v. 5, n. 6, 2025

Journal of
Engineering
Research

Acceptance date: 20/05/2025

II-1198 - TECHNICAL AND FINANCIAL COMPARISON OF THE DISINFECTION EFFICACY OF PERACETIC ACID AND SODIUM DICHLOROISOCYANURATE FOR DISINFECTING TREATED SEWAGE SAMPLES FROM THE DANCING DAYS SEWAGE TREATMENT PLANT

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Abstract: The sewage treatment carried out at sewage treatment plants (STPs) has the function of removing the contaminants present, with the aim of leaving the treated sewage in a condition to be discharged into the receiving bodies. One of the main contaminants in sewage is pathogenic microorganisms and in order to eliminate this risk to public health and the environment, sewage disinfection processes are carried out. Disinfection aims to inactivate the pathogenic microorganisms naturally present in sewage using various physical-chemical processes, the main ones being the application of chemical products (chlorine compounds, ozone, phoracetic acid, etc.) and ultraviolet (UV) radiation. The use of chemical products is the most common practice in the disinfection of sewage from COMPESA's sewage treatment plants, so we need to constantly buy various chemical products available on the market, which are constantly changing in price and have a direct impact on the company's operating costs. Therefore, in this work, bench tests were carried out with jar-tests at COMPESA's Sewage Laboratory, in which the disinfectant products sodium dichloroisocyanurate and peracetic acid were tested on the sewage treated at the Dancing Days WWTP. In these tests we applied the products under different conditions of application dosage and contact times with the aim of reducing the Thermotolerant Coliform Concentration, the microbiological parameter measured, below the limit of 1,000NMP/100mL recommended by the state legislation of Pernambuco (IN 03/2018 of the CPRH). With this laboratory data and the costs of the products, we can assess which has the best disinfection efficiency and its financial viability, as well as estimating the performance of the products under operational conditions in the treatment units of the WWTPs. The treated sewage used in the tests was collected at the Dancing Days sewage treatment plant, which is a conventional

COMPESA sewage treatment plant operated by BRK Ambiental in Recife/PE, and has a UASB reactor design followed by a Percolator Biological Filter and Secondary Decanter, later followed by a contact tank with the application of a sodium dichloroisocyanurate solution to disinfect the treated effluent. Compesa is the concessionaire for public sanitation services in the state of Pernambuco, and chemical product costs are one of the four largest monthly operating costs. In view of the above, tests with various chemical products for disinfecting sewage are of great importance from a technical point of view and from the point of view of managing chemical product costs. The company's Quality Control Management and the Companhia Pernambucana de Saneamento (COMPESA) itself supported the development of this work. We also had the support of chemical engineer Thiago Machado, from Peróxido do Brasil, who provided the sample of peracetic acid at 15% by mass.

Keywords: Disinfection, Treated Sewage, Chemical Product, Disinfection Efficiency, Chemical Product Cost, Peracetic Acid, Sodium Dichloisocyanurate, Jar-test, Thermotolerant Coliforms.

Figure 1 - Dancing Days WWTP (top view).

MATERIALS AND METHODS

To carry out the bench tests, the treated sewage was collected from the outlet box of Percolator Filter No. 1, before the sewage disinfection stage at the Dancing Day WWTP, and was then filled into 20-liter plastic gallons and packed in Styrofoam boxes with ice and transported to the Sewage Laboratory of COMPESA's Quality Control Management (GQL).

Figure 2: Dancing Days WWTP percolator filter (collection point for treated sewage).

As soon as the treated sewage samples arrived at the laboratory, they were subjected to flocculation tests using static "jar-test" reactors in HEXIS equipment, under the conditions described below.

Initially, jar tests were carried out to determine the consumption demand of peracetic acid, according to the manufacturer's instructions:

- Addition of a dosage of 1.5 mg/L of peracetic acid with contact times of 5 minutes and 10 minutes.

- Addition of a dosage of 3.0 mg/L of peracetic acid with contact times of 5 minutes and 10 minutes.

In all the jar-tests, gradients of $50s^{-1}$were used to agitate the samples at the predefined times. All the results of the demand tests showed residual concentrations of peracetic acid between 0.5 and 1.5 mg/L, indicating that the compounds present in the sewage did not consume all the product applied, regardless of the dosage used. We concluded that there was no minimum dosage required, so we were free to test any dosage range applied. After the demand test, jar tests were carried out on the treated sewage with different dosages of the chemical products applied and different agitation times in the 6 jars.

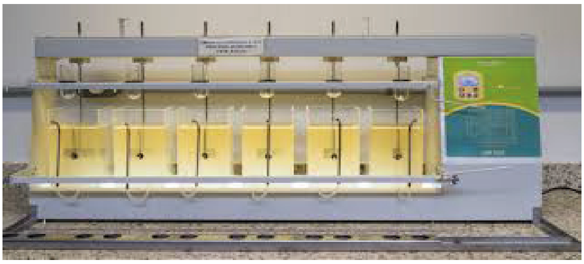

Figure 3 - Jarteste test in equipment with 6 jars.

