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Kansas Water Science Center

Cyanobacterial (Blue-Green Algal) Blooms: Tastes, Odors, and Toxins

Freshwater and marine harmful algal blooms (HABs) can occur anytime water use is impaired due to excessive accumulations of algae. In freshwater, the majority of HABs are caused by cyanobacteria (also called blue-green algae). Cyanobacteria cause a multitude of water-quality concerns, including the potential to produce taste-and-odor causing compounds and toxins that are potent enough to poison animals and humans. Taste-and-odor compounds and toxins are of particular concern in lakes, reservoirs, and rivers that are used for either drinking water supplies or full body contact recreation. Taste-and-odor compounds cause malodorous or unpalatable drinking water and fish, resulting in increased treatment costs and loss of aquacultural and recreational revenue. Cyanobacterial toxins (cyanotoxins) have been implicated in human and animal illness and death in over fifty countries worldwide, including at least 35 U.S. States. Human toxicoses associated with cyanotoxins have most commonly occurred after exposure through drinking water or recreational activities.

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Status - Active

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Explore More Science:

Cyanobacteria may produce taste-and-odor compounds that cause malodorous or unpalatable drinking water. Cheney Reservoir, Kansas. June 2003. Photo Courtesy of KDHE.

Algal Toxins
Taste-and-odor
Harmful Algal Blooms (HAB) Research
Cyanobacteria
Water

water-quality concerns, including the potential to produce taste-and-odor causing compounds and toxins that are potent enough to poison animals and humans. Taste-and-odor compounds and toxins are of particular concern in lakes, reservoirs, and rivers that are used for either drinking water supplies or full body contact recreation. Taste-and-odor compounds cause malodorous or unpalatable drinking water and fish, resulting in increased treatment costs and loss of aquacultural and recreational revenue. Cyanobacterial toxins (cyanotoxins) have been implicated in human and animal illness and death in over fifty countries worldwide, including at least 35 U.S. States. Human toxicoses associated with cyanotoxins have most commonly occurred after exposure through drinking water or recreational activities.

"Taste-and-odor producing cyanobacteria Cyanobacteria may also produce toxins that are potent enough to poison humans and animals such as cattle and dogs. Mozingo Lake, Missouri. October 2001. Photo by J. L. Graham.

The cyanobacterial compounds most commonly associated with taste-and-odor episodes are geosmin and 2-methylisoborneol (MIB). Cyanobacteria also produce a chemically and bioactively diverse group of toxins, all targeting fundamental cellular processes and thereby affecting a wide range of organisms. Cyanotoxins implicated in human illness include microcystin, cylindrospermopsin, anatoxin, saxitoxin, and β-methylamino alanine (BMAA) Kansas Department of Health and Environment. Because of potential human health risks, cyanotoxins are currently on the U.S. Environmental Protection Agency drinking water contaminant candidate list (CCL).

Although anecdotal reports are common, few studies have documented the distribution, occurrence, and concentration of taste-and-odor compounds and toxins in cyanobacterial blooms throughout the United States. In addition, while the general factors influencing cyanobacterial bloom formation are well known the specific factors driving particular occurrences of taste-and-odor compounds and toxins remain unclear. Taste-and-odor compounds and cyanotoxins represent both economic and public-health concerns and resource managers, drinking water treatment plant operators, lake associations, and local officials are increasingly faced with decisions about cyanobacteria that affect public awareness, exposure, and health. Understanding the environmental factors associated with the occurrence and concentration of taste-and-odor compounds and cyanotoxins is key to lake

management and drinking water treatment decisions and minimization of human health risks.

Current Studies

Cheney Reservoir

Severe taste-and-odor episodes in Cheney Reservoir, a key drinking water supply for the city of Wichita, Kansas, during the early 1990's prompted water-quality studies to identify and mitigate potential causes. Recent USGS studies have focused on real-time estimation of water-quality constituent concentrations and transport from the watershed and the description of in-reservoir conditions that may result in cyanobacterial production of taste-and-odor compounds. The taste-and-odor compound geosmin, probably produced by the cyanobacterial genera *Anabaena*, is the likely cause of taste-and-odor episodes in Cheney Reservoir. Continuously monitored variables, such as light, temperature, conductivity, and turbidity have been used to successfully predict when geosmin concentrations will exceed the human detection limit of 10 nanograms per liter (view real-time estimates of geosmin concentrations in Cheney Reservoir). Ongoing studies at Cheney Reservoir will link biological, physicochemical, hydrological, and meteorological processes to refine relations to estimate taste-and-odor occurrences and develop new relations with other variables of concern, such as cyanotoxins. The city of Wichita plans to use these models, along with other variables measured in real time, to aid the management of the resource and decrease water-treatment costs.

Cyanobacteria may form thick accumulations in near-shore areas. Binder Lake, Iowa. August 2006. Photo by J. L. Graham

"Taste-and-odor producing cyanobacteria bloom in Cheney Reservoir, south-central Kansas. Cheney Reservoir, Kansas. June 2003. Photo Courtesy of KDHE.

