UCMR4 Cyanotoxins

What Will You Do If You Find Them?

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What are algae?

- Most are microscopic, photosynthetic organisms
- More of an ecological term than taxonomic
- Base of the aquatic food web; many algae are necessary and good
- However, some algae, particularly the blue-green algae (cyanobacteria) are a nuisance (surface scums, taste and odor, cyanotoxins)
What do cyanobacteria need to grow?

- Light / Temperature / Carbon Dioxide
- Macro-Nutrients (Nitrogen, Phosphorus)
- Micro-Nutrients (Iron, Silica, others)
- For most Mid-Atlantic freshwater systems, phosphorus is the primary limiting nutrient

1 lbs of phosphorus has the potential to generate up to 1,100 lbs of wet algae biomass

More phosphorus means more algae
Nuisance freshwater algae

Planktonic Bloom

• What caused this?
• Is this bloom harmful?
• How do I manage it?
• How do I prevent it?

Filamentous Mat Algae
What’s driving the concern?

EPA Health Advisories (2015)

<table>
<thead>
<tr>
<th>10-DAY HEALTH ADVISORIES</th>
<th>LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microcystins</strong></td>
<td></td>
</tr>
<tr>
<td>Children pre-school age and younger (under 6 years old)</td>
<td>0.3 µg/L</td>
</tr>
<tr>
<td>School-age children (6 years and older)</td>
<td>1.6 µg/L</td>
</tr>
<tr>
<td><strong>Cylindrospermopsin</strong></td>
<td></td>
</tr>
<tr>
<td>Children pre-school age and younger (under 6 years old)</td>
<td>0.7 µg/L</td>
</tr>
<tr>
<td>School-age children (6 years and older)</td>
<td>3.0 µg/L</td>
</tr>
</tbody>
</table>

Table 1. U.S. EPA’s National 10-Day Health Advisories
Managing algae and cyanobacteria and controlling toxins
(Intra-cellular and Extra-cellular toxins)

- Understanding your water supply
- Monitoring, triggers and management protocols
- Controlling algae and cyanobacteria in water supply
- Intake options
- Pretreatment options
- Treatment process modifications (avoid unintended consequences)
- Capital improvements
- Alternate water sources

Chemicals → Flocculation → Setting → Filtration → Storage → Pumping → Distribution System
‘Just a few drops’

Date posted: Thursday, January 17, 2013 9:05 AM EST

- **To express my reaction to the knowledge that Anabaena is present in our water is in one word called “scared.”**

- **It takes only a few drops of this toxic water for it to be harmful to people and pets**
Monitoring, Management and Treatment plan

Monitoring: Collect site-specific data in the reservoir to assess and respond to conditions (not just pH, DO, temp – but PO4, phycocyanin, cell counts)

Management: Implementation of in-lake and watershed-based measures to improve water quality

Treatment: Develop more of a proactive than reactive treatment strategy for the reservoir and implement control measures at the WTP
Monitoring and response strategies will be system-specific

Indicators are an important tool
- Selected parameters
- Frequent monitoring
- Developing “triggers”

Monitoring location, timing, and frequency must balance competing objectives
- Practical within utility operating constraints
- Provide actionable information

What might result from a trigger?
- Increased monitoring
- Monitoring of additional parameters
- Increasing coordination with other PWS
- Modification of treatment
## Indicators and triggers – example

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Range of Results</th>
<th>Action Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus (P)</td>
<td>mg/L</td>
<td>0.03 - 0.09</td>
<td>Greater than 0.05 mg/L; trigger to treat lake with nutrient inactivator NOT chelated copper product</td>
</tr>
<tr>
<td>Chlorophyll a / Phycocyanin (PC) fluorescence</td>
<td>ug/L</td>
<td>Chl-a 3.1 - 340</td>
<td>20 to 30 ug/L Chl-a; trigger to perform algae/cyanobacteria cell counts to determine the dominant algal group</td>
</tr>
<tr>
<td>Secchi Depth (Water Clarity)</td>
<td>M</td>
<td>1.0 - 6.6</td>
<td>Less than 1 meter; trigger to perform algae/cyanobacteria cell counts, and possible lake treatment</td>
</tr>
<tr>
<td>Cyanobacteria Cell Counts</td>
<td>cells/mL</td>
<td>0 - 493,469</td>
<td>5,000 cells/mL; trigger to treat lake with chelated copper product, however, lower thresholds may apply depending on season/species</td>
</tr>
<tr>
<td>Geosmin</td>
<td>ng/L</td>
<td>&lt; 5 - 61.7</td>
<td>&gt; 10 ng/L (Implement PAC)</td>
</tr>
<tr>
<td>MIB</td>
<td>ng/L</td>
<td>&lt; 5 - 17.7</td>
<td>&gt; 10 ng/L (Implement PAC)</td>
</tr>
</tbody>
</table>
Monitoring for cyanotoxins

Will be needed to determine treatment needs and process adjustments Currently required for many systems during UCMR4 testing (2018 - 2020)

- ELISA (total Microcystins) – EPA Health Advisories (10 day HAs) – Some issues with the ELISA test

