Chlorine efficiency in the reducing coliforms in the sanitary effluent of septic tank treatment systems with anaerobic filter

ABSTRACT:

The lack of basic sanitation is still a problem in Brazil, only about half of all sewage produced undergoes treatment, due to difficulties in introducing sanitary effluent treatment plants considering that most Brazilian cities do not have financial resources for implementation and maintenance of these stations. In this way, many cities have been adopting different methods for treating sewage before discarding into the rain network. Thus, this work aimed to analyze the efficiency of chlorine in the reduction of coliforms in the sanitary effluent of a treatment system with septic tank, anaerobic filter and disinfection. Six sanitary sewage treatment systems were evaluated from different condominiums from august to december 2019. To check its efficiency, the following parameters were analyzed: pH, thermotolerant coliforms, free residual chlorine and chemical oxygen demand (COD). The results showed that of the six stations evaluated, only one (16,78%) presented the amount of thermotolerant coliforms within the permissible standards. Furthermore, of these only three stations (50%) presented the concentrations of free residual chlorine according to the required parameters. In addition, COD was high at four (66,66%) of the analyzed stations. These data allow us to conclude that the efficiency of chlorine in the reduction of coliforms in the sanitary effluent from a septic tank treatment system, anaerobic filter and disinfection unfortunately may not be happening, because this type of system needs to be well operated and inspected frequently, since the operation is mostly done by users.

Keywords: coliforms, disinfection, sanitary effluent, basic sanitation

1. Introduction

The lack of basic sanitation is still a problem in Brazil, even with the consolidation of the idea that investin this area drastically reduces spending on public health. Although, some advences have been done at the water and efluente treatment system the absence of a suitable system of basic sanitation expose the structural weakness of a system that can induce a myriad of diseases (Pereira et al., 2021). It is importante to stand out, that only 44,9% of sewer generated in Brazil are treated and besides that, only 102,1 milions of habitants have access to sewage collection (Soares et al., 2020)

The water resources contamination is responsible mainly by cause diarrheal diseases and this culminated in 1,4 milion deaths in 2010, including 17,4% of child deaths with 28 dias until one year and 11,9% of child deaths with one to four years. Of these deaths, 502.000 was attributed to inappropriate drinking water and 280.000 to inadequade sanitation (Lozano et al., 2012; Prüss-Ustün et al., 2014).

However, the IBGE (Brazilian Institute of Geography and Statistics) 2015 presents diseases related to inadequate sanitation in five categories according to their form of transmission. Being them diseases of fecal-oral transmission, such as diarrhea, enteric fevers and hepatitis A, vector-borne diseases like, dengue, yellow fever, leishmaniasis, lymphatic filariasis, malaria and Chagas disease, diseases transmitted by contact with water for example, schistosomiasis and leptospirosis, hygiene-related diseases such as, eye disease, (trachoma, conjunctivitis) and skin diseases (superficial mycoses) and diseases caused by geo-helminths and teniasis (helminthiasis, teniasis).

Frequently, most of the time there are many difficulties in introducing sewage treatment plants considering that the majority of Brazilian cities do not have financial resources to install and maintain these stations, as well as ample space and ideal soil permeability characteristics are needed to build the sink, resulting in the adoption of others convenient solutions. In Santa Catarina according to the IBGE (2017), of the 295 municipalities, only 131 have a sewerage collection, and according to Trata Brazil (2018) about 76.3% of the catarinense population does not have sewage collection, this way the state is in ninth worst position in this regard, compared to other states in Brazil.

As well as the municipality of São Miguel do Oeste-SC, many small cities in Brazil still do not have a sewage treatment plant and there is often incorrect disposal of sanitary and domestic waste, which results in contamination of shallow and deep water sources, as well as wide spread of diseases caused by pathogenic microorganisms that inhabit people's intestines, that by defecating they eliminate them to the environment, as previously mentioned.

In particular, the municipality of São Miguel do Oeste, located in the extreme west of the state of Santa Catarina (SC) does not have a collective sanitary effluent treatment plant and that is why it is important to check the operation of the treatment systems used.

Furthermore, it is observed that in addition to São Miguel do Oeste, other cities in the western region, also present problems in relation of water quality for human consumption and surface waters as, for example, the one in rivers, through several researches carried out by the university (UNOESC, Campus of São Miguel do Oeste - SC) like Rohden et al. (2009), Scapin, Rossi and Oro (2012), Rossi et al. (2012) and Rossi et al. (2018) point out the contamination found.

