U.S. EPA Update on Development of Recreational Ambient Water Quality Criteria for Cyanotoxins

Public Stakeholder Webinar
February 22, 2016

Health and Ecological Criteria Division
Office of Water
Webinar Logistics

• Today’s webinar will consist of a presentation discussing the basic science being considered in the development of the criteria followed by a Q&A section.

• Please mute your microphones.

• We will only take questions in the Chat Box.

• Please enter your questions in the chat box at any time during the webinar.

• Your questions will be discussed during the Q&A section.
Presenter

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Health and Ecological Criteria Division
Office of Water
US Environmental Protection Agency
Cyanobacteria (aka Blue-green Algae)

Anabaena

Microcystis

Aphanizomenon

Microcystis

Human Hair

64µm
Cyanobacteria occur naturally in marine and freshwater ecosystems.

- Some species can form blooms that can produce toxins, these are known as Harmful Algal Blooms (HABs).
- Blooms are dependent on numerous factors, including nutrient loading, temperature, and weather patterns.
- In freshwater, cyanobacteria are the most common; some produce highly potent cyanotoxins.
- Different toxins can be produced by a number of different species making visual monitoring difficult.
• In June 2015, EPA published Drinking Water Health Advisories for two cyanotoxins: Total Microcystins and Cylindrospermopsin.
• These advisories are based on consumption of finished drinking water containing these cyanotoxins.
• EPA recommended levels for two age groups: children pre-school age and younger (≤ 6yo); and, school-age children through adults (>6 yo)

<table>
<thead>
<tr>
<th>Toxin</th>
<th>Health Advisory Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 6 yo</td>
</tr>
<tr>
<td>Microcystins</td>
<td>0.3 µg/L</td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>0.7 µg/L</td>
</tr>
</tbody>
</table>

http://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations
• People can also be exposed to cyanotoxins during recreational activities.

• EPA is currently reviewing the state of the science describing the human health effects from exposure to cyanobacteria and the toxins microcystins and cylindrospermopsin during recreation.

• EPA will use the information to support derivation of 304(a) ambient water quality criteria protective of primary contact recreation.
Regulatory Context

• Collecting information on guidelines recommended by other governments.
• Evaluating what is recommended and the scientific basis for the recommendation.

• Collating state-reported information on recreational ‘health advisories’ issued due to HABs.
• Including the toxin occurrence and concentration, when reported.
## Summary of State Recreational Water Guidelines for Cyanobacteria and Cyanotoxins

<table>
<thead>
<tr>
<th>Recreational Water Guideline Type and Scope</th>
<th>Number of States and List of States</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative guidelines for cyanobacterial cells only</td>
<td>6 states Arizona, Connecticut, Idaho, Maine, New Hampshire, and Wisconsin</td>
<td>Measurements for these criteria including cyanobacterial cell densities, proportion of toxigenic cyanobacteria, chlorophyll concentration, and Secchi disk depth measurements.</td>
</tr>
<tr>
<td>Quantitative guidelines for cyanotoxins only</td>
<td>8 states California, Illinois, Iowa, Nebraska, New York, Ohio, Vermont, and Washington</td>
<td>State guidelines address four cyanotoxins in order from most to least common: microcystins (17 states) cylindrospermopsin (7 states) anatoxin-a (6 states) saxitoxin (3 states)</td>
</tr>
<tr>
<td>Quantitative guidelines for both cyanotoxins and cyanobacterial cells</td>
<td>10 states Indiana, Kansas, Kentucky, Massachusetts, Oklahoma, Oregon, Rhode Island, Texas, Utah, and Virginia</td>
<td></td>
</tr>
<tr>
<td>Qualitative guidelines only</td>
<td>6 states Delaware, Maryland, Montana, North Carolina, North Dakota, and West Virginia</td>
<td>Examples include: presence of surface scum visible discoloration presence of potentially toxic algae</td>
</tr>
</tbody>
</table>

Note: EPA found that Texas and North Carolina published guidelines in the past, but the guidelines can no longer be found on their website.
Selected International Recreational Water Guidelines for Cyanotoxins

<table>
<thead>
<tr>
<th>Authority/State</th>
<th>Recreational Water Guidance/Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO (2003)</td>
<td>Relative Probability of Acute Health Effects</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Very High</td>
</tr>
<tr>
<td>Australia</td>
<td>10 µg/L microcystins total; cyanobacteria total &gt;= 4 mm³/L (biovolume); Microcystis aeruginosa &gt; 50,000 cells/mL</td>
</tr>
<tr>
<td>Canada</td>
<td>20 µg/L microcystins total; cyanobacteria total: &gt;= 100,000 cells/mL</td>
</tr>
<tr>
<td>New Zealand</td>
<td>12 µg/L microcystin total; cyanobacteria total &gt;= 1.8 mm³/L (biovolume)</td>
</tr>
</tbody>
</table>

• Other countries have developed guidelines for cyanobacteria and cyanotoxins.
• Some use or adapt recommendations made by the World Health Organization (WHO) in 2003.
• Some have derived their guidelines using local monitoring information, specific risk assessments or other metrics.
HABs Monitoring in Recreational Waters - 2015

• States reported at least 252 notices for HABs.
• These included cautions, warnings, public health advisories, and public health warnings, due to the presence of algae or toxins or both.

