Old City, New Ideas: Peracetic Acid in Wastewater Disinfection at St. Augustine

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Wastewater treatment plants are required to disinfect effluent prior to discharge in order to destroy any pathogenic organisms present and minimize public health concerns. Chlorine has been the principal disinfection method in the wastewater industry, despite the fact that disinfection with chlorine produces chlorinated disinfection byproducts (DBPs), including trihalomethanes (TTHMs), that are toxic to aquatic life. In recent years, many municipalities have been required to install dechlorination systems in order to address DBPs, but upgrading an existing plant with a dechlorination process typically results in significant capital cost and operational complexity.

The 2.7 million-gallon-per-day (MGD) wastewater treatment plant in St. Augustine has a chlorination/dechlorination disinfection system, but plant officials decided to seek an alternative disinfection process that did not generate DBPs, was cost effective, and was simple to operate. The plant investigated disinfection options such as ozone and ultraviolet disinfection, but peracetic acid (PAA) disinfection was deemed the most attractive option because the plant's existing contact chamber could be used for the PAA technology, providing large capital cost savings to the municipality.

After successful bench-scale testing with PAA, a full-scale demonstration test was conducted to evaluate the performance of the PAA disinfection system compared to the existing chlorination/dechlorination system, based on several evaluation criteria:

- Disinfection performances
- Aquatic toxicity
- Disinfection byproducts
- Chemical consumption/sustainability

Trial Overview

Disinfectant

VigorOx® WWTII, manufactured by FMC Corporation, was selected for the study. The product is a proprietary 15-percent peracetic acid formulation that is approved by the U.S. Environmental Protection Agency for wastewater disinfection, EPA Reg. No. 65402-8. The PAA solution breaks down to the non-harmful products water, oxygen, and acetic acid (vinegar).

Disinfection Layout

The St. Augustine Wastewater Treatment Plant (Figure 1) has two identical disinfection contact tanks. Each tank receives 50 percent of the 2.7-MGD plant flow. After consulting with FMC Corporation, plant management deployed a PAA disinfection system consisting of a storage tank, a dispensing system, and a PAA residual monitor to treat the first contact tank. The second contact tank continued to operate using the existing chlorination/dechlorination system, enabling plant managers to conduct a direct, head-to-head comparison of the two technologies.

Figure 1: St. Augustine Wastewater Treatment Plant

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Both disinfection systems were connected to the plant's SCADA system and identical flow pacing equipment was installed at each contact tank. The flow pacing equipment enabled chemical dosage and flow rates to be controlled in real time. The plant's flow data, pathogen counts, chemical dosage rates, and residual data were recorded during the trial.

Trial Results

Disinfection performances

A wastewater disinfectant's performance can be quantified based on two specific pathogens of concern: *enterococci* and *fecal coliform* (FC). Effluent grab samples from both disinfection tanks were tested several times a week.

Enterococci

Figure 2 shows that an average concentration of 1.5 parts per million (ppm) PAA reduced the *enterococci* count between 1 and 6 CFU/100mL, well below the plant discharge limit of 35 CFU/100 mL. The average chlorine dose of 7 ppm yielded similar *enterococci* results to PAA with one outlier at 29 CFU/100mL. Thus, the test demonstrated an opportunity for the plant to use a lower concentration of PAA (versus chlorine) and still meet *enterococci* disinfection requirements.

Fecal Coliform (FC)

The plant's discharge permit limit for FC is 200 CFU/100mL. Figure 3 shows the PAA treatment performance side by side with the chlorination/dechlorination treatment per-

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formance. The data showed that an average PAA dosage of 1.5 ppm yielded similar disinfection performance to an average chlorine dosage of 7 ppm, and that both disinfection processes were effective in keeping FC count below the discharge limit.

Aquatic Toxicity Results

Wastewater can produce adverse effects on the biological system, damaging its infrastructure and causing death to aquatic life. The criteria for aquatic toxicity testing are mortality and reproduction rate. *Mysidopsis bahia* (mysid shrimp) and *Menidia beryllina* (tidewater silverside) were the species used for both acute and chronic toxicity testing.

During the trial, testing for acute and chronic toxicity at dilution levels ranging from 0 percent (control) to 100 percent effluent. The first set utilized treated effluent from the chlorination/dechlorination process (see Table 1). The second set utilized the PAA-treated effluent (see Table 2).

