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Cyanobacterial Blooms: Tastes, Odors, and Toxins

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U.S. Geological Survey

Oklahoma Clean Lakes and Watershed Association Meeting

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Overview

- Cyanobacterial Harmful Algal Blooms
- Cyanotoxins in Midwestern Lakes
  - Occurrence
  - Seasonality
  - Environmental Influences
- Treatment Options
  - Watershed Management
  - In-Lake Treatment
  - Drinking-Water Treatment

St. Johns River, Florida
Photo courtesy of J. Pinto

Ohio Recreational Area
Photo courtesy of L. Merchant-Masonbrink

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Cyanobacterial Harmful Algal Blooms

- Ecologic Concerns
  - Low dissolved oxygen
  - Fish kills
- Economic Concerns
  - Loss of recreational revenue
  - Taste and odor
    - Olfactory sensitivity to taste-and-odors at low concentrations (5-10 ng/L)
  - Added drinking water treatment costs
- Health Concerns
  - Toxicity
    - Cyanotoxins are on the EPA Contaminant Candidate List

Binder Lake, Iowa

Marion Reservoir, Kansas

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Cyanobacterial Toxins and Taste-and-Odor Compounds

	Hepatotoxins		Neurotoxins		Dermatoxins	Taste/Odor	
	CYL	MC	ANA	SAX		GEOS	MIB
Anabaena	X	X	X	X	X	X	?
Aphanizomenon	X	?	X	X	X	X	
Microcystis		X			X		
Oscillatoria/Planktothrix		X	X	X	X	X	X

Photos courtesy of A. St. Amand

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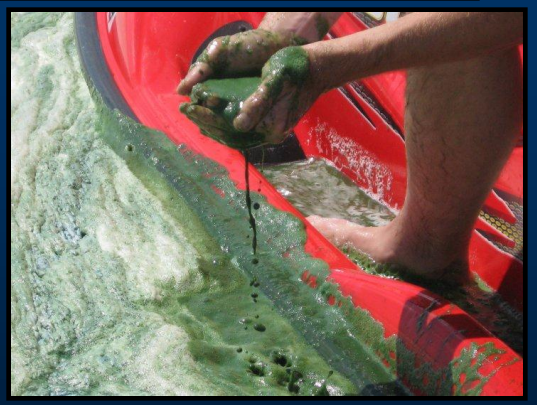
After Graham and others, 2008

Cyanotoxin Exposure

- Ingestion and inhalation during recreational activities (most likely)
  - WHO Guideline for microcystin-LR: 20 µg/L
- Inhalation of aerosolized toxins
- Consumption in drinking water
  - WHO Guideline for microcystin-LR: 1 µg/L

Do not try this at home (or anywhere else)!



Grand Lake St. Marys, Ohio
Source of Photos Unknown

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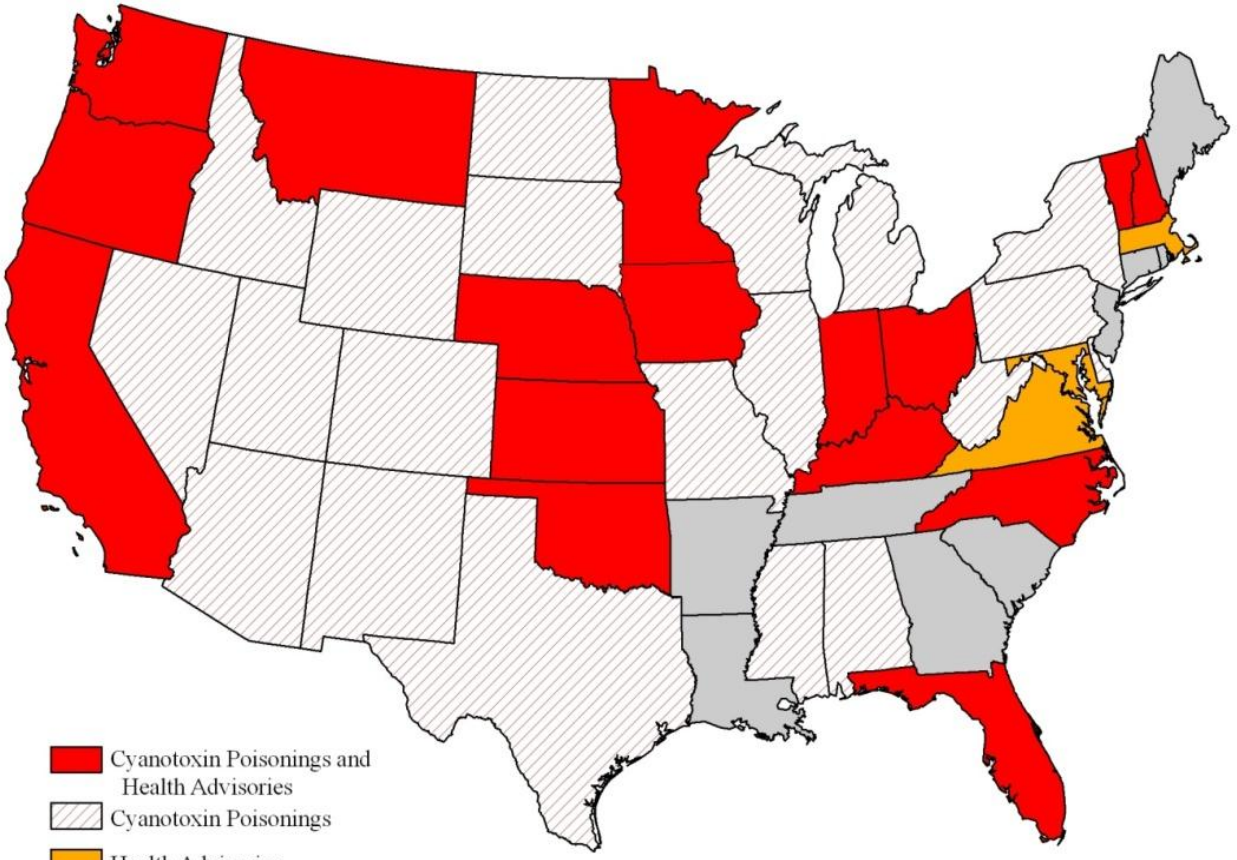
At Least 36 U.S. States Have Anecdotal Reports of Human or Animal Poisonings Associated with Cyanotoxins