Currently, in addition to the septic tank system with a sink, in São Miguel do Oeste-SC an aerobic treatment system with filtration and chlorination has been widely used. Note that most residential and building units have systems installed as described in the NBR 7229/1993 and NBR 13969/1997, but these, in general, are not monitored and the few systems that are being monitored had several problems because there is no standardization in the operation of the systems.

In the last months, the local public prosecutor's office has requested monitoring through laboratory tests, but it is observed that there are many variables regarding the efficiency and functioning of this type of treatment system, mainly related to chlorination, because in the aforementioned legislation the amount of calcium hypochlorite tablets needed is not determined, neither the frequency at which these tablets should be glued at the chlorinator.

Therefore, numerous problems are being detected, because often those who realize the operation of sanitary sewage treatment systems with chlorination are the own residents of the building systems, who often lack the knowledge about the necessity of puting calcium hypochlorite tablets in the system. This has created many problems and discussions by residents and public bodies (Health Surveillance System and Public Ministry).

Thus, it is observed that is necessary to guide users, once in the NBRs used by the engineering área, there are gaps between the theory and practice of using and installing this system and the data generated by that work can be used as a tool for making decision regarding the functioning and operation of these systems.

However, we can mention that data regarding this type of treatment is scarce and there are no data described in the literature for monitoring these effluents in the state of Santa Catarina, which makes it important to publish these results, as they become crucial to subsidize future conservation plans, besides being an alert for other cities that use this system without evaluating its functioning.

2. Materials and methods

2.1. *Samples*

The samples were collected on six building located in the municipality of São Miguel do Oeste (Figure 1), once a week, from August to December 2019. The samples transported in thermal boxes to the Microbiology Laboratory of the University of the West of Santa Catarina - UNOESC, campus of São Miguel do Oeste / SC.

For discussion of results and for ethical reasons, wastewater treatment plants (ETE) were named in this work as ETE-A, ETE-B, ETE-C, ETE-D, ETE-E and ETE-F.

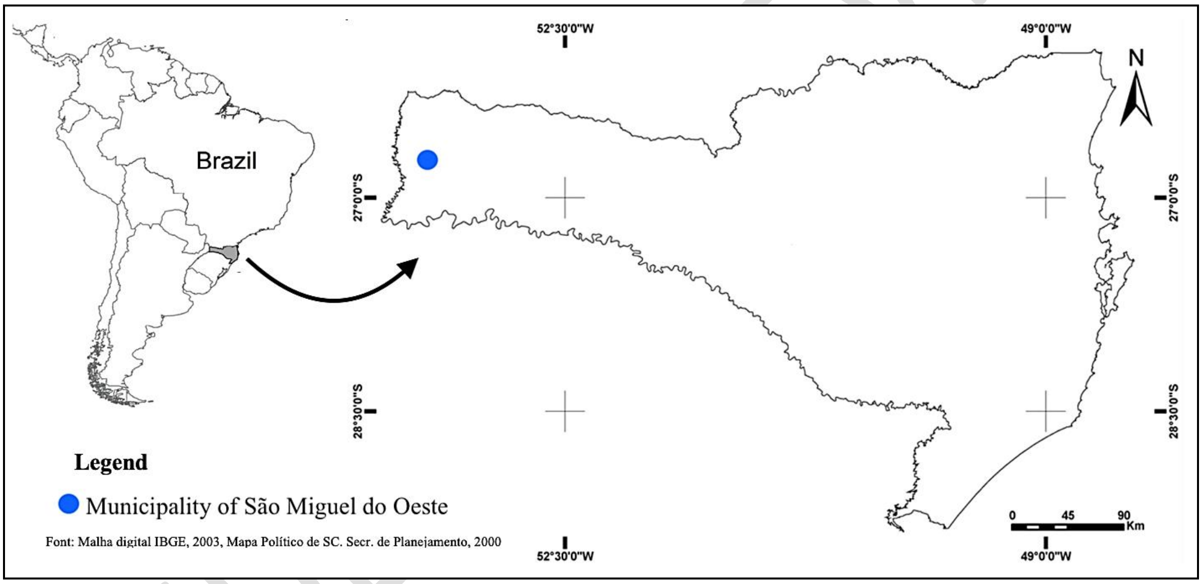

Figure 1. Map of Santa Catarina, with emphasis on São Miguel do Oeste, where this study was carried out.

2.2. *Analyzes performed*

In the university laboratory, tests were realized to determine the fundamental parameters for the research, they are: pH, free residual chlorine, chemical oxygen demand (COD) and thermotolerant coliforms.

The specific physical-chemical and microbiological parameters, as well as the methodologies used are shown in Table 1.

Table 1. Analyzes that were carried out with their respective methodologies.

