CASE STUDY

Disinfection of Secondary Effluent Using 22% Peracetic Acid at the M.C. Stiles Waste Water Treatment Facility

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Introduction

Peracetic acid (PAA) has proven to be an effective disinfectant for secondary effluent treatment at waste water treatment facilities throughout the United States. The combination of rapid disinfection kinetics along with a short half-life has contributed to greater adoption of PAA for use in secondary effluent disinfection. The City of Memphis has decided that PAA would be a cost effective and environmentally responsible disinfectant for treatment of their secondary effluent at the M.C. Stiles Waste Water Treatment Plant in Memphis, TN.

A previous pilot study was conducted at M.C. Stiles using 15% PAA and was shown to be effective at reducing *E. coli* counts to below the NPDES permitted monthly average level of 126 CFU/100mL. Enviro Tech has a primary registration for 15% PAA and was the first company to receive an EPA registration to include disinfection of waste water. In May 2015, Enviro Tech was granted an EPA registration for a more concentrated 22% PAA formulation that is approved for use in secondary effluent waste water disinfection. The use of this new higher concentration of PAA should result in a significant cost savings for the waste water treatment facility. Enviro Tech's 22% PAA product provides customers with a 32% reduction in chemical use when compared to 15% PAA to yield the same PAA ppm concentration. Other benefits may include less on-site PAA storage, reduced freight costs, and potentially a lower cost of PAA pumps and controllers for the customer due to the reduced volume needed to achieve the same PAA concentration.

The goals of this pilot study are to (1) evaluate the effectiveness of 22% PAA in secondary effluent wastewater at the M.C. Stiles WWTP to meet the NPDES discharge permit limits, (2) optimize the 22% PAA feed rate and control algorithm to achieve successful disinfection, (3) assess BOD_5 contribution from 22% PAA vs. untreated water and (4) to compare relative performance against 15% PAA. Materials and Methods

DISINFECTION PRODUCT

The 22% PAA product used for this pilot study is **Peragreen® 22WW** (EPA Reg. 63838-20), produced by Enviro Tech Chemical Services, Inc. Peragreen® 22WW is an equilibrium mixture of 22% peracetic acid, 5% hydrogen peroxide, and 42% acetic acid.

Location of Equipment:

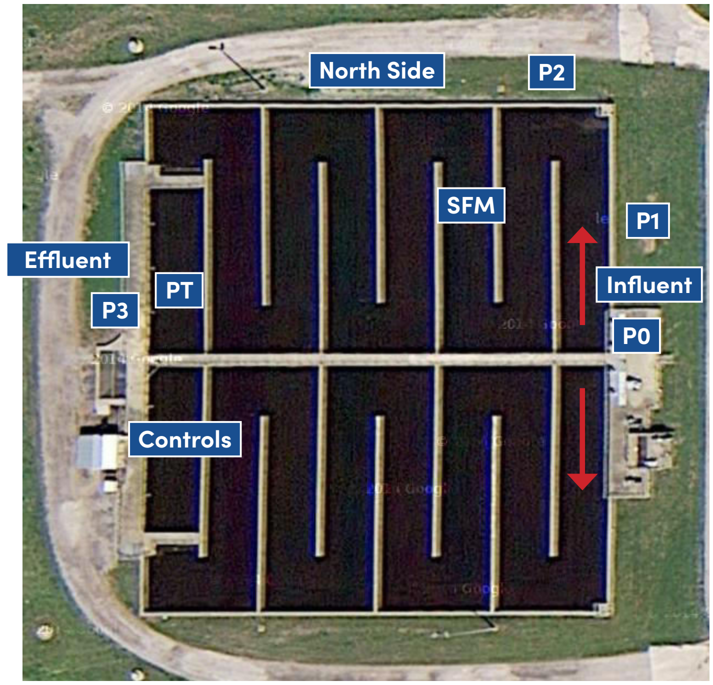


FIGURE 1. Equipment locations and descriptions

P0 – PAA Dose Point, pH and ORP Probes
P1 – Position of PAA probe 1
P2 – Position of PAA probe 2
P3 – Position of PAA probe 3
SFM – Position of ISCO Signature LaserFlow™ Meter (TIENet®360 LaserFlow™) PT – ISI 0-10psi pressure transducer for water depth measurement

