PERACETIC ACID AS A METHOD OF EFFLUENT WASTEWATER DISINFECTION IN LANGLEY, BC

LAM NGUYEN[1*], ANDRES GRAFFE [1], TOM CANDY PH.D. [2]

[1] US PEROXIDE LLC

[2] PEROXYGEN DERIVATIVE SOLVAY CHEMICALS

ABSTRACT

Metro Vancouver's Northwest Langley WWTP is a 3.2 MGD secondary plant which has traditionally used sodium hypochlorite followed by sodium bisulfite for disinfection during their disinfection season (April 1st – October 31st) in order to meet the British Columbia Ministry of Environment's guideline of 200 MPN/100ml. The use of peracetic acid (PAA) as an alternative disinfection method was evaluated by Metro Vancouver with the collaboration of US Peroxide in a multi-year pilot program. Based on the study's results, 12% peracetic acid was a means of disinfection at NLWWTP that was just as effective as sodium hypochlorite/sodium bisulfite based on compliance discharge and at a lower chemical dose rate. The log reduction in fecals was proportional to the dose of PAA and a dose of 1.5 mg/L was sufficient to satisfy regulatory requirements. The effluent wastewater treated with PAA passed the toxicity tests (LC_{50}) at all concentrations 1.5-2.5 mg/L of PAA; in fact no fish were killed in these tests. British Columbia's Ministry of Environment deemed these results compliant and allowed Metro Vancouver to use PAA during part of the 2013 disinfection season. The plan during the second year of this study is to further strengthen the case for PAA as an alternate disinfectant for NWLWWTP by proving its reliability over a full disinfection season and by further studying any potential receiving environmental effects.

KEYWORDS

Wastewater disinfection, peracetic acid, Metro Vancouver, chlorine replacement

INTRODUCTION

The Northwest Langley wastewater treatment plant treats about 3.2 MGD of wastewater. Located in Langley at 10301 - 201 Street, the plant provides secondary treatment to wastewater from about 27,000 residents in the Walnut Grove area of Langley. Traditionally the Northwest Langley WWTP used sodium hypochlorite (SHS) followed by sodium bisulfite (SBS) for disinfection during the disinfection season (April 1st – October 31st) in order to meet the British Columbia Ministry of Environment's guideline of 200 MPN/100ml before discharging to the Frazer River. To avoid any potential of chlorine by-products discharge to the outfall, the NWLWWTP looked at different disinfection alternatives to 1) meet the British Columbia Ministry of Environment's guideline of 200 MPN/100ml, 2) result of no byproducts, and 3) minimize capital investments. Peractic Acid (PAA) was chosen as an alternative method due to its simplicity and the ability to satisfy British Columbia Ministry of Environment's guideline. Also, the desirable attributes of PAA for wastewater disinfection are the ease of implementing treatment (without the need for expensive capital investment), broad spectrum of activity even in the presence of heterogeneous organic matter, absences of persistent toxic or mutagenic residual or by-product, no quenching requirement (i.e. no dechlorination), small dependence on pH, short contract time, and effectiveness for primary and secondary effluents (Kitis, et.al., 2004).

Figure 1: Northwest Langley Wastewater Treatment Plant

METHODOLOGY

In August 2013 the Northwest Langley Wastewater Treatment Plant contracted with US Peroxide (US Peroxide LLC, Atlanta, Georgia, and USA) to evaluate the use of PAA as an alternative disinfection technology to meet British Columbia Ministry of Environment's guideline of 200 MPN/100ml. US Peroxide provided the PAA product, a double-walled chemical storage tank and PAA dosing module, temporary containment system, real-time PAA residual measurement and feed rate control, remote telemetry monitoring, data collection, , application support and reporting. The Northwest Langley Plant maintained their existing chlorination and dechlorination dosing facility to serve as a backup in case of malfunction on the PAA feed system, though this was not needed during the study. The PAA storage and dosing system is shown in Figure 2.

