2018: The Year of Toxic Algal Blooms

Karl Morgenstern, Eugene Water & Electric Board

McKenzie Watershed Council Meeting, September 13, 2018
Discussion Summary

• Background on Harmful Algal Blooms & Cyanotoxins

• What Happened in 2018
  – Salem/North Santiam River
  – McKenzie River

• Factors that will influence toxic blooms in future

• What is being done to prepare and respond to future blooms
Harmful Algal Blooms

“Blue-green algae” are actually not algae at all but single-celled organisms called cyanobacteria. Cyanobacteria are photosynthetic bacteria that share some properties with algae and are found naturally in freshwater and saltwater. Some species of cyanobacteria can produce toxins, which are known to be harmful to human health above a certain level.
Basic conditions favoring cyanobacterial blooms are well known:

- Light Intensity & Total Sunlight Duration
- Nutrient Availability (especially Phosphorus)
- Warmer Water Temps
- Higher pH
- Precipitation Events
- Slow Moving & Stratified Water
- Low Zooplankton Grazing Pressure
Algal Toxins A New and Emerging Problem

Philosophical Transactions of the Royal Society
No. 83 pg 4069
Letter to the Editor, December 19, 1671

“Account of an Inland Sea (or Lake) near Dantzick, yielding at certain season of the year a green substance, which causes certain death”
- Mr. Christopher Kirkby

…The water sweet and wholesome; but only in the three summer months, June, July, and August, it becomes every year, during the dry weather, green in the middle, with a hairy efflorescence, which green substance, being by some violent wind forced ashore, and with the water drunk by any cattle, dog, or poultry, causes certain and sudden death; whereas at the same time, that a knowing and ingenuous person saw three dogs killed with this…
Cyanobacteria Facts

- One of the oldest life forms on earth, 3+ billion years old.
- Occur naturally in both terrestrial and aquatic environments.
- Several thousand species have been identified, but estimates suggest this represents less than half of all living species.
- Although commonly referred to as blue-green algae, cyanobacteria are actually photosynthetic bacteria.
  - Created earth’s O2 atmosphere
- Some species capable of producing toxins.
- Many species can fix nitrogen.
- All need a source of phosphorus
- Can regulate buoyancy
Cyanobacteria Morphology
Cyanobacteria can be unicellular, colonial or filamentous.

Suspended Phytoplankton

Benthic Periphyton
Cell Structure – *Dolichospermum* Example
Life Cycle – *Dolichospermum*

Example
Potentially Toxic Suspended Planktonic Cyanobacteria

- *Dolichospermum* (formerly *Anabaena*)
- *Aphanizomenon*
- *Gloeotrichia*
- *Microcystis*
- *Cylindrospermopsis*

Photos by Kurt Carpenter and Barry Rosen, USGS
Potentially Toxic Benthic Cyanobacteria

Photos by Kurt Carpenter, USGS
Potential drinking water impacts from HABs

• Cyanotoxins – hard to treat
• Dissolved Organic Matter
  – Precursor to disinfection by-products (DBPs)
• Taste and odor issues
• Turbidity & intake clogging
• Increased diurnal pH/DO cycles
Toxins associated with various Cyanobacteria

<table>
<thead>
<tr>
<th>Genus of Algae</th>
<th>Toxin Produced</th>
<th>Toxin Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dolichospermum</em> (Anabaena)</td>
<td>Anatoxin, Saxitoxin</td>
<td>Neurotoxin</td>
</tr>
<tr>
<td></td>
<td>Microcystin, Cylindrospermopsin</td>
<td>Hepatotoxin</td>
</tr>
<tr>
<td><em>Aphanizomenon</em></td>
<td>Anatoxin, Saxitoxin</td>
<td>Neurotoxin</td>
</tr>
<tr>
<td></td>
<td>Cylindrospermopsin</td>
<td>Hepatotoxin</td>
</tr>
<tr>
<td><em>Planktothrix</em> (Oscillatoria)</td>
<td>Anatoxin</td>
<td>Neurotoxin</td>
</tr>
<tr>
<td></td>
<td>Cylindrospermopsin, Microcystin</td>
<td>Hepatotoxin</td>
</tr>
<tr>
<td><em>Cylindrospermopsis</em></td>
<td>Cylindrospermopsin</td>
<td>Hepatotoxin</td>
</tr>
<tr>
<td><em>Gloeotrichia</em></td>
<td>Microcystin</td>
<td>Hepatotoxin</td>
</tr>
<tr>
<td><em>Microcystis</em></td>
<td>Microcystin</td>
<td>Hepatotoxin</td>
</tr>
</tbody>
</table>

All species produce Lipopolysaccharides that can cause skin irritation.
Cyanotoxin Challenges

- Toxins can potentially pass through treatment systems.
- Toxin levels don’t often correlate with cell counts.
- Toxin sources may be located a considerable distance upstream of drinking water intakes.
- Oxidation and other treatment processes can lyse cells and potentially release toxins.
How Can You Tell if Toxins are Present?

