original article

Disinfection of stabilization pond effluent by peracetic acid and sodium hypochlorite

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ABSTRACT

Aims: In this study, the efficiency of peracetic acid (PAA), sodium hypochlorite (NaOCl) and combination of both disinfectants for disinfection of stabilization pond effluent was assessed.
Materials and Methods: The samples was collected during four months. All samples were analyzed as triplicate according to the Standard Methods. Microbial tests were carried out to total coliform (TC), fecal coliform (FC) and fecal streptococci (FS) . Also, the physical characteristics such as the total suspended solids, and also chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were analyzed.
Results: In this study, the application of combined disinfectants lead to reduction of total coliform, fecal coliform and fecal streptococci from 2.8×10^5, 2.2×10^5 and 7.1×10^4 to 1.6×10^3, 5×10^1 and 1.9×10^2 MPN/100 ml, correspondence to 2.55, 3.64 and 1.83 log removal value (LRV), respectively.
Conclusions: The study demonstrated that application of combined PAA and NaOCl in disinfecting the effluent of the stabilization pond will promote the efficiency of disinfection process in inactivating the coliform group bacteria and fecal streptococci.

Key words: Disinfection, fecal coliform, fecal streptococci, NaOCl, PAA, total coliform

INTRODUCTION

Reclamation and reuse of municipal wastewater has increased in recent years. However, reuse must be safely implemented to avoid endangering public health and the environment.[1]

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In a very limited number of cases, treated wastewater discharges without disinfection are permitted; these are approved on a case-by case basis. The development of new technologies has extended the possibilities for wastewater reuse.[2] The negative effects of wastewater disinfection byproducts (DBPs) on human health and the ecosystem have attracted increasing attention. Compared to drinking/natural water, there are higher pathogen levels and more types of organic and inorganic matter. Therefore, disinfection of wastewater for discharge or reuse is more complex than for drinking/natural water.[3]

The effective reuse of the treated municipal wastewater (TMWW) as a source of irrigation water for agricultural production can be accomplished by meeting the following

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prerequisites: (i) Adequate control of pathogens (ii) Elimination and control of harmful chemicals (organic compounds, pharmaceutical substances) and heavy metals (iii) Control of the undesirable effects on soil and plants (iv) Consideration of economic, legal, and institutional issues (v) Securing public acceptance, perception, and liability.[4]

Generally all human activities cause pollution, so that it is advisable that, before discharging into the environment, all industrial and urban sewage should undergo treatment process.[5]

On careful examination performed on the effluent of Shahreza wastewater treatment plant, it was observed that, due to an inappropriate disinfectants and the existence of a number of microorganisms, particularly total and fecal coliforms, the sewage could not meet the required environmental standards. The sewage was not well-treated, so that it could not be discharged into surrounding areas and penetrating into the underground water.

Using a combination of peracetic acid and sodium hypochlorite to disinfect the secondary treated effluent, the present study is designed to evaluate the system efficiency of reducing a number of microorganisms, particularly total and fecal coliforms.

According to the article by Ceretta R *et al.* (2008) Peracetic acid presented bactericidal action for all the microorganisms studied was most effective at a concentration of 2500 ppm. The data analyzed presented statistical significance between concentrations at a 0.05% level of significance. The inhibition zones increased for all the microorganisms in the agar diffusion test, proportionately with the increase in antimicrobial agent concentration. Observation revealed that for Pseudomonas aeruginosa, the mean inhibition zone was the smallest among all the microorganisms studied, even at a concentration of 2500 ppm. In contrast, *Staphylococcus aureus* presented the greatest inhibition zone. The results presented in the minimum bactericidal concentration (MBC) tests indicate that, when Pseudomonas aeruginosa and Salmonella choleraesuis were inoculated at concentrations of 800 ppm and 1500 ppm, they still developed colonies.[6]

