Implementation of Routine Cyanobacterial Toxicity Monitoring in Lakes Sammamish, Washington and Union

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Cyanobacteria (a.k.a. blue-green algae)

- Found throughout the world in freshwater habitats
- Can produce a variety of toxins
- Increasing awareness of health risks from exposure to toxic blooms
Factors likely to contribute to toxin production

- Bloom conditions (e.g., warmer temperatures, high nutrients, light)
- Wind patterns creating surface scums
- Lake mixing/turnover in autumn

Green Lake bloom 2002
# Cyanobacterial Toxins

<table>
<thead>
<tr>
<th>Toxin Group</th>
<th>Primary target organ in mammals</th>
<th>Cyanobacterial genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystins</td>
<td>Liver</td>
<td><em>Microcystis, Anabaena, Planktothrix (Oscillatoria), Nostoc, Hapalosiphon, Anabaenopsis</em></td>
</tr>
<tr>
<td>Nodularin</td>
<td>Liver</td>
<td><em>Nodularia</em></td>
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<tr>
<td>Anatoxin-a</td>
<td>Nerve Synapse</td>
<td><em>Anabaena, Planktothrix (Oscillatoria), Aphanizomenon</em></td>
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<tr>
<td>Anatoxin-a (S)</td>
<td>Nerve Synapse</td>
<td><em>Anabaena</em></td>
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<tr>
<td>Aplysiatoxins</td>
<td>Skin</td>
<td><em>Lyngbya, Schizothrix, Planktothrix (Oscillatoria)</em></td>
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<tr>
<td>Cylindrospermopsins</td>
<td>Liver</td>
<td><em>Cylindrospermopsis, Aphanizomenon, Umezakla</em></td>
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<tr>
<td>Lyngbyatoxin-a</td>
<td>Skin, G.I. Tract</td>
<td><em>Lyngbya</em></td>
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<tr>
<td>Saxitoxins</td>
<td>Nerve Axons</td>
<td><em>Anabaena, Aphanizomenon, Lyngbya, Cylindrospermopsis</em></td>
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<tr>
<td>(LPS)</td>
<td>Potential irritant; affects any exposed tissue</td>
<td>ALL</td>
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</tbody>
</table>
Most Common Toxins

- **Microcystins**
  - Liver

- **Anatoxin-a**
  - Nerve

- **Saxitoxin**
  - Nerve
Symptoms of Exposure to Liver Toxins

- **Acute Effects** - vomiting, diarrhea, pain
- **Chronic Effects** - include liver tumors
King County Cyanotoxin Monitoring Program

- 1997 and 1999 Toxic blooms measured in Lake Sammamish and Green Lake
- 2002 - began routine sampling at Major Lakes sites
- 2005 - added Swimming Beach sites

Lake Sammamish bloom 1997
Objectives

- Evaluate the presence of microcystin, a hepatotoxin (liver toxin), to protect human health.
- Estimate concentrations and geographic extent of the toxicity, should it be present.
- Establish relationships between microcystin and cyanobacteria species/abundance.
- Evaluate environmental conditions leading to toxin production in cyanobacteria.
Current Monitoring

- 13 Major Lakes sites
- 11 Swimming Beach sites
- Samples collected weekly Mar - Oct
- Alternating between Major Lake and Swimming Beach programs

2007 Cyanobacteria Toxicity Monitoring
Sampling

**Discrete sub-surface**
  
or
  **Integrated composite**

  - Microcystins
  - Phytoplankton
  - Chlorophyll
  - Nutrients

**In situ measurements**

  - Physical/Chemical Parameters
    (Major Lakes only)
Laboratory Methods

- **Extraction:**
  Microcystins are extracted by cell lysing (freezing and sonication)

- **Analysis:**
  Particulate and dissolved microcystins are measured using two types of laboratory analysis
Microcystin Tests

- **ELISA**
  (Enzyme linked immunosorbent Assay)
  - commercial, antibody-based
  - Measures predominantly Microcystin-LR

- **PPIA**
  (Protein Phosphatase Inhibition Assay)
  - Measures combined toxicity of all congeners
ELISA
Microcystin molecule binds to antibody
PPIA
Substrate + Enzyme = Yellow End Product
All Microcystins inhibit enzyme
<table>
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<tr>
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<td><strong>0.320</strong></td>
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<td>0.015</td>
<td>0.029</td>
<td>0.020</td>
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</tbody>
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Results
Lake Washington
2003 – 2006

- World Health Drinking Standard Guideline = 1.0 ug/L
- May 30, 2006 Bloom at Matthews Beach = 52 ug/L or 47.1 ug/L
Lake Sammamish
2003 – 2006
Lake Union
2003 – 2006

PPIA

ELISA

Microcystin LR Equivalents (µg/L)

Microcystin LR Equivalents (µg/L)
Conclusions

- Microcystins detected in all lakes
- Concentrations well below WHO guideline for drinking water (except one bloom at Matthews Beach)
- No significant correlation with other water quality parameters
Ecology’s Fresh Water Algae Control Program

- Freshwater algae identification
- Toxicity testing
- Utilizes the King County Environmental Lab
<table>
<thead>
<tr>
<th>Location</th>
<th>Site</th>
<th>Concentration (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pierce Co.</td>
<td>Wapato</td>
<td>4,810</td>
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<tr>
<td></td>
<td>Steilacoom</td>
<td>221</td>
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<td></td>
<td>Spanaway</td>
<td>121</td>
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<tr>
<td>Snohomish Co.</td>
<td>Cassidy</td>
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<td>Island Co.</td>
<td>Lone</td>
<td>92</td>
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<tr>
<td>Kittitas Co.</td>
<td>Fiorito</td>
<td>55</td>
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<tr>
<td>Grant Co.</td>
<td>Potholes Res.</td>
<td>41</td>
</tr>
</tbody>
</table>
2008 Toxin Analysis

- **Microcystins**
  (hepatotoxins)

*NEW!!*

- **Anatoxin-a**
  (neurotoxin)
Our new HPLC