Analyze	Method used
pH	Electrometric SM 4500 H+ B
Free residual chlorine	Merck colorimetric analogous to SM 4500
COD	Merck colorimetric analogous to SM 5220
Thermotolerant coliforms	Multi-tube fermentation – SM 9221-B

SM- Standard Methods for the Examination of Water and Wastewater, 2017.

Source: Adaptation of Standard Methods for the Examination of Water and Wastewater (2017).

The hydrogenonic potential (pH) were determined using a Hanna HI 98194 multiparameter probe. The other chemical parameters - chemical oxygen demand (COD) and Free residual chlorine were determined using a multiparameter spectrophotometer model Pharo 100, Spectroquant Merck. The Number most probable (NMP) of thermotolerant coliforms were determined using the multiple tube method was performed using Sodium Lauryl Sulfate Broth (Merck) and E.C. Broth (Merck).

After done the analyzes, the effluent samples were discarded at the UNOESC effluent treatment system - Campus São Miguel do Oeste.

2.3. Statistical analysis and results interpretation

To discuss the results, were calculated arithmetic average were calculated and standard deviation of samples from the six sewage treatment plants. Principal component analysis (PCA) was also used to group effluent quality indicators and to explain the relation between them, Pearson's correlation was performed.

To check if the analyzed stations had effluents within the permissibility parameters, the following legislation was used: CONAMA 430/2011, CONAMA 357/2005, NBR 7229/1993 and NBR 13969/1997.

2.4. Analysis of users' perception of sewage treatment plants

To evaluate the perception of users and professionals who accompany the treatment of the sewage related to the operation and maintenance of the stations, a questionnaire was applied with objective questions.

3. Results and discussions

The results showed that of the six sewage treatment plants (ETE) analyzed, only one (16.67%), ETE-C, was able to reduce, on average, the amount of thermotolerant coliforms and reach the permissible standards (Log <3 MPN / 100mL) by CONAMA 430/2011 during the period evaluated (Table 2).

As can be seen in Table 2, there are high values for the standard deviations of some parameters (thermotolerant coliforms, COD, free residual chlorine) and these can be explained by the fact that there were many variations found in the results of the analyzes in diferents collections of the samples.

Table 2. Minimum, maximum results with average and standard deviation of the analyzed parameters of the six sanitary effluent treatment plants during the months August and december 2019.

ETE	**pH**			**Free residual chlorine (mg L^{-1})**			**COD (mg L^{-1})**			**Thermotolerant coliforms (Log MPN/100 ml)**		
	Aver.	**Min.**	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**	**Min.**	**Max.**

A	7,21 ± 1,21	3,43	8,3	0,76 ± 1,28	0,05	5,4	750,1± 430,66	60	2205	3,26± 1,19	1,48	4,38
B	7,89 ± 0,48	6,5	8,35	0,27 ± 0,31	0,05	1,1	416 ± 302,88	229	1500	3,98± 0,62	2,49	4,38
C	2,32 ± 0,58	1,44	3,19	367,2± 135,17	51	649	108,8± 236,69	10	936	1,52± 0,2	1,48	2,36
D	7,70 ± 0,44	6,67	8,55	0,65 ± 0,76	0,07	2,58	552 ± 171,35	284	1046	3,74± 1,12	1,48	4,38
E	8,034± 0,29	7,42	8,38	0,31 ± 0,39	0,05	1,4	491,7± 83,67	360	636	3,93± 0,65	2,30	4,38
F	7,61± 0,42	6,63	8,08	0,27 ± 0,30	0,06	1,42	233,5± 82,91	106	480	3,50± 0,98	1,48	4,38

NOTE: To calculate the values refering to the average and standard deviation about the results of thermotolerant coliforms, the minimum value was considered 1,48 Log MPN/100 mL and how the maximum detection value 4,38 Log MPN/100 mL according to the detection limits of the fermentation method in multiple tubes used in this work.

In addition, as shown in Table 2, ETE-C was the system that presented the lowest values of thermotolerant coliforms and COD, on the other hand, it obtained the highest values of free residual chlorine.

In this station (ETE-C), also during the collections, a high increase in the effluent level was observed on rainy days, thus indicating a probable infiltration of rainwater into the system. The rainwater input into the system can alter the results, as it contains less organic load and does not have coliforms of fecal origin. Thus, it is possibly by this reason that the ETE-C has shown the most satisfactory results in relation to the other stations worked.

According to CONAMA 430/2011 Art. 9 in the control of the conditions of discharge of effluents, the mixture of sewage with better quality water, such as supply, sea and open cooling systems without recirculation, is prohibited for dilution before its release.

