

Greenville, Illinois

April 27-28, 2004

- **Evaluation of Results of Lake Water Analyses**
- **Operator Training on Water Microbiology**
- **Demonstration of the Use of the Microscope**



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Background and Summary

At the request of Greenville's City Manager, Jim Stevens, John and Tom O'Connor of H₂O'C Engineering spent two days on-site at the Greenville Water Treatment Plant. During that time, they conducted operator training in microbiology and demonstrated the use of the microscope in identifying particles and algal cells. They also reviewed new data on lake water quality collected by the Greenville plant operators over the past year.

Over the past year, Greenville water department staff have been conducting more comprehensive analyses of plant influent (lake water) quality. These analyses included daily measures of ammonium ion and dissolved oxygen as well as iron and manganese. The results of these analyses were reviewed and, by agreement with Water Superintendent, Jeff Leidner, the lake water quality monitoring protocol will be slightly modified. Some analyses will be eliminated or reduced in frequency while others will be added.

In particular, it was agreed that analysis for organic matter and disinfection by-products will be added to the lake, plant and distribution system monitoring program. These analyses will allow estimates to be made of the degree of removal of dissolved organic constituents, including taste-and-odor compounds. This will be of particular importance when Greenville's filters are modified to include granular activated carbon filter caps for adsorption of dissolved organic matter. The new analyses will be conducted weekly to monthly depending upon the observed rate of change of the parameters in source, finished and distributed waters.

In recent months, the Greenville water department has obtained new equipment, including a Nikon compound light microscope and a state-of-the-art Phipps and Bird laboratory jar testing apparatus (shown below). The jar testing apparatus is routinely used to determine the proper chemical dosage for effective coagulation of particles (such as algae and bacteria) in the source water. The microscope will allow observation and enumeration of the particles present in source, settled and filtered water.



Greenville's microscope and jar testing apparatus H₂O'C's epifluorescence microscope set-up

Microscopic Analysis

In July, 2003, H₂O'C Engineering recommended that Greenville purchase a light microscope with phase contrast objectives and an epifluorescence (ultraviolet light) attachment that will allow the observation and photographing of bacteria as well as algae.

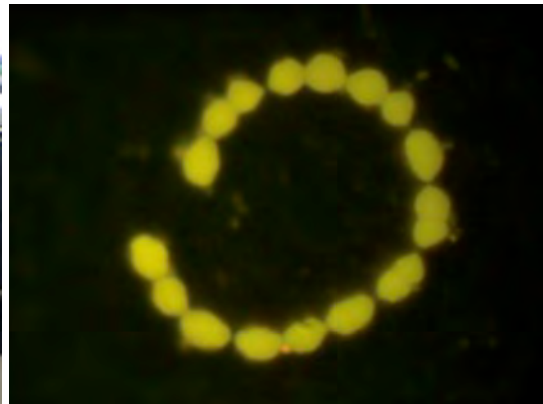
Greenville has recently purchased a Nikon compound light microscope without the attachments. This microscope will allow water department staff to observe and identify algae in the lake water. It should also enable operators to make a variety of other visual observations related to organism and particle removal throughout the treatment process. It can be used to observe microbial growth and accumulations in distribution system dead ends.



Sample Preparation, Microscopic Observation



Organism Identification



Operator Training Credit

To maintain certification as licensed water treatment plant operators, Greenville staff must obtain 30 hours of IEPA-approved training over each three year period. Since H₂O'C Engineers have long conducted operator training in Illinois, IEPA approved the award of 8 hours of training credit for in-plant instruction. Certificates of completion of training were given to five Greenville operators.

Laboratory Capabilities for Assessing Lake and Treated Water Quality

Ammonium Ion

Beginning last summer, the Greenville water treatment plant laboratory has been performing daily analyses on lake water for ammonium ion. The results of the analyses now routinely show the presence of ammonium ion in the plant influent water with periodic high transient concentrations. The operators will now investigate the source of this ammonia and its relationship to rainfall events and water travel time in the lake. Following treatment, the analysis indicates that there is no free ammonium ion in the finished water entering the distribution system.

Considering the importance and necessity for continually monitoring ammonium ion, we recommend the purchase of an ion-specific electrode for ammonium ion. The use of this ion probe, in lieu of wet chemical methods, will save time and money as well as eliminate laboratory chemical use and waste.

Dissolved Oxygen

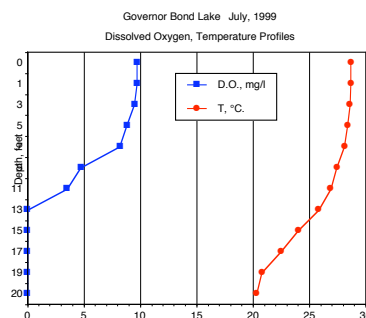
Water withdrawn at the plant intake generally contains significant amounts of dissolved oxygen. At times, influent oxygen levels are above saturation. This is due to the production of oxygen in the lake due to algal photosynthesis. At other times, oxygen levels are slightly undersaturated, probably due to microbial respiration.

The measured oxygen concentrations for the past year should be tabulated and compared with saturation concentrations expected at the temperature of the influent water. These results for the past year should also be plotted to show the annual variation in oxygen concentrations. If influent oxygen levels are consistently near or above saturation, the results diminish the rationale for supplemental lake aeration.

Since algal oxygen production varies with daylight, a study is planned where influent oxygen concentrations (or vertical profiles near the intake) will be measured every four hours throughout a 24-hour period when algal growth is evident and relatively extensive. This work will be facilitated by using Greenville's new YSI dissolved oxygen probe. This unit is attached to the end of a 24-foot long cable so that the probe can be lowered from the surface to the bottom of the lake, thereby providing a complete vertical profile of oxygen concentrations (See 1999 profile below).