Control – Untreated water sample collection point

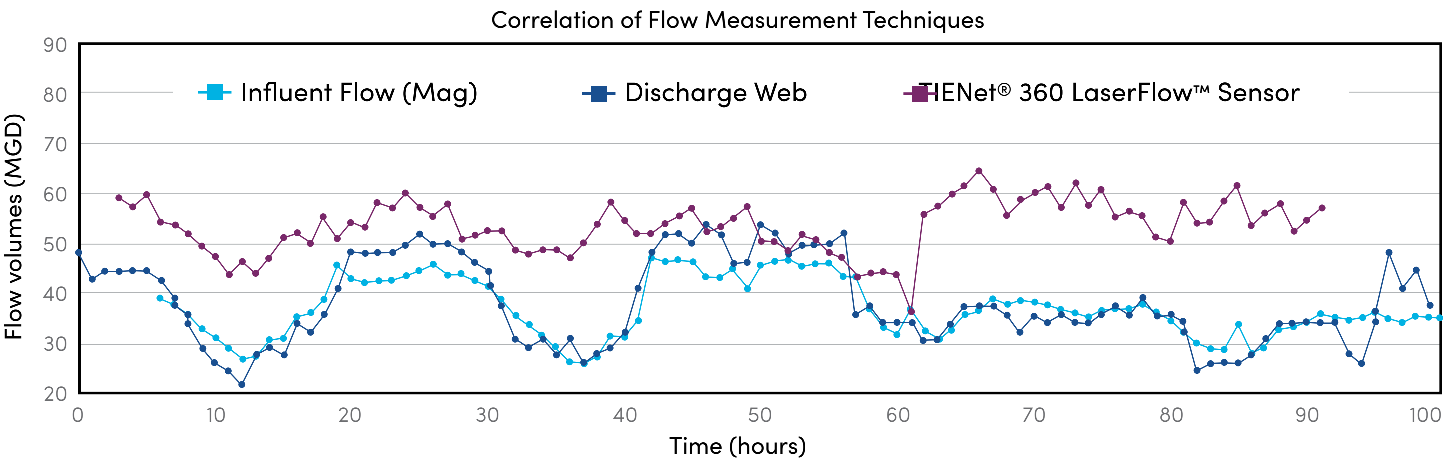
TRIAL SETUP

For this 22% PAA trial, half of the M.C. Stiles plant's effluent was treated and the other half was untreated. The existing disinfection chamber that was originally designed for chlorine disinfection receives effluent from clarifiers by gravity flow on either side of the primary treatment system. Flow is combined in the mixing chamber and is divided into two serpentine contact channels, a North contact chamber and a South contact chamber. The injection of PAA for the half-scale trial was established at the inlet of the North contact chamber labeled in this study as P0. To achieve appropriate mixing and to reduce the potential for laminar flow of PAA, Enviro Tech determined that a 200 GPM centrifugal recirculating pump would be ideal to mix the effluent water and **Peragreen® 22WW** at approximately a 100:1 ratio (depending on flow) and return the mixed product at the center of the sluice gates concurrent with the contact channel feed 17' below the water surface. This configuration ensures complete and rapid mixing which is essential for collecting consistent PAA residual measurements and proper disinfection in high solids environments. Three recirculating sample pumps were installed to supply three amperometric probes and one potentiostatic probe to monitor PAA residual levels at P1, P2, and P3 (See Figure 1).

Results

DETERMINING PLANT FLOW VOLUMES

A total of three different methods were used to monitor the real-time volume of secondary effluent; (1) Stiles plant influent volumes were recorded from the operations control room, (2) continuous level of the contact channel exit weir was measured by a submersible pressure transducer and (3) flow velocity was measured by wide angle multi-point laser. It was determined before the trial that it is imperative to know the flow rate of effluent in real time manner so the most effective and economic dose of PAA can be applied. Proportional automatic control of the PAA feed rate was achieved using both weir height and flow velocity. Due of the operational conditions, there was approximately a 6-hour delay between when the lift station and the entrance to the disinfection chamber. Based on this information, the influent volume data from the laser and the pressure sensor in **Figure 1** was shifted by 6 hours in order to correlate operations volume data with flow rate at the contact channel. Figure 1. Correlation of the three effluent volume measurements.



BIOLOGICAL OXYGEN DEMAND

Biological Oxygen Demand (BOD) is an important consideration in wastewater treatment operations. Discharging wastewater high in BOD into an aquatic environment such as the Mississippi River can be disruptive to aquatic organisms. All equilibrium PAA formulations contain acetic acid, which increase BOD in the treated water

15% Peracetic Acid

Compound	*Dose (ppm)*	*BOD_5 Contribution (ppm)*
PAA	1	0.49
GAA	1.033	0.64
Total		**1.13**

Peragreen® 22WW (22% Peracetic Acid)

Compound	*Dose (ppm)*	*BOD_5 Contribution (ppm)*
PAA	1	0.49
GAA	2.045	1.27
Total		**1.76**

FIGURE 2. Theoretical contribution of BOD from acetic acid in 15% and 22% peracetic acid formulations.