The toxicity results show a higher survival rate for the M. bahia and the M. beryllina in the PAA treated effluent when compared to the chlorination/dechlorination treated effluent. The growth rate results for both disinfection systems were comparable. The overall trend showed that PAA was slightly less toxic to aquatic life than chlorination/dechlorination.

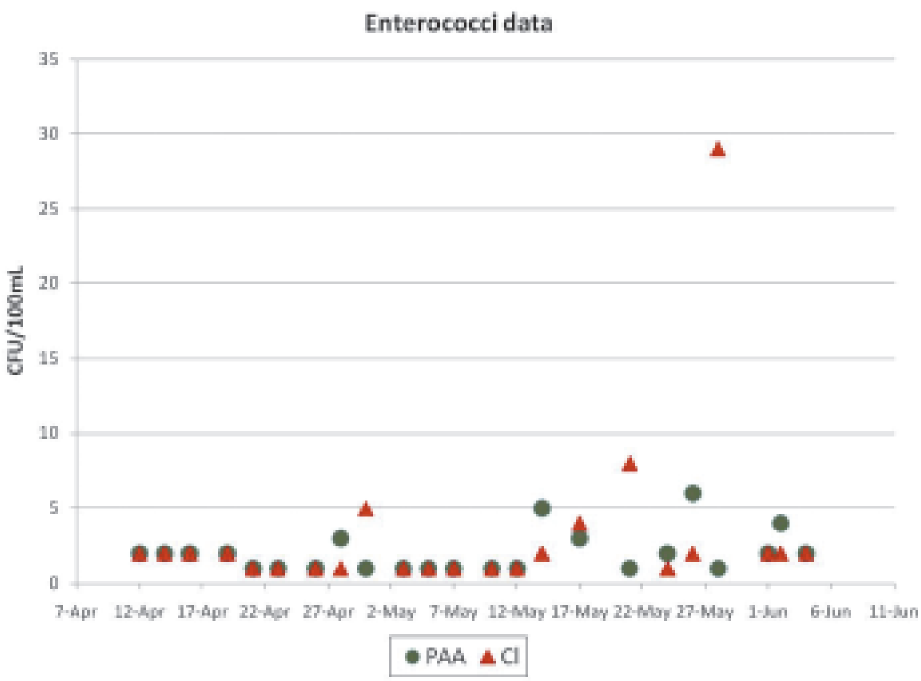

Figure 2: Enterococci graph

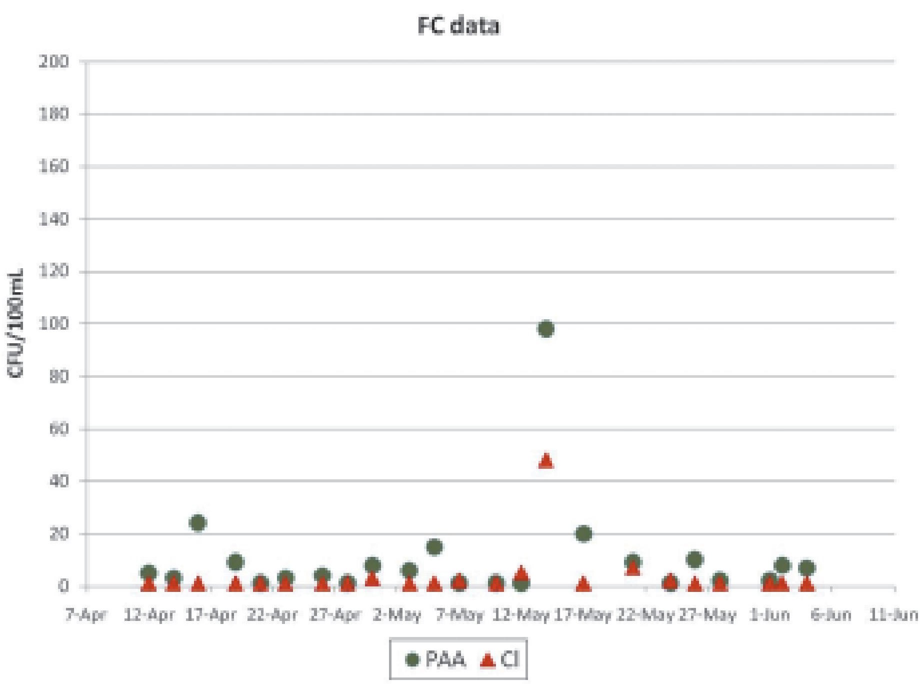

Figure 3: Fecal Coliform graph

DBP Results

DBPs are chemicals formed as a result of the reaction between the disinfectant added to the water and naturally occurring organic material present in the water. The U.S. Environmental Protection Agency has established discharge effluent limits for DBPs (see Tables 3 & 4).