In relation to pH, it is observed that, in general, this factor has few problems to adapt the legislation since the majority (66,67%) systems remained within the permissible standards (5,0-9,0).

However, samples from ETE-C (16,67%), presented low pH values in all collections performed, in which they varied from 1,44 to 3,19 generating great concern. This acidity can be explained and correlated with the high amount of chlorine in that season, because Monteiro et al. (2014) explains that chlorine in water is intended to inactivate or destroy disease-causing organisms that may still be present after treatment, but due to its dissociation in water it can decrease the pH, increasing the acidity of the water.

This acidic pH can cause environmental risks, because according to Leira et al. (2017) Fishes have capacity to survive and grow better in wather with neutral pH or slightly alkaline (between 6 – 9). When surpass that pH range, your growth will be affected, and still, may occur mortalities, mostly in species that present dificulties to set the osmotic balance at the level of gills, generating respiratory problems.

The results also demonstrated that the ETE-C was the only one to answer the recommended parameters (> 0,5 mg L^{-1}) for free residual chlorine in all collections, with values ranging from 51 to 649 mg L^{-1} with an average of 367.2 mg L^{-1} as shown in table 2.

On the other hand, the averages of the results presented by TEE-A and TEE-D, although they are in accordance with the legislation, it is necessary to emphasize that during the analysis values below 0.5 mg L^{-1} were found.

As Cazaudehore et al. (2019) the DQO is defined how much oxygen required to the degradation of organic compounds, being used how one of the main parameters of organic contamination in wastewater treatment plants. Thus, the high values found for this parameter in most systems (66,67%) are worrying (Table 2), since the entry of organic matter of anthropic origin in the aquatic environment greatly increases the amount of nutrients available in the environment, unbalancing the processes of photosynthesis and decomposition, leading to eutrophication that causes serious environmental problems (Cetesb, 2020).

Although CONAMA resolution 357/05 does not refer to the COD parameter in the classification of bodies of water and in the patterns of discharge of liquid effluents, this is a global parameter used as an indicator of the organic content of wastewater and surface water and widely used in the monitoring of wastewater treatment plants. (Aquinoet al., 2006).

Person's correlation analyzes performed between the results obtained from COD and thermotolerant coliforms demonstrated that there is a low positive correlation (R= 0,159) between the presence of organic matter (indirectly measured by COD) and the presence of thermotolerant coliforms as can be seen in figure 2.

Those datas can be justified by the fact that the organic matter being at the sanitary effluents are not just of fecal origin, but include proteins, carbohydrates, humic substances, lipids, lignins, orgnic acids, e other biological substances produced during the treatament. (Xiao et al., 2020).

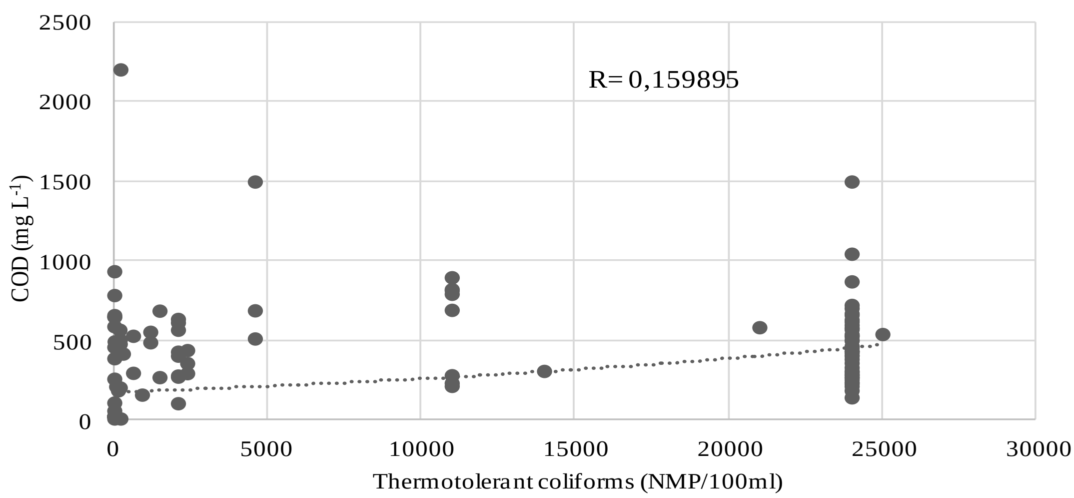

Figure 2: Correlation between COD values and thermotolerant coliforms of sanitary effluents after treatment.

In addition, it was verified that there was a negative correlation (R= - 0,439) between the results found of free residual chlorine and thermotolerant coliforms, that is, the higher the concentrations of free residual chlorine, the lower the results found for the thermotolerant coliforms.