Kansas River

Cyanobacteria (also called blue-green algae)

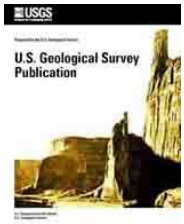
may produce toxins and taste-and-odor compounds that cause substantial economic and public health concerns, and are of particular interest in lakes, reservoirs, and rivers that are used for drinking-water supply. The Kansas River is a primary source of drinking water for about 800,000 people in northeastern Kansas. The sources, frequency of occurrence, and causes of cyanobacteria and associated toxins and taste-and-odor compounds in the Kansas River have not been fully characterized. The development of an advance notification system of changing water-quality conditions and cyanotoxin and taste-and-odor occurrences will allow drinking-water treatment facilities time to develop and implement adequate treatment strategies.

Blue-green algae on the Kansas River.(Public domain.)

The USGS Organic Geochemistry Research Laboratory (OGRL)

The OGRL has a USGS approved GC/MS method for the analysis of the taste-and-odor compounds geosmin and 2-methylisoborneol (MIB). In addition, the lab currently analyzes for the cyanotoxin microcystin using enzyme-linked immunosorbent assays (ELISA). Methods are being developed for the LC/MS/MS analysis of cyanotoxins including microcystins, anatoxin, cylindrospermopsin, and β -methylamino alanine (BMAA).

Below are publications associated with this project.



Year Published: 2015

National Field Manual for the Collection of Water-Quality Data. U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9

The mission of the Water Resources Discipline of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems....

AA

Attribution: Kansas Water Science Center, Water Resources

Year Published: 2014

Experimental manipulation of TN:TP ratiossuppress cyanobacterial biovolume and microcystinconcentration in large-scale in situ mesocosms

A global dataset was compiled to examine relations between the total nitrogen to total phosphorus ratio (TN:TP) and microcystin concentration in lakes and reservoirs. Microcystin concentration decreased as TN:TP ratios increased, suggesting that manipulation of the TN:TP ratio may reduce microcystin concentrations. This relationship was...

Harris, Theodore D.; Wilhelm, Frank M.; Graham, Jennifer L.; Loftin, Keith A.
Attribution: Kansas Water Science Center, Water Resources

View Citation

Year Published: 2014

Experimental additions of aluminum sulfate and ammonium nitrate to in situ mesocosms to reduce cyanobacterial biovolume and microcystin concentration

Recent studies suggest that nitrogen additions to increase the total nitrogen:total phosphorus (TN:TP) ratio may reduce cyanobacterial biovolume and microcystin concentration in reservoirs. In systems where TP is >100 µg/L, however, nitrogen additions to increase the TN:TP ratio could cause ammonia, nitrate, or nitrite toxicity to...

Harris, Ted D.; Wilhelm, Frank M.; Graham, Jennifer L.; Loftin, Keith A.
Attribution: Kansas Water Science Center

Year Published: 2014

Land use patterns, ecoregion, and microcystin relationships in U.S. lakes and reservoirs: a preliminary evaluation

A statistically significant association was found between the concentration of total microcystin, a common class of cyanotoxins, in surface waters of lakes and reservoirs in the continental U.S. with watershed land use using data from 1156 water bodies sampled between May and October 2007 as part of the USEPA National Lakes Assessment. Nearly two...

Beaver, John R.; Manis, Erin E.; Loftin, Keith A.; Graham, Jennifer L.; Pollard, Amina I.; Mitchell, Richard M.
Attribution: Kansas Water Science Center, Water Resources, Environmental Health, Ecosystems, Toxic Substances Hydrology Program

View Citation

Year Published: 2013

Relations between DNA- and RNA-based molecular methods for cyanobacteria and microcystin concentration at Maumee Bay State Park Lakeside Beach, Oregon, Ohio, 2012

Water samples were collected from Maumee Bay State Park Lakeside Beach, Oregon, Ohio, during the 2012 recreational season and analyzed for selected cyanobacteria gene sequences by DNA-based quantitative polymerase chain reaction (qPCR) and RNA-based quantitative reverse-transcription polymerase chain reaction (qRT-PCR). Results from the four DNA...

Stelzer, Erin A.; Loftin, Keith A.; Struffolino, Pamela
Attribution: Kansas Water Science Center, Ohio-Kentucky-Indiana Water Science Center, Water Resources, Region 1: North Atlantic-Appalachian

View Citation

Year Published: 2013

A review on cylindrospermopsin: the global occurrence, detection, toxicity and degradation of a potent cyanotoxin

Cylindrospermopsin is an important cyanobacterial toxin found in water bodies worldwide. The ever-increasing and global occurrence of massive and prolonged blooms of cylindrospermopsin-producing cyanobacteria poses a potential threat to both human and ecosystem health. Its toxicity is associated with metabolic activation and may involve mechanisms...

de la Cruz, Armah A.; Hiskia, Anastasia; Kaloudis, Triantafyllos; Chernoff, Neil; Hill, Donna; Antoniou, Maria G.; He, Xuexiang; Loftin, Keith; O'Shea, Kevin; Zhao, Cen; Pelaez, Miguel; Han, Changseok; Lynch, Trevor J.; Dionysiou, Dionysios D.
Attribution: Kansas Water Science Center, Water Resources

View Citation

Year Published: 2013

Model documentation for relations between continuous real-time and discrete water-quality constituents in Cheney Reservoir near Cheney, Kansas, 2001--2009

Cheney Reservoir, located in south-central Kansas, is one of the primary water supplies for the city of Wichita, Kansas. The U.S. Geological Survey has operated a continuous real-time water-quality monitoring station in Cheney Reservoir since 2001; continuously measured physicochemical properties include specific conductance, pH, water temperature...