Table 1 shows the dosages of the chemical products applied and the stirring times in the jars, which correspond to the contact times of the sewage with the products, because as soon as the pre-defined time was reached the stirring was stopped and samples were taken from each jar, and in each of these samples we added chemical products to paralyze the reactions with the disinfectants: in the samples with peracetic acid we added catalase enzyme solution and in the samples with dichlor we inserted sodium thiosulfate solution. Aliquots 1 mL were taken from each of these samples and transported to the inoculation room and then placed in the incubation ovens at a temperature of 44.5ºC.

DOSAGE (mg/L)	CONTACT TIME (min)
2	5
3	5
4	5, 10, 20
6	5
8	5

Table 1: Dosages of disinfectants and contact times in Jar-test trials.

The inoculations of the sewage samples in the greenhouses were carried out with dilutions defined according to the history of the analyses of the effluents from the Dancing Days WWTP, as follows, and followed the procedures described in the *Standard Methods for the Examination of Water and Wastewater*:

BLANK SAMPLE: $10^4$and 10^6

PERACETIC ACID

For a contact time of 5 minutes at the different concentrations applied:

- 2 mg/L: $10^4$and 10^5
- 3 mg/L: $10^4$and 10^5
- 4 mg/L: $10^4$and 10^5
- 6 mg/L: $10^2$and 10^4
- 8 mg/L: 10^2

For a time of 10 minutes:

- 4 mg/L: 10^2

For a time of 20 minutes:

- 4 mg/L: 10^2

SODIUM DICHLOROISOCYANURATE

For 5 minutes at the different concentrations applied:

- 2 mg/L: $10^3$and 10^4
- 3 mg/L: $10^3$and 10^4
- 4 mg/L: $10^2$and 10^3
- 6 mg/L: 10^2
- 8 mg/L: 10^2

For a time of 10 minutes:

- 4 mg/L: 10^2

For a time of 20 minutes:

- 4 mg/L: 10^2

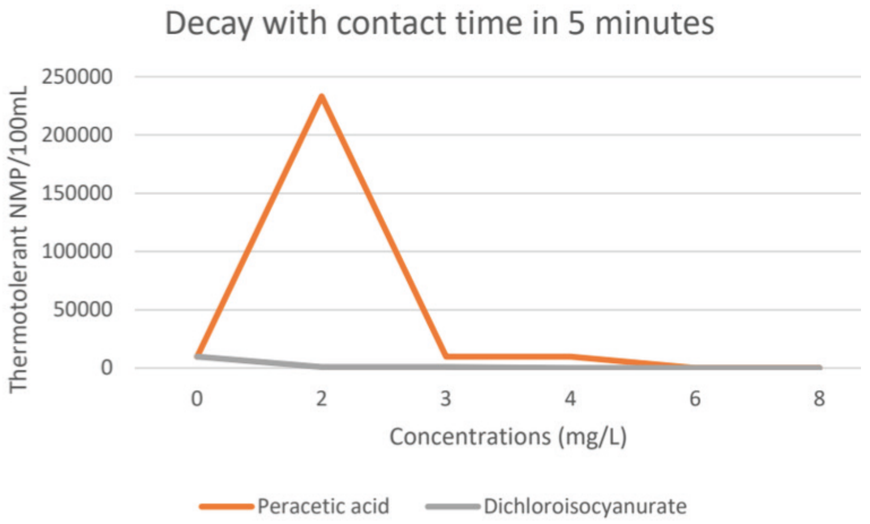

Figure 4: Number of thermotolerant coliforms in relation to the dosage of each product applied.

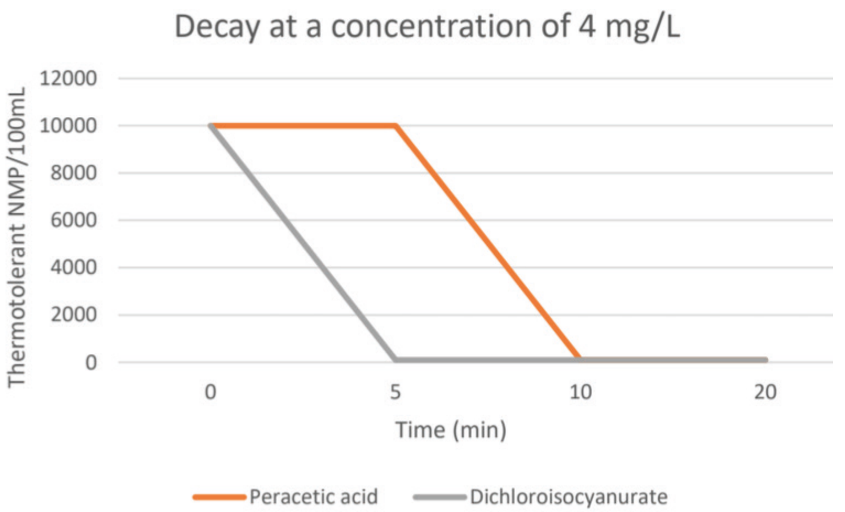

Figure 5 - Number of thermotolerant coliforms in relation to the contact time of each product.