The **Peragreen® 22WW** contains roughly double the amount of acetic acid per dose compared to a 15% PAA formulation but the theoretical BOD_5 contribution from 22% PAA is not double the 15% PAA BOD_5 contribution. The above theoretical calculation predicts that for every 1 mg/L (ppm) of PAA from 15% peracetic acid, the BOD_5 would increase by approximately 1.13 ppm. **Peragreen® 22WW** contributes approximately 1.76 ppm to the BOD_5 as a comparison. The BOD_5 contribution of **Peragreen® 22WW** at a 14 ppm dose should theoretically increase the BOD_5 by 24.6 ppm, but in actual use the BOD_5 contribution was less. The BOD_5 was measured and compared at the P3 location in the treated and untreated (control) contact chambers (Figure 3).

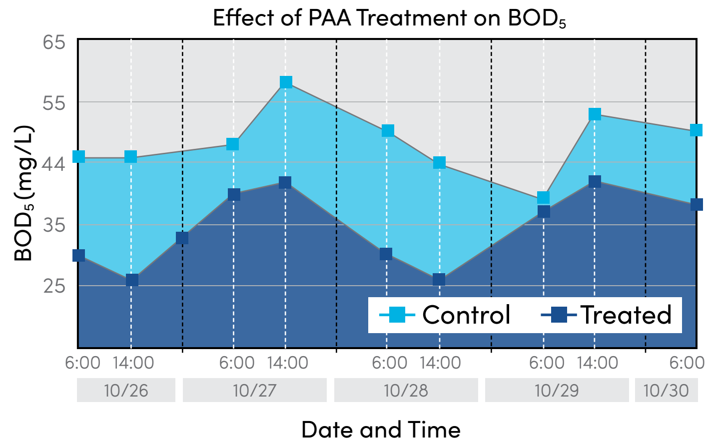


FIGURE 3. BOD_5 comparison in the treated and untreated effluent wastewater

The average BOD_5 in the untreated effluent (n=9) was 35 ppm ± 7 ppm. The average BOD_5 in the 14 ppm PAA treated sample was 48 ppm ± 5 ppm. As discussed, the effluent treated with **Peragreen® 22WW** provided a BOD_5 contribution less than theoretically calculated. A 13 ppm increase in BOD_5 should not have a meaningful impact on meeting the NPDES permit (No. TN0020701) which stipulates an effluent limitation of 85% removal of BOD_5 . A historical analysis of the past 5 months (May-September 2015) of data from the Monthly Operating Reports (MORs) for the M.C. Stiles WWTP showed an average reduction in BOD_5 of 92.6 percent removal. Based on this data and the average BOD_5 contribution from 22% PAA of approximately 13 ppm, the average decrease in the BOD_5 percent removal is approximately 3%.

E. COLI REDUCTION

The primary reason for implementing a disinfection intervention such as PAA is to reduce the microbiological counts in the effluent to meet the NPDES permit limit. The M.C. Stiles facility mainly focuses on the reduction of *E. coli* spp. The NPDES permit requires that the monthly geomean *E. coli* count cannot exceed 126 CFU/100 mL. Therefore, in this study 126 CFU/100mL *E. coli* counts was the goal and would determine the appropriate dose of PAA. Samples of effluent were taken from the P2 and P3 location in the treated contact chamber and samples were taken from the P3 location of the untreated (control) contact chamber. The samples were transported to a local laboratory1 where they were analyzed for *E. coli* counts (CFU/100ml).