- LC/MS/MS (Individual cyanotoxins and congeners)
  - Microcystin (LR, LA, LF, LY, RR, YR)
  - Nodularin
  - Anatoxin-a
  - Cylindrospermopsin

- Strip test kits and automated readers for Microcystins and Cylindrospermopsin. Also the CAAS system – Cyanotoxin Automated Assay System
In-lake management measures

- De-stratification / aeration system
- Use of nutrient inactivation (early in the season)
- Floating wetland islands (by feeder streams)
- Biomanipulation (fish stocking, etc.)
- Ultrasonic treatment

*Aeration helps maintain measurable amounts of dissolved oxygen throughout the water column*

*Reducing release of phosphorous from bottom sediment, which can fuel algae growth*
Watershed based management measures

- Streambank / shoreline stabilization
- Creation / expansion of riparian / wetland edge
- Possible stormwater management of residential / agricultural lands (nutrient control)
- Preserve / protect forested lands within the watershed
Treatment strategy for the reservoir

• Use water quality data to determine when to treat as opposed to sticking to regularly scheduled treatments (e.g. twice a month starting in June)

• Make an effort to treat during/just prior to the log phase of a bloom (i.e. high rates of growth) – don’t wait too long, and monitor frequently
  – Copper based algaecides will lyse cells

• Use of liquid chelated copper-based algicides may work better than copper sulfate in shallow reservoirs. Copper sulfate may sink to reach deeper blooms.

• Low reservoir levels and no flow can be challenging
  – You may lose the battle
  – Reservoir treatment normally restricted by permit requirements
Water treatment plant modifications and upgrades

• Intake gate changes to avoid blooms
• Cessation of any pre-oxidation (chlorine, ozone, etc.)
• Optimization of coagulation/flocculation
• Better utilization of existing CT disinfection potential to inactivate toxins (CyanoTOX Calculator)

• Improved removal of intact cyanobacteria cells (Dissolved Air Flotation or DAF)?
• Installation of powdered activated carbon (PAC)
  ➢ 10 to 20 ppm, high CT. Watch the sludge!
• Installation of biologically active filters
• Nano-filtration (up to 80% removal of MCs)
• Alternate water source?
Things to keep an eye on

• Continue to develop your monitoring program with increased monitoring/treatment during the early/ mid-summer period, along with further development of the treatment strategy table
• Encourage EPA and state agencies to develop and implement agricultural management practices to reduce nutrients and runoff
• Remain aware of developing technologies and treatment strategies
• What does a 10-day Health Advisory really mean?
Online monitoring

Using multi-parameter probes – at your intake or on a buoy(s) – or a drone?

Multi-probe to simultaneously measure:
- Phycocyanin (PC) fluorescence
- Chlorophyll-a (Chl-a) fluorescence
- pH, temperature
- Dissolved oxygen
- Conductivity
- Turbidity
Some AWWA tools…

CYANOTOXINS RESOURCE COMMUNITY

- A spreadsheet tool to assess removal of extracellular cyanotoxins by chlorine, ozone, chlorine dioxide and potassium permanganate
- A PAC Calculator tool to assess proper dosages for toxin removal

http://www.awwa.org/resources-tools/water-knowledge/cyanotoxins.aspx
AWWA cyanotoxin resource community (cont.)

CYANOTOXINS ESSENTIALS

AWWA Technical Resources

- Cyanotoxin Oxidation Calculator - CyanoTOX, Version 2 (XLS)
- Managing Cyanotoxins in Drinking Water: A Technical Guidance Manual for Drinking Water Professionals (PDF)
- Water Utility Managers Guide To Cyanotoxins (PDF)
- Cyanotoxins in US Drinking Water: Occurrence, Case Studies and State Approaches to Regulation (PDF)
- Testing Protocols for Site-Specific Oxidation Assessments (PDF)
- Testing Protocols for Site-Specific Powdered Activated Carbon Assessments (PDF)
- Powdered Activated Carbon Calculator for Site-Specific Assessments (XLS)
- AWWA testimony on 2015 Drinking Water Protection Act (PDF)
- Enactment of 2015 Drinking Water Protection Act

Related Resources

- USEPA Resources on Cyanotoxins in Drinking Water
- Water Research Foundation Report Managing Cyanotoxins (PDF)
- Water Research Foundation Projects
- Health Canada: Cyanobacterial Toxins in Drinking Water
- World Health Organization: Toxic cyanobacteria in water - A guide to their public health consequences, monitoring and management

AWWA PUBLICATIONS
EPA’s Recommended Approach:

- Remove intact cells as best you can
- Minimize preoxidation
- Apply PAC at >20 ppm
- Increase post-chlorination (free chlorine) – use CyanoTOX calculator

- EPA Incident Action Checklist – HABs (Oct 2017)
- EPA Risk Communication Toolbox – HABs (June 2017)
Addressing Multiple Objectives

**Systems must simultaneously manage and address a number of issues:**

- Provide an adequate supply of potable water
- Remove / disinfect microbes
- Control formation of disinfection byproducts
- Prevent/ achieve removal of taste and odor causing compounds
- Maintain corrosion control
- Maintain reliable treatment under a wide range of conditions

Managing cyanotoxins effectively requires identifying recognition & response strategies that do not create unintended consequences
Thank you

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