Real-Time Estimation of Taste-and-Odor Occurrences in Cheney Reservoir, Kansas

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For additional information visit the USGS Web site at:
Cheney Reservoir Project: *http://ks.water.usgs.gov/studies/qw/cheney/*
Cyanobacteria: *http://ks.water.usgs.gov/studies/qw/cyanobacteria/*
Real-Time Water-Quality: *http://ks.water.usgs.gov/rtqw/*

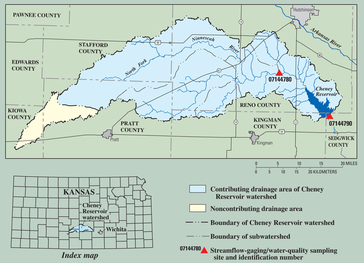
Introduction

- Cyanobacterial-related taste-and-odor events have been a concern in Cheney Reservoir, Wichita, Kansas, since the early 1990's.
- Drinking water suppliers get most of their customer complaints because of cyanobacterial-related taste-and-odor issues (Taylor and others, 2005).
- An advanced warning of taste-and-odor occurrence provides drinking-water-treatment facility operators time to implement adequate treatment strategies.

Taste-and-odor producing cyanobacterial bloom near the drinking-water intake on Cheney Reservoir, June 2003. Photograph courtesy of Kansas Department of Health and Environment.

Cheney Reservoir Studies

- Since 2000, real-time water-quality monitors have been operated on the North Fork of the Ninnescah River, the main tributary to Cheney Reservoir, and in Cheney Reservoir to develop relations between inflows, in-reservoir processes, and taste-and-odor and toxin producing cyanobacterial blooms.



Location of Cheney Reservoir watershed and real-time water-quality monitoring sites at the inflow and near the dam. Figure from Christensen and others, 2006.

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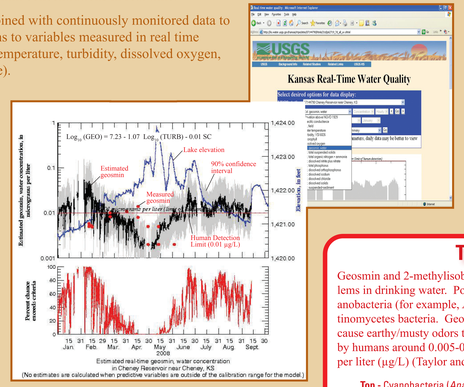
Model Development

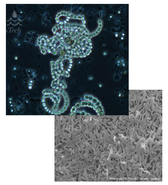
- Data collected during 2001–03 were used to develop a model to estimate Cheney Reservoir geosmin concentrations in real time.
- Discrete samples were combined with continuously monitored data to relate geosmin concentrations to variables measured in real time (specific conductance, pH, temperature, turbidity, dissolved oxygen, and chlorophyll fluorescence).
- Multiple regression was used to develop a relation between geosmin and the real-time variables turbidity and specific conductance; the resulting model is used to provide hourly estimates of geosmin concentration on the World Wide Web at *http://ks.water. usgs.gov/rtqw* (Christensen and others, 2006).
- The city of Wichita currently uses these real-time geosmin estimates, along with other variables measured in real time, as a management tool and to decrease water-treatment costs.



Real-time estimates of geosmin concentrations in Cheney Reservoir. Web display includes measured and regression-estimated geosmin concentrations and probability of exceeding the human detection level of 0.01 µg/L.

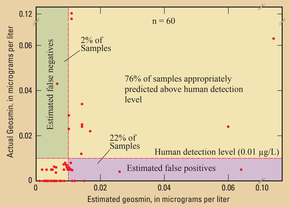
Tastes-and-Odors

Geosmin and 2-methylisoborneol (MIB) commonly cause taste-and-odor problems in drinking water. Potential sources of geosmin and MIB include the cyanobacteria (for example, *Anabaena* and *Oscillatoria/Planktothrix*) and the actinomycetes bacteria. Geosmin and MIB cause earthy/musty odors that are detectable by humans around 0.005-0.01 micrograms per liter (µg/L) (Taylor and others, 2005).



Top - Cyanobacteria (*Anabaena circinalis*). Image courtesy of PhycoTech, Inc. **Bottom** - Actinomycetes bacteria. SEM Image courtesy of Chiba University, Japan

Model Limitations



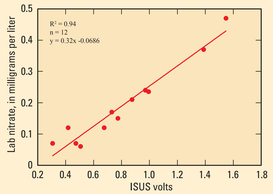
Comparison of regression estimated and measured geosmin concentrations in Cheney Reservoir during 2001–08. Comparison does not include regression estimates calculated when predictive variables were outside of model limits.

- Evaluation of the existing real-time geosmin model for Cheney Reservoir indicates that, within existing model limits (turbidity < 36 FNU, specific conductance 790–915 µS/cm), geosmin estimates are conservative (the model is more likely to overestimate concentrations than underestimate concentrations).
- The geosmin model for Cheney Reservoir is a useful tool, but was developed within a relatively narrow range of environmental conditions, and does not perform as well outside of model limits.
- The model does not link the timing and magnitude of inflow events with cyanobacterial bloom and taste-and-odor occurrence.

Continuous monitoring site on the Cheney Reservoir intake tower. Photograph by Trudy Bennett, USGS, February, 2007.

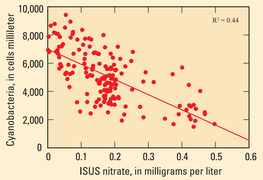
Ongoing Investigations

- Rapid analysis (within 48 hours) of taste-and-odor compounds now allows an adaptive sampling strategy in response to taste-and-odor events.
- Several real-time sensors have been installed in Cheney Reservoir since 2003 including: wind speed and direction, light, nitrate (ISUS and MicroLab sensors), and phycocyanin fluorescence (an estimate of cyanobacterial abundance).



Relation between ISUS readings and laboratory measured nitrate.

- Nutrients and light are key environmental factors influencing cyanobacterial bloom development (Graham and others, 2008); measuring these variables in real-time may facilitate model development and enhance understanding of the factors driving cyanobacterial bloom development and taste-and-odor-events.
- Long-term continuously monitored data from both the North Fork Ninnescah River and Cheney Reservoir may allow determination of the lag-time between watershed inputs and reservoir response and the inclusion of a temporal component in real-time models.
- The geosmin model for Cheney Reservoir will be re-evaluated and include meteorological, hydrological, physical, chemical, and biological data; a real-time model also will be developed for the cyanobacterial toxin microcystin.



Based on real-time data, nitrate and cyanobacterial abundance appear to be inversely related in Cheney Reservoir.

Implications for Long-Term Studies

- The relations between environmental variables and cyanobacterial taste-and-odor compounds are complex and vary among sites and over time.
- Long-term (multiple-year) studies are essential to the development of effective empirical models and allow the incorporation of a level of environmental variability (including meteorology, flood and drought events, and changing physical, chemical, and biological conditions) that is necessarily excluded from models that are developed from short-term data sets.

Biofouling of the MicroLab nitrate analyzer after operation for a month in Cheney Reservoir. Photographs by Trudy Bennett, USGS, June 2008.

Selected References

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