Algal Growth and Vegetation at Lake Spillway



Depletion of Dissolved Oxygen at Lake Bottom

Total and Dissolved Organic Carbon

A comparatively new and advanced measure of the organic content of water is total organic carbon (TOC). While TOC varies markedly with season, nutrient-enriched lake waters have been found to be particularly high in TOC during summer periods of high water temperatures and algal blooms.

A simplified analytical method for analysis of total and dissolved organic carbon (TOC, DOC) has recently been developed by Hach Chemical Company (<http://www.hach.com/Spec/toca.htm>). This colorimetric method does not require the purchase of a costly, dedicated organic carbon analyzer and appears to be suitable and cost-effective when only routine, in-house TOC and DOC analyses are required. The analysis can be conducted using Greenville's new state-of-the-art, pre-programmed, recording colorimeter. This Hach colorimeter also stores data on the results of hundreds of analyses.

For weekly analysis of lake water influent and plant effluent TOC and DOC, this new method should be utilized by Greenville to determine whether it will effectively allow monitoring of seasonal changes in lake organic content plus provide a quantitative assessment of the effectiveness of the treatment processes presently used to remove organic matter.

New USEPA regulations will require water utilities using surface water to remove total organic carbon in an effort to reduce the formation of disinfection by-products (DBPs). DBPs are formed when waters rich in organic matter are chlorinated. Greenville will likely be required to reduce TOC by, at least, 35%.

Disinfection By-Products: Trihalomethanes

When waters high in organic content, as indicated by high TOC, are chlorinated, the disinfection by-products, trihalomethanes and haloacetic acids (THM, HAA) are slowly formed over a period of hours to days. These groups of compounds are regulated in finished drinking water at levels of 80 and 60 $\mu\text{g/l}$, respectively. As a result, their concentrations are being monitored on a quarterly basis by the Illinois EPA for regulatory purposes. In general, THM and HAA tend to be higher at more remote points in a distribution system owing to longer contact time between the organic matter and the disinfectant residual.

Hach Corporation has developed a simplified method for measuring trihalomethanes for plant and distribution system operational control. Once again, this method is keyed to measurement using the colorimeter already available in the Greenville laboratory. Only a digester and the necessary prepackaged chemicals for conducting the THM analysis will be required.

Data Storage, Tabulation and Presentation of Results

Although limited in storage capacity, modern laboratory analyzers are recording data electronically. Accordingly, transfer of data to a central processor is required for long-term data storage, tabulation on spreadsheets and plotting of results. We recommend the water department purchase a portable (laptop) computer to facilitate the management of their data.

Recommendations

Supplementary Laboratory Supplies and Equipment	Estimated Cost
Specific Ammonium Ion Probe	\$400
Microscopy Supplies:	
Membrane filter apparatus (Millipore)	
0.2 μm and 3 μm polycarbonate membranes (Poretics)	
forceps, slides, cover slips,...	\$600
Digester and Reagents for TOC and THM analyses (Hach, 50 tests each)	\$1,000
Eclipse E600/E400 epifluorescence attachment for Nikon Eclipse E200 E2-TF trinocular eyepiece	\$5,000
Microscope table	
Laptop computer for data acquisition, storage, graphing and presentation	\$1,500
BART test kits for bacterial groups (Distribution System Monitoring)	
Sulfate reducing, taste-and-odor-producing (cyanobacteria), nitrifying, slime-forming bacteria,...	\$360

Data Management

Graph one year of plant influent (lake water) data for:

- Temperature
- Dissolved Oxygen
- Ammonium Ion
- Iron, Manganese

Graph Finished Water:

- Disinfectant Residual
- Hardness
- pH

Lake Water Quality

Initiate treatment with chelated copper sulfate prior to onset of algal bloom (i.e., spring)



Membrane Filtration Apparatus

Distribution System Model and In-tank Mixing

A computer-based hydraulic model of the distribution system using EPANET should be constructed. Distribution system operations should be evaluated and alternate scenarios investigated in an attempt to reduce water residence times (stagnation), particularly in storage facilities. The model should also be used to assist in the development of the optimal unidirectional flushing protocol. Finally, the model should be of assistance in controlling flows to minimize travel times and eliminate dead-ends leading to the formation of disinfection by-products during distribution. [~\$5,000]

Subsequently, it may be necessary to install in-tank mixers in some or all of the storage facilities.



Lime Softening

The average hardness in the lake water for the year 2002 was 97 mg/l as CaCO₃ equivalent. This was reduced to an average of 82 mg/l as CaCO₃ eq. in the finished water, a 15% reduction.

In the summer months, when influent hardness was lowest, the plant effluent was equal to or slightly harder than the raw water. In the winter, hardness reductions increased to about 33%. Although chemical costs are modest, there did not appear to be any significant advantage to softening Governor Bond Lake water, particularly during the period from May to August.

However, the addition of lime does offer some treatment advantages. Lime neutralizes the acid produced by the addition of alum. It also precipitates magnesium hydroxide at high pH. It is known to inactivate virus at pH > 11.

The qualitative observation by plant personnel that the addition of lime improves plant performance may be correct if the additional precipitation of magnesium hydroxide results in greater clarification of the water in the ClariCone settling compartment. Alternately, this practice consumes more carbon dioxide for pH stabilization and produces more, and lighter, coagulant sludge.

Operationally, it appears that lime should be added when softening in excess of 20% of total hardness can be achieved (possibly, October to April) or when it is found that settled water turbidities will be significantly improved by the lime addition.

2002 Hardness: Lake and Finished Water

