Interim Progress Report

Reduction of Taste and Odor in Source Water of the Anderson Regional Joint Water System

September 17, 2014

Background and Objectives

For the past two years, the Anderson Regional Joint Water System (ARJWS) has experienced intermittent taste and odor (T&O) problems in its raw and finish water from its treatment plant on the Six and Twenty Creek arm of Hartwell Lake, Anderson, South Carolina. This makes it difficult or impossible to provide the quality of drinking water (odor-free) that customers have expected. Taste and odor problems in this case result from chemicals naturally produced by certain algae (e.g., blue-green algae and diatoms) inhabiting the water. The two most common T&O compounds are 2-methylisoboneol (MIB) and geosmin, which are terpene alcohols that give water an undesirable and potent "earthy" taste and odor. Most people can taste or smell MIB and geosmin in water at concentrations as low as 10 parts per trillion (nanograms per liter, ng/L). With MIB concentrations reaching as high as hundreds of parts per trillion in recent weeks in Hartwell Lake, measures were needed to control T&O producing organisms near the ARJWS water intake in order to produce odor-free drinking water.

To discern the proximate cause or source of the T&O compounds in the lake, the Clemson University and SynTerra research team sampled water and sediments near the ARJWS water intake on August 16, 2014 and identified several benthic and epiphytic organisms that can contribute to T&O, including the blue-green algae *Oscillatoria, Anabaena,* and *Planktothrix* and diatoms *Tabellaria* and *Fragilaria*. As a result, the ARJWS elected to conduct a one-time pilot algaecide application to determine efficacy and cost effectiveness of chemical control of putative T&O producing organisms.

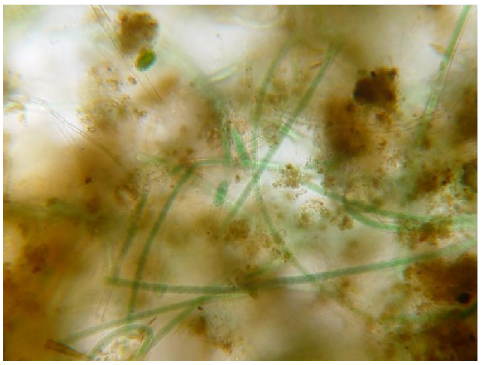
Clemson University conducted laboratory assays on water and algae samples and based on the results of that study, proposed application of the copper-based algaecide Algimycin (1 mg copper per liter for two acre feet) and the peroxide-based Phycomycin (100 pounds per acre foot for two acre feet) to target the putative T&O producing organisms. Approximately 160 acres of the Hartwell Lake littoral zone (from the water line to the 25' depth contour) and 4 acres around the ARJWS water intake structure were designated for algaecide application. Phycomycin was used primarily around the water intake structure. The algaecides are registered for application to drinking water by the U.S. Environmental Protection Agency.

Requests for bids to conduct algaecide application were issued on August 26, 2014. Aquaservices, Inc., a South Carolina certified applicator, conducted the algaecide application on September 4 and 5, 2014. Following algaecide applications, ARJWS received reports of fish mortality that included primarily threadfin shad and other small baitfish and some carp, mainly in two coves treated with Algimycin. It was evident that some of these fish came into contact with the algaecide during treatment. The South Carolina Department of Natural Resources and U.S. Army Corps of Engineers were notified and investigated, and reports were filed with the South Carolina Department of Health and Environmental Control. While incidental effects on fish are unlikely when using these algaecides, there are circumstances where some fish may be exposed. The fish loss in this case was isolated, and measures will be taken to prevent reoccurrence if future algaecide applications are considered.

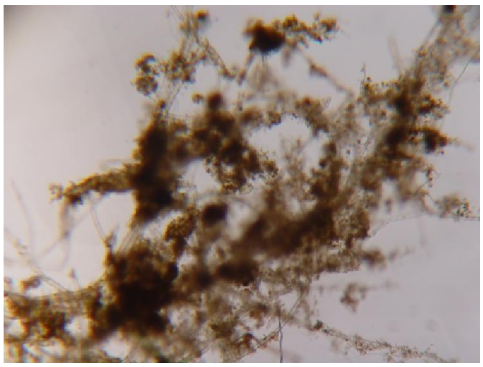
This interim report provides results to date on responses of putative T&O producing organisms to algaecide exposures in the lake, MIB and geosmin concentrations in the raw water, and concentrations of algaecide active ingredients (copper and peroxide) before and after algaecide applications.

Results

The algaecide applications were successful at eliminating putative taste and odor producing organisms. The following photographs depict the removal of targeted algal cells (blue-green), indicating effective treatment. Microscopy indicated that desirable algae such as some of the diatoms were not affected by the treatment.