MICROBIOLOGICAL TEST RESULTS

After 18 hours of incubation in the ovens, the microbiological tests obtained the following results, shown in Tables 2, 3 and 4:

BLANK SAMPLE		
DOSAGE (mg/L)	CONTACT TIME (min)	MPN/100mL
Not applicable	Not applicable	<10.000

Table 2: Contact time in jar tests.

PERACETIC ACID		
DOSAGE (mg/L)	CONTACT TIME (min)	MPN/100mL
2	5	2,33x105
3	5	<10.000
4	5	<10.000
6	5	<100
8	5	100
4	10	100
4	20	<100

Table 3: Disinfectant dosages and contact times in jar-test trials.

SODIUM DICHLOROISOCYANURATE		
DOSAGE (mg/L)	CONTACT TIME (min)	MPN/100mL
2	5	1,0x103
3	5	<1000
4	5	<100
6	5	1,0x102
8	5	<100
4	10	<100
4	20	<100

Table 4: Disinfectant dosages and contact times in jar-test trials.

Figures 1 and 2 show the comparative results of the decrease in the number of Thermotolerant Coliforms as a function of the increase in the dosage applied of the different chemical products.

TECHNICAL FEASIBILITY RESULTS

The results showed that an increase in the dosages of the chemical products led to a gradual decrease in the remaining concentration of bacteria, as did an increase in the contact time with each product. The results were expected as these physical and chemical parameters act directly on the inactivation mechanisms of microorganisms, but the figures showed some differences between the actions of the disinfectants.

Considering the fixed contact time of 5 minutes, we observed that both products were able to gradually reduce the remaining count of thermotolerant coliforms with increasing dosage, but there was a peak at a dosage of 2 mg/L in the peracetic acid test, which could be a contamination in the sample collection or processing procedure. Sodium dichloroisocyanurate was more efficient at removing coliforms than peracetic acid, because at any concentration applied, the remaining amount of thermotolerant coliforms was lower when dichloro was applied than when the acid was applied. In addition, dichloroisocyanurate was able to reach the desired limit of 1,000NMP/100mL at a concentration of 3mg/L, while peracetic acid required an applied dosage of 6 mg/L to reach the same concentration of coliforms.

Considering the results of Thermotolerant Coliforms as a function of contact time, with a fixed dosage of 4 mg/L, it can be seen that the decay with the use of sodium dichloroisocyanurate occurred more quickly than the decay with peracetic acid, since with 5 minutes of contact time with dichloro the count reached <100NMP/100mL, while with the same 5 minutes of contact time with peracetic acid the result was <10.000NMP/100mL, a value higher than that achieved by the other disinfectant.

The results showed that from a dosage of 6mg/L any of the products achieves the desired disinfection result, and that from a counting time of 8 minutes the remaining Thermotolerant Coliform count is practically the same, and both disinfectants showed similar results and can be used under longer contact time conditions.

FINANCIAL VIABILITY RESULTS

By analyzing the costs of each product and the dosages needed to reach the target value of 1,000NMP/100mL of Thermotolerant Coliforms, it was possible to estimate the daily quantity needed of each product and the amounts spent to disinfect the sewage at the Dancing Days WWTP. For the calculations, we used the current average flow rate at the WWTP, which is 167 L/s, and obtained the following results:

-Cost of Sodium dichloroisocyanurate (granules), 60% concentration (by mass): R$18.59/Kg.
- Dosage required: 3mg/L
- Quantity of dichloroisocyanurate /day: 43.28 Kg
-Estimated daily cost of dichloroisocyanurate: R$800.79.

- Cost of 15% peracetic acid (by mass): R$22.82 /Kg.
- Applied dosage required: 6mg/L
- Amount of acid/day: 86.57 Kg
- Estimated daily cost of acid: R$1,975.52.

CONCLUSIONS

This study compared the efficiency of various chemical products used in the disinfection of sewage treated at the Dancing Days WWTP, and concluded that the two products used in the study, sodium dichloroisocyanurate and peracetic acid, were able to inactivate pathogenic microorganisms, measured by the microbiological parameter thermotolerant coliforms, and were able to disinfect the sewage up to the limit number recommended by the state environmental standard.

The results of these experiments showed greater disinfection efficiency for dichloroisocyanurate, regardless of the concentration used and the detention time chosen. The tests indicated lower estimated costs for disinfection using dichloro than peracetic acid, making dichloro a better alternative for disinfection in this study, both from a technical and financial point of view.

Further tests will be necessary to determine the performance of peracetic acid in other operating conditions, and also to compare it with other disinfection agents, such as ultraviolet radiation equipment, and also to ratify the results obtained in this comparison.

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