Guidelines for Design and Sampling of Cyanobacterial Toxin and Taste-and-Odor Studies

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U.S. Department of the Interior
U.S. Geological Survey
There are Many Potential Sources of Variability that May Influence Study Outcomes
Many Cyanobacteria Produce Toxins and Taste-and-Odor Compounds

<table>
<thead>
<tr>
<th></th>
<th>Hepatotoxins</th>
<th>Neurotoxins</th>
<th>Dermatoxins</th>
<th>Taste/Odor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CYL</td>
<td>MC</td>
<td>ANA</td>
<td>SAX</td>
</tr>
<tr>
<td><strong>Dolichospermum</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Aphanizomenon</strong></td>
<td>X</td>
<td>?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Microcystis</strong></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oscillatoria/Planktothrix</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Photos courtesy of PhycoTech, Inc.

After Graham and others, 2008
Cyanobacteria Present Many Challenges to Study Design and Sample Collection

- Kansas Department of Health and Environment sample results from October 5, 2015
  - Cell count: 804,667,500 cells/mL
  - Microcystin Concentration: 30,000 µg/L
- Cell count: 7,371 cells/mL
- Microcystin Concentration: < 1 µg/L
Cyanobacteria Present Many Challenges to Study Design and Sample Collection
Sample Concentrations Can Vary Considerably Depending on When, Where, and How Samples Are Collected

After Graham and others, 2006
Consistent Guidelines for Study Design and Sample Collection are Essential for Nationally Comparable Data

SIR 2008-5038 Guidelines for Design and Sampling for Cyanobacterial Toxin and Taste-and-Odor Studies in Lakes and Reservoirs (Graham and others)

http://pubs.usgs.gov/sir/2008/5038

USGS National Field Manual Chapter 7.5 Cyanobacteria in Lakes and Reservoirs: Toxin and Taste-and-Odor Sampling Guidelines (Graham and others)

http://water.usgs.gov/owq/FieldManual/Chapter7/7.5
Clear Understanding of Study Objectives is Essential to Selecting the Appropriate Sampling Approach

- Study objectives dictate:
  - When, where, and how samples are collected
  - Variables measured
  - Ancillary data collected
Considerations When Choosing Sampling Locations and Approaches

• Specific study objectives
• Stratification
• Areal and water-column distribution of cyanobacteria
• Flexibility of sampling plans
  – Where and how to collect samples often is decided in the field
Common Types of Samples

- Surface samples
- Discrete-depth samples
  - Location of the cyanobacterial community is known
  - Structure of interest at depth
  - Vertical water column distribution of interest
- Depth-integrated samples
  - Integrated photic zone
  - Integrated epilimnion
  - Integrated water column
Common Sampling Approaches

- Plankton Net Sampling
- Whole Water Sampling
- Filter/Filtrate Sampling

Total Toxin = Intracellular Toxin + Dissolved Phase Toxin + Particulate Toxin
# Reconnaissance Studies

Assess Occurrence, Distribution, and Concentration

After Graham and others, 2008

<table>
<thead>
<tr>
<th>General objective</th>
<th>Site location</th>
<th>Sample frequency</th>
<th>Sample type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regional studies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spatial variability</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Emphasis on presence/absence</td>
<td>Single representative site, typically an open, deep water site</td>
<td>Single point in time when most cyanobacterial-related issues occur</td>
<td>Integrated photic zone, integrated epilimnion, surface sample</td>
</tr>
<tr>
<td></td>
<td>Site will be determined based on the location of surface accumulations and scums</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emphasis on presence/absence and changes in concentration with time</td>
<td>Single representative site, typically an open, deep water site</td>
<td>Multiple times during the period when most cyanobacterial-related issues occur</td>
<td>Integrated photic zone, integrated epilimnion, surface sample</td>
</tr>
</tbody>
</table>
| | | • Weekly  
| | | • Bi-weekly  
| | | • Monthly  
| | | • Annually |
| **Spatial and temporal variability** |               |                  |             |
| Emphasis on presence/absence and changes in concentration over time | Multiple sites | Multiple times during the period when most cyanobacterial-related issues occur | Integrated photic zone, integrated epilimnion, integrated water column, surface sample |
| | | • Weekly  
| | | • Bi-weekly  
| | | • Monthly |
| Emphasis on spatial changes within the lake or water column over relatively short periods of time | Single representative site | Multiple points in time when a cyanobacterial bloom is occurring | Integrated photic zone, integrated epilimnion, integrated water column, surface sample, discrete depth |
| | Multiple sites | | |

