

Why Public Water Systems Should Use Fluorometers to Monitor for Chlorophyll and Cyanobacteria, and Realize a <1 Year Payback

The following case file is based on a White Paper written by James Hoelscher, consultant to Turner Designs, and former Laboratory Manager for the Beaver Water District, Arkansas.

Limitations of Traditional Measurement Systems

Many Public Water Systems (PWSs) that treat surface water from streams, rivers, lakes, and reservoirs have long had in place traditional algae monitoring programs for the identification and enumeration of algae, and less frequently, for algae produced taste and odor compounds. These programs, while useful, have the following limitations:

1. They do not yield results in real-time
2. They can analyze only a few samples per day at best
3. They are expensive in labor and analysis costs
4. Very often they miss important algae assemblages at specific depths at intakes, as well as periodic but brief algae blooms.

A very significant improvement to these traditional monitoring programs would be the inclusion of continuous, real-time, on-line fluorometric analysis for both chlorophyll *a* and cyanobacteria pigments in raw surface waters at intake structures, as well as upstream at remote watershed monitoring stations. Detection of significant trends in either parameter could then trigger *in situ* (submersible), multi-parameter profiling that would incorporate chlorophyll *a* and cyanobacteria sensors in conjunction with standard water quality parameters (depth, temperature, DO, turbidity, etc.) at these monitoring stations to indicate when and at what depths to take discrete field samples for algae identification and enumeration; taste and odor compounds; and cyanobacteria toxins.

Such a PWS monitoring program would allow for real-time, on-line raw water surveillance coupled with targeted field and laboratory analyses at the lowest labor and analysis costs while providing PWS with pertinent data for process control and ultimately public drinking water protection. With the almost unpredictable occurrence of algae blooms during many times of the year, such an integrated monitoring program utilizing a series of specific fluorescence sensors would be invaluable to PWSs. Even during periods when algae numbers are low and when blooms or taste and odor outbreaks have rarely occurred in the past, very useful data can be obtained to determine baseline ecological conditions for predictive modeling during the more likely periods.

Fluorometric Monitoring Complements Traditional Techniques

For progressive PWSs, looming on the horizon will be the future, required EPA Unregulated Contaminant Monitoring Rule (UCMR) that will include monitoring for cyanobacteria and their toxins (see EPA Drinking Water Contaminant Candidate List 2, Notice, Federal Register, April 2, 2004, pages 17406-17415). By instituting fluorometric monitoring now, progressive PWSs can quickly develop databases of chlorophyll *a* and cyanobacteria pigment occurrence in their source water supplies coupled with algae identification and enumeration, taste and odor compounds, and cyanobacteria toxins. Such databases would also be invaluable to address possible concerns over what will be very limited UCMR sampling (only four quarterly samples per one monitoring year). This UCMR data will be made available to the public, and can be used to set new treatment requirements for PWSs.

Limitations of Quarterly Sampling Cycle.

Several potential monitoring concerns that PWSs can experience with such a low frequency of sampling and analyses include:

- 1) Approved UCMR laboratories analyzing samples may have turn around times (TATs) from days to weeks. It is possible to be in the next monitoring quarter before the previous quarter's results become available. In this case, re-sampling for compliance confirmation could not be done. Also, this allows for no real-time process control changes to have been made should the results come back high.
- 2) That then begs the next question: When should a PWS take each UCMR quarterly sample from the standpoint of being the most representative of typical or average cyanobacteria numbers and cyanotoxin concentrations? Considering just how rapidly a potentially harmful algae bloom (HAB) can occur and then disappear, this would be almost impossible to determine without a significant increase in actual monitoring.
- 3) When should a PWS take each UCMR quarterly sample from the standpoint of being the most representative of the worst case cyanobacteria numbers and cyanotoxin concentrations? Each PWS should set out to determine this from the standpoint of process control and response, public health protection, and drinking water safety. Again, this would be almost impossible to determine without a significant increase in actual monitoring or monitoring triggered by significant upward trends in cyanobacteria pigment fluorescence.
- 4) If the quarterly UCMR monitoring results detect significant cyanobacteria numbers and cyanotoxin levels, is that typical? If such are detected in only one of the four quarterly samples, that will be interpreted as a 25% occurrence rate which is quite serious. If you have additional monitoring results in your database to indicate through the use of fluorometers that the rate is much less, then you can assure both the regulators and the public that the actual long-term occurrence rate was in fact much less and that you responded to the detections that did occur in real to near real-time.
- 5) If the quarterly UCMR monitoring results do not detect any cyanobacteria and cyanotoxins, is that in fact typical? If such are detected in none of four quarterly samples, that would be interpreted as a 0% occurrence rate which may or may not be true (i.e., possibly a false negative occurrence rate) which likewise is quite serious. A real-time monitoring system would supply a complete data record that may indicate significant qualitative that would trigger specific tests to determine the actual occurrence rate of cyanobacteria numbers and cyanotoxins. Realistic and accurate monitoring data will always help any PWS in both the short and long term to address potential problems.