NUMBER OF HEALTH ADVISORIES ISSUED BY MONTH

<table>
<thead>
<tr>
<th>Month</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>7</td>
</tr>
<tr>
<td>February</td>
<td>4</td>
</tr>
<tr>
<td>March</td>
<td>2</td>
</tr>
<tr>
<td>April</td>
<td>3</td>
</tr>
<tr>
<td>May</td>
<td>14</td>
</tr>
<tr>
<td>June</td>
<td>25</td>
</tr>
<tr>
<td>July</td>
<td>95</td>
</tr>
<tr>
<td>August</td>
<td>81</td>
</tr>
<tr>
<td>September</td>
<td>19</td>
</tr>
</tbody>
</table>
# Range of 2015 Reported Microcystin Levels

<table>
<thead>
<tr>
<th></th>
<th>Microcystin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Cyanotoxin</strong></td>
<td><strong>627.7</strong></td>
</tr>
<tr>
<td><strong>Concentration (µg/L)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Median Cyanotoxin</strong></td>
<td><strong>20</strong></td>
</tr>
<tr>
<td><strong>Concentration (µg/L)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Range of Cyanotoxin</strong></td>
<td><strong>0.2-42000</strong></td>
</tr>
<tr>
<td><strong>Concentration (µg/L)</strong></td>
<td></td>
</tr>
</tbody>
</table>
Ambient Water Quality Criteria (AWQC) Development for Recreational Exposures

- Clean Water Act §304(a) recreational Ambient Water Quality Criteria (AWQC) recommend values protective of human health given a primary contact recreational exposure scenario.

- Goal: To provide guidance to ensure safety for recreational exposures to cyanobacteria and cyanotoxins.

- Objective 1: To develop §304(a) recreational AWQC recommendations for the cyanotoxins microcystin and cylindrospermopsin.

- Objective 2: To evaluate state of the science in regards to human health effects from recreational exposures to cyanobacteria and discuss within the AWQC as appropriate.
Scoping the criteria

• Focus on human exposure as a result of primary contact recreation activities such as swimming where immersion and incidental ingestion of ambient water are likely.
  • Dermal and inhalation exposures associated with primary contact recreation will be considered if data are sufficient.
  • Consumption of fish and shellfish will not be considered in the assessments.

• Develop AWQC based on the same peer-reviewed science as supported EPA’s Drinking Water Health Advisories for microcystins and cylindrospermopsin.
  • The Health Effects Support Documents (HESDs) discussed the human health effects from exposure to these toxins and the key studies used to derive a reference dose (RfD).
  • The health advisories used the RfDs to derive health-protective recommendations given a drinking water exposure scenario.
  • EPA plans to use the same RfD values to derive health-protective AWQC recommendation given a recreational exposure scenario.
Scoping the criteria

• Develop a conceptual model to help guide the AWQC development.
• Identify the potential pathways of human health risk from recreational exposures to cyanobacteria and their toxins.
• Identify factors and endpoints that will be addressed quantitatively and qualitatively within the criteria document.
Conceptual Model of Cyanotoxin and Cyanobacteria Exposure Pathways While Recreating

STRESSORS
- Cylindrospermopsin
- Microcystins
- Cyanobacteria cells

SOURCES
- Lakes, ponds, and rivers (freshwater, inland)
- Estuaries, bays, lagoons and oceans (marine, coastal)

EXPOSURE ROUTES
- Oral
  - Incidental ingestion while recreating
- Dermal
  - Dermal contact while recreating
- Inhalation
  - Incidental inhalation while recreating

RECEPTORS
- General population (adults and children)
- Children

ENDPOINTS
- Liver damage
- Kidney damage
- Reproductive effects
- Developmental effects
- Cancer
- Inflammatory response effects, e.g., GI distress, skin irritation
Stressors: agents that cause an effect

• Some States already use both measures as criteria.
• Considering both the cyanotoxins (quantitatively) and cyanobacterial cells (qualitatively).
• Toxin-related effects:
  • Liver (microcystin)
  • Kidney (cylindrospermopsin)
• Cell-related effects:
  • Various endpoints with many considered inflammatory responses.
  • Gastrointestinal (GI), Dermatologic, Eye/ear, Respiratory
  • Dermatologic, GI and respiratory symptoms are the most frequently reported following outbreaks of HAB-related illness in recreational waters (CDC)
Stressor: Cylindrospermopsin

• Exposure pathway: oral ingestion of drinking water (by gavage)
• Key Study Selected: Humpage and Falconer (2002, 2003); 11 weeks drinking water study in mice
• Most sensitive endpoint: kidney damage
  • Increased weight of kidney and decreased urinary protein

Information on this slide taken from EPA’s Drinking Water Health Advisory for the Cyanobacterial Toxin Cylindrospermopsin (2015).
Stressor: Microcystins

