Predicting Taste and Odor Events in Kansas Reservoirs – Phase 1

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Taste and Odor Events in Kansas Reservoirs

Algal blooms are a common occurrence in Kansas reservoirs (Figure 1). Blooms of cyanobacteria, or blue green algae, are of particular concern because several species produce compounds (i.e. geosmin and 2-methylisoborneol (MIB)) that often cause drinking water to taste and smell bad (Figure 2). The purpose of this research project is to better understand the factors leading to algal blooms and associated taste and odor events, and to develop tools that can be used to predict the occurrence of blooms.

Workgroup Overview

The Drinking Water Taste and Odor Workgroup was recently created to help translate up-to-date scientific research into practical water resource management and treatment strategies. The workgroup consists of scientists and representatives from university, state and federal agencies and water treatment facilities. The workgroup had its first meeting on July 21st, where we discussed the workgroup objectives and briefly outlined the parameters for participation that are expected from researchers and water treatment personnel.

The Taste and Odor Workgroup will meet again in late October 2006 at the Kansas Biological Survey (KBS) to discuss the progress of the project and to evaluate future directions.

Predicting Taste and Odor Events in Kansas Reservoirs: Overall Project Goals

The Taste and Odor Workgroup was created as part of a larger project that was designed to develop relatively simple tools that can be used to predict the occurrence of taste and odor events in Kansas drinking water reservoirs. In order to accomplish this goal, several complementary approaches are being combined. Specifically, we will:

(1) Establish a workgroup of scientists and water treatment personnel to provide continual input into our research findings, and help translate these findings into feasible management strategies and decision-making applications.
Compile previously collected water quality data and information on past taste and odor events from Kansas reservoirs

Sample Kansas reservoirs for a number of water quality variables that may be useful in predicting taste and odor events

Develop and test alternative methods for routinely monitoring water quality conditions (i.e. satellite imagery) in reservoirs that will be easier for water treatment personnel to use than traditional methods (Figure 3)

Develop a predictive model using remotely sensed landscape data that may provide advance warning of potential taste and odor problems

Water Treatment Personnel – How you can help

The participation of water treatment personnel is indispensable to the overall success of this project. You should have recently received a mailing from the KBS requesting data from your drinking water reservoirs. Specifically, we are asking water treatment personnel to help us in several ways.

First, we ask that you inform us of Taste and Odor (T&O) events immediately so that we can collect samples in an attempt to understand the conditions that allow them to develop. Detailed observations of the event, including duration and distinct characteristics of the taste and odor, are very useful. Conditions on the lake itself as well as its corresponding watershed can also be helpful (i.e. weather conditions, water color and visibility, reports from local fishermen, etc).

Second, we are requesting any previously collected data from your drinking water reservoir. Past observations are important with respect to the frequency, severity and duration of T&O events. We are also requesting any parallel water quality (i.e. nutrients, algal biomass as measured by chlorophyll a, geosmin) measurements that may have been collected during these events.

T&O treatment methods and the relative success of those methods should also be reported. This could open up a dialogue between water treatment personnel and potentially lead to more effective and less expensive treatment strategies as we become more adept at predicting and dealing with T&O events. Perhaps we could also provide samples of T&O compounds at the next meeting, since it may be possible for us to detect differences between specific compounds and thus make observations of T&O events a bit more useful.
Taste and Odor Events

Although there are a variety of factors that can contribute to T&O events, we are focusing specifically on events caused by algae (and/or bacteria) that produce T&O compounds such as geosmin and MIB.

Algal blooms often result from nutrient enrichment or eutrophication. Nitrogen and phosphorus are the most important nutrients observed during algae blooms associated with T&O events. Of the mineral nutrients required for algal growth, N and P are the least abundant and are in highest demand. Thus, these two key nutrients, relative to all of the other resources that are necessary for normal algal growth, are said to be growth-limiting.

The main sources of excess nutrients in aquatic ecosystems in the Midwest are wastewater disposal, confined animal feeding operations (CAFOs) and conventional agriculture. Wastewater and CAFOs can be dealt with at the source, so they are relatively easy to control. Yet, in the case of agriculture, rainfall events wash nutrients and soil into the rivers and streams that feed drinking-water reservoirs. This can cause nutrient concentrations in the reservoir itself to increase, thereby creating conditions that can lead to algae blooms. Conversely, a lack of rainfall on a particular watershed can cause reduced water releases from the reservoir, creating a situation where the immobile water stagnates, increasing nutrient concentrations, as there is no fresh rainwater to dilute it.