After Graham and others, 2009

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Microcystins Are Common and Widespread in the United States, Particularly in the Midwest

33% of lakes had detections (n=1,028)

Maximum concentration: 230 µg/L

Median: <0.10 µg/L (0.52 µg/L*)

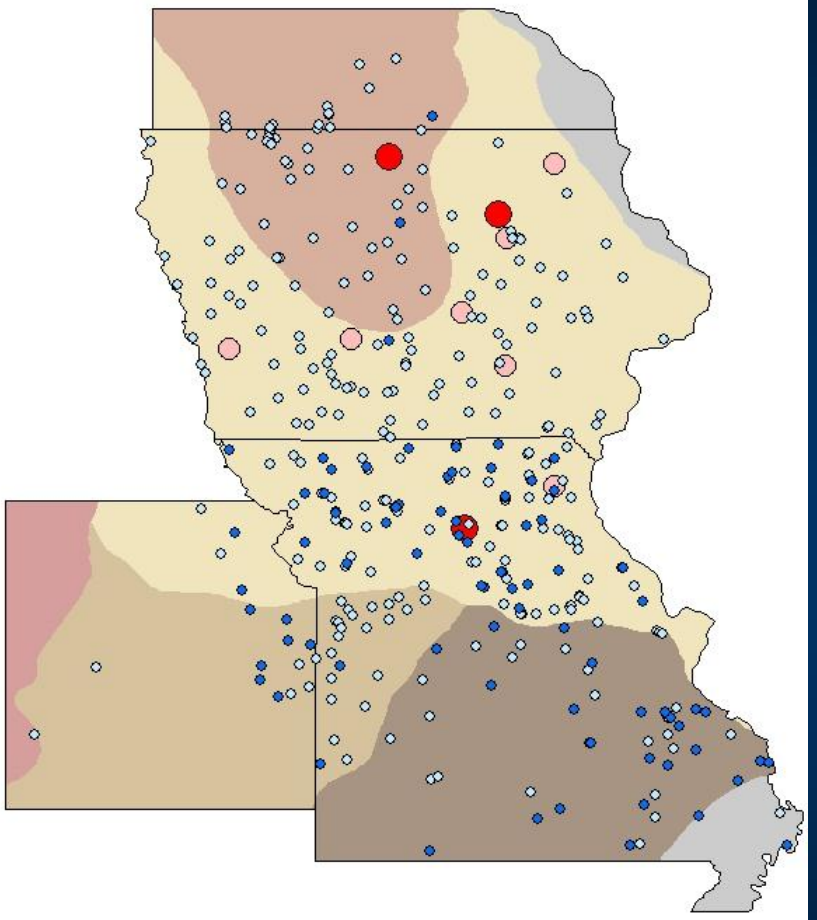
Mean: 1.0 µg/L (3.0 µg/L*)

*Detections only

Microcystins are Widespread and Common in the Midwest

OZARK HIGHLANDS (OH)
OSAGE PLAINS (OP)
DISSECTED TILL PLAINS (DT)
WESTERN LAKE (WL)
PLAINS BORDER (PB)

CONCENTRATION/RISK
- NOT DETECTED
- LOW (<10 ug/L)
- MODERATE (10-20 ug/L)
- HIGH (> 20 ug/L)

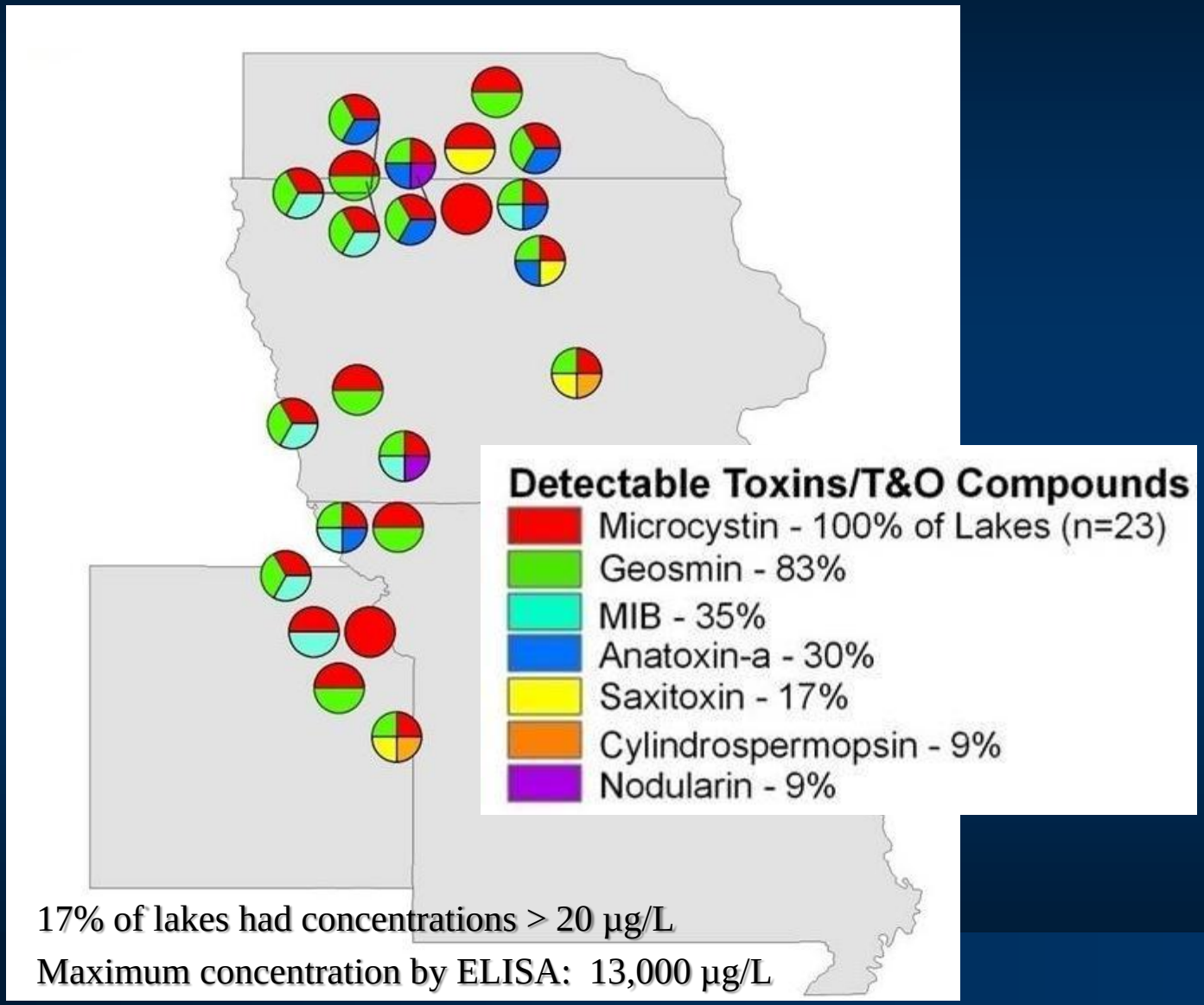


78% of lakes had detections (n=359)