According to Pianowski et al. (2003) for inactivating a large amount of thermotolerant coliforms in sanitary effluents it is necessary to maintain at least 4 mg L^{-1} of Chlorine and contact time of at least 30 minutes. This concentration of free residual chlorine was not observed in most of the samples analyzed in this study it was only observed on ETE-C and sporadically on ETE-A) being this, possibly, one of the determinant factors for the inefficiency of the system in eliminating thermotolerant coliforms.

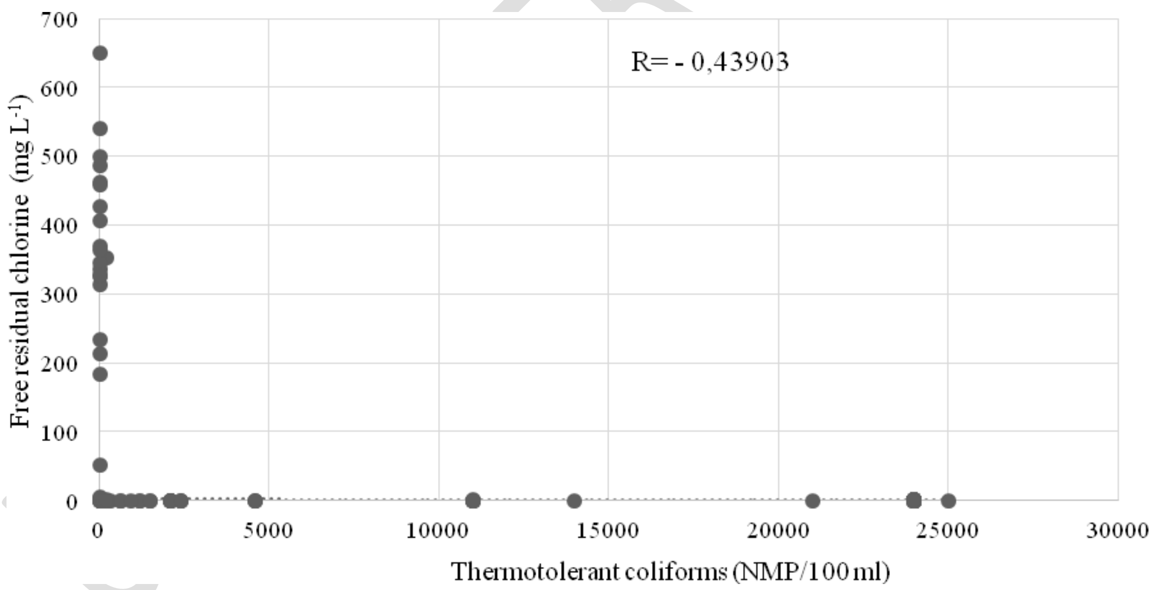

Figure 3. Correlation between the values of thermotolerant coliforms and free residual chlorine from sanitary effluents after treatment.

Studies are being accomplished to ascertain the decrease in the contact time of sodium hypochlorite with the effluent and recently Boni et al. (2020) demonstrated that the best results obtained to decrease the amount of *E.coli* in sanitary effluents from ETE with biological treatment is 30mg L^{-1} sodium hypochlorit*e* with contact of at least 1 minute, which in practice would be very important, as it would not take time to retain the effluent.

Another factor that may be interfering with the amounts of free residual chlorine, with consequent interference in the elimination of thermotolerant coliforms are the high concentrations of organic matter existent in sanitary effluents, because the performance of the hypochlorite becomes impaired, since it becomes complex with organic matter and becomes less effective (Cerreta et al., 2020).

According to Jordão and Pessoa (2011) organic substances, nitrogenous, aromatic, some metals and sulfides, are the compounds found in sanitary effluents that most interfere in the chlorination process. As can be seen in figure 4, there was a negative correlation (R= –0,410) between the COD values obtained in the analyzes together with the free residual chlorine.

In this way, it is possible that the presence of organic matter, indirectly indicated by the COD values, negatively affects concentrations of free residual chlorine, that is, high concentrations of organic matter lead to low concentrations of free residual chlorine.

