GE
Water & Process Technologies
Analytical Instruments

Application Note

Reducing Costs at a Drinking Water Plant through Monitoring of Total Organic Carbon (TOC) and Process Optimization

Introduction


City of Englewood's Allen Water Filter Plant

As many municipalities strive to balance regulations set forth in the USEPA's Safe Drinking Water Act, they are growing more concerned about how to reduce spending in their plant treatment processes. Today many drinking water plants, like the City of Englewood in Colorado, are using total organic carbon (TOC) monitoring and process optimization to produce high quality water while also achieving significant cost reductions. This paper discusses the importance of TOC monitoring in process optimization, and how the City of Englewood used this technique to save over $100,000 in one year.

Why TOC for Process Optimization

The USEPA Disinfectants and Disinfection Byproduct Rule (D/DBPR) attempts to limit exposure of harmful byproducts in drinking water that form from the interaction of a water source's naturally occurring organics or TOC, and a municipal plant's disinfectant process. The D/DBPR not only sets limits for the disinfection byproducts (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAA5), but also establishes a TOC percentage removal requirement. Many water utilities use a conventional or direct filtration treatment process, which uses coagulants to remove TOC. The USEPA uses the term "enhanced coagulation" to define the process of obtaining improved removal of TOC, also called DBP precursors, by conventional treatment in order to limit DBP formation.

Utilities often associate enhanced coagulation and improved TOC removal with increased spending. This is not always the case if a plant fully understands its TOC levels and how each process parameter change affects TOC. In fact, cost reduction is commonly the outcome of optimizing a treatment process with TOC monitoring. Although there is no fail-safe formula for optimizing enhanced coagulation processes, routine monitoring of the parameters that affect TOC removal efficiency can provide valuable information. A utility can meet their TOC removal requirements without over- or underfeeding coagulant, even when water quality conditions fluctuate.

The efficiency of TOC removal in coagulation relies on a number of different parameters including coagulant type, coagulant dosage, and pH. The nature of the organics in a water source is also critical, and since it can be variable, it is not easily interpreted for optimization. In general, TOC removal efficiency improves with increasing chemical dosage. However, one coagulant may be more effective than another, especially at differing pH levels. Most coagulants also reach a threshold where adding more coagulant will not improve the TOC removal, and will simply generate more waste. In turn, this increases chemical spending and waste removal costs without the benefit of further TOC reduction. This is why it is critical that a utility fully understands the impact each process change has on TOC.

Steps to Achieving Process Optimization

Because it is difficult to identify the specific correlation of all the parameters in a plant's treatment process, a TOC analyzer is the tool that can take the mystery out of process optimization. The first step to a process optimization study is typically a jar test study, which uses a small portion of the plant's water in multiple bench-scale containers while adding a different chemical in each. The jar test, coupled with a TOC grab sample measurement and turbidity measurement, is highly effective for comparing many different coagulants and their corresponding efficiency. In the past, a visual inspection of the jar test was performed to see how well particles adhered to one another for turbidity removal. Given that the optimum coagulation conditions for turbidity removal do not always correspond to what is optimum for organic removal, a plant must monitor both TOC and turbidity.

The next step, once a coagulant is chosen from the jar test, is implementing continuous TOC monitoring. Since a plant's source water can change rapidly, including pH, alkalinity, and the organic composition of the water, on-line TOC monitoring is the most effective means for frequent process observation. The on-line TOC analyzer can give a continuous readout of a plant's influent or effluent TOC levels, allowing the plant to calculate its actual TOC removal based on residence time. The plant can then modify dosage, pH, and other parameters to further increase TOC removal, if necessary. If a plant relies on a third party laboratory for its TOC values, the results will typically arrive too late to actually impact the current plant process.

A utility with an on-site TOC analyzer is able to make an informed decision for the best chemical and operating parameters for its treatment process based on its own water quality requirements and economic criteria. If the level of TOC removal in the plant is appropriate for drinking water standards, chemical usage can be decreased, consequently reducing chemical costs as well as reducing the volume of waste generated and the associated hauling costs. This is exactly what the City of Englewood accomplished.

Englewood's Process Optimization Study

The Allen Water Filter Plant in Englewood, Colorado, a suburb of Denver, is a conventional treatment facility capable of 28 MGD (106,000 m^3/day). Its primary source, the South Platte River, is treated with aluminum sulfate, a common coagulant, in its three-tiered flocculation system, which is followed by a settling basin (see **Figure 1**). The flocculation and settling pretreatment step is then followed by GAC filters.