Maximum concentration: 52 µg/L

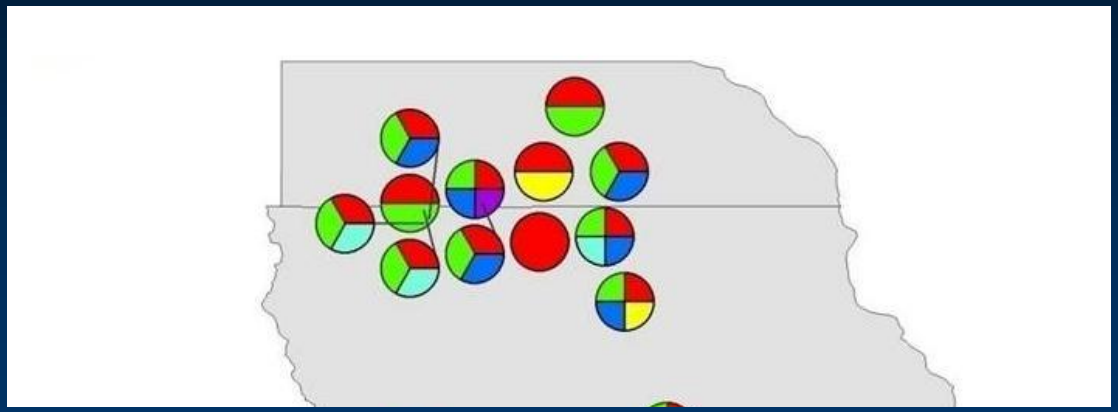
After Graham and others 2004, 2006, and 2009

Multiple Toxins and Taste-and-Odor Compounds Frequently Co-Occur in Cyanobacterial Blooms



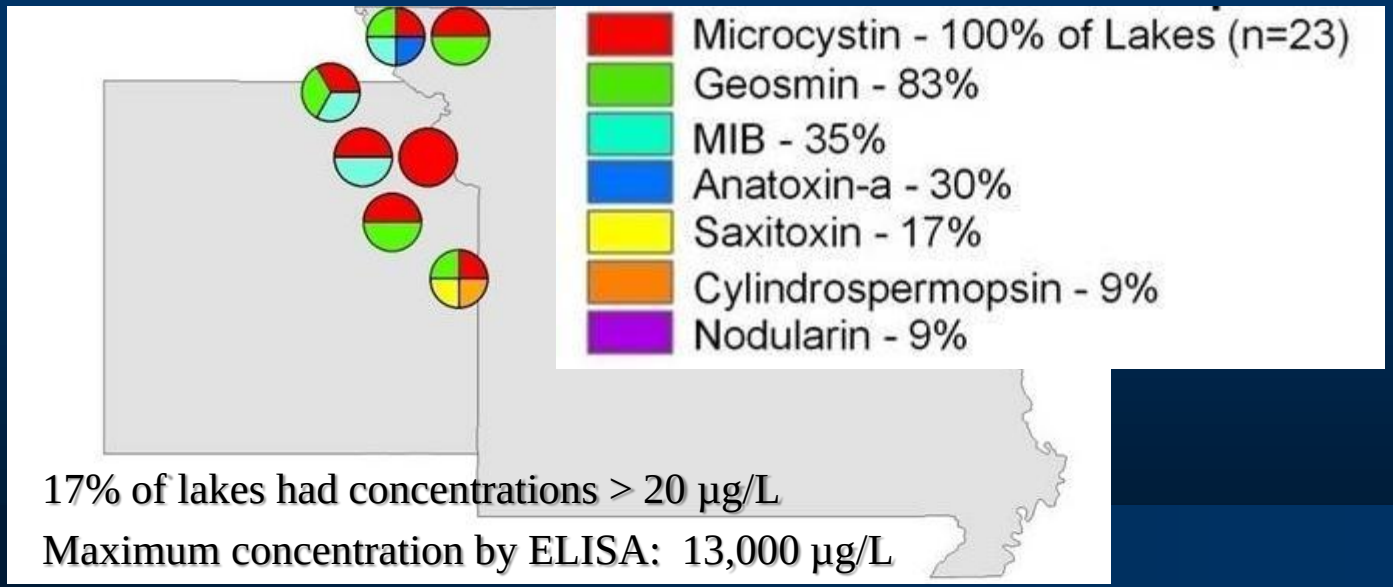
After Graham and others, 2010

Multiple Toxins and Taste-and-Odor Compounds Frequently Co-Occur in Cyanobacterial Blooms



"Algae may make for stinky water, but it poses no health risks"