Figure 2: Peracetic Acid System Installation at Northwest Langley Wastewater Treatment Plant

PAA is a strong oxidant and disinfectant that is becoming increasingly accepted as an environmentally-friendly alternative to chlorine and hypochlorite. Its oxidation potential is higher than that of chlorine or chlorine dioxide. PAA is commercially available in the form of equilibrium mixture containing acetic acid, hydrogen peroxide, and water as shown by the following equation (Kitis, et al., 2004).

$$CH_3CO_2H + H_2O_2 \rightleftharpoons CHCO_3H + H_2O$$

Where,

CH_3CO_2H = Acetic Acid

$CHCO_3H$ = Peracetic Acid

H_2O_2 = Hydrogen Peroxide

H_2O = Water

The disinfectant activity of PAA is based on the release of active oxygen, which is thought to PAAdisrupt sulfhydryl (-SH) and disulfide (S-S) bonds within enzymes. Hence, important components in cell membranes are broken by oxidative disruption. It is likely PAA irreversibly damages the chemi-osmotic function of membrane transport through rupture or dislocation of cell walls, which seriously impedes cellular activity (Lefevre, et al., 1992). It also has been shown that PAA produces little to no toxic or mutagenic by-products after reaction with organic material present in treated wastewater effluents or surface waters used for drinking water (Kitis, et al., 2004).

The PAA storage and dosing system is located at the west end of the plant downstream of the secondary effluent. PAA was injected into the inlet of a 486 yd^3 contact chamber with a retention time of approximately 45 minutes. To ensure rapid mixing, PAA was injected into a 4 by 4 flow channel structure box with continuous mechanical mixing. PAA was fed on flow pace controlled by flow signal input provided by the plant.