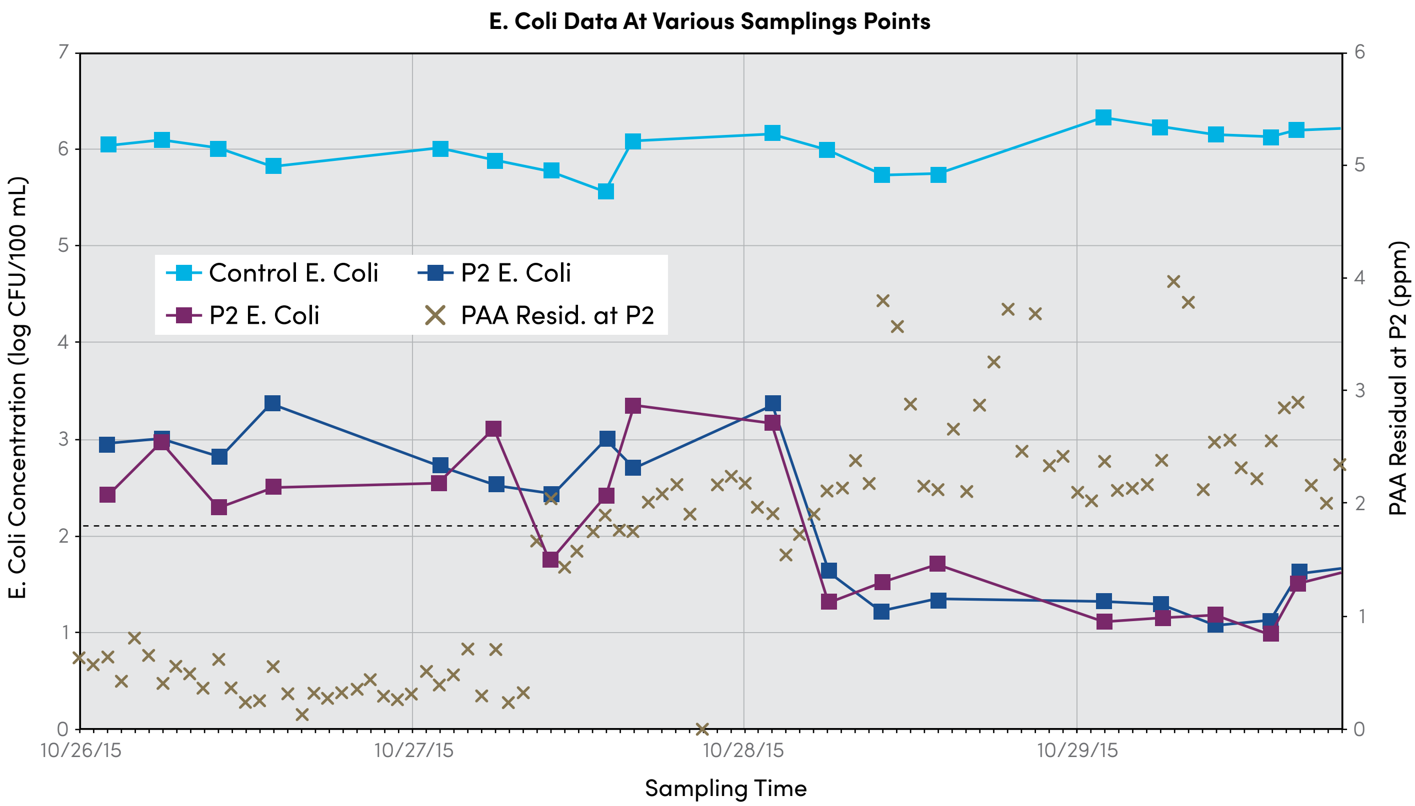


FIGURE 4. ***E. coli*** **concentration over a 5-day time interval in the treated and untreated effluent.**

An initial dose of 10 ppm PAA was selected as the disinfection treatment based on previous laboratory microbiological studies. However, this concentration did not achieve the desired microbial reductions and *E. coli* counts were periodically above the 487 CFU/100mL daily-permitted limits. Therefore, the concentration of PAA was increased to 14 ppm on 10/28/2015. Dosing a nominal 14 ppm PAA and maintaining a residual concentration of >2 ppm PAA at P2 was found to be important to maintaining *E. coli* concentrations below the daily target of 487 CFU/100mL. Even though a 10 ppm dose did not consistently yield *E. coli* reduction below 487 CFU/100mL the geomean over the 5-day time was 109.7 CFU/100mL which is below the monthly target geomean.

15% PAA COMPARISON

A simple trial was conducted on the last day of the study to compare the PAA residuals at P2 in the contact chamber from either 15% PAA or 22% PAA. The goal of this comparison was to confirm that feeding 22% PAA will result in approximately a 32% chemical use savings when compared to 15% PAA. Each PAA formulation was dosed for 45 minutes at P0 prior to the start of gathering PAA residual readings at P2. The feed rates where the same for each formulation and were based on 14ppm from 22% PAA. PAA residuals were then measured every 15 minutes for an hour. The average PAA residual at P2 from 15% PAA was 1.53ppm and the average PAA residual at P2 from 22% PAA was 2.88ppm. The concentration difference at P2 was approximately 47%. The difference may be attributable to organic demand consuming more of the 15% PAA, but this simple study confirms that 22% PAA yields at least a 32% reduction in chemical use.