-Concord Monitor, Concord, NH July 7, 2006

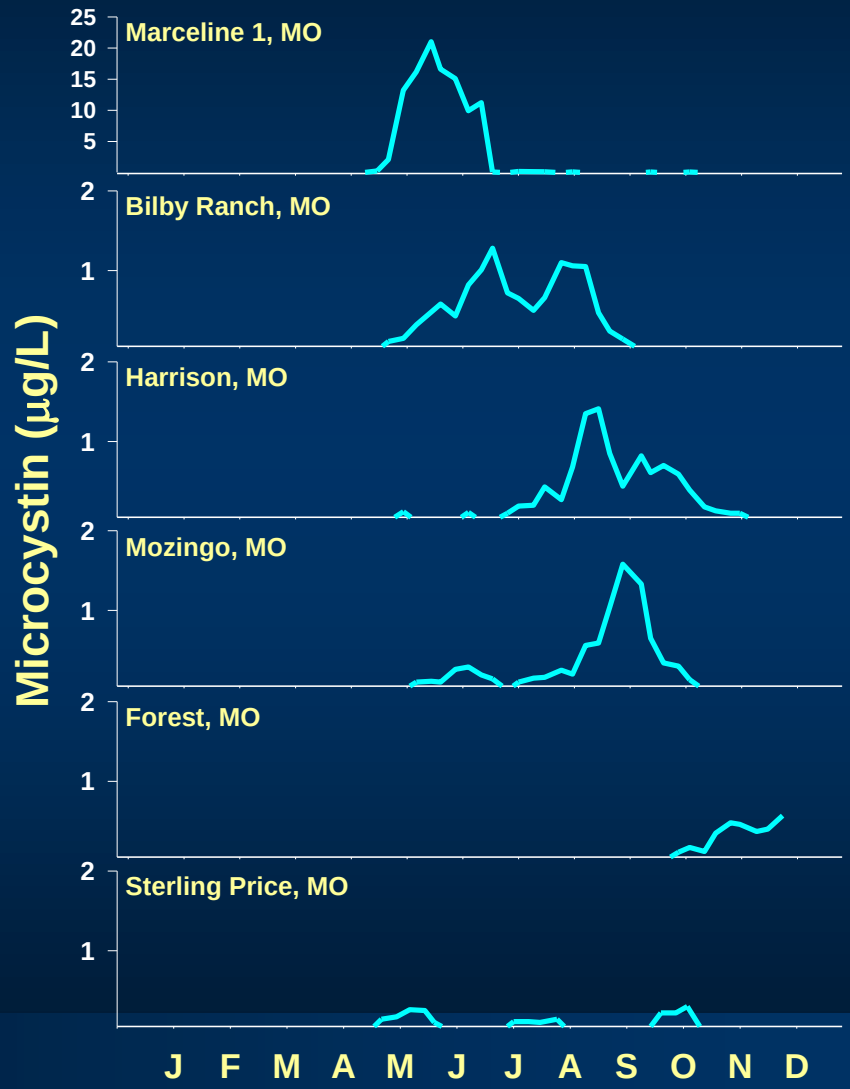


After Graham and others, 2010

Seasonal Patterns in Microcystin Concentration are Unique to Individual Lakes and Peaks May Occur Anytime Throughout the Year

Weatherby Lake, Missouri
January, 2007

Mozingo Lake, Missouri
October, 2001



After Graham and others, 2006

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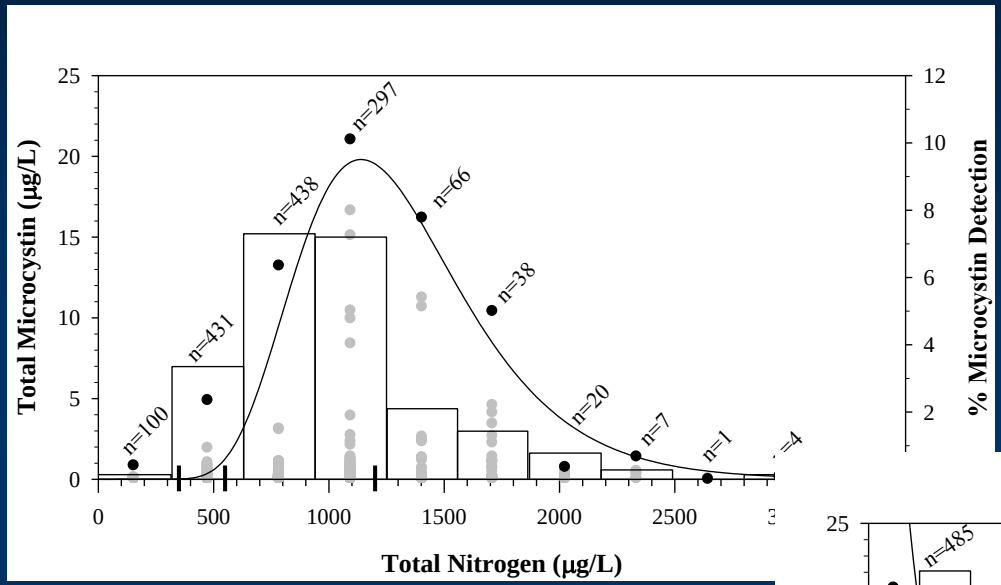
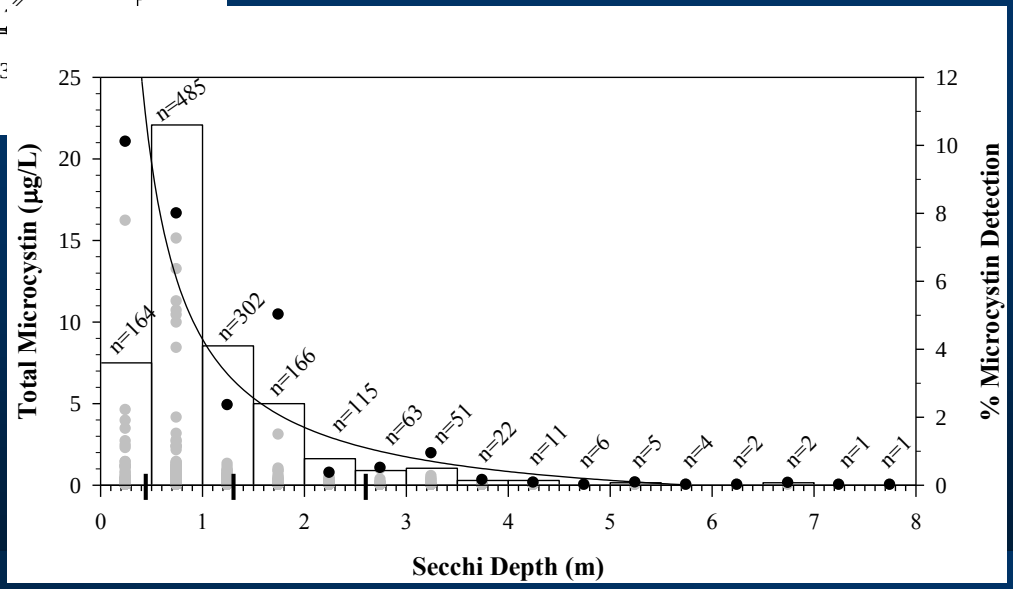
Regional Associations Between Microcystin and Environmental Variables Are Not Linear