The study by Stiina R. *et al.* (2011) showed that biofilm-forming bacteria from a paper machine treated with peracetic acid were mainly sphingomonads. Only thin biofilms accumulated at a few sites in this machine, indicating that the biocide was effective. The genera reported to be prevalent in biofilms of paper machines and known to grow abundantly on the R2A medium have been described as species of the genera Deinococcus, Meiothermus, Bacillus, Paenibacillus, and Pseudoxanthomonas.[7]

In the absence of effluent chlorination, the WWTP investigated in the study by Cristina P *et al.* (2012) has a good efficiency in removing the influent toxicity. This evidence is confirmed by the absence of toxicity with all the tests utilized in the recipient water body both downstream and upstream of the plant discharge, except for the 15th sample from DS site that presented a TU value with P. subcapitata. Whereas, in the second sampling period (2006-2007), we found a low toxicity in one US sample and in two DS samples after the effluent treatment with NaOCl; the disinfection of these samples might have used the highest concentrations of sodium hypochlorite (4.58 and 5.00 mg/L).[8]

In automatic milking systems, rapid methods to detect mastitis and also to prevent mastitis are very important since reduced milk quality and economic losses are the consequences of mastitis. Based on IDF Standard 148 a rapid and reliable method to detect somatic cell count with Coulter Counter technique was developed in the study by Antje *et al.* (2010) and the efficiency of peracetic acid (PAA) to prevent bacterial cross-contamination was investigated using Escherichia coli as test microorganism.[9]

Based on the results of the study by Hashemi *et al.* (2010), we concluded that the UV reactor was unable to improve the microbial quality of secondary wastewater effluent without pretreatment and this is related to the low transmittance of the effluent. Disinfection of clarified and filtered effluents with the MP lamp in moderate to high doses is suitable for reducing the bacteria load down to the local standards for agricultural reuse.[10]

MATERIALS AND METHODS

To carry out an accuracy test, a number of samples (approximately 10 percent) were provided in duplicate and the pilot under study was set up with 2 disinfectants in various doses.

To determine the total and fecal coliform and fecal streptococci, microbial tests were performed on all sewage samples. Four samples were employed in this study, namely: (a) Sample of treated effluent taken from the stabilization pond of the wastewater treatment plant as the control sample. (b) Peracetic acid sample in various doses with 30 min detention time. (c) A sodium hypochlorite sample in various doses with 30 min detention time (d) A composite sample of PAA and NaOCl in various doses with 30 min detention time. A comparison was made between the results of analyses and the wastewater discharge standards set by Iran Environment Protection Organization.1000 total coliforms per 100 ml, and 400 fecal coliforms per 100 ml were defined as standard. Table 1 shows the parameters which are contrary to standards of stabilization pond treated effluent of wastewater treatment plant of Shahreza. The test results were analyzed with SPSS and Excel software. Table 2 shows the disinfectant doses.

RESULTS

The primary objective of the present study was to compare the disinfection effect on Shahreza secondary treated effluent, following a combined treatment method with PAA and NaOCl as the disinfectants. These results shown in Figures 1-3 and Tables 3-5.

DISCUSSION

The present study demonstrate that a combination of PAA and NaOCl in various doses in disinfecting the secondary treated effluent of Shahreza wastewater treatment plant, promotes this method efficiency with respect to a reduction or total removal of coliform group bacteria. Figure 1 shows that combined treatment method caused a reduction in pre and post-treated total coliform bacteria from an average of 2.8×10^5 (MPN/100 ml) to an average of 1.6×10^3(MPN/100 ml), respectively

Figure 2 shows different disinfection methods adopted to reduce fecal coliform bacteria. We evidence that the combined treatment method with PAA and NaOCl as disinfectants, produces the most desired effect on reducing the fecal coliform bacteria in secondary treated effluent. The Figure shows a reduction in post-treated fecal coliforms from an average of 1.28×10^5 to an average of 3.00×10^2 In other words, in combined treatment, an average of 99.7 percent reduction in fecal coliform bacteria was observed and fecal coliform could meet less than the standard of 400 (MPN/100 ml) in the effluent of wastewater treatment plant.