The intensity and duration of rainfall is also important. An inch or two of rain occurring as a slow drizzle over a long period of time will be absorbed into the soil, whereas a short torrential downpour will quickly wash over the soil, taking the surface layer of the soil and its associated nutrients with it. The biological impacts of rainfall events depend upon how the land is managed at each watershed, the time of year, what fertilizers are being applied, and at what amounts and frequencies.

During the summer months, the upper layer (the epilimnion) of the water body heats up relative the lower layer (the hypolimnion) and the lake becomes thermally stratified. Except in cases of severe weather, the warm upper layer and cold lower layer will not mix until late fall, when the upper layer cools due to seasonal variations in the weather. When thermal stratification occurs, decomposition of decaying organic matter can use up dissolved oxygen in the lower layer. This layer sometimes can become completely oxygen-free and incapable of supporting most aquatic life, especially fish. Under these anoxic conditions, lake sediments have been found to release biologically available phosphorus into the water column. This newly released phosphorus will normally remain in the hypolimnion until the fall, when the layers mix. The excess phosphorus is immediately available to support the growth of algae, and may contribute to the occurrence of undesirable fall/winter blooms.

Many species of cyanobacteria seem to be favored by high concentrations of total phosphorus (TP), and by low ratios of total nitrogen to total phosphorus (TN:TP) because they are capable of fixing nitrogen from the atmosphere into an organically available form. These
nuisance cyanobacteria can dominate when phosphorus is present in excess and nitrogen is limiting.

Scientists from both the University of Kansas and the USGS have shown that there are strong relationships between the T&O compound geosmin and chlorophyll in Kansas reservoirs. Therefore, it may be possible to use chlorophyll as an early indicator or predictor of T&O events. By routinely monitoring chlorophyll levels with relatively simple laboratory techniques, water treatment personnel may be able to determine in advance when water should be treated in order to reduce the likelihood of a T&O event.

A database of reservoir data will be created for use in the development of predictive tools. Data on past taste and odor events that is submitted by water treatment personnel will be combined with newly collected reservoir data.

Reservoir Sampling

Throughout the summer and fall, the Kansas Biological Survey (KBS) will sample five reservoirs (Big Hill, Marion, Clinton, Gardner and Cheney) at biweekly intervals for nutrients, chlorophyll $a$, and geosmin. As mentioned earlier, the KBS will also sample reservoirs that are currently experiencing algal blooms within 48 hours of notification by water treatment personnel.

Additional information is being collected by the United States Geological Survey (USGS) and the United States Army Corps of Engineers (USACE) lake monitoring programs. Therefore, the KBS is coordinating their research efforts with these groups in hopes of decreasing the time intervals between sampling. More sampling dates will give us a more precise picture of what relationships between key water quality variables.

Figure 4. KBS personnel collecting water samples from Clinton Reservoir.

The KBS collects water samples at a depth of 1.5m from three sites on each reservoir (main basin, transitional, and riverine zones). In addition, depth profiles of pH, temperature, conductivity, turbidity, and dissolved oxygen are collected with a Horiba multiprobe unit. Water samples are returned immediately to the lab at KBS for analysis of nutrients, chlorophyll $a$, and geosmin (Figure 4). We are also collecting samples for algal identification and enumeration to identify species associated with the production of T&O compounds. Finally, samples are being collected for the identification and enumeration of herbivorous zooplankton, which can have significant impacts on algal biomass and species composition (Figure 5).
Project Results to Date

A total of eight Kansas reservoirs have been sampled so far (the five study reservoirs plus several additional reservoirs). We have observed geosmin concentrations above human detection limits in most of the reservoirs. We are currently exploring relationships among key water quality parameters to determine if relationships can be developed to predict both geosmin concentrations and T&O events.

In June, the KBS observed a severe algal bloom at Marion Reservoir. This bloom occurred in the riverine zone, near the arms of the reservoir, and was characterized by a layer of algae that covered the entire surface of the reservoir. During this time there were also high levels of phosphorus and geosmin. The bloom followed a weekend of heavy storms.

Big Hill has the lowest concentrations of nutrients and chlorophyll a of any of the 8 study lakes. However, it has also had the highest concentrations of geosmin, contradicting our hypothesis that there is a positive relationship between chlorophyll and geosmin. For this reason, Big Hill is one of the most important (and exciting) lakes we study as part of this project as we are exploring additional hypothesis. One possible explanation is that the Big Hill T&O events may be associated with Actinomycetes, a group of fungi-like bacteria that are known to occur independently of chlorophyll a concentrations and to produce T&O-causing compounds. Because of this, we have started to collect water samples that we hope to get analyzed for Actinomycetes concentrations.

Depending on the number of T&O events observed, the KBS’s sampling efforts will continue into fall 2006. We will also begin to identify and enumerate the phytoplankton and zooplankton samples collected from the reservoirs.

Please send findings and inquiries to:

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