DBP results from a chlorine treatment test are presented in Table 3. Untreated effluent grab samples were taken from the plant's side stream and tested for DBPs once chlorine was added (chlorine start), after disinfection was completed (chlorine end), and after the dechlorinating agent was added (after dechlorination).

Total trihalomethanes (TTHMs) concentration was found to be 194.19ug/L after disinfection. After the dechlorinating agent was added, TTHMs concentration decreased to 170.70ug/L, suggesting that the dechlorinating agent had only a limited capability of reducing TTHMs concentrations.

Results showed that there were virtually no TTHMs generated by the PAA disinfection process. Currently, many wastewater treatment plants in North America are having difficulty meeting DBP permits. This trial test suggested that conversion to PAA disinfection could provide a low-capital solution to resolve DBP issues.

Other results

The plant's SCADA data revealed that the average chemical usage for chlorination/dechlorination system was 235 gallons per day, while the PAA system used only 23 gallons per day of chemical to meet the same disinfection requirements.

Plant operators observed that the PAA treatment was easier to adjust and maintain dosing in response to rapid changes in plant flow rate, compared to the chlorine system. This may be attributed to the lower PAA chemical feed rate compared to that of chlorine.

Field studies have demonstrated that changes in wastewater characteristics can impact the dosage of PAA required for effective pathogen control. In order to address this challenge, FMC developed a proprietary PAA analyzer unit that can accurately measure and record PAA residuals in real time and may be integrated with a plant's automated control system and flow pacing equipment to enable plant operators to

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Table 1: Toxicity results from chlorination/dechlorination

	M. bahia		*M. beryllina*	
%	**Survival**	**Growth**	**Survival**	**Growth**
Control	97.5	0.390	100	2.096
6.25	85	0.375	97.5	1.986
12.5	97.5	0.415	97.5	2.333
25	90	0.372	100	2.226
50	77.5	0.414	100	2.562
100	82.5	0.377	97.5	2.506

Table 2: Toxicity results from PAA

	M. bahia		*M. beryllina*	
%	**Survival**	**Growth**	**Survival**	**Growth**
Control	92.5	0.353	100	2.374
6.25	90	0.383	100	2.487
12.5	95	0.380	100	2.491
25	95	0.396	100	2.426
50	90	0.377	100	2.563
100	97.5	0.358	97.5	2.337

Table 3: Disinfection byproducts from a chlorination/dechlorination treatment

Volatiles	Effluent limit (annually)	Chlorination start	Chlorination end	After de-chlorination
Bromodichloromethane [ug/L]	22	95.55	65.72	56.82
Bromoform[ug/L]	360	22.64	20.90	19.62
Chloroform[ug/L]	470.8	49.25	26.13	21.55
Dibromochloromethane[ug/L]	34	102.99	81.44	72.71
Total Trihalomethanes[ug/L]	-	270.43	194.19	170.70

Table 4: Disinfection byproducts from PAA treatment

Volatiles	Effluent limit (annually)	PAA start	PAA end	After de-chlorination
Bromodichloromethane [ug/L]	22	0.6	0.6	0.6
Bromoform[ug/L]	360	0.6	0.6	0.6
Chloroform[ug/L]	470.8	0.64	0.64	0.64
Dibromochloromethane[ug/L]	34	0.75	0.75	0.75
Total Trihalomethanes[ug/L]	-	0.6	0.6	0.6

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adjust PAA dosage rates based on real time to help ensure consistent pathogen control while optimizing chemical consumption.

Conclusion

The objective of the St. Augustine trial was to compare a PAA disinfection system to a chlorination/dechlorination system at a full scale over an extended period based on pathogen results, environmental impact, and cost.

At the St. Augustine plant, the PAA system achieved equivalent disinfection performance for both *enterococci* and *fecal coliform* compared to the chlorine treated system. The PAA system was found to have some environmental advantages, since it did not generate DBPs and exhibited less toxicity to aquatic life.

The PAA system was found to be 10 percent less expensive compared to the chlorination/dechlorination system because PAA was more efficient, with 1.5 ppm PAA concentration delivering equivalent microbial performance to 7.0 ppm of chlorine. Finally, the PAA system offered the St. Augustine plant some additional soft benefits, including the opportunity to reduce its overall disinfection chemical consumption by 90 percent and to respond more rapidly to changes in flow rates.

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