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After Graham and Jones, 2009

There is No Single Environmental Variable that is Consistently Associated with Microcystin Occurrence and Concentration

Reservoir*	Strongest Correlate	r_s	p-value	n
Bilby	Conductance	-0.86	<0.01	48
Forest	Chlorophyll > 35 µm	0.67	<0.01	49
Harrison	Total Nitrogen	0.78	<0.01	49
Marceline	Dissolved Organic Carbon	0.66	<0.01	49
Mozingo	Magnesium	-0.84	<0.01	13
Nodaway	Nitrate	-0.46	<0.01	49
Paho	*Ceriodaphnia* abundance	0.81	<0.01	28
Sterling	Sodium	0.60	0.03	13

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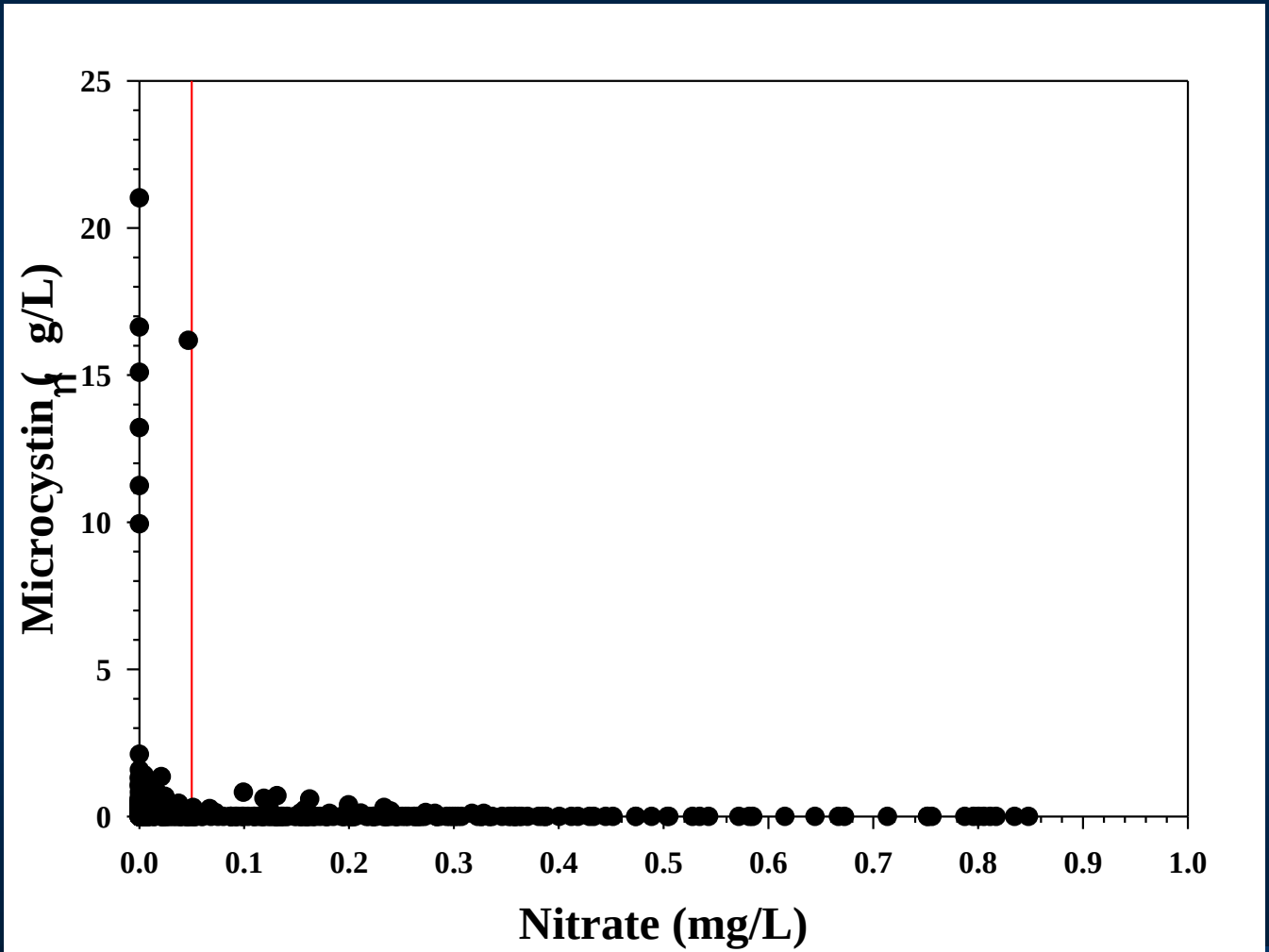
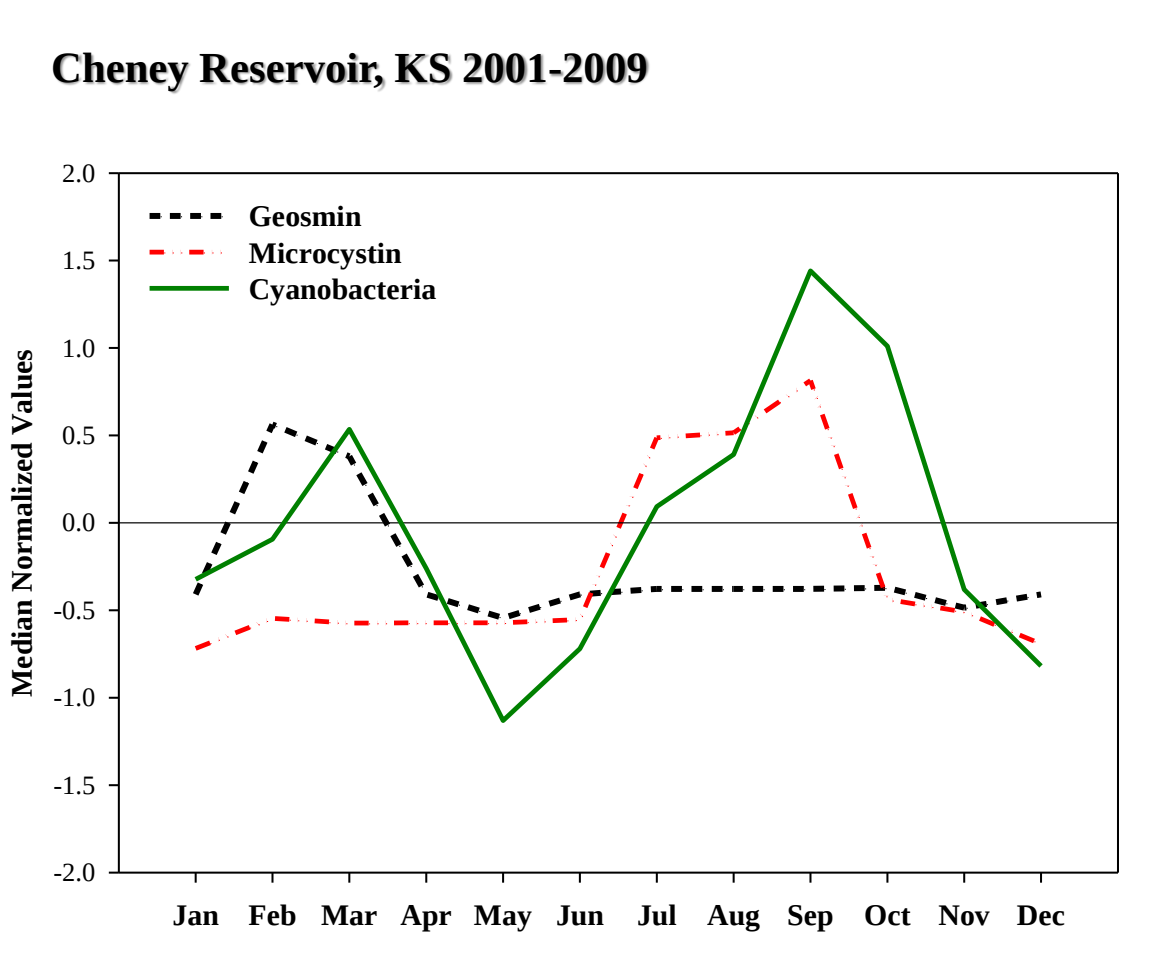
*Reservoirs were sampled weekly during January-December 2004