After Graham and others, 2008
In the 2007 National Lakes Assessment, Microcystins Were Detected in About 32% (n=1252) of Analyzed Samples.
Seventy-Eight Percent of Lakes in a Regional Study had Detectable Microcystins at Least Once During 1999-2006

Measured by ELISA

78% of lakes had detections (n=359)
Maximum concentration: 52 µg/L

After Graham and others 2004, 2006, and 2009
Microcystins were detected in all bloom samples collected in a 2006 regional study. After Graham and others, 2010.
Monitoring Studies
Evaluate the Potential for Human Health Risks and Taste-and-Odor Events

<table>
<thead>
<tr>
<th>General objective</th>
<th>Site location</th>
<th>Sample frequency</th>
<th>Sample type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational areas</td>
<td>Beaches</td>
<td>Routine basis during periods of peak recreational use</td>
<td>Surface sample</td>
</tr>
<tr>
<td></td>
<td>Open water areas used for full-body contact recreation</td>
<td>• Daily</td>
<td>Integrated photic zone</td>
</tr>
<tr>
<td></td>
<td>Bay or cove areas used for full-body contact recreation</td>
<td>• Weekly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public access sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking-water supplies</td>
<td>Location relevant to the drinking-water intake(s)</td>
<td>Routine basis</td>
<td>Discrete depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Daily</td>
<td>Integrated photic zone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Weekly</td>
<td>Integrated epilimnion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>During periods when events have historically occurred</td>
<td>Integrated water column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>During events</td>
<td></td>
</tr>
</tbody>
</table>

After Graham and others, 2008

Figure Courtesy of E. O'Brien, IA DNR

Notice
An algae bloom has made this area potentially unsafe for water contact. Avoid direct contact with visible surface scum.
Zoned Warning Status in a Kansas Reservoir was Not Substantially Influenced by Sample Collection Technique

After Foster and others, 2016
## Interpretive Studies
Assess the Processes that Affect the Spatial and Temporal Distribution and Abundance of Cyanobacteria and Associated Compounds

<table>
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<tr>
<th>General objective</th>
<th>Site location</th>
<th>Sample frequency</th>
<th>Sample type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental factors influencing spatial and/or temporal occurrence</td>
<td>Single representative site, typically an open, deep water site • Sites for drinking-water studies are typically located near intakes</td>
<td>Routine basis • Weekly • Bi-weekly • Monthly</td>
<td>Integrated photic zone Integrated epilimnion Integrated water column Discrete depth</td>
</tr>
<tr>
<td>Real-time estimation of occurrence/concentration</td>
<td>Multiple sites • Sites where cyanobacterial blooms are known to initiate • Sites where cyanobacteria are typically abundant • Inflow sites¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictive models</td>
<td>Sites where surface accumulations/scums are located</td>
<td>Event samples Sampling plans need to be flexible enough to respond to events</td>
<td>Surface sample</td>
</tr>
</tbody>
</table>

After Graham and others, 2008
Temporal Variability Also Can Span Orders of Magnitude Across Seasons and Years

After Graham and others, 2017
In the Kansas River, Measured Concentrations of Cyanobacteria and Associated Compounds Varied Depending on Sample Location and Method
Conclusions

• Cyanobacteria present several unique challenges to study design and sample collection.

• A clear understanding of study objectives is essential to selecting the appropriate sampling approach.

• Understanding and quantifying variability is key to interpreting results.
USGS:

http://ks.water.usgs.gov/cyanobacteria

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