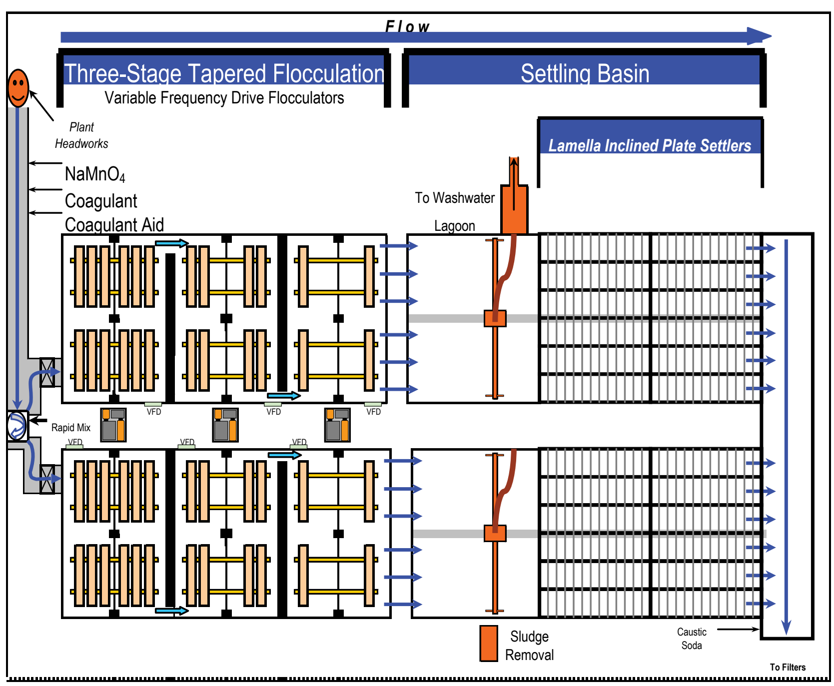

Figure 1: City of Englewood Pre-Treatment

When the Stage 1 D/DBPR was implemented, the Englewood plant was dosing aluminum sulfate at an average rate of 60 mg/L. With this dosage rate the water utility was well within the new TOC percentage removal regulations and DBP limits. However, the plant was paying almost $137,000 in coagulant costs and had $100,000 in associated disposal costs from the sludge produced in their pretreatment step.

In the next year as chemical costs rose, Englewood performed some limited testing, sending out TOC samples to a third party laboratory, and was able to reduce the coagulant dosage rate to 45 mg/L without significantly impacting their TOC percentage removal.

The following year the city invested in a Sievers TOC Analyzer to perform a complete process optimization study. The plant operators used the TOC analyzer to continuously monitor their influent and effluent water TOC values and were able to adjust their dosage rate to 36 mg/L. Because they were able to gain instantaneous results from their TOC analyzer, rather than waiting for TOC results to return from the laboratory, they further decreased their chemical costs to $86,000, and in turn reduced the associated disposal costs by almost half to $50,600. After purchasing the Sievers TOC Analyzer, the plant achieved over $100,000 per year in savings. (See **Figure 2**.)

Joe Pershin, Water Production Administrator at the City of Englewood, summarized his experience with the process optimization study and TOC monitoring. "Prior to purchasing the Sievers TOC Analyzer, samples would be sent to a lab with a minimum two-week turnaround. That was fine for compliance monitoring, but useless for process optimization. Now with the TOC analyzer, the operators can see results immediately and adjust the plant accordingly. The cost of the TOC analyzer has paid for itself many times over in chemical savings and residuals management."

Through continuous process monitoring, this year Englewood has been able to optimize the aluminum sulfate feed even further to 20 mg/L and still meet the TOC removal and settled turbidity requirements. Once the plant has run at the dosage rate for one year they will realize a savings of over $145,000 (see **Figure 2**) despite a 30% increase in their chemical costs since the implementation of the stage 1 D/DBPR.

Why Choose Sievers Technology?

The Sievers 900 Series has a TOC analyzer for every municipal application (5310 C Laboratory, 900 On-Line, 900 Portable). Each complies with USEPA-approved UV/Persulfate oxidation methodology in Standard Methods 5310 C and USEPA 415.3 (Determination of TOC, DOC and UV254 in Source Water and Drinking Water). The Sievers 900 Series TOC technology's convenience, ease of use, and low operating costs, makes it the choice of many leading municipalities for their TOC testing needs. In addition, no special training is required to operate the analyzer and an automated wizard-style calibration process means that anyone can easily calibrate the instrument. Any municipal operator can install, operate, and maintain a Sievers TOC analyzer.

	Dosage (mg/L)	Coagulant Usage (per yr)	Coagulant Costs (per yr)	Coagulant Savings (per yr)	Coagulant Waste (per yr)	Disposal Costs (per yr)	Total Savings (per yr)
Stage 1 D/DBPR Implemented	60	1,410,588 lbs	$136,827	NA	1830 cubic yards	$100,650	NA
Coagulant Reduction	45	959,049 lbs	$106,454	$30,373	1250 cubic yards	$68,750	$62,723
Sievers TOC In-House: 1st Optimization Study	36	728,028 lbs	$86,003	$50,824	920 cubic yards	$50,600	$100,874
Further Optimization with Sievers TOC	20	426,174 lbs*	$53,698*	$83,129*	700 cubic yards*	$38,500*	$145,279*

*Usage, costs, and savings are calculated for one year based on current dosage rate recently implemented

Figure 2: City of Englewood's Efforts to Reduce Costs and Optimize Treatment Process

Sievers 900 Series

The Sievers 5310 C Laboratory TOC Analyzer, designed specifically for municipal drinking water applications, offers automated TOC removal percentage calculations. It can operate standalone or with the 900 Autosampler for high-capacity laboratory applications such as repetitive jar testing. For on-line TOC monitoring, the Sievers 900 On-Line and 900 Portable Analyzers provide continuous, reliable results for process optimization needs and also are capable of grab samples at anytime. The 900 Portable Analyzer can be easily transported to any point in a distribution system for immediate TOC results in on-line or grab mode.

The Sievers 900 Series Analyzers are entirely self-contained and require no high-purity gases, catalysts, external reagents, or ultrapure gas generators making them easy to place at any point in a treatment plant or in the smallest laboratory. With only a yearly calibration and quarterly maintenance requirement, the upkeep of the analyzers will not hinder operators' current schedules.

A large, color touch-screen display provides an intuitive menu to quickly set operating parameters and trend data. A USB port facilitates data download directly into a Microsoft® Excel spreadsheet, and the analyzer's 4-20 mA output allows for remote monitoring and alarms through a SCADA system.

For more information, visit www.geinstruments.com. Find a sales partner near you through the "Contact Us" Section.

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