Nitrate was the Only Variable that Showed a Clear Among-Reservoir Pattern in Relation to Microcystin



Seasonal Patterns and Environmental Influences May Be Relatively Consistent Between Years in Some Lakes



Continuous Water-Quality Monitors Can Be Used to Develop Models to Compute Geosmin Concentrations in Real Time

Home | View Data | Methods | Constituents | Models | Bibliography | Links

NRTWQ Home >> Kansas >> View Data >> 07144790

Plot | Data Table | Statistics | Duration Curve | Site Info | Model Info

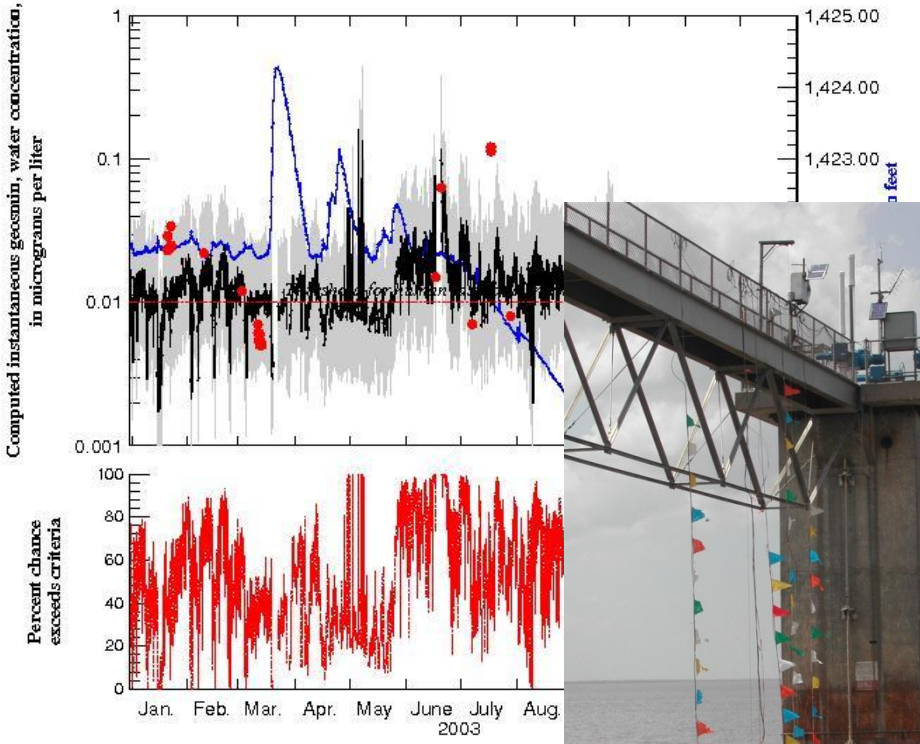
USGS station: 07144790 Cheney Reservoir near Cheney, KS — Go to NWISWeb

Constituent: Computed geosmin — concentration — hourly — < Go >

Time period:

- Elevation
- Specific conductance at 25 degrees Celsius
- pH
- Water temperature
- Turbidity, YSI model 6026
- Total chlorophyll
- Diss. oxygen
- Computed diss. solids
- Computed sodium
- Computed chloride
- Computed diss. nitrate + nitrite
- Computed diss. orthophosphorus
- Computed total org. N + NH3
- Computed total phosphorus
- Computed suspended sediment
- Computed total suspended solids
- Computed geosmin