In Italia, Caretti *et al.* (2003) conducted a research on disinfecting the treated effluent using PAA and UV. The study revealed an increased disinfection effect on treated effluent. The observed effect was due to the free radicals produced as a result of chemical reactions between PAA and wastewater, and consequently a UV improved impact on treating system.[11]

Table 1: Parameters contrary to standards in wastewater treatment plants of shahreza

Parameters	Standard values	Values in effluent without disinfection
Total coliform	1000 MPN/100 ml	3.3×10^5MPN/100 ml
Fecal coliform	400 MPN/100 ml	3.3×10^5MPN/100 ml

Table 2: Disinfectants mode

Mode	Value	Mode	Value
1	NaOCl (15 mg/L) + PAA (6 mg/L)	6	NaOCl (15 mg/L) + PAA (18 mg/L)
2	NaOCl (10 mg/L) + PAA (9 mg/L)	7	NaOCl (10 mg/L) + PAA (36 mg/L)
3	NaOCl (15 mg/L) + PAA (10 mg/L)	8	NaOCl (10 mg/L) + PAA (36 mg/L)
4	NaOCl (10 mg/L) + PAA (6 mg/L)	9	NaOCl (12 mg/L) + PAA (21 mg/L)
5	NaOCl (25 mg/L) + PAA (18 mg/L)	10	NaOCl (15 mg/L) + PAA (15 mg/L)

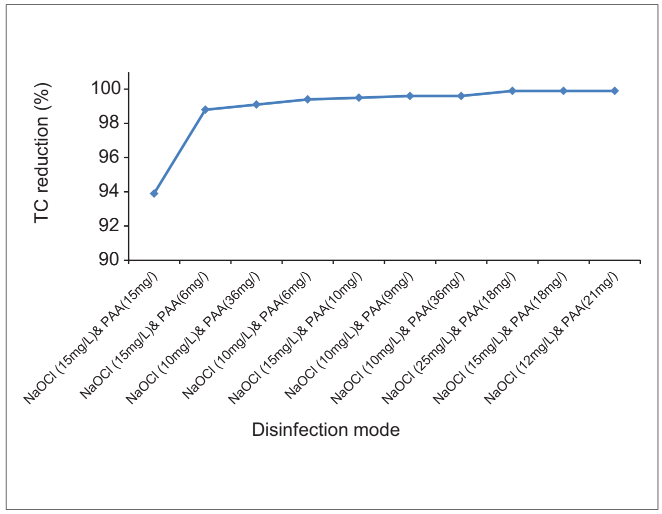

Figure 1: Comparison of total coliform reduction treating with PAA and NaOCl in various Doses

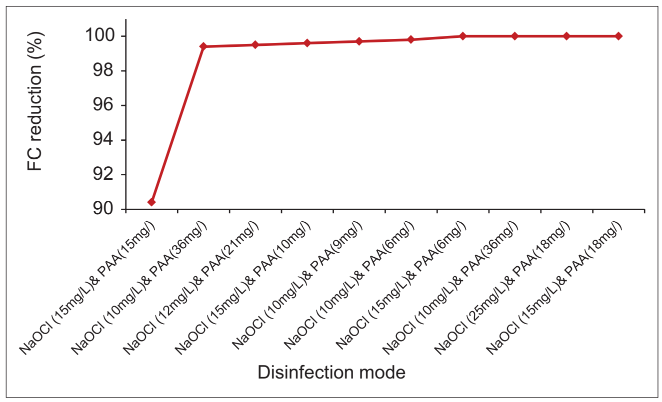

Figure 2: Comparison of fecal coliform reduction treating with PAA and NaOCl in various doses

