Cyanotoxins in Freshwaters of the United States: Occurrence and Emerging Technologies

Jennifer L. Graham, Keith A. Loftin, and Guy M. Foster
U.S. Geological Survey

EPA Region 10 HABs Workshop
March 29, 2016
At Least 39 States in the Nation Have Had Anecdotal Reports of Cyanotoxin Poisoning

After Graham and others, 2009
In August 2015, 24 States Had Toxic Algal and Health Advisories for Cyanobacteria

Explanation:
- Red: States with Toxic Algal and Health Advisories
In the 2007 National Lake Assessment Microcystin Concentrations > 1 µg/L Were Most Common in the Upper Midwest

33% of lakes had detections (n=1,028)
Maximum concentration: 230 µg/L
Median: <0.10 µg/L (0.52 µg/L*)
Mean: 1.0 µg/L (3.0 µg/L*)

*Detects only

After Beaver and others, 2014
Cylindrospermopsins Were Detected by ELISA in About 4% (n=659) of Analyzed Lakes; Occurrence was Most Common in the South
Saxitoxins Were Detected by ELISA in About 8% (n=678) of Analyzed Lakes; Occurrence was Most Common in the Upper Midwest and the South.
Microcystins are Widespread and Common in the Midwest

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

After Graham and others 2004, 2006, and 2009
Multiple Toxins and Taste-and-Odor Compounds Frequently Co-Occur in Cyanobacterial Blooms

After Graham and others, 2010
Cyanobacterial Toxins and Taste-and-Odor Compounds May Be Transported for Relatively Long Distances Downstream from Lakes and Reservoirs
Microcystins Also Occur in Smaller Streams

39% of stream sites had detections (n=75)
Maximum concentration: 3.2 µg/L
Median: 0.11 µg/L
Mean: 0.29 µg/L
Vertical Migration or Wind Movement of Surface Accumulations May Rapidly Change the Areal Distribution of Cyanobacteria

Rock Creek Lake, Iowa
2006 Beach Closure Event

Beach Area
Monday
July 31

Beach Area
Thursday
August 3

Photo Courtesy of IA DNR

Boat Ramps
Friday
August 11

Photos Courtesy of IA DNR
Vertical Migration or Wind Movement of Surface Accumulations May Rapidly Change the Aerial Distribution of Cyanobacteria

Rock Creek Lake, Iowa
2006 Beach Closure Event

WHERE DID THE CYANOBACTERIA GO?

Most likely explanation is redistribution in the water column

Photos Courtesy of IA DNR

USGS science for a changing world
Sample Concentrations Can Vary Considerably Depending on When, Where, and How Samples Are Collected

<table>
<thead>
<tr>
<th>Time</th>
<th>Surface</th>
<th>Integrated Photic Zone</th>
<th>Integrated Epilimnion</th>
<th>Integrated Water Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>0930</td>
<td>118</td>
<td>74</td>
<td>84</td>
<td>61</td>
</tr>
<tr>
<td>1330</td>
<td>88</td>
<td>64</td>
<td>70</td>
<td>58</td>
</tr>
<tr>
<td>1700</td>
<td>65</td>
<td>50</td>
<td>55</td>
<td>45</td>
</tr>
</tbody>
</table>

After Graham and others, 2006
New Technologies Allow Ground-to-Space Assessment of HABs
Genetic Data Help Identify Systems with the Potential for Cyanotoxin Production

Ohio Lakes, Summer 2013

*Microcystis* mcyE DNA

*Planktothrix* mcyE DNA

After Francy and others, 2015
New Sensors are Promising, But We Are Still Learning Limitations and Best Practices for Optimal Use

After Francy and others, 2015
Continuous Water-Quality Monitors Can Be Used to Develop Models to Compute Probability of Cyanotoxin Occurrence in Real Time

After Stone and Graham, 2013
New Sensor Technologies Allow New Applications, Such as High Resolution Spatial Data Collection

Milford Reservoir, KS, July 2015
New Sensor Technologies Allow New Applications, Such as High Resolution Spatial Data Collection

Bushy Park Reservoir, SC
http://sc.water.usgs.gov/projects/bushypark_wq/

Courtesy of C. Journey
Aerial- and Ground-Based Cameras Show Potential as Early Warning Indicators
Emerging Technologies

Satellites are Essential Tools for HAB Monitoring in Coastal Areas and the Great Lakes

LAKE ERIE HAB TRACKER

No HAB Detected

Please click here to access our experimental predictions of Lake Erie algal bloom intensity and extent. The HAB Tracker is updated daily to make five-day forecasts of harmful algal bloom intensity and distribution based on satellite remote sensing, forecast meteorology, and a hydrodynamic model.

<table>
<thead>
<tr>
<th>Microcystin Sampling</th>
<th>Real-time Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAB Tracker</td>
<td>Vertical Mixing Analysis</td>
</tr>
</tbody>
</table>

Hypoxia Monitoring

Resources

- Lake Erie HABs Bulletin (Experimental)
- Bulletin Sign Up
- Bulletin Archive

Overview of guidelines on algal toxins

HABs FAQs

Algal Bloom Flickr Gallery

MODIS Satellite Imagery

http://www.glerl.noaa.gov/res/HABs_and_Hypoxia/
Emerging Technologies

Tools to Utilize Satellites for Inland HAB Monitoring are Being Developed

Cyanobacteria Assessment Network (CyAN) Project
Unifying Themes in Harmful Algal Bloom Research

• Individual systems are unique.

• Spatial and temporal variability present challenges to data collection, analysis, and interpretation.

• Sensor technology and genetic approaches provide important information on spatiotemporal variability and environmental influences.

• A variety of tools for early warning and prediction are being developed and used.
Additional Information:

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

jlgraham@usgs.gov
785-832-3511