Not This One

Not This One

Which one of these contain 72 ug/L of Microcystin-LR?
Salem’s Drinking Water
Source and System
What Happened in Salem?

- May 8, 2018 - Staff noticed an algal bloom on Detroit Lake
  - Staff increased sampling efforts and began toxin sampling

- On May 25 - Staff received data that indicated detection above Health Advisory levels
  - Staff held conference call with OHA; received information that EPA guidelines allow for 10-day “cushion” so utilities can make treatment adjustments and resample.
  - Operational changes made on May 25 and May 26 – switch to well water at Geren Island, activate ASR wells, activate Salem-Keizer intertie.

- May 27 – Large leak on Transmission Line #2 – went back to surface water to keep up with demand; daily sampling started.
- May 28 – Staff repairing Transmission Line #2
- May 29 – Conference call with OHA, EPA – Vulnerable Population Health Advisory issued in late afternoon
Salem’s Water System

1- River
2- Pre-treatment
3- Filtration
4- Disinfection & Fluoridation
5- Corrosion Control
6- Delivery
Challenges

- EPA Guidelines for two different groups with a 10-day exposure
- Communication with critical customers
- Emergency alerts and Public Notification Issues
- Water Distribution Sites
- Run on bottled water supplies
- Internal communications – arming staff with critical information
- Messaging for internal and external customers
- ELISA vs. LCMSMS
- Delay in receipt of data from contracted labs
Cylindrospermopsin Detections at Reservoir Outfalls

- S. Fork below Cougar
- Blue River @ McK Hwy
- MDL
- MRL
- Drinking Water (Adult)
- Drinking Water (Child)
- Rec GV (Humans)
- Rec GV (Dogs)

Concentration (µg/L)

Date:
- 5/14/18
- 6/3/18
- 6/23/18
- 7/13/18
- 8/2/18
- 8/22/18
Raw Water Results for Cylindrospermopsin

Date Sampled

Result in ug/L

0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

4/11/2018
4/18/2018
4/25/2018
5/2/2018
5/9/2018
5/16/2018
5/23/2018
5/30/2018
6/6/2018
6/13/2018
6/20/2018
6/27/2018
7/4/2018
7/11/2018
7/18/2018
7/25/2018
8/1/2018
8/8/2018
8/15/2018
8/22/2018
8/29/2018

EWEB
EWEB Treatment Response

• Turn off pre-chlorination

• Feed carbon into raw water basins

• Increase post filter chlorination
2018 Cyanotoxin Detections - McKenzie Subbasin

- McKenzie River at Hayden Bridge
- South Fork McKenzie River (below dam)
- Blue River (below dam)
- Flow Contribution of S. Fork and Blue River to McKenzie River at Hayden Bridge

Note: The OHA acute or short-term drinking water toxicity value for children 5 years and younger for cylindrospermopsin is .7 ug/L.
Cyanotoxin Monitoring Requirements
Oregon Health Authority
July 2018

Raw water (intake) monitoring:
Every 2 weeks
May 1 through October 31

No

Yes

Cyanotoxins
Equal to or greater
than 0.3 ug/L?

No

Yes

Recreational HAB Advisory upstream?

Entry Point monitoring: Within 24 hours, then weekly

Discontinue EP monitoring if cyanotoxins are ND at EP and less than 0.3 ug/L in raw water in two consecutive samples

Confimation EP sample within 24 hours and begin EP monitoring: Daily

Cyanotoxins detected at EP confirmation sample?

Yes, > or = to HAL

Yes, < to HAL*

No

EP monitoring: Daily

Return to weekly EP monitoring if ND in two consecutive samples

Criteria to lift advisory:
• Two consecutive daily EP samples below HAL and
• Two consecutive daily sets of distribution samples below HAL
  Once lifted, continue applicable raw and EP monitoring

• Issue Do-Not-Drink Advisory within 24 hours (water system and any purchasers)
• Begin distribution sampling: Daily (PWS and purchasers)
Warmer winters reduce snowpacks by 63-95%
Climate Change Impacts to SWE

- Loss of snow pack in 3,000’ to 4,500’ zone
  - 56% of volume of water currently stored as snow
  - Equivalent of two Cougar Reservoirs, or ~ 400,000 acre feet
  - More rain on snow events
- Peak spring snow melt/runoff happens 12 days earlier

Higher temps/longer dry Season = Increased HABs

(Sproles et. al., 2013)
Frequency of Occurrence

Standard Deviation – Extreme Hot Weather

(Hansen et. al., 2012)
Increasing frequency & scale of wildfires across the west

Wildfires appear to provide nutrient loads during winter flushing from storms.