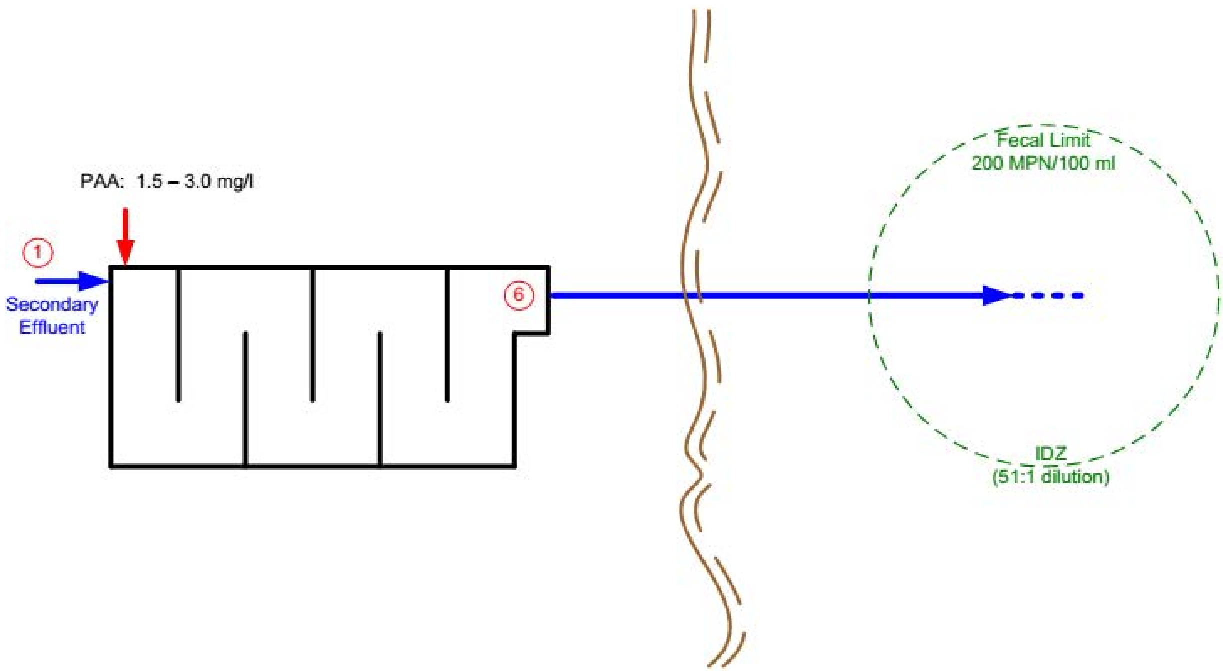

Figure 3: Northwest Langley Wastewater Treatment Plant disinfection overview

A test plan was executed whereby different doses of 12% PAA (1.5, 2.0, 2.5 and 3.0 mg/L) were evaluated. The test included PAA residuals at the inlet and outlet of the contact chamber, fecal coliform counts, and biotoxicity tests (LC_{50}) at the point of discharge. During the trial, other parameters were tracked such as total suspended solids, cBOD, and wastewater temperature and flow rate. PAA residual at the point of discharge was monitored closely in order to avoid dosing over the required discharge limit of 2 mg/L set by Environment Canada. Continuous grab samples and online residual analyzers were used to ensure that discharge permit was met and logged at all times during the demonstration.

RESULTS

The demonstration started in August 2013 and went through December 2013. During this period, PAA was used as the sole means of disinfection at Langley.

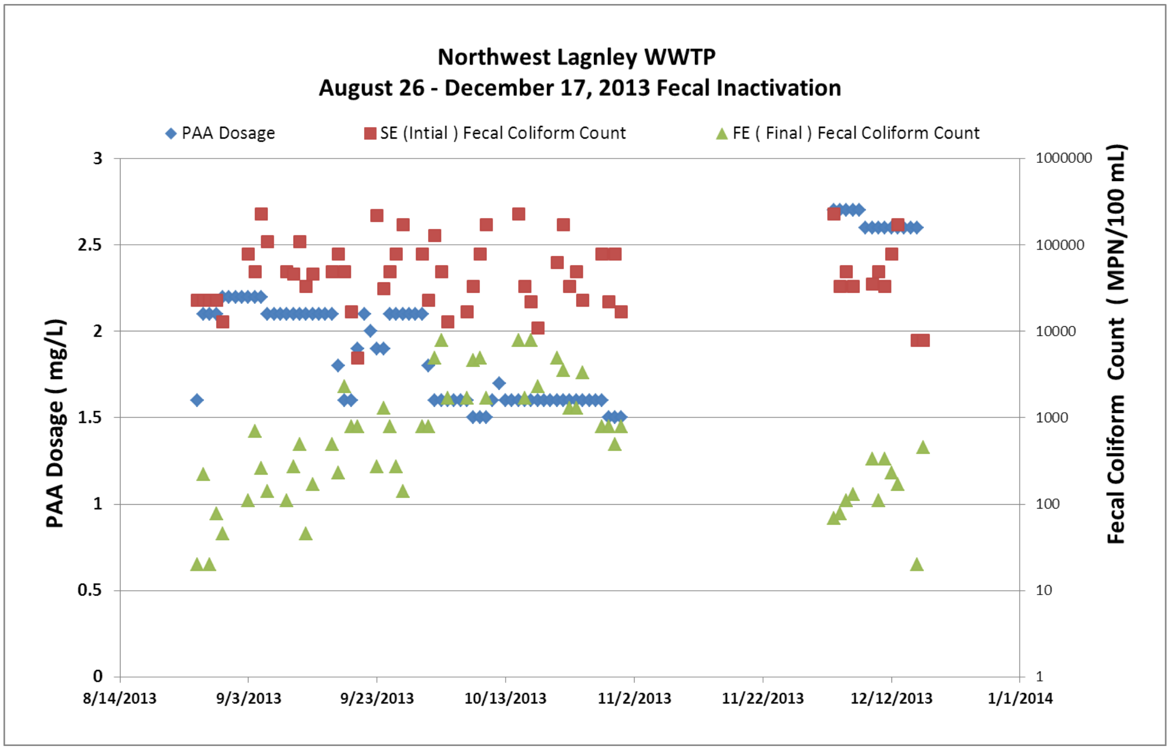

Figure 4: NWLWWTP fecal coliform inactivation using PAA as disinfectant between August 26th and December 17th 2013

As shown in Figure 4, samples taken from the secondary effluent (SE) had fecal counts ranging between 4900 – 230000 MPN/100 mL. All final effluent (FE) fecal counts were below 10,000 MPN/100 mL, which would satisfy the discharge limit once the 51:1 dilution factor is taken into account (200 MPN/100 mL X 51=10200 MPN/100 mL).

