Cyanobacteria and Associated Compounds in the Kansas and Ohio Rivers

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KDHE Harmful Algal Blooms Stakeholder Meeting
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2011 Harmful Algal Blooms and Reservoir Releases in the Kansas River Watershed

Kansas River serves as a drinking water supply for 800,000 Kansans

Missouri River Flooding + Late Summer Reservoir Releases + Harmful Algal Blooms = Concerns About Transport of Cyanotoxins and Taste-and-Odor Compounds Potentially Affecting Drinking Water Supplies

Milford Lake, September 2011
Photo courtesy of E. Looper, USGS
Cyanobacterial Toxins and Taste-and-Odor Compounds May Be Transported for Relatively Long Distances Downstream from Lakes and Reservoirs

Graham and others, 2012

http://pubs.usgs.gov/sir/2012/5129/

SEPTEMBER 8, 2011

TOTAL MICROCYSTIN, IN MICROGRAMS PER LITER

WORLD HEALTH ORGANIZATION PROVISIONAL GUIDELINE FOR FINISHED DRINKING WATER

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT GUIDELINE FOR PUBLIC HEALTH WARNING

ANALYTICAL METHOD DETECTION LIMIT

DISTANCE UPSTREAM FROM CONFLUENCE WITH MISSOURI RIVER, IN MILES

WHO PROVISIONAL DRINKING-WATER GUIDELINE

ANALYTICAL DETECTION THRESHOLD
5 Year Study in the Kansas River - Objectives

- Characterize sources, frequency of occurrence, and potential causes of cyanobacteria and associated compounds in the Kansas River.

- Develop models to provide real-time estimates for a number of constituents, including cyanotoxins and taste-and-odor compounds.
Kansas River Study Sites
5 Year Study in the Kansas River - Approach

- Real-time water-quality monitors at USGS streamgages at Wamego and De Soto.

- Routine sample collection at these 2 sites about 18 times per year; reservoir outflows sampled during releases and cyanobacterial blooms.
Discrete Samples Have Been Collected Over a Range of Streamflow Conditions, Including Reservoir Releases
Cyanobacteria Rarely Dominated the Phytoplankton Community at Wamego During July 2012-November 2015

WAMEGO

Relative Abundance

Abundance

KDHE Guideline for Public Health Watch

KDHE Guideline for Public Health Warning

Cyanobacterial Abundance (cells per milliliter)
Cyanobacteria Were More Abundant at De Soto than Wamego, But Rarely Dominated the Phytoplankton Community During July 2012-November 2015

![Graph showing the relative abundance and abundance of cyanobacteria over time at De Soto. The graph includes data points for relative abundance and abundance, with KDHE guidelines for public health warning and watch indicated.]
Potential Microcystin and Taste-and-Odor Producers in the Kansas River July 2012-November 2015

Potential Taste-and-Odor Producers

- Anabaena, Aphanizomenon, Oscillatoria, Phormidium, Planktolyngbya, Pseudanabaena

- Present in 58% of samples (n=130) collected during July 2012-November 2015

Potential Microcystin Producers

- Anabaena, Anabaenopsis, Aphanocapsa, Microcystis, Oscillatoria, Phormidium, Planktolyngbya, Pseudanabaena

- Present in 48% of samples (n=130) collected during July 2012-November 2015
Geosmin was Detected More Frequently at the Kansas River Study Sites than Microcystin or MIB during July 2012-November 2015

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>% MC(^1) Detection</th>
<th>% MIB(^2) Detection</th>
<th>% GEOS(^2) Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wamego</td>
<td>73</td>
<td>23</td>
<td>44</td>
<td>71</td>
</tr>
<tr>
<td>De Soto</td>
<td>74</td>
<td>23</td>
<td>34</td>
<td>84</td>
</tr>
<tr>
<td>Republican</td>
<td>23</td>
<td>56</td>
<td>61</td>
<td>91</td>
</tr>
<tr>
<td>Big Blue</td>
<td>17</td>
<td>12</td>
<td>82</td>
<td>65</td>
</tr>
<tr>
<td>Delaware</td>
<td>22</td>
<td>8</td>
<td>64</td>
<td>95</td>
</tr>
<tr>
<td>Overall</td>
<td>209</td>
<td>27</td>
<td>47</td>
<td>81</td>
</tr>
</tbody>
</table>