Cheney Reservoir, KS



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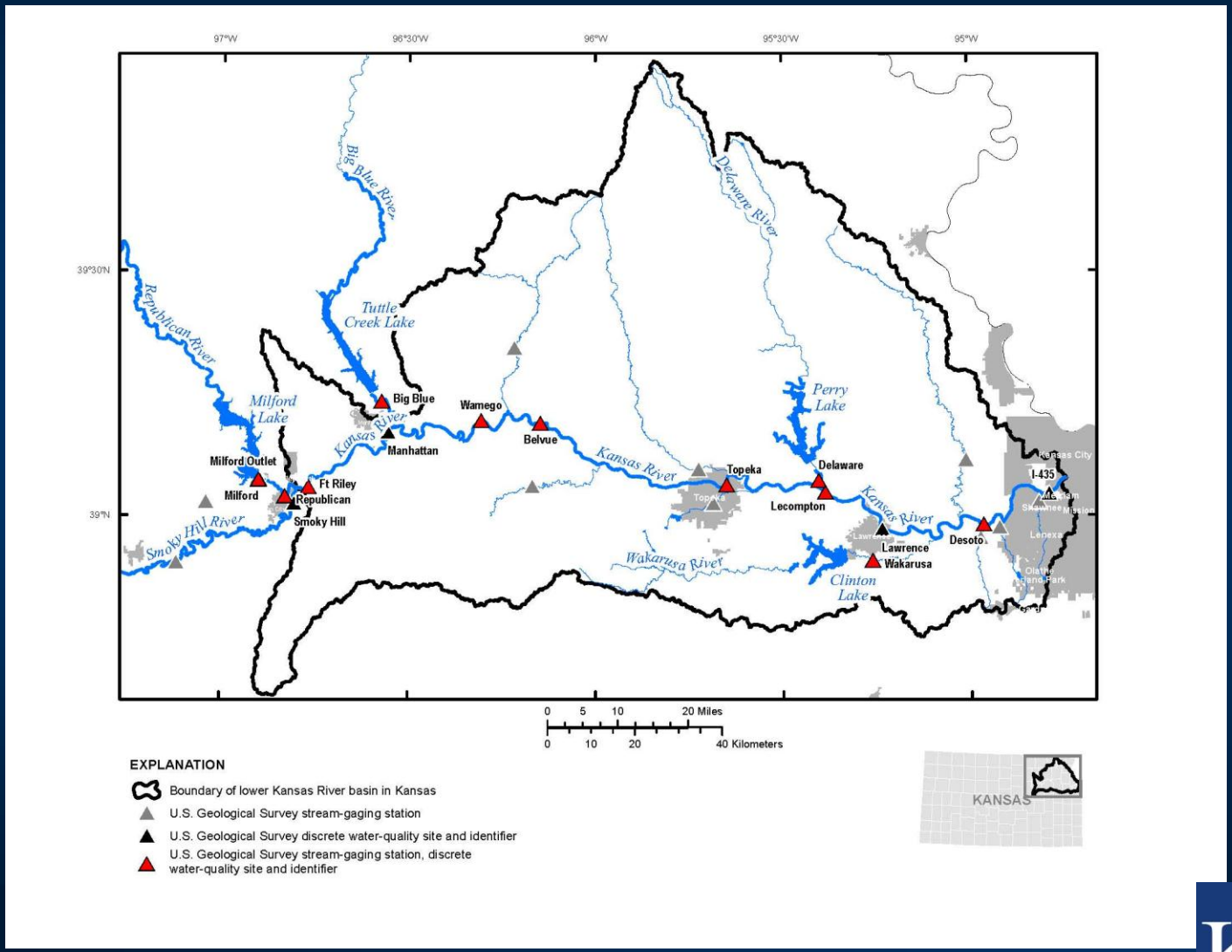
http://nrtwq.usgs.gov/ks/

Cyanobacterial Harmful Algal Blooms in Kansas During Summers 2010 and 2011 Resulted in Toxins and Taste-and-Odor Concerns in Surface-Water Supplies Used for Drinking Water, Including the Kansas River



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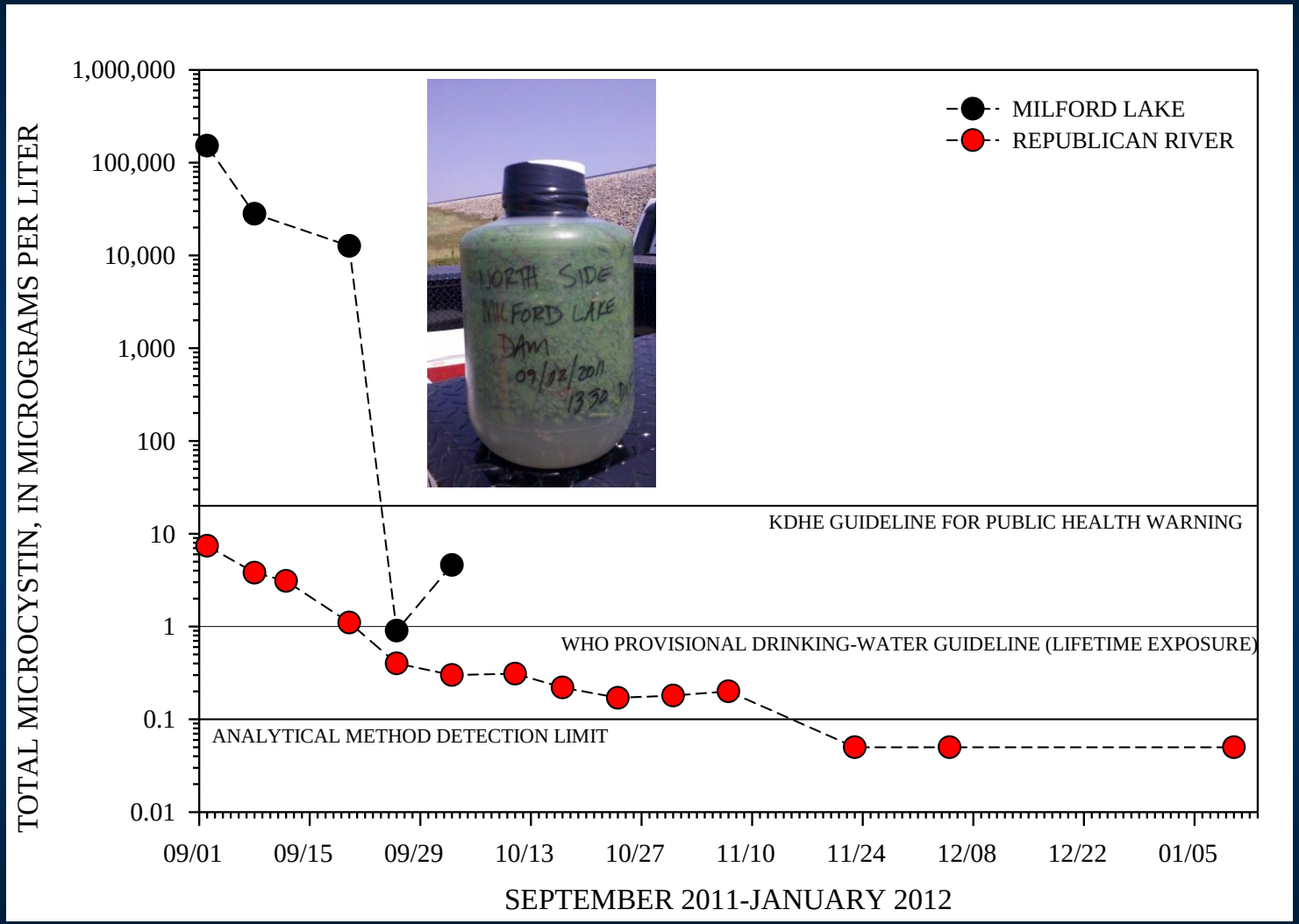
Kansas Water Office