Stone, Mandy L.; Graham, Jennifer L.; Gatotho, Jackline W.
Attribution: Kansas Water Science Center, Water Resources

View Citation

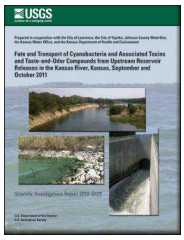
Year Published: 2013

Initial results from a reconnaissance of cyanobacteria and associated toxins in Illinois, August--October 2012

Ten lakes and two rivers in Illinois were sampled in August–October 2012 to determine the concentrations and spatial distribution of cyanobacteria and associated cyanotoxins throughout the State. The reconnaissance was a collaborative effort of the U.S. Geological Survey and the Illinois Environmental Protection Agency. Sample results indicated...

Terrio, Paul J.; Ostrodka, Lenna M.; Loftin, Keith A.; Good, Gregg; Holland, Teri
Attribution: Kansas Water Science Center, Central Midwest Water Science Center, Water Resources, Region 4: Mississippi Basin

View Citation



Year Published: 2012

Fate and transport of cyanobacteria and associated toxins and taste-and-odor compounds from upstream reservoir releases in the Kansas River, Kansas, September and October 2011

Cyanobacteria cause a multitude of water-quality concerns, including the potential to produce toxins and taste-and-odor compounds. Toxins and taste-and-odor compounds may cause substantial economic and public health concerns and are of particular interest in lakes, reservoirs, and rivers that are used for drinking-water supply, recreation, or...

Graham, Jennifer L.; Ziegler, Andrew C.; Loving, Brian L.; Loftin, Keith A.
Attribution: Kansas Water Science Center, Water Resources

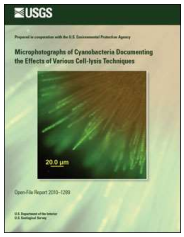
View Citation

Year Published: 2011

Relations between hydrology, water quality, and taste-and-odor causing organisms and compounds in Lake Houston, Texas, April 2006-September 2008

Lake Houston is a surface-water-supply reservoir and an important recreational resource for the city of Houston, Texas. Growing concerns over water quality in Lake Houston prompted a detailed assessment of water quality in the reservoir. The assessment focused on water-quality constituents that affect the aesthetic quality of drinking water. The...

Beussink, Amy M.; Graham, Jennifer L.
Attribution: Oklahoma-Texas Water Science Center, Kansas Water Science Center, Water Resources, Region 6: Arkansas-Rio Grande-Texas-Gulf



Year Published: 2011

Microphotographs of cyanobacteria documenting the effects of various cell-lysis techniques

Cyanotoxins are a group of organic compounds biosynthesized intracellularly by many species of cyanobacteria found in surface water. The United States Environmental Protection Agency has listed cyanotoxins on the Safe Drinking Water Act's Contaminant Candidate List 3 for consideration for future regulation to protect public health. Cyanotoxins...

Rosen, Barry H.; Loftin, Keith A.; Smith, Christopher E.; Lane, Rachael F.; Keydel, Susan P.
Attribution: Kansas Water Science Center, Water Resources, Environmental Health, Ecosystems, Toxic Substances Hydrology Program

View Citation

Year Published: 2010

Cyanotoxin mixtures and taste-and-odor compounds in cyanobacterial blooms from the midwestern united states

The mixtures of toxins and taste-and-odor compounds present during cyanobacterial blooms are not well characterized and of particular concern when evaluating potential human health risks. Cyanobacterial blooms were sampled in twenty-three Midwestern United States lakes and analyzed for community composition, thirteen cyanotoxins by liquid...

Graham, Jennifer L.; Loftin, Keith A.; Meyer, Michael T.; Ziegler, Andrew C.
Attribution: Kansas Water Science Center, Environmental Health, Ecosystems, Toxic Substances Hydrology Program

View Citation

Below are multimedia items associated with this project.

JULY 25, 2016

Spatiotemporal Variability of Cyanobacterial Harmful Algal Blooms

Spatiotemporal Variability of Cyanobacterial Harmful Algal Blooms with Respect to Changing Environmental Conditions

Attribution: *Kansas Water Science Center*

JULY 25, 2016

Preliminary Assessment of Cyanotoxin Occurrence in Lakes and Reservoir

Attribution: Kansas Water Science Center

Below are partners associated with this project.

Kansas Department of Health and Environment: Advisories / Warnings