Benthic Periphyton as a Source of Cyanotoxins in Three Oregon Rivers Used for Municipal Drinking-Water Supply

Kurt Carpenter
Research Hydrologist
U.S. Geological Survey
Oregon Water Science Center
Portland, Oregon

Protecting Drinking Water Sources from Cyano-HAB Impacts in the Willamette Basin
Willamette Basin Partners' Workshop
April 28, 2021

U.S. Department of the Interior
U.S. Geological Survey
HABs Can Involve..

Phytoplankton AND Benthic “Periphyton”

Timothy Lake

North Fork Reservoir

Clackamas River Basin
2016-18 Study of Drinking Water Sources
64 Sampling Sites

- Clackamas, North Santiam, and McKenzie Rivers
- Main-stem, upper and lower basin tributaries, reservoirs, springs, and raw source water at DWTPs
“Multiple Lines of Evidence” Sampling Approach

- **Cyanobacteria colonies and mats** (n=81) hand-picked during visual surveys
- **Plankton net tows** (n=84) from reservoirs and riverine sites to identify cyanobacteria and cyanotoxins in transport to downstream DWTP intakes
- **SPATTs** (n=122) Deployment of solid-phase adsorbent toxin trackers in drinking-water intakes, tributaries, main-stem sites, and a few reservoirs
Cyanotoxin Analyses

- Cyanotoxins extracted following 3 freeze-thaw cycles
- Microcystins, cylindrospermopsins, anatoxins, and saxitoxins analyzed
- Analyze with Enzyme-Linked Immunosorbent Assays (ELISA) for 4 cyanotoxins

- Positive detection when extract concentration exceeded the lowest standard.. so conservative
Results

• 91% of 81 samples tested positive for one or more cyanotoxins

• Seven benthic samples from the Clackamas Basin contained all 4 cyanotoxins - two samples of *Nostoc* “ears” and five samples of *Microcoleus*
Nostoc parmeloides ("Ears")

Tested Positive:
- Cylindrospermopsins
- Microcystins
- Anatoxins
- Saxitoxins

USGS Unpublished Data Subject to Revision
Microcoleus ("Mats")

Clackamas River at McIver Park

Tested Positive:
- Cylindrospermopsins
- Microcystins
- Saxitoxins
- Anatoxins

Cymbelloid stalked diatoms

USGS Unpublished Data Subject to Revision
Oscillatoria ("Mats")
Common in many habitats and rivers, streams, and wetlands

Tested Positive:
Cylindrospermopsins
Microcystins
Anatoxins

USGS Unpublished Data Subject to Revision
**Wollea**

Upper Clackamas River, in mats of stalked diatoms *(Cymbella janischii)*

**Tested Positive:**
- Cylindrospermopsins
- Microcystins
- Saxitoxins

*Photo: Barry Rosen/USGS Emeritus, FGSU*

*USGS Unpublished Data Subject to Revision*
Results

- 91% of 81 samples tested positive for one or more cyanotoxins
- Only 7 samples tested negative for all 4 toxins
- *Microcoleus, Oscillatoria* and *Nostoc* were the most common toxic benthic taxa
- Genes often present along with toxins

Cyanotoxin Detections in Benthic Cyanobacteria

- Microcystins
- Cylindrospermopsins
- Anatoxins
- Saxitoxins

Anatoxin not detected

USGS Unpublished Data Subject to Revision
Benthic Cyanobacteria Commonly Found in Plankton Net Tows

USGS Unpublished Data Subject to Revision
Conclusions

- Presence of all 4 primary cyanotoxins confirmed in numerous samples of benthic cyanobacteria
- Plankton net tow samples contained cyanobacteria, including *Nostoc* (especially) in transport to drinking water intakes
- Since toxins are intracellular, risk is unknown but frequent detection in SPATTs indicates that some toxin is dissolved in water
- Toxins might associate with sediments or organic carbon and be transported downstream
Thank You!

Acknowledgements

Clackamas River Water Providers (Kim Swan)
City of Estacada (Chris Lewis)
Clackamas River Water (Suzanne DeLorenzo and Tracy Triplett)
Clackamas County Water Environment Services (Andrew Swanson)
City of Lake Oswego (Kari Duncan)
North Clackamas County Water Commission
South Fork Water Board (John Collins)
Eugene Water and Electric Board (David Donahue and Karl Morgenstern)
City of Salem (Brandin Hilbrandt)
US Army Corp of Engineers (Holly Bellringer, Norman Buccola, Tina Lundell)
USGS (Barry Rosen, Terry Slonecker)
**Summary**

- 544 cyanotoxin detections in 289 samples from 59 sites
- Anatoxin-\(\alpha\) and microcystins were detected in 63% and 60% of SPATTs
- All 4 cyanotoxins detected in 8% of samples (all sample types)

### Total (ADDA)

<table>
<thead>
<tr>
<th></th>
<th>Detection Sites</th>
<th>202</th>
<th>78</th>
<th>135</th>
<th>129</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodularins</td>
<td></td>
<td>70%</td>
<td>27%</td>
<td>47%</td>
<td>45%</td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td></td>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatoxin-(\alpha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxitoxin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection Sites</th>
<th>Detections</th>
<th>66</th>
<th>21</th>
<th>23</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins/</td>
<td>66%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodularins</td>
<td>79%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatoxin-(\alpha)</td>
<td>27%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxitoxin</td>
<td>79%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection Sites</th>
<th>Detections</th>
<th>73</th>
<th>21</th>
<th>77</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins/</td>
<td>73%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodularins</td>
<td>60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatoxin-(\alpha)</td>
<td>63%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxitoxin</td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection Sites</th>
<th>Detections</th>
<th>59</th>
<th>32</th>
<th>34</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins/</td>
<td>59%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodularins</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>41%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatoxin-(\alpha)</td>
<td>44%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxitoxin</td>
<td>40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection Sites</th>
<th>Detections</th>
<th>4</th>
<th>4</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins/</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodularins</td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatoxin-(\alpha)</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxitoxin</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Color Legend:

- > 50%
- 40-50%
- 15-30%
- 0%