



## Evaluation of effluent quality in water treatment plants in the Ipojuca River basin

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## SUMMARY

This study aimed to evaluate the physical-chemical and microbiological parameters of the sewage treatment plants in the municipalities of Tacaimbó, Rendeiras, and Gravatá in the state of Pernambuco, using descriptive and multivariate statistics and a computer tool. The parameters analyzed were provided by Pernambuco's Water and Sanitation Company (COMPESA), with all samples collected during 2020. The analysis results were compared to the values recommended by current federal and state environmental legislation. The assessment of the quality of effluents from the Ipojuca River basin helped analyze the contribution made by the Environmental Sanitation Program to the depollution of the Ipojuca River basin's waters. By analyzing the descriptive statistics of the effluent quality parameters, it can be generally concluded that the STPs studied meet the requirements defined by the environmental agencies, especially regarding organic matter removal. Using multivariate statistics, it was possible to conclude that the most significant variation in the data is related to the parameters that represent pollution (organic matter). This occurrence may represent failures in collection and storage procedures and inefficient operation at certain times of the year. The proper operation of sewage treatment systems is essential for maintaining the environmental quality of water bodies.

**KEYWORDS:** Multivariate. Sewage. Statistics.

## 1 INTRODUCTION

The accelerated growth of the world population, together with the increasing volume of sanitary sewage produced, has contributed to the degradation of the environment through the pollution of natural resources and destabilization of ecosystems, causing severe environmental and social problems. The growing search for environmental sanitation solutions and sewage treatment technologies is fundamental to recovering and maintaining the population's quality of life and the environment (SCOTTÁ, 2015).

Pimenta *et al.* (2002) define sewage treatment as a stabilizer of the organic matter of a given effluent to transform it into inorganic (mineralization and consequent reduction of (BOD) through removing pathogenic microorganisms.

The start of the development of technologies for treating sanitary sewage dates from the end of the 19th century, focusing on the removal of sedimentable solids that primarily originated in these systems; however, it was not noticed that this parameter represented only 1/3 of the organic load and that the other 2/3 were represented in the soluble and colloid forms. The applied treatments did not allow contact between the sediment fractions and the active bacteria in the reactor, resulting in an efficiency of removing organic matter of 30 to 40% (FARIAS, 2013).

With the advances in reactor studies, the researchers realized that there was a need for more significant contact of the effluent with bacteria that degraded organic matter and that the process would become more efficient if there were the immobilization of this biomass through the insertion of active sludge in the reactor, growing the bacterial mass in order to promote anaerobic digestion of organic matter. This conception gave rise to the basis of anaerobic treatment with UASB (Upflow Anaerobic Sludge Blanket) reactors of high capacity and efficiency in the removal of the organic part due to the contact of organic matter and bacterial mass (HAANDEL *et al.*, 2003).

The Ipojuca River in Pernambuco is among Brazil's three most polluted rivers and is the primary source of domestic sewage pollution (treated or in nature). Fresh sewage transports nutrients to the river, increasing the proliferation of algae in the environment, which leads to a decrease in the oxygen index dissolved in the water, impacting the quality of life of aquatic animals (SILVA, 2017).

The Environmental Sanitation Program of the Ipojuca River - PSA Ipojuca, created in 2013,

aims to promote environmental sanitation in the Ipojuca River basin through the implementation of sewage systems, expansion of coverage of existing systems, and improvement in treatment rates in municipalities whose headquarters is located on the banks of Ipojuca. With this, it is intended to improve environmental quality and increase the availability of good-quality water. It also promotes complementary actions that include socio-environmental diagnosis, installation of environmental parks, and forest replacement of riparian forests. The PSA Ipojuca aims to reduce the daily organic load released on the Ipojuca River, as for DBO<sub>5</sub>, by about 18.65 tons. This reduction represents approximately 45.4% of the domestic load, which ensures better water quality in the rivers and reservoirs used primarily for public supply (IDB, 2012). Some Wastewater Treatment Plants (STP) are in operation in this context.

## 2 OBJECTIVE

This work aims to evaluate the physical-chemical and biological parameters of the STPs in the municipalities of Tacaimbó, Gravatá, and Rendeiras, located in the town of Caruaru, under the analysis of descriptive and multivariate statistics, with the application of a computational tool.

## 3 METHODOLOGY

The physical-chemical and biological parameters of the present study were produced by Pernambuco's Water and Sanitation Company (COMPESA), Recife. The samples were collected over 2020 by the Company's team. The collections made in the STPs Tacaimbó, Rendeiras, and Gravatá compose a table of samples of the simple type by manually collecting the treated effluent.

The Tacaimbó STP consists of a preliminary treatment unit consisting of a grating, desanding unit, flow measurement device, a sewage pumping station, a secondary treatment unit for the removal of biodegradable organic matter formed by the anaerobic up-flow reactor, and a sludge blanket (UASB), followed by activated sludge; and finally chlorination disinfection. The station can treat a maximum final flow plan of 33.0 L/s, serving a population of 12,307 inhabitants, and has steps for sewage treatment.

The Rendeiras STP in Caruaru was designed to treat an end-of-plan flow of 450 L/s and is expected to serve a population of 148,000 inhabitants. Currently, its sewage treatment stages consist of a preliminary treatment unit, made up of a grating, desanding unit, flow measurement device, a secondary treatment unit for the removal of biodegradable organic matter, made up of UASB reactors, followed by activated sludge and polishing ponds. Finally, the effluent undergoes a chlorination disinfection process.

