps 3-5: Monitoring, Treatment Adjustments, and Communication

- **Key objectives:**
  - Determine if cyanotoxins have reached or are likely to reach the raw water intake
  - Determine the effectiveness of cyanotoxin removal via drinking water treatment operations
  - Adjust or consider additional treatment to reduce risks from cyanotoxins in drinking water
  - Confirm whether cyanotoxins are detected in finished water
  - Reduce risks from cyanotoxins in drinking water
  - Inform the public of the need to take actions to reduce their risks

Step 5: Monitor for Cyanotoxins in Finished Water, Treatment Adjustments and Public Communications

	Low Level	Medium Level	High Level
	Microcystins: ≤ 0.3 µg/L	Microcystins: > 0.3µg/L ≤ 1.6 µg/L	Microcystins: > 1.6 µg/L
			
Communication	Continue communication with State primacy agency and local health officials on monitoring results.	Notify local public health agency, primacy agency and the public. Recommend use of alternative sources for bottle-fed infants and young children of pre-school age.	Notify local public health agency, primacy agency and the public. Recommend '<u>Do Not Drink/ Do Not Boil Water'</u> advisory for all consumers.
Treatment Actions	Modify treatment as necessary to keep algal toxins below HA values.	Adjust existing treatment to reduce the concentration to below 0.3 µg/L as soon as possible. Modify or amend treatment as necessary.	Adjust existing treatment to reduce the concentration to below 0.3 µg/L as soon as possible. Modify or amend treatment as necessary.
Monitoring	Continue sampling raw and finished water at least 2-3 times per week until levels are below quantification in at least 2-3 consecutive samples in raw water, then return to Step 3.	Continue sampling raw and finished water daily until finished water levels are below quantification in at least 2-3 consecutive samples.	Continue sampling raw and finished water at least daily until finished water levels are below quantification in at least 2-3 consecutive samples.

H.R. 212

- On August 7th, 2015, H.R. 212 (Drinking Water Protection Act) was signed into law
- Directed EPA to develop and submit a strategic plan for assessing and managing risks associated with algal toxins in drinking water provided by public water systems

Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water

Strategy Submitted to Congress to Meet the Requirements of P.L. 114-45

Product of the
United States Environmental Protection Agency

November 2015

- Strategic plan developed with input from:
  - Various EPA Offices and Regions
  - Federal partners from the Interagency Working Group established by the Harmful Algal Bloom and Hypoxia Research and Control Act Amendments of 2014
  - Stakeholders through a listening session webinar including states, utilities, industry representatives and environmental organizations
  - Transmitted to Congress in November 2015

- EPA's strategic plan includes steps and timelines for:
  - **Assessing Human Health Effects.** Evaluating and summarizing risks to human health from drinking water systems contaminated with algal toxins
  - **Listing of Algal Toxins.** Developing and maintaining list of algal toxins which may have adverse human health effects
  - **Publishing Health Advisories**. Determining whether to publish additional health advisories for the list of algal toxins
  - **Providing Treatment Options.** Evaluating and providing guidance on feasible treatment options
  - **Providing Analytical and Monitoring Approaches.** Developing and providing guidance on analytical methods and monitoring techniques, particularly monitoring frequency

Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water

- EPA's strategic plan includes steps and timelines for, continued:
  - **Summarizing the Causes of HABs.** Summarizing factors that cause toxin-producing HABs to proliferate and release toxins
  - **Recommending Source Water Protection.** Evaluating and recommending feasible source water protection practices
  - **Strengthening Collaboration and Outreach.** Entering into cooperative agreements and provide technical assistance to affected states and PWSs

- Identifies information gaps

- Assembles and publishes information from each federal agency that has examined algal toxins or addressed public health concerns related to HABs

EPA's Office of Water Ongoing Cyanotoxin Management Activities

- Developing cyanotoxin management plan templates to help utilities nationwide manage cyanotoxins
  - The templates, based on real-world utility plans, are anticipated to be completed in 2016
- Included cyanotoxin monitoring at drinking water utilities on the proposed UCMR 4 list
- Regional workshops focusing on HABs and source water protection activities
- Recent public meeting on April 29th to seek feedback from the public on strategies for managing cyanotoxin risks to drinking water
- Continue to support states and utilities in their cyanotoxin management efforts

Contact Information

Contacts

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CyanoHABs website
https://www.epa.gov/cyanohabs




Questions?