• Microcystin-LR, considered a surrogate for all microcystins
  • Toxicity data are most complete
  • LR is the same or more toxic than other congeners, based on available data
• Key Study Selected: Heinze, 1999; 28 day drinking water study in rats
• Most sensitive endpoint: liver toxicity
  • Increase in liver weight and in liver enzymes

Information on this slide taken from EPA’s Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxins (2015).
Stressor: Cyanobacterial Cells

• Cell components other than the toxins produced have been implicated as etiologic agents (e.g., lipopolysaccharides, phycocyanins)

• Linkage to health suggested by epidemiological evidence
    • Demonstrated a significant trend for increasing symptom occurrence with an increase in cell density.
    • Did not observe an association between the presence of hepatotoxins and symptom occurrence

• HAB-related illness outbreaks in recreational waters reported by CDC suggests that cell-related endpoints can be an important public health consideration.

• EPA envisions a qualitative evaluation of health effects from cyanobacterial cells.
Sources: where is the stressor coming from?

- Focusing on freshwater occurrence of HABs producing microcystin and cylindrospermopsin.
  - All HAB-related outbreaks reported by CDC in the last two reporting cycles occurred in fresh water.
- Evaluating reports of upstream fresh water HAB events affecting the downstream interface with estuarine/marine waters.
Exposure Routes: How are recreators exposed?

- Surveying the scientific literature for information on the three exposure routes.
- Evaluating literature to identify differences in exposure levels used by EPA, States, and other regulatory authorities to inform the recreational exposure scenario in this AWQC.
- Finding less information is available on dermal and inhalation exposure routes compared to ingestion.
- HAB-related illness outbreaks in recreational waters reported by CDC suggests dermal and inhalation pathways can be important to consider.
  - Outbreaks: dermal > ingestion > inhalation
Evaluating studies which measured or surveyed recreational water ingestion (n=6).

Swimming is associated with the highest incidental ingestion rates compared to other recreational activities.

Ingestion volumes described in these studies ranged from 0 to 0.154 L (duration of ingestion varied among the studies).

Ingestion average for adults: 0.016 L

Ingestion average for <18 yo: 0.037 L

Currently evaluating age ranges and groups considered in these studies.
Exposure Routes: Current Thinking

• EPA plans to include the oral ingestion route quantitatively within the AWQC.

• EPA envisions discussing dermal and inhalation exposures qualitatively.

• Specialized exposures, such as ceremonial uses of surface waters, will also be discussed qualitatively.
Receptors: Populations and/or life stages exposed to the stressor

• Evaluating children-specific parameter values that could support the development of AWQC benchmarked to children’s recreational exposures.
  • Four states (CA, OH, IN, and MA), Grayson Co., TX, Australia, and New Zealand calculated guideline values based on both children-specific and adult exposure parameters.
  • Five states (ID, OR, UT, VA, and WA) and Canada calculate guidelines values based on children-specific parameters only.
Receptors: Identifying the population

• Children’s smaller body mass compared to adults increase the potential for toxic effects.

• Children tend to have more exposure during recreation:
  • Ingest more water, both incidentally and hand-to-mouth
  • Spend more time in contact with near shore waters.

• CDC reports that 66% of HAB-associated outbreaks in 2009-2010 were < age 19. Thirty-five percent were age 9 or younger.

• 80% of all confirmed illness reports due to fresh water cyanotoxin exposure involved (or exclusively involved) children (Weirich and Miller, 2014).
Receptors: Pets and Agricultural Animals

• Searching the literature and reviewing published reports for information on animal (pets and livestock) poisonings linked to exposure to cyanotoxins.

• Envision discussing how states could use and/or adapt the AWQC for developing values protective of animals.
Receptors: Current Thinking

• Because:
  • Children incidentally ingest more water during recreational activities than adults.
  • Children spend more time swimming in fresh waters compared to adults.
  • Children can be exposed more frequently compared to adults.

• EPA intends to derive criteria protective for a child who ingests water incidentally while swimming.
Current Thinking Summary

- Focus on a recreational scenario where immersion and incidental ingestion of ambient water are likely.
- Focus on fresh waters, but consider reports of potential effects at the estuarine interface.
- Recommend AWQC for the cyanotoxins microcystins and cylindrospermopsin.
- Benchmark the AWQC to children’s exposures.
- Consider cell densities (for now, qualitatively)
- Evaluate dermal and inhalation exposure routes.
- Characterize effects to domesticated animals and livestock
Outreach and Stakeholder Engagement

• EPA is planning to have a HAB-related session at the 2016 Recreational Water Conference in April.

• EPA is planning to hold additional webinars in 2016.
  • Engage with stakeholders
  • Communicate our progress
  • Provide a venue for feedback
  • Forum for information/data sharing

• We want to hear from you!
  • Do you have information that you think would be helpful to EPA’s efforts?
  • Topics for consideration for future webinars?
EPA HAB information

- EPA’s CyanoHAB web portal:
  - [http://www.epa.gov/cyanohabs](http://www.epa.gov/cyanohabs)

- Information about:
  - cyanobacteria and cyanotoxins
  - Detection methodologies
  - Health and ecological effects
  - Research news
  - Causes and prevention
  - Control and treatment

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