[1] Waypoint Analytical, Inc. 2790 Whitten Road Memphis, TN 38133

Conclusions

PLANT FLOW VOLUMES AND PAA RESIDUAL MONITORING

In this pilot study the plant flow was monitored using three different methods: Plant influent volume with existing mag meters, water depth at the contact chamber exit weir, and a LaserFlow open channel flow meter in the contact chamber. When the plant influent volumes are time-shifted by 6 hours they correlate well with the values obtained from the contact chamber exit weir. The LaserFlow meter correlated somewhat with the influent flow rate and exit weir flow rate but the flow meter discounted no flow or negative readings by default and inherently read high as a result. Further custom coding would be necessary to develop a satisfactory all-inclusive algorithm, but the LaserFlow meter trended well. Regardless of the false high readings from the LaserFlow meter, the metering pump still dosed a nominal 14 ppm PAA based on weir level readings. The concentration of 14 ppm PAA was chosen based on measurable residual, good efficacy against *E. coli*, and significant economy compared to previous recommendations against maximum organic demand and *E. coli* levels as high as 2.2 million CFU/100ml.

Three amperometric probes were set up at three different locations in the contact chamber: P1, P2, and P3. While amperometry is a common way to measure oxidants such as PAA, it proved to be a sub-optimal choice for this system due to the rapid deterioration of the sensitive membranes due to high concentration of organic material in the water. The Palin Modified DPD Methodology proved to be the best and most accurate way to analyze the effluent for PAA residual concentration. The DPD meter was operated manually and used to test the residual concentration of PAA at the various sampling points. Fully automated DPD meters are available for use in high organic demand environments.

BIOLOGICAL OXYGEN DEMAND

Peracetic acid disinfection does have the potential to increase the BOD_5. Theoretically the BOD_5 may increase by up to 24.6 ppm with a 14 ppm PAA dose from 22% PAA, but an average increase of 13 ppm in BOD_5 was observed in this study. Based on the available MORs from M.C. Stiles WWTP, the BOD_5 contribution from 22% PAA is expected to reduce the percent removal of BOD_5 by approximately 3%. This 3% reduction in the percent removal from 22% PAA would still allow the plant to exceed the NPDES permit limit for BOD_5 effluent removal of 85%.

E. COLI REDUCTION

The daily permitted limit for *E. coli* at the M.C. Stiles facility is 487 CFU/100mL with a monthly geomean of 126 CFU/100mL. The initial PAA dose was 10 ppm but since the *E. coli* concentrations were not consistently below daily permitted limits the concentration was increased to 14 ppm PAA. Once the concentration of PAA was increased to 14 ppm the *E. coli* counts were reduced to well below the daily permitted limit. The geomean was calculated over the 5-day time interval and yielded a 109.7 CFU/100 mL concentration, which is below the monthly permitted geomean. The results of this study suggest that when there are industrial users online, a nominal 14 ppm PAA may be dosed into the effluent and a residual PAA concentration target of >2 ppm should be maintained at the P2 location in order to yield *E. coli* concentrations under the permitted daily and monthly limits. It is important to note that there was were no PAA residual spikes during this pilot study (>6ppm PAA) due to the implementation of appropriate upfront mixing to eliminate the potential for laminar flow of PAA.

15% PAA COMPARISON

A simple trial was conducted on the last day of the study to compare the PAA residuals at P2 in the contact chamber from either 15% PAA or 22% PAA. The goal of this comparison was to confirm that feeding 22% PAA will result in approximately a 32% chemical use savings when compared to 15% PAA. The average PAA residual at P2 from 15% PAA was 1.53ppm and the average PAA residual at P2 from 22% PAA was 2.88ppm. The concentration difference at P2 was approximately 47%. The difference may be attributable to organic demand consuming more of the 15% PAA, but this simple study confirms that 22% PAA yields at least a 32% reduction in chemical use.

OVERALL

Enviro Tech completed this half-scale 22% PAA pilot study to demonstrate that 22% PAA is a good choice for large scale secondary effluent disinfection at the M.C. Stiles Waste Water Treatment Facility. By employing a combination of precise redundant flow measurements, a feed forward and feedback process control algorithm and continuous mixing to prevent PAA residual spikes, Enviro Tech demonstrated that 22% PAA may be used to effectively and economically treat the secondary effluent at the M.C. Stiles Waste Water Treatment Facility.