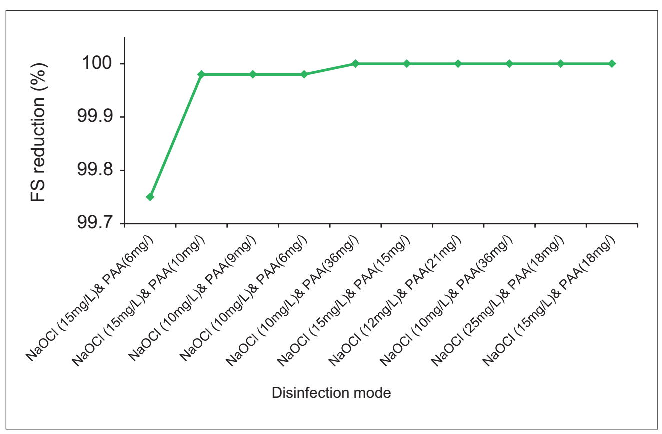

Figure 3: Comparison of fecal streptococci treating with PAA and NaOCl in various doses

Table 3: Determination of fecal coliform treated with NaOCl doses (12, 15, 25 mg/l) and PAA doses (21, 18 mg/l)

Data	Effluent	PAA	Reduction		NaOCl	Reduction		PAA + NaOCl	Reduction	
			%	LRV		%	LRV		%	LRV
NaOCl (25 mg/L) + PAA (18 mg/L)	1.10E+04	3.60E+02	96.7	1.49	1.00E+00	100.0	>4.04	1.00E+00	100.0	>4.04
NaOCl (15 mg/L) + PAA (18 mg/L)	4.60E+04	7.50E+02	98.4	1.79	3.60E+01	99.9	3.11	1.00E+00	100.0	>4.66
NaOCl (12 mg/L) + PAA (21 mg/L)	2.80E+04	1.50E+03	94.6	1.27	9.10E+02	96.8	1.49	1.50E+02	99.5	2.27
Average	2.83E+04	8.70E+02	96.6	1.51	3.15E+02	98.9	1.95	5.00E+01	99.8	2.75

Table 4: Determination of total coliform treated with NaOCl doses (12, 15, 25 mg/l) and PAA doses (21, 18 mg/l)

Data	Effluent	PAA	Reduction		NaOCL	Reduction		PAA+NaOCl	Reduction	
			%	LRV		%	LRV		%	LRV
NaOCl (25 mg/) + PAA (18 mg/L)	4.30E+04	4.60E+03	89.3	0.97	1.00E+00	99.9	> 5.63	3.60E+01	99.8	4.08
NaOCl (15 mg/) + PAA (18 mg/L)	1.10E+05	4.60E+03	95.8	1.38	3.00E+01	99.9	3.56	1.50E+02	97.8	2.86
NaOCl (12 mg/) + PAA (21 mg/L)	1.50E+05	9.30E+03	93.8	1.21	1.00E+00	99.9	> 5.18	2.10E+02	99.5	2.85
Average	1.01E+05	6.17E+03	92.96	1.21	1.00E+01	99.9	4.01	1.32E+02	99.0	2.88

Table 5: Determination of fecal streptococci treated with NaOCl doses (10 mg/l) and PAA doses (15, 10, 6 mg/l)

Data	Effluent	PAA	Reduction		NaOCl	Reduction		PAA+NaOCl	Reduction	
			%	LRV		%	LRV		%	LRV
NaOCl (15 mg/L) + PAA (6 mg/L)	3.6E+04	4.20E+02	98.8	1.93	3.60E+02	99.0	2.00	9.10E+01	99.7	2.60
NaOCl (15 mg/L) + PAA (10 mg/L)	4.6E+05	4.20E+03	99.1	2.04	6.20E+02	99.9	2.87	7.50E+01	99.9	3.79
NaOCl (15 mg/L) + PAA (15 mg/L)	3.9E+03	6.40E+02	83.6	0.78	9.80E+01	97.4	1.60	1.00E+00	100.0	>3.59
Average	1.67E+05	1.75E+03	93.83	1.98	3.60E+02	98.7	2.67	5.53E+01	99.87	3.48

Stampi *et al.* also carried out a study to evaluate PAA efficiency in disinfection process. It was evidenced that fecal microorganisms reduced by 97% in 20 min of contact time and with PAA concentration (in the range of 2-1/5).[12]