\(^1\)Microcystin was analyzed by –adda specific ELISA with an analytical detection threshold of 0.1 µg/L

\(^2\)Geosmin and MIB were analyzed by GC/MS with an analytical detection threshold of 1.0 ng/L
Microcystin was Detected in 27% of Samples Collected at the Kansas River Study Sites from July 2012 through November 2016

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>MC &gt; 0.1 µg/L (n)</th>
<th>MC &gt; 0.3 µg/L (n)</th>
<th>MC &gt; 1.6 µg/L (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wamego</td>
<td>73</td>
<td>17</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>De Soto</td>
<td>74</td>
<td>17</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Overall</td>
<td>147</td>
<td>34</td>
<td>11</td>
<td>4</td>
</tr>
</tbody>
</table>
With the Exception of Late Summer 2012 and 2014, Microcystin Detections in the Kansas River Have Been Relatively Uncommon
Microcystin Occurrence in the Kansas River is Associated with *Microcystis*
Microcystin Occurrence in the Kansas River is Associated with Flow Contributions from Milford Reservoir Greater than 30%
MIB Dynamics Differed Among Sites and Relations with the Cyanobacterial Community and Flow Conditions were More Complex than Microcystin Relations
MIB Dynamics Differed Among Sites and Relations with the Cyanobacterial Community and Flow Conditions were More Complex than Microcystin Relations
Real-Time Water-Quality Notification System for the Kansas River

- Real-time water-quality notification systems have been successfully developed for Cheney Reservoir and recreational beaches in Ohio.

- Logistic regression models for the Kansas River have been developed for cyanobacterial abundance, geosmin, and microcystin.

- The report for the logistic regression models is in preparation for publication.

Kansas River Study - Next Steps

- Online publication of real-time water-quality models.
- Validation and verification of models through continued data collection.
- Final analyses for interpretive report for publication in 2017.
2015 Ohio River HAB Event

Greg Youngstrom
Environmental Scientist
ORSANCO

Erich Emery
Water Quality Specialist / Biologist
U.S. Army Corps of Engineers
Great Lakes & Ohio River Division
Reported ‘paint spill’ at ORM 84

Toxin concentration 41 ug/L

Identified as *Microcystis aeruginosa*
Week of 24-AUG

New Bloom Reports

Microcystis Aeruginosa cell counts up to 31,000,000 cells/ml

Toxin concentration 630 ug/L

30-SEP RAIN!!!
Algae visible at Newburgh L&D (ORM776)

Widespread reports of improving conditions in the upper river.
As of 29-OCT

Crews are gathering additional data to support lifting the remaining advisories.
Where To Sample?
Where To Sample?
Summer 2015 Monthly Precipitation Relative to Normal

May

June

July

August

September

Percent of Normal Rainfall (2015)

%  0.00 - 50.00
%  50.01 - 100.00
%  100.01 - 200.00
%  200.01 - 300.00
%  300.01 - 530.00
# Comparison of Events in the Kansas and Ohio Rivers

## Similarities

- Events that affect several hundred miles of river
- Microcystin produced by *Microcystis*
- Rainfall, runoff, and hydrology are important drivers

## Differences

- Flow regulation by upstream reservoirs (Kansas) vs. locks and dams (Ohio)
- Development of persistent surface scums in the Ohio River
- Concentrations of microcystin and *Microcystis* orders of magnitude higher on the Ohio River
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.

Scientific Investigations Report 2015–5120

U.S. Department of the Interior
U.S. Geological Survey

http://pubs.er.usgs.gov/publication/sir20155120
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Additional Information Available on the Web:
Real-Time Data - http://waterdata.usgs.gov/ks/nwis