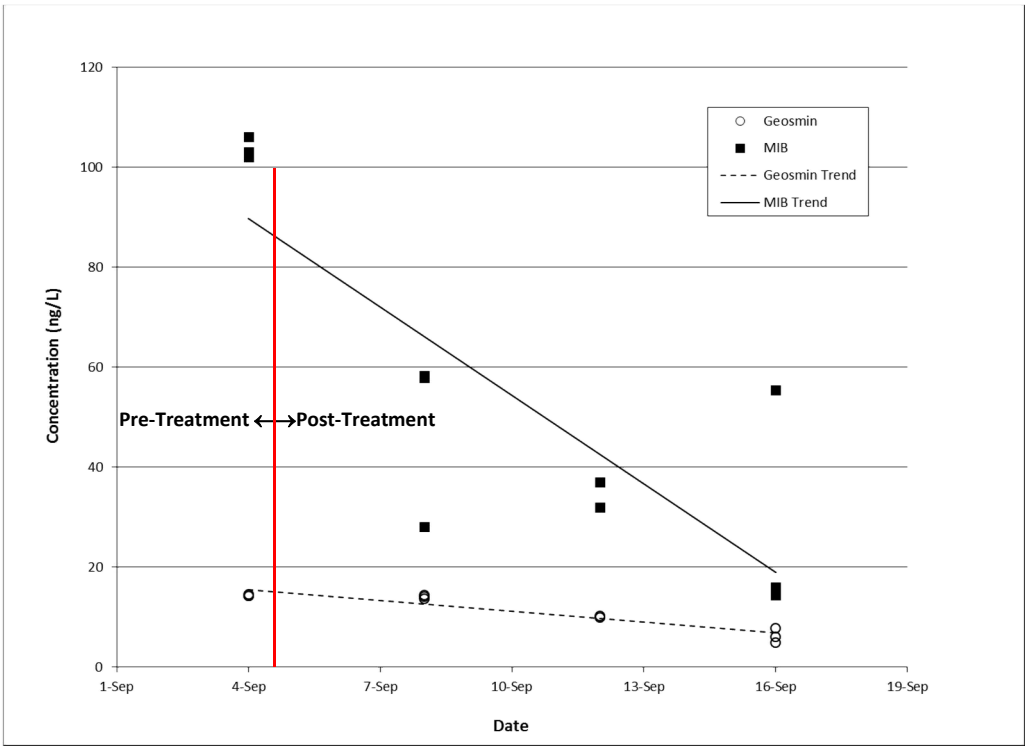


Pre-Treatment



Post-Treatment

MIB and geosmin concentrations declined significantly in the raw water (graph below) after algaecide applications. Pre-treatment MIB concentrations (September 4, 2014) ranged from 102 to 106 ng/L. Post-treatment MIB concentrations have declined steadily, down to 14 ng/L twelve days after treatment. Geosmin was 14 ng/L prior to treatment and has declined to as low as 5 ng/L twelve days after treatment.



Concentrations of copper, the active ingredient in Algimycin, were measured in water near the intake and in the areas of application (160 acres from the shoreline to the 25' depth contour) pre- and post-treatment. Pre-treatment (or "background) total copper concentrations (unfiltered) in Hartwell Lake ranged from 2.4 to 20.6 parts per billion (µg/L). Three days after treatment, total copper (unfiltered) ranged from 16.5 to 101 µg/L, and returned to background concentrations seven days after treatment (20.6 µg/L at the water intake).

Phycomycin, the peroxide-based algaecide, was applied to 4 acres around the water intake structure. The degradation products of Phycomycin when applied to water are oxygen and water. Hydrogen peroxide was measured in water around the intake structure before and after Phycomycin application. Prior to treatment, hydrogen peroxide was not detected in the treatment area. Fourteen hours after Phycomycin application, hydrogen peroxide concentrations ranged from 2.7 to 3.7 mg/L through the water column. By three days after treatment, hydrogen peroxide was not detected in the water column of the treatment area.

Several toxicity experiments on water and sediments collected from the treatment areas pre- and post-algaecide application are currently underway at Clemson University. The purpose of these experiments is to characterize potential effects on sensitive fish and invertebrates from algae treatment and to confirm dissipation of the algaecides. Test organisms include the fathead minnow (*Pimephales promelas*) and an amphipod or microcrustacean (*Hyalella azteca*). Both organisms are sensitive and recommended by the U.S. EPA for evaluating toxicity of water and sediments. No adverse effects on the test animals have been observed to date in water or sediments sampled 10 days post-treatment.

Conclusions

Taste and odor compounds have significantly declined in the ARJWS raw water following algaecide application, and concentrations of algaecide active ingredients in water have returned to background. Based on the data that we have acquired to date, we are very optimistic that the recent algae treatment near the water intake in Hartwell Lake to control production of taste and odor compounds will be successful. Depending on how long the water takes to get from Anderson to customers, we should notice a difference in the taste of the water soon. This is the only algae treatment that we anticipate this year. We are continuing to monitor the lake in the vicinity of the water intake and will be conducting more comprehensive research on the water in this area in the coming months.