Table 1: Log reduction in fecal coliform counts and residual PAA levels at final effluent at various doses.

PAA Dosage (mg/L)	Average PAA Residual Final Effluent (mg/L)	Fecal Coliform Inactivation (Log Removal)
1.5	< 0.4	1.2
2.0	<0.6	2.3
2.5	<0.8	2.7

Table 1 (above) shows a distinct relationship between the dosage and the log reduction in fecal coliform, the log reduction increases with dose (as expected) and begins to plateau above 2.0 mg/L. Dosing of PAA was limited to below 3.00 mg/L due to the discharge limit of 2.0 mg/L, and it was shown that a dose of 2.5 mg/L assured this could be safely attained (residual PAA < 1.1 mg/L). Final effluent samples were also tested for fish toxicity and all samples were shown to pass 96 hour LC_{50}. Considering that the effluent is diluted by a factor of 51 at the point where it enters the Fraser River, it is safe to conclude that disinfection using PAA at this location is not harmful to the aquatic life.

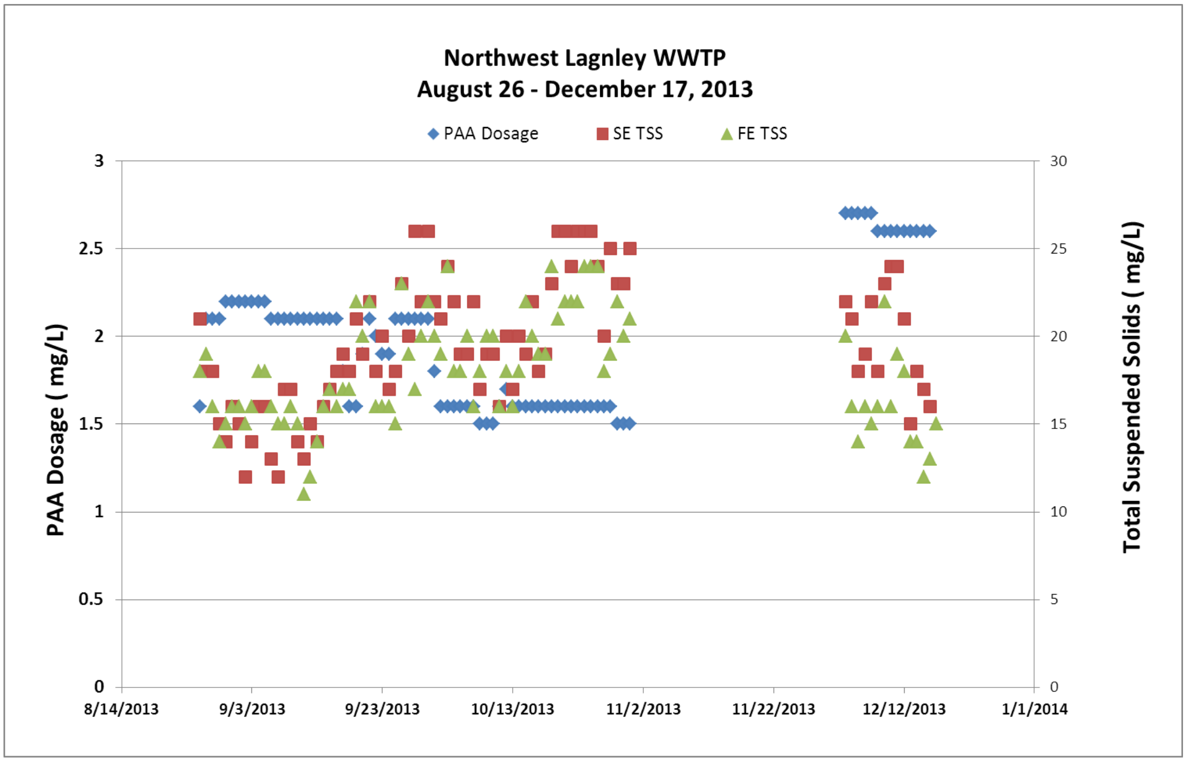

Figure 5: Comparison of total suspended solids of the final effluent and secondary clarifiers at various PAA doses