Increased nutrients mean increased blooms
What Are We Doing?

• Research to increase understanding

• Multi-Faceted Monitoring Approach
  – New OHA rules = more data across OR

• Real-Time Assessment Tools

• Increasing Analytical Lab Capabilities

• Increasing Treatment Capabilities

• Interagency Coordination & Response
OSU/EWEB research project
To assess nutrient, carbon, Metals, bacteria loads.

Focusing on fall/early winter Storms

Require USFS assistance to gain access to areas for study
Harmful Algal Bloom Sampling – every 2 weeks
Multi-Faceted Monitoring

• Sample every 2 weeks at Cougar/Blue River reservoir & outfall, and EWEB intake
  – For nutrients, cell counts, cyanotoxins, organic carbon, and general WQ parameters
  – Toxin hits increase to weekly

• USGS SPATT deployments (leave in water for 30 days)

• Microscope ID/photograph
EWEB.ORG

McKenzie Water Quality Data

Web Portal
The McKenzie watershed water quality web portal provides partner agencies, researchers, watershed stakeholders and the interested public with data and information collected by the Eugene Water & Electric Board on the health of the McKenzie River, Eugene’s source of drinking water.

Water Quality Database
The database contains water quality data collected since the 1950s from 67 water quality monitoring locations to monitor baseline water quality and, more recently, storm events. Monitoring locations are distributed from the headwaters to the confluence of the McKenzie River, and also includes tributaries, stormwater conveyances, and power canals. Samples are analyzed for various water quality parameters that fall into the following broad groups: Bacteria/Algae, Emerging Contaminant, Major Ion, Metal, Nutrient, Pesticide, Petroleum Hydrocarbon, Semi-Volatile (SVOC) and Volatile Organic Compound (VOC) and General.

Please review the site disclaimer by clicking here.
Please visit our source protection program’s home page to learn more about our activities:
http://www.eweb.org/sourceprotection

Data Exploration
All data are available for viewing, exploration and download. Options include:

- Spatial depiction of monitoring locations and results (where was a parameter or parameter suite monitored or detected or did the parameter exceed a benchmark).
- Through charts and tables explore how often a parameter was monitored, detected or found to exceed a benchmark, with options to focus those queries by station, by parameter, by date and by benchmark.
- Through charts and tables explore by parameter or monitoring station, baseline water quality. Target queries through control of station, parameter (or suite), date and benchmark.
- Through charts and tables explore by parameter or monitoring station, storm event water quality. Target queries through control of station, parameter (or suite), storm event, and benchmark. Compare to available flow and precipitation data for that storm event.
- Download all or selected portions of the database in MS Excel format. Print charts and tables created during queries to Adobe pdf.

Click here to see links to the selected benchmarks used to evaluate EWEB’s water quality data.

Click here to see browser and system recommendations.
Real-Time Monitoring

• % flow from reservoirs at Vida (>30% triggers alarm at plant)

• WQ sondes at Vida and Hayden Bridge

• Future: Add floating WQ sonde in Cougar Reservoir for vertical monitoring
Example EEM showing fDOM region and selected fluorescence peaks

Content provided by Kurt Carpenter, USGS
Organic Carbon Study

Excitation-Emission Matrices (EEMs) of 5 types of McKenzie River Basin carbon sources

Content provided by Kurt Carpenter, USGS
Increased Analytical Capabilities

• EWEB WQ Lab increased its capabilities
  – Currently: **bacteria**, nutrients, UV254
  – Purchased ELISA equipment to analyze for **cyanotoxins**
  – Future: TOC & DOC

• Quick turnaround, ability to handle samples at moments notice, significantly reduced cost, good QA/QC
EWEB Water Treatment Options

Treatment Responses

1. Remove intact algal cells and prevent cell lysing
   - Stop pre-chlorination of raw water
   - Start coagulant aid
   - Increase backwash frequency

2. Reduce or remove algal toxins
   - Start powdered activated carbon
   - Increase chlorine residuals
   - Slowdown pumping to increase contact time

Piloting biofilter approach with U of T
Interagency Coordination

Preliminary thoughts around increased EWEB/ACOE Coordination:

- Weekly prediction on dam operations
- When algal blooms are occurring in reservoirs
- When blooms are producing cyanotoxins
  - Reduce quantity
  - Increase physical release point in Cougar
- EWEB access for more efficient monitoring
- Share data via web-based tools
Contact Karl Morgenstern at:
(541) 685-7365 or via e-mail Karl.morgenstern@eweb.org

www.eweb.org/sourceprotection