Payback Results from Efficiency Improvements

Turner Designs fluorometers for monitoring *in vivo* fluorescence start as low as \$1,750. An automated monitoring system may require some additional hardware, data logger, etc. if existing equipment is already fully utilized. The actual cost will vary depending on the specific system size but the capital costs will typically easily be recouped in the first year.

The fast payback results from the efficiency improvement that can be realized from automated monitoring. Using *in vivo* fluorescence to trigger more definitive sampling and analyses only when needed results in a more cost-effective use of limited staff.

The second source of savings results from improvements in process response and control resulting from using real-time or near real-time monitoring. Based on a response plan of action, upward swings and spikes in chlorophyll *a* and/or cyanobacteria pigment trends will enable: better anticipation of filter head loss and backwash cycles; more optimum powdered activated carbon feed rates; etc.

In all PWS cases, using automated *in vivo* fluorescence sensors will be both cost and process control effective and efficient.

Summary

Each PWS should modify its traditional algae monitoring program to include fluorometric analyses in the field, on-line, and in the laboratory for both chlorophyll *a* and cyanobacteria pigments as discussed above. Such analyses should in turn trigger additional monitoring by the more traditional methods for algae identification and enumeration and for taste and odor compounds when significant upward trends are detected. Finally, fluorometric analyses for cyanobacteria pigments should likewise in turn trigger additional monitoring for cyanotoxins. See the attached Table I: Typical Lake Annual Algae Cycling and Recommended Monitoring Program for guidance on how easy and useful it would be to integrate fluorometric monitoring at PWSs. Such a fully integrated monitoring program will attain the highest level of accurate and cost effective monitoring, real-time process control and response, public health protection, and drinking water safety.

For further information, visit our web site: www.turnerdesigns.com

Table I: Typical Midwest Lake Annual Algae Cycling and Recommended Monitoring Program

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Algae Population	+	++	+++++	++++	++++	+++++	++++	+++++	+++++	+++	++	+
Cyanobac. Population	+	+	++	+	+	+	++	+++	++++	+++	++	+
Fluoro-metric Testing	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench	Continuous on-line, Submersible profiling, Lab bench
Fluoro-metric Results	Baseline	Baseline	First spikes	Additional transient spikes	Additional transient spikes	Additional transient spikes	Additional transient spikes	Additional transient spikes	Additional transient spikes	Fewer transient spikes	Last transient spikes	Baseline
Algae ID & Counts	Monthly	Biweekly	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Monthly
Cyanobac. Toxin Tests	Monthly	Biweekly	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Each spike	Monthly
Geosmin & MIB Tests	Monthly	Biweekly	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Twice per Week	Monthly
Notes:	Uniform destratification Lake completely mixed	Uniform destratification Lake completely mixed Storm water inflow, high turbidities	First algae blooms First Geosmin production Lake beginning to warm but still destratified Storm water inflows, high turbidity	Geosmin production, first taste & odor complaints Lake warming faster Turbidity reduction, more light penetration	Spring pollen flow Onset of thermal stratification Geosmin production Additional taste & odor complaints	Second series of algae blooms Rapid rate of thermal stratification Geosmin production Additional taste & odor complaints	Intense thermal stratification Maximum light penetration Geosmin and MIB production, T&O complaints Lake draw down for hydropower, evaporation	Highest summer surface temperatures Geosmin and MIB production Increase in T&O complaints Lake draw down for hydropower, evaporation	Beginning of lake surface cool down Greatest Geosmin and MIB production Greatest number of T&O complaints Lake draw down for hydropower, evaporation	Thermal destratification underway Geosmin and MIB production Large number of T&O complaints Lake draw down for hydropower, evaporation	Thermal destratification completed Taste and odor season typically ends T&O complaints typically continue for some time	Uniform destratification Lake completely mixed

Cyanobac. = Cyanobacteria (blue-green algae)

Geosmin & MIB (2-Methyl Isoborneol) = potent taste & odor compounds produced by algae & other organisms. Cyanotoxins may be produced concurrently but have no odor.