Microcystins were Detected in the Republican River from September 2-November 7, 2011



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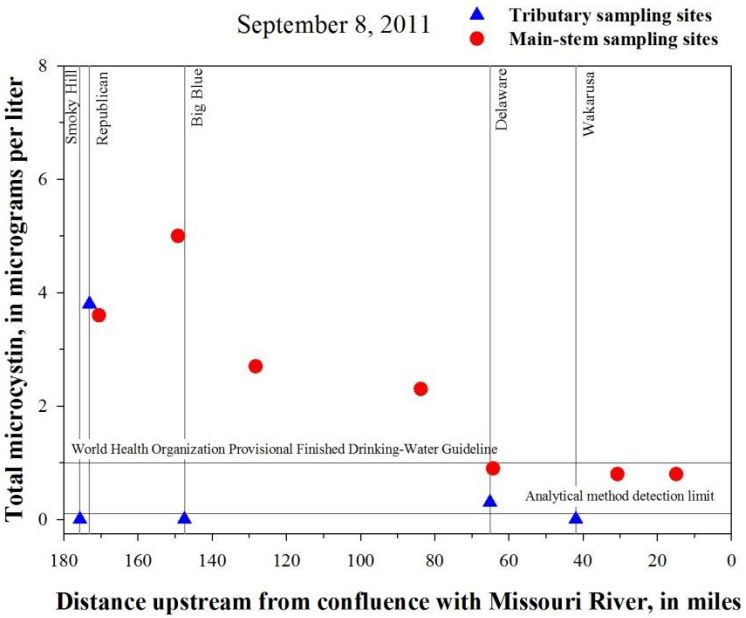
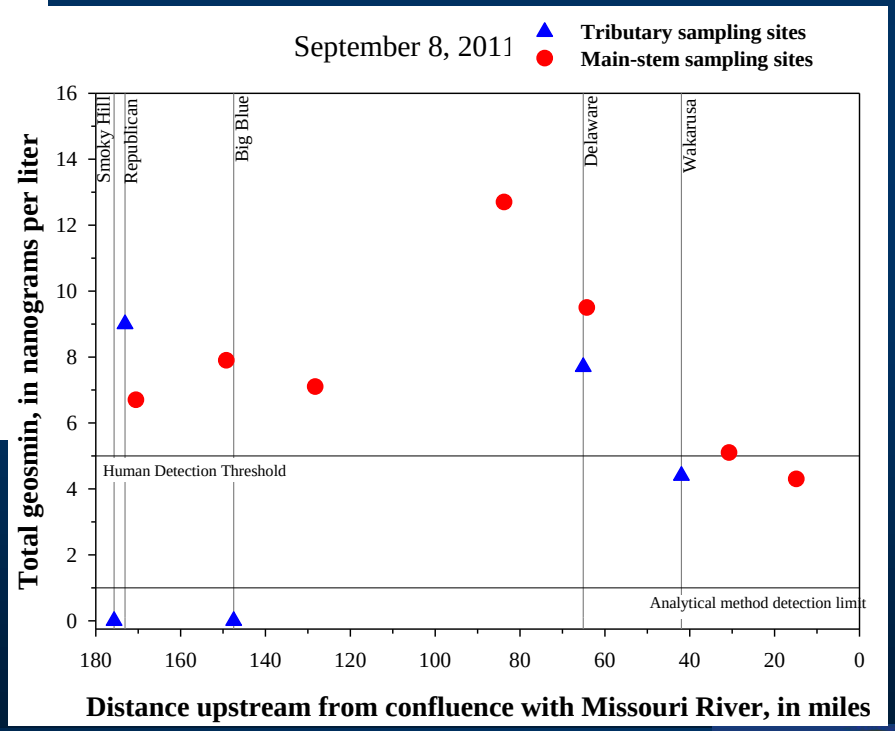
During September 2011, Toxins and Taste-and-Odor Compounds Were Detected Throughout A 160-Mile Reach of the Kansas River, from Just Downstream from Milford Reservoir to Kansas City, Kansas





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Kansas Water Office

Conclusions

- Cyanobacterial blooms and associated toxins and taste-and-odor compounds commonly occur throughout the United States.
- The cyanotoxin microcystin is common in the Midwest and may reach levels that can cause health concerns.
- Much more study is needed to develop reliable means of predicting and responding to cyanobacterial blooms to ensure public health protection.

Milford Lake, Kansas
September 2011

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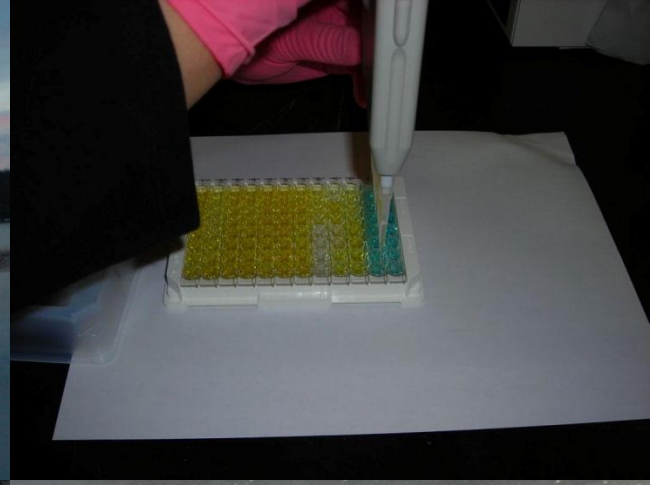



Additional Information:

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

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