Health Effect Considerations of HABS

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Exposure to Cyanobacteria and Cyanotoxins

- Recreational Activities (most common)
- Food
- Drinking water
- Algal dietary supplements
- Medical procedures (dialysis)-rare
<table>
<thead>
<tr>
<th>Cyanotoxins</th>
<th>Acute Health Effects in Humans</th>
<th>Most common cyanobacteria producing toxin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystin-LR</td>
<td>Abdominal pain, Headache, Sore throat, Vomiting and nausea, Dry cough, Diarrhea, Blistering around the mouth, and Pneumonia, possible cancer promoter</td>
<td>Microcystis, Anabaena, Nodularia, Planktothrix, Fischerella, Nostoc, Oscillatoria, and Gloeotrichia</td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>Fever, Headache, Vomiting, Bloody diarrhea</td>
<td>Cylindrospermopsis, Aphanizomenon, Umezakia, Anabaena, Lyngbya, Rhaphidiopsis</td>
</tr>
<tr>
<td>Anatoxin-a group</td>
<td>Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death*</td>
<td>Chrysosporum (Aphanizomenon), Cuspidothrix, Cylindrospermopsis, Cylindrospermum, Dolichospermum, Microcystis, Oscillatoria, Planktothrix</td>
</tr>
<tr>
<td>Lipopolysaccharides (LPS)</td>
<td>Irritant</td>
<td>All gram (-) bacteria and variable amounts in cyanobacteria</td>
</tr>
</tbody>
</table>

*death observed in animals

Table adapted from Lesley D’Anglada
US EPA OW
### Routes of Exposure

<table>
<thead>
<tr>
<th>Routes of Exposure</th>
<th>Recreational Drinking Water</th>
<th>Food/Dietary Supplement</th>
<th>Occupational</th>
<th>Medical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingestion</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Inhalation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dermal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Intravenous</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Severity of health effects depends on toxin(s), dose, route of exposure, and individual’s health status.
- Children, elderly, and possibly people with pre-existing health conditions could be at increased risks.
Exposure Guidelines for Cyanobacteria and Cyanotoxins

EPA Draft Recreational Ambient Water Quality Criteria (AWQC) for Cyanotoxins

<table>
<thead>
<tr>
<th>Microcystins</th>
<th>Cylindrospermopsin</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 µg/L (^{a,b})</td>
<td>8 µg/L (^{a,b})</td>
</tr>
</tbody>
</table>

- a) Swimming Advisory: not to be exceeded on any day
- b) Recreational Criteria for Water Body Impairment: not exceeded more than 10 percent of days per recreational season up to one calendar year.
EPA Drinking Water Health Advisory (10 Day)

<table>
<thead>
<tr>
<th>Cyanotoxin</th>
<th>Bottle-fed infants and pre-school children</th>
<th>School-age children and adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins</td>
<td>0.3 µg/L</td>
<td>1.6 µg/L</td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>0.7 µg/L</td>
<td>3 µg/L</td>
</tr>
</tbody>
</table>

Lower health advisory values for younger children based on higher water intake per body weight for children 5 years old and younger.
WHO Guidelines for Cyanotoxins

1.0 µg/L MC-LR

- Lifetime exposure
- In water with cyanobacterial cells, this value applies to the total free and cell-bound toxin
## Kansas Health Advisories for Recreational Water

<table>
<thead>
<tr>
<th>Public Health Watch—</th>
<th>Public Health Warning—</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A hazardous condition <strong>may</strong> exist</td>
<td>• Conditions <strong>are unsafe</strong></td>
</tr>
<tr>
<td>• Signs posted at public access locations</td>
<td>• Signs posted at all public access locations</td>
</tr>
<tr>
<td>• Water may be unsafe for humans/animals</td>
<td>• Water contact <strong>should not</strong> occur</td>
</tr>
<tr>
<td>• Discourage water contact</td>
<td>• All conditions of Public Health Watch remain in effect</td>
</tr>
<tr>
<td>• 4-20 µg/L toxin</td>
<td>• <strong>Toxin ≥20µg/L</strong></td>
</tr>
<tr>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td>• Cyanobacteria cell counts 80,000-250,000 cells/ml</td>
<td>• Cyanobacteria cell counts ≥250,000 cells/ml</td>
</tr>
</tbody>
</table>
Case Example- Giannuzzi et al 2011, Argentina Lake

- Healthy 19 year old man on jet ski treded water in an intense Microcystis bloom x 2 hours
- Water conditions 4 hours post-exposure: MC-LR 48.6µg/L and cyanobacteria cell concentration ~34,000 cells/ml
- Man experienced 3 week illness with gastrointestinal stage → pulmonary stage → liver toxicity
Challenges to Identification of Causative Toxin

Patient

- Evidence of cyanobacteria or toxin in bloodstream, stomach contents, or feces could be difficult to detect if medical attention delayed
- Early health effects are often nonspecific and may not be linked to HAB exposure
- Specific toxin identification requires advanced techniques (applies to environmental aspect too)

Environmental

- Cyanobacteria and toxin content are dynamic in respect to time and space in the body of water and within the water column; delayed sampling may represent a different environment
Schematic illustration of scum-forming potential changing the cyanotoxin risk from moderate to very high (After Falconer et al., 1999)
If You Are Exposed

• Shower immediately
• Seek medical attention if symptoms develop and let healthcare provider know about HAB exposure
• No “point-of-use” test to confirm exposure
• Supportive care is only treatment- no antidote
Toxicology Research on Cyanotoxins and Challenge of Health Guidelines and Advisories

- **Human data is gold standard**, but limited and confounded with other variables
- **Mammalian data with appropriate route of exposure**
  - Best controlled study type
  - Oral studies limited by cost of toxin

Majority of existing research done using inappropriate route of exposure *in vivo* (intraperitoneal to conserve toxin) or cell culture assays (*in vitro*) - helps elucidate mechanism of toxicity, but *interpretation unusable for human exposure*
Chernoff Lab Comparative Toxicity of Eight Microcystin (MC) Congeners

MC-LR    MC-LW
MC-RR    MC-YR
MC-WR    MC-LY
MC-LA    MC-LF

- Given orally by gavage to mice
- Samples taken 24 hours after single dose
- Study repeated with intraperitoneal (i.p.) dose
- To do oral and i.p. studies on two demethylated forms of MC-RR common in Europe
Chernoff Lab Comparative Toxicity of Eight Microcystin (MC) Congeners

Relative Toxicity

By oral or injection route:

Most toxic: \( \text{MC-LA} > \text{MC-LR} \)

Least toxic: \( \text{MC-RR} \)
Study Data

Example of comparison of Microcystin-LR, -LA, -LW, -LY, -RR given orally to mice measured by response of elevated liver enzyme as a marker of liver injury
Take Home Points:

- Public Education ✓ (addressed by Kansas HAB program)
- Monitoring, Reporting and Response ✓ (addressed by Kansas HAB program)
- More cyanotoxin animal toxicology data for guidance with human health
- Communication of experiences from Kansas and Region 7 (and beyond) to EPA ORD and our laboratory to help guide research priorities for HABS
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