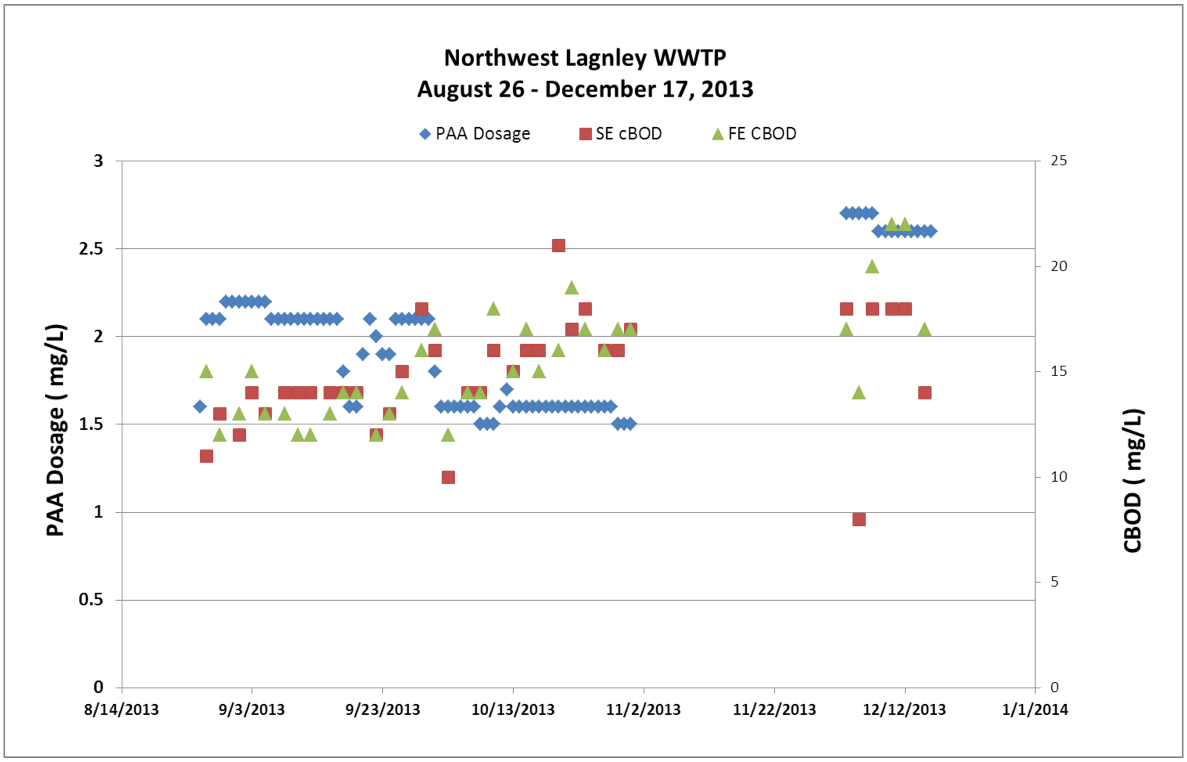

Figure 6: Comparison of cBOD of the final effluent and secondary effluent at various PAA doses.

Other parameters such as total suspended solids (TSS), $cBOD_5$ and pH were measured in order to verify that the PAA was not altering the water quality such that the discharge permit would be exceeded. As shown in Figure 5 andFigure 6, the TSS and the $cBOD_5$ levels remained the same before and after disinfection. It has been reported that that PAA can increase cBOD by a small amount (1-3%) due to its organic nature (CH_3CO_2H and $CHCO_3H$), however this was not observed during this demonstration. Additionally, pH values were not shown to change despite the acidity of the PAA ($pH < 2$), likely due the small amount of PAA needed in this situation.