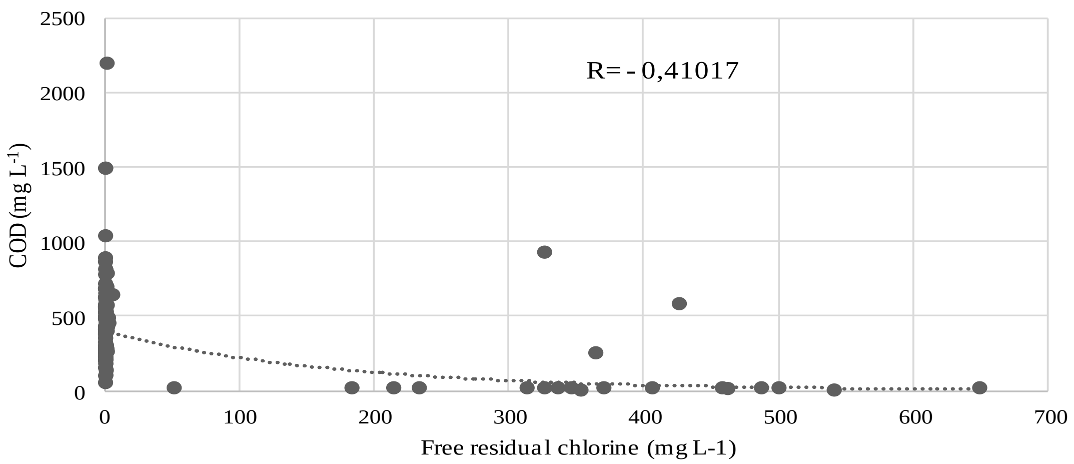

Figure 4. Correlation between COD values and free residual chlorine from sanitary effluents after treatment.

However, after comparing the values presented by the systems, we can see a strong negative correlation (R= - 0,891) between pH and free residual chlorine, that is, the increased presence of free residual chlorine is significantly related to the decrease in the pH of the sample as can be seen in figure 5, this fact being mainly perceptible in the results of the TEE-A and TEE-C, which concomitantly present the highest values of free residual chlorine and the lowest values found for the pH during the evaluated period (table 2).

The effluent pH variation can occur because of the addiction of calcium hypochlorite or sodium hypochlorite that, according Rebecca et. al. (2019) when it comes in contact with water, it dissociates generating the hypochlorous acid and, consequently, there will be decrease in pH.

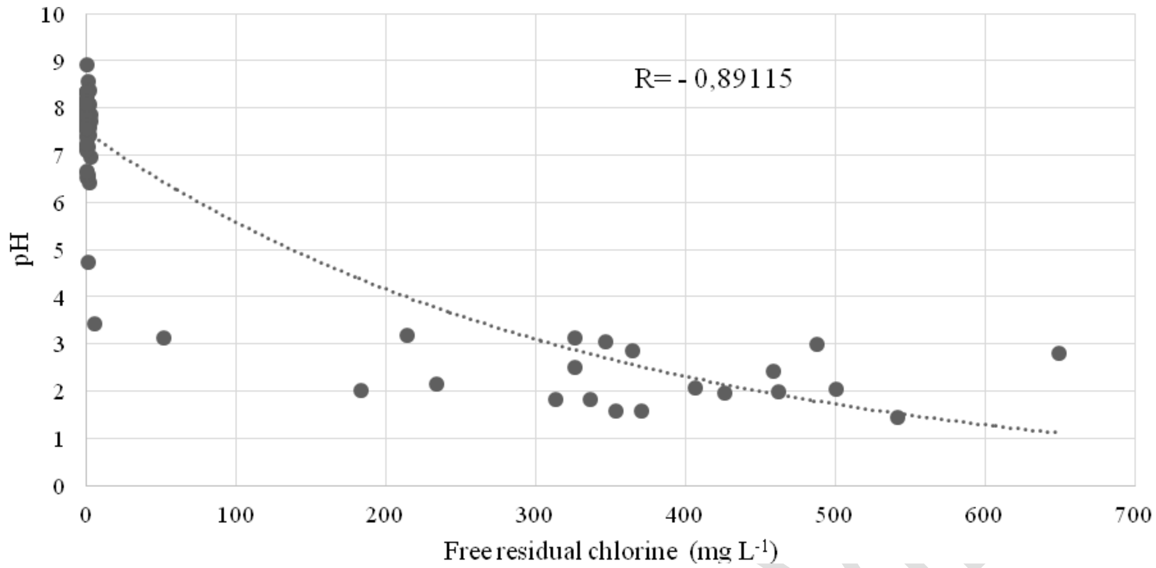

Figure 5. Correlation between pH values and free residual chlorine from sanitary effluents after treatment.

Figure 6 shows the results obtained with the multivariate analyzes, in which it was possible to correlate all the parameters evaluated and promote their separation in two groups. In the first group, there is a positive relation between pH, thermotolerant coliforms and free residual chlorine, the COD stay isolated in the second group, indicating that there is a correlation between pH, free residual chlorine and the presence of coliforms as mentioned earlier.