Table 3 shows different disinfection methods adopted to reduce the fecal coliform bacteria. We evidence that combined treatment with PAA and NaOCl as disinfectants, produce the most desired effect on reducing the fecal coliforms in secondary treated effluent. The Table shows a reduction in post-treated fecal coliforms from an average of 2.8×10^4 to an average of 5.00×10^1. In other words, in combined treatment, an average 99/8% reduction in fecal coliform bacteria was observed. Disinfection method using NaOCl and PAA with an average 98/9 and 96/6 percent in reduction, respectively, brings about the most appreciable effect on disinfecting the fecal coliform bacteria. According to the standards defined by Iran Environment Protection Organization, in order to be discharged into the surface water or used in agriculture, fecal coliform level is expected to be below acceptable standard of 400 MPN/100 ml. taking the mentioned data into consideration, we can draw the conclusion that the doses tested in this study, meet the acceptable standard for discharging into surface water and farmlands. However, the recommended dosage for disinfection purpose in combined treatment method is 15 mg/L dose of NaOCl+18 mg/L dose of PAA.

Veschetti *et al.* (2003) made a comparative study on the efficacy of PAA and NaOCl in disinfecting the secondary treated effluent in Rome. Going through the activated sludge process, the present study revealed that PAA has a bactericidal effect on total and fecal coliform, pseudomonas and salmonella, which is similar to the results produced by disinfection method using NaOCl. The study also demonstrated that, as compared to NaOCl, PAA has less infection effect on reducing fecal streptococci and anti *E. coli* bacteriophage.[13]

Acceptable environmental standards will be met with employing combined treatment method using PAA and NaOCl in disinfecting treated effluent of Shahreza wastewater treatment plant. Also, total and fecal coliform bacteria existed in the treated effluent can reach the standards to be discharged into surface water.

Table 4 shows different disinfection methods adopted to reduce the total coliform bacteria. We evidence that combined treatment with PAA and NaOCl as disinfectants, produce the most desired effect on reducing the total coliforms in secondary treated effluent. The Table shows a reduction in post-treated total coliforms from an average of 5.51×10^5 to an average of 1.32×10^2. In other words, in combined treatment, an average 99/9% reduction in total coliform bacteria was observed. Disinfection method using NaOCl and PAA with an average 98.8 and 92.9 percent in reduction, respectively, brings about the most appreciable effect on disinfecting the total coliform bacteria. According to the standards defined by Iran Environment Protection Organization, in order to be discharged into the surface water or used in agriculture, total coliform level is expected to be below acceptable standard of 1000 MPN/100 ml. Given the produced results, all three doses tested in this method have the same effect on reducing the total coliform bacteria. Therefore, the recommended dosage for disinfection purposes in combined treatment method is 15 mg/L dose of NaOCl+18 mg/L dose of PAA.

Figure 3 shows that all disinfectant doses reduced the fecal streptococci by 99/9% against the control sample. The results revealed that, as compared to PAA, NaOCl produced more disinfection effect, while a combined application of the two disinfectants led to a reduction in NaOCl dosage, yet promoted the disinfection efficacy.

Further examination of Table 5 shows that 15 mg/L of PAA and 15 mg/L of NaOCl can be proposed as the most appreciable disinfection doses used to reduce the fecal streptococci. By using 15 mg/L of NaOCl and 15 mg/L of PAA, alone, fecal streptococci shows a 97.4 and 83.6 percent reduction, respectively, and 100 percent reduction in combined treatment method.

Following combined treatment method, the present study revealed a reduction in pre-treated fecal streptococci from an average of 2.2×10^5 (MPN/100 ml) to a post-treated fecal streptococci level of 0.5×10^1(MPN/100 ml). The present study demonstrated that NaOCl in the presence of PAA caused a reduction in NaOCl dose, and consequently conventional chlorine disinfectants can be replaced with more suitable disinfectants.

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