Abstracts

Wednesday, April 30

Session G4: Detecting and Predicting Cyanotoxins

10:00 – 11:30 am | Room 237

Long-term and Seasonal Trends in Phosphorus Loading to Lake Erie: Links to Harmful Algal Blooms with Insights from 2011 and 2012

Laura Johnson[1], David Baker[1], R. Peter Richards[1], Richard Stumpf[2], Aaron Roerdink[1], Remegio Confesor[1], Jack Kramer[1], Ellen Ewing[1] and Barbara Merryfield[1]
[1]*Heidelberg University, Tiffin, Oh.*, [2]*National Oceanic and Atmospheric Administration, Silver Spring, Md.*

Abstract
Historically, cultural eutrophication of Lake Erie was a major concern, and through efforts by the United States and Canada starting with the Great Lakes Water Quality Agreement, western Lake Erie became less eutrophic by the mid-1990s. However, over the past decade Lake Erie has been experiencing a recurrence of harmful algal blooms (HABs) in the western basin and an increase in hypoxia in the central basin. The National Center for Water Quality Research at Heidelberg University has been monitoring major tributaries to Lake Erie for up to 38 years. In the agricultural watersheds (*e.g.*, Maumee and Sandusky rivers), long-term trends in loads and concentrations indicate that total phosphorus (TP), which consists of particulate and dissolved P, has decreased since the mid-1970s, whereas dissolved reactive P (DRP) has been increasing drastically since the mid-1990s. Trends in the Cuyahoga River, which is dominated by point-source inputs of P, are quite different - TP and DRP decreased in the mid-1980s and have since leveled off. Thus, increased DRP and HABs appear to be associated with recent patterns in agriculture such as surface broadcasting of fertilizers, build-up of P at the soil surface, unnecessary fertilizer application, increased soil compaction from large equipment, and increased tile drainage intensity. By comparing P loading and HABs in 2011 and 2012, we've gained insight into the potential response of Lake Erie to reduced P loading. In 2011, the HAB in Lake Erie was the largest on record, largely attributed to record-breaking spring P export from the Maumee River followed by abnormally warm and calm lake conditions. In contrast, 2012 had one of the worst droughts in decades. Subsequently, spring P loading from the Maumee River was very low and the 2012 HAB in Lake Erie was minor. On an annual timescale, DRP loading was similar between 2011 and 2012, indicating that timing of DRP loading drives Lake Erie HAB formation. The 2011/2012 comparison also indicates that the Western Basin can respond rapidly to decreased P inputs. Thus, management practices that decrease P runoff (*e.g.*, the 4R concept) should help reduce the occurrence of HABs in Lake Erie.

Understanding and Predicting Harmful Cyanobacterial Algal Blooms at Lake Erie and Ohio Inland Beaches

Erin A. Stelzer, Chris D. Ecker and Donna S. Francy
US Geological Survey, Columbus, Oh.

Abstract
Harmful algal blooms (HABs) have become a water-quality issue at some of Ohio's inland lakes and along the Lake Erie shoreline. The HABs are caused by cyanobacteria (blue-green algae) that produce microcystin and other toxins. For toxin production to occur, the microcystin synthetase genes (*mcy*) must be present in the genome of toxic strains. Monitoring for cyanobacteria genes and the *mcy* genes, which can be detected by molecular methods such as quantitative polymerase chain reaction (qPCR), and for algal pigments using optical sensors may provide an early warning system for HABs. These include sensors based on the fluorescent properties of chlorophyll (indicative of total phytoplankton abundance) and phycocyanin (indicative of cyanobacterial abundance).

The U.S. Geological Survey (USGS), in cooperation with state and local agencies, collected data over a recreational season (May–October, 2013) to better understand the links among cyanobacteria community structure, environmental and water-quality factors, and HAB toxicity. Samples were collected at 8 Lake Erie and inland lake beaches weekly to monthly from several locations within each designated swimming area. Field crews measured specific conductance, dissolved oxygen, pH, temperature, chlorophyll, phycocyanin, and Secchi depth at the time of sampling. Composite samples were preserved and subsequently analyzed for dissolved and total nutrients, cyanotoxins, phytoplankton abundance and community structure, and cyanobacteria and *mcy* genes by qPCR. Preliminary results from 2013 will be presented including information on what genera of cyanobacteria cause HABs and the concentrations of various toxins produced by cyanobacteria at Ohio beaches. Comparisons between DNA-based qPCR methods (which reveal the presence of toxin genes) and RNA-based methods (which can detect microcystin-producing cyanobacteria that are actively expressing the toxin genes) will also be presented. This project will provide data on the potential use of qPCR assays, sensor measurements, or other water-quality or environmental variables to provide an early warning of HAB development in freshwater lakes.

