Human Health Risks Associated with HABs

Sonia Joseph
Michigan Sea Grant/NOAA Center of Excellence for Great Lakes and Human Health
## Toxins produced by freshwater planktonic cyanobacteria

<table>
<thead>
<tr>
<th>Toxin type</th>
<th>Primary organ affected</th>
<th>Produced by</th>
</tr>
</thead>
<tbody>
<tr>
<td>microcystins</td>
<td>liver</td>
<td>Microcystis, Anabaena, Oscillatoria</td>
</tr>
<tr>
<td>anatoxins</td>
<td>nervous system</td>
<td>Anabaena, Aphanizomenon, Oscillatoria</td>
</tr>
<tr>
<td>saxitoxins</td>
<td>nervous system</td>
<td>Anabaena, Aphanizomenon, Cylindrospermposis</td>
</tr>
<tr>
<td>cylindrospermpopsins</td>
<td>liver</td>
<td>Cylindrospermposis, Aphanizomenon</td>
</tr>
<tr>
<td>LPS</td>
<td>skin irritant</td>
<td>all of the above</td>
</tr>
</tbody>
</table>
What makes a cyanobacterial bloom toxic?

- Stimulation of toxin production by environmental factors
- Shift in community composition

Environmental factors:
- Light
- Nutrients
- Temperature
- Trace metals

- Mostly non-toxic
- Mostly toxic strains

(Zurawell et al. 2005)
What makes a cyanobacterial bloom toxic?

- **Stimulation of toxin production by environmental factors**
  - 2-10 fold change in toxicity
  - Not producing toxin → Producing toxin

- **Shift in community composition**
  - 10-1000 fold change in toxicity
  - Mostly non-toxic → Mostly toxic strains

(Zurawell et al. 2005)
World Health Organization

- **Recommended Guidelines**
  - Drinking water = 1μg/L
  - Low risk recreational = 2-4μg/L
  - Moderate risk recreational = 20μg/L
  - High risk recreational = avoid visible scums
Concerns about Microcystis

- Degrade water quality
  - Taste/odor issues; aesthetics; hypoxia

- Toxin production: hepatotoxin microcystin
  - Human health effects (OHH)
  - Ecosystem effects
    - reduced grazing
    - altered food web
    - bioaccumulation
Microcystin

100x more toxic
Microcystin Case Studies

- Brazil
  - 1988, gastro-enteritis epidemic over 2000 cases reported and 88 deaths.
    - *Anabaena and Microcystis* bloom.
  - 117 patients developed liver disease attributed to dialysis with microcystin-contaminated water, 50 deaths

- Rural Chinese populations infected with Hepatitis-B and drinking water contaminated with microcystins
  - Liver cancer link.
Cylindrospermopsis

- Now found in the Great Lakes
- Mainly hepatotoxin (liver)
Palm Island Case Study

- Major bloom in Australian reservoir (1979)
- Drinking water chlorinated but not filtered
- Taste and odor complaints
- Treatment with copper sulfate
- Approx 150 complaints of malaise, anorexia, vomiting, headache and stomach pain.
- A culture of the reservoir water revealed the presence of *Cylindrospermopsis raciborskii*. 
Health Effects of Anatoxins:

**Anatoxin-a**: sufficient exposure can lead to paralysis, asphyxiation and death; oral LD$_{50}$ (mice) $\approx$ 5 ppm; repeated exposures to toxin caused fetal malformations and stunted growth in hamster litters; no maternal toxicity noted

**Anatoxin-a(S)**: potent organophosphate produced by *A. flos-aquae*; this toxin blocks acetylcholinesterase activity; no oral toxicity studies could be found; symptoms include muscle weakness, respiratory distress and convulsions

Courtesy of Dr. David Stone, Oregon Dept of Health Services
Case study anatoxin-a

In July 2002, five teenagers went swimming in a pond at a golf course in Dane County, Wisconsin. The pond was described as “scummy” and “dirty.” The boys splashed around and two had their head submerged underwater.

Of the two who went underwater, one boy died of acute heart failure 48 hours later and the other became ill with acute diarrhea and abdominal pain. Blood tests on the boys confirmed the presence of *A. flos aquae* and anatoxin-a.

An algal toxin expert was quoted as saying the toxin was present in amounts that could cause symptoms & death based on animal studies, but was puzzled by the amount of time that had elapsed prior to death (Milwaukee Journal Sentinel, Sept. 5, 2003). Typically, neurological toxins act in minutes or hours versus days.

Courtesy of Dr. David Stone, Oregon Dept of Health Services