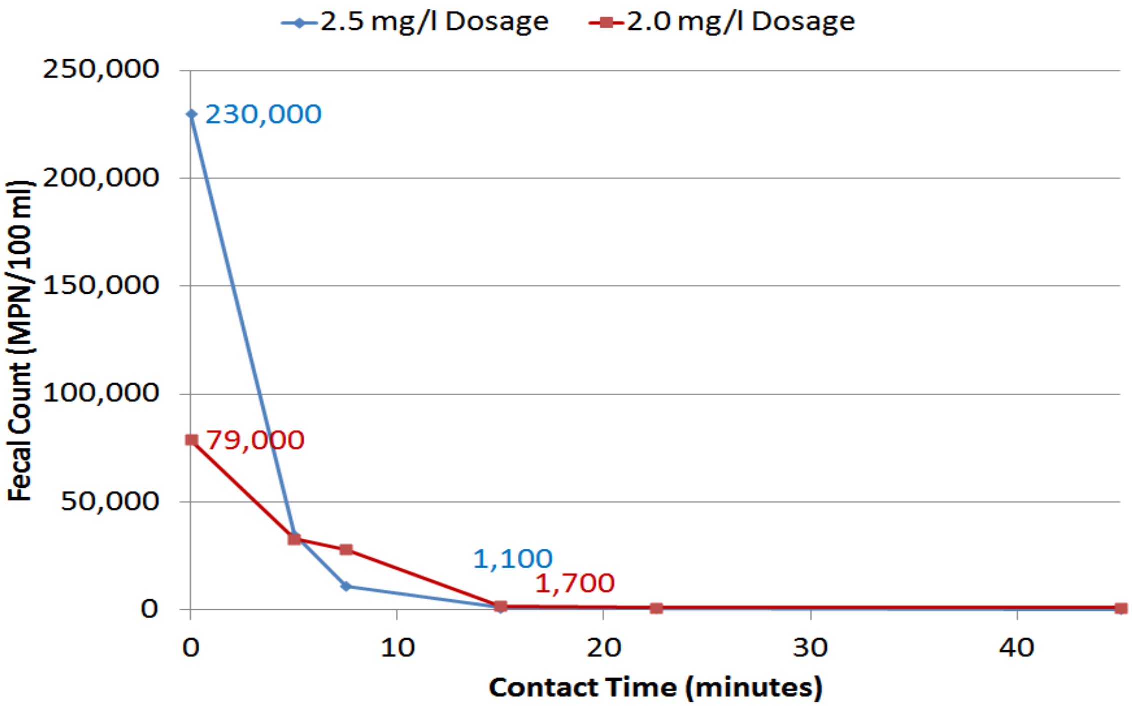

Figure 7: Fecal coliform inactivation kinetics

The kinetics of fecal coliform inactivation were also explored. Samples were taken at various locations in the contact basin and at different PAA doses. These data showed that the majority of the disinfection occurs in the first 15 minutes.

SUMMARY AND CONCLUSIONS

This evaluation, conducted by Metro Vancouver in collaboration with US Peroxide, at the Northwest Langley Wastewater Treatment Plant (NLWWTP), tested on full-scale the use of peracetic acid (PAA) as an alternative disinfection method to sodium hypochlorite (with dechlorination). The results show PAA to be a suitable alternative disinfectant technology for NLWWTP to achieve their discharge permit. The target fecal coliform kills were achieved with measurable impact on effluent toxicity, TSS, cBOD or pH.

REFERENCES

Kitis, Mehmet (2004) Disinfection of wastewater with peracetic acid: a review. Environmental International 30: 47-55.

Lefevre, F., J.M. Audic, and F. Ferrand (1992) Peracetic acid disinfection of secondary effluents discharged off coastal seawater. Water Science Technology 25: 155-163.

Dancey, K. (2009) Peracetic Acid, a new disinfection approach. Proceedings from the PCNWA Conference.

Gillette, R., Marks, K., and Pawluk, D. (2003) City of Roseville alternative disinfection study. WEFTEC.

ECETOC JACC No. 40. Peracetic acid (CAS No. 79-21-0) and its equilibrium solutions.

WEF. (2006) Wastewater disinfection training manual.