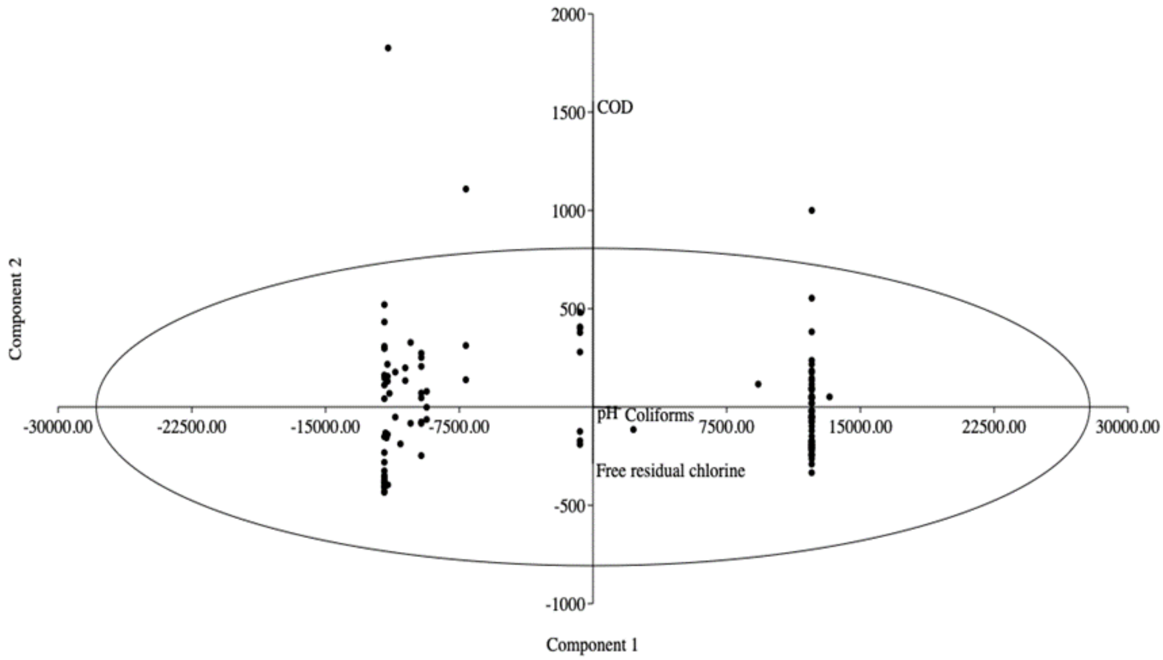

Figure 6. Multivariate analysis of the parameters evaluated for the sanitary effluents of this research.

After conducting the interviews, a certain uniformity was observed in the various responses obtained. As can be seen in figure 7, all interviewed affirmed that they received instructions on how to perform the correct operation of the system and that the replacement of calcium hypochlorite tablets occurs fortnightly. However, these highlighted that they do not believe in the efficiency of the treatment, since these systems presented recurring problems, including the generation of unpleasant smell.