Development of a Molecular Toolbox for Analyses of Bloom-Forming and Toxin-Producing Cyanobacteria in Upper Klamath Lake, Oregon

Sara Eldridge
US Geological Survey, Klamath Falls, Oreg.

Abstract
Upper Klamath Lake (UKL), Oregon, experiences a seasonal progression of cyanobacteria-dominated and toxic blooms, creating poor water quality that may be detrimental to endangered fish species. A recent U.S. Geological Survey (USGS) study of microcystin concentrations, produced primarily by *Microcystis aeruginosa*, and associated nutrient concentrations and ratios, indicated that microcystin occurrence in UKL was associated with the decline of the first major bloom of non-toxin-producing *Aphanizomenon flos-aquae* during the 2007 through 2009 field seasons and highlighted the importance of understanding the ecological interactions between phytoplankton species for predicting periods of elevated cyanotoxin concentrations. Since 2010, the USGS long-term water quality monitoring program has also included sample collection for the identification and enumeration of phytoplankton species to support microcystin monitoring in the lake and to provide data necessary for validating phycocyanin probe data. Analysis of these samples has been only through microscopic counts, which is time-consuming, subject to a high degree of error for certain groups (particularly *Microcystis* because of the low frequency and irregular morphology of the colonies in UKL), and cannot be used to determine which cells are potentially toxigenic. DNA-based molecular methods provide rapid and sensitive diagnoses for the presence of toxigenic or potentially toxigenic cyanobacteria and are valuable tools for biomass estimations and general ecological studies. Molecular methods can also be used to simultaneously address spatial and temporal variation and under different conditions. The UKL molecular toolbox includes a multilevel approach for the rapid analysis of the cyanobacterial community structure and the detection of microcystin-producing strains in water samples with the following levels of sensitivity: 1) quantitative analysis of the cyanobacterial community structure using DNA sequencing, 2) rapid detection and quantification of toxic and nontoxic strains of *Microcystis aeruginosa* using PCR and qPCR, and 3) quantification of total cyanobacteria and species of interest using qPCR, and determination of the relative abundance ratios of total cyanobacteria to specific taxonomic groups, species of interest, and toxin producers. With modification, these techniques can be applied to different sample types (water, sediment, tissue) and, overall, provide a more cost-effective means of surveying phytoplankton species for routine monitoring than by microscopy alone.

Estimating Geosmin and Microcystin Occurrences with Real-Time Water-Quality Monitors, Cheney Reservoir, Kansas, 2001-2012

Jennifer Graham and Mandy Stone
US Geological Survey, Lawrence, Kans.

Abstract

Cheney Reservoir, a primary source-water supply for the city of Wichita, Kansas, routinely experiences cyanobacterial blooms that cause drinking-water treatment concerns associated with taste-and-odor compounds (geosmin) and cyanotoxins (microcystin). Discrete and continuously-measured data were collected in Cheney Reservoir during 2001-2012 for developing reliable tools to estimate geosmin and microcystin occurrence in real-time. Model development related geosmin and microcystin to environmental variables measured easily in real-time (temperature, pH, specific conductance, turbidity, dissolved oxygen, chlorophyll, cyanobacteria, and light). A preliminary linear-regression model using turbidity and specific conductance (R2=0.71, n=18) that estimated geosmin concentration met with some success, but was not robust over time. Logistic-regression models that estimated probabilities that geosmin would exceed a 5 ng/L threshold and microcystin would exceed a 0.1 µg/L threshold were more robust. The geosmin model included turbidity and a seasonal component (sensitivity=70%, n=127) and the microcystin model included chlorophyll and a seasonal component (sensitivity=89%, n=94). The logistic models performed well under a range of environmental conditions, including some of the most extreme hydrologic events and cyanobacterial blooms observed during the 13-year study. Logistic models indicate the probability of event occurrence, but not magnitude, and allow the user to define the probability at which geosmin and microcystin become a concern. Current models provide hourly probability estimates of geosmin and microcystin exceeding designated thresholds and are available on the internet at http:// nrtwq.usgs.gov/ks/. Hourly probability estimates of geosmin and microcystin occurrence will aid the City of Wichita in source-water management and drinking-water treatment decisions.