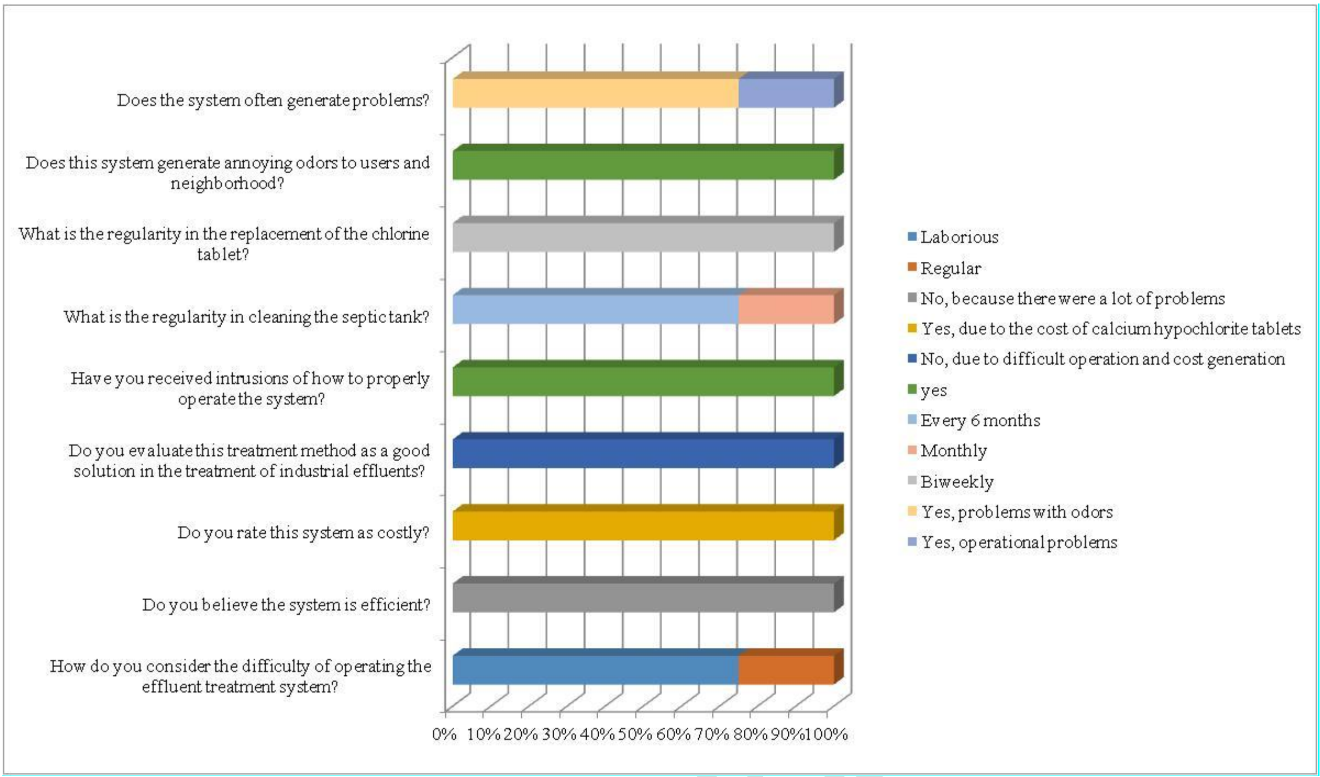

Figure 7: Analysis of users' perception of sewage treatment plants analyzed in this research.

In addition, the interviewees stated that they do not evaluate this method as a good solution for the treatment of effluents in building systems, due to the difficult operation, which in general was classified as hardworking, it requires high costs for maintenance and replacement of calcium hypochlorite tablets. When asked about cleaning septic tanks, most (75%) reported that it occurs every six months, while the minority (25%) declared to do it monthly (Figure 7).

Finally, it should be noted that the results obtained through this work demonstrated that the efficiency of chlorine in reducing coliforms in the sanitary effluent of a septic tank treatment system, anaerobic filter and disinfection can work, as long as properly sized and operated with careful and professional manner.

In order to obtain an effluent within the permissible parameters, it is important that all stages of treatment be efficient, because chlorination is only able to deliver satisfactory results with the join action of the septic tank and anaerobic filter. According to CONAMA 430/2011, effluents from any polluting source can only be released directly into the receiving bodies after due treatment, in order to meet the support capacity of the receiving body, that is, without compromising the water quality according to its framing class.

Therefore, in addition to replacing the calcium hypochlorite tablets, it is important to pay attention to the need for cleaning the system determined in the sizing, or by the operator's perception. Therefore, it was observed that the efficiency of the treatment is related to several factors, each location presents a behavior that needs to be monitored and adjusted, avoiding environmental damage and the well-being of the population.

4. CONCLUSIONS

The results of this study showed that the majority (83.33%) of the treatment systems evaluated were not completely effective in reducing microbiological contamination during the monitoring period. The system (ETE-C) that presented the best results possibly has rainwater infiltration, factor that support good results, considering that the waters of this origin have less organic load and do not contain coliforms of fecal origin.

The efficiency of all stages of treatment is essential to achieve legal parameters in the final effluent. If the septic tank and the anaerobic filter did not perform their function of reducing organic matter well calcium hypochlorite is not able to reduce the number of pathogenic microorganisms, because it ends up being consumed in the oxidation of organic compounds.

In addition, we can conclude that there are several factors that influence the functioning of the treatment system, so it must be carefully sized and carefully operated, however it is noted that the operators are usually the own users, who have little technical knowledge and lack information.

Therefore, it is important to develop programs and actions that demonstrate the importance of the correct operation of these systems as well as their importance in public health, in view of the fact that sanitary sewage poses great risks to the health of different forms of life and it threatens water quality, a fundamental natural resource for survival.

Thus, the results of this work suggest the development of more studies in the area seeking to verify if the concentration and the contact time with calcium hypochlorite suggested by NBR 13969/97, if it is appropriate, in addition to other aspects that influence the functioning and efficiency of this treatment system, in view of the lack of information, as well as the various factors that affect the operation of these systems.

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