The Gravatá STP has a treatment capacity of 140 L/s, benefiting around 30,000 inhabitants. Its sewage treatment stages consist of a preliminary treatment unit made up of a grating, a desanding unit, a flow measurement device, a secondary treatment unit for the removal of biodegradable organic matter made up of a UASB reactor, an activated sludge system, and an ultraviolet disinfection system that treats the waste and returns it to nature with a high level of quality.

The collection, conditioning, and transport of samples from treated effluent of the STPs followed the Company's quality control recommendations based on the Standard Methods for Examination of Water and Wastewater.

Spreadsheets were made to obtain the general information on the parameters used in this work, containing the information on the physical-chemical and microbiological parameters to be used in the descriptive statistical analysis information of the data.

After a consistency analysis of the data, to identify values not feasible or still failed in filling out the spreadsheets, descriptive statistics were performed where the number of replicates, the mean, the median, the minimum, and maximum values were calculated, the general sum per group, the Variance, the standard deviation, the 25% and 75% percentiles, the asymmetry, the kurtosis, the geometric mean and the coefficient of variation. Data normality was also verified by performing the Shapiro-Wilk normality tests, complementing the statistical summary of the data. The Statistica 12.0 package (STATSOFT, INC., 2011) determined the various parameters.

Descriptive graphs were elaborated to verify how the data are presented, its trend, and the variables' relation. Parametric descriptions of mean, standard deviation, median, 1, and 3 quartiles were also considered in the analysis of each parameter to show normality or non-normality in the data.

The factor analysis was performed by transforming the correlation matrix by estimating a factorial matrix containing factor loads for each variable in each factor obtained. Then, the loads of each variable in the factors were interpreted to identify the latent structure of the variables.

It was possible to reduce multivariate data and detect structure in the relationship between the data, using principal component analysis and transforming them into a new set of variables. The principal components result from a linear combination of the original variables. In this analysis, all the effluent quality parameters from the STP1 (Tacaimbó), STP2 (Rendeiras), and STP3 (Gravatá) stations were used in order to determine the characteristics that play the most significant role in the behavior of the variables when they act together in the respective discharges into the receiving body (Ipojuca River).

Because the variables under study have values with different scales, it was necessary to standardize them to have a mean of 0 and a constant variance of 1.

The application of Bartlett's sphericity ( $p$ -value  $< 0.05$ ) and KMO (coefficient 0.74) tests showed that the sample size of the water quality data set was adequate for PCA.

#### **4 RESULTS**

The results of the physicochemical and biological analyses of the STP Tacaimbó, STP Rendeiras, and STP Gravatá were compared to the values recommended by National Environmental Council (CONAMA) Resolution nº 430/2011, for freshwater, class 3, the framework of the Ipojuca River and the Technical Standard 2007/2001 of the State Environment Agency (CPRH).

Table 1 - Statistical distributions of physical-chemical and biological parameters of STPs and their respective parametric and "p-value" tests

Estação	Distribution	Parameter	Statistic test	p-(value)	Hypothesis
	statistics	Physicochemical and biological			
ETE1 – Tacaimbó	Normal	Temperature; Alkalinity; Dissolved Oxygen; Total Solids; Fixed Solids; Volatile Solids	Shapiro – Wilk	p>0,05	Not rejected H <sub>0</sub>
	Non- normal	pH; Chlorides; Biochemical Oxygen Demand; Chemical Oxygen Demand; Sedimentable Solids; Suspended Solids; Fixed Suspended Solids; Volatile Suspended Solids; Phosphorus; Oils & Greases; Total Coliforms	Mann-Whitney	P<0,05	Rejected H <sub>0</sub>
ETE2 – Rendeiras	Normal	pH; Alkalinity; Chlorides; Dissolved Oxygen; Chemical Oxygen Demand; Total Solids; Fixed Solids; Volatile Solids; Suspended Suspended Solids; Fixed Suspended Solids; Volatile Suspended Solids; Phosphorus; Oils & Greases;	Shapiro – Wilk	p>0,05	Not rejected H <sub>0</sub>
	Non- normal		Mann-Whitney	P<0,05	Rejected H <sub>0</sub>
ETE3 – Gravatá	Normal	Temperature; pH; Alkalinity; Chlorides; Dissolved Oxygen; Biochemical Oxygen Demand; Chemical Oxygen Demand;	Shapiro – Wilk	p>0,05	Not rejected H <sub>0</sub>
	Non- normal	Sedimentable Solids; Total Solids; Fixed Solids; Volatile Solids; Suspended Solids; Fixed Suspended Solids; Volatile Suspended Solids; Oils & Greases. Phosphorus; Total Coliforms;	Mann-Whitney	P<0,05	Rejected H <sub>0</sub>

**H<sub>0</sub> – The null hypothesis in the standard distribution admits that the means of the values of each parameter of the STPs do not differ; they are equal. H<sub>0</sub> - null hypothesis in the non-normal distribution admits that the medians of the values of each parameter of the STPs do not differ; It means they are the same.**

Source: Prepared by the authors, 2023.

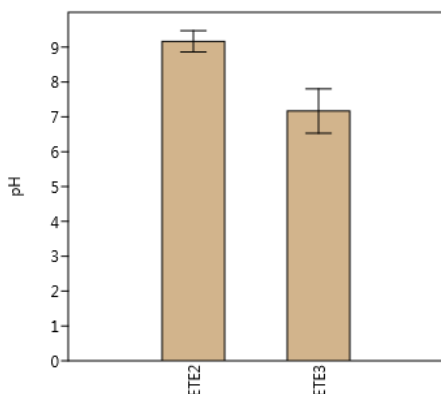
Table 1 above presents the statistical distributions of the physical-chemical and biological parameters of the three sewage treatment plants, their respective parametric tests, and the "p-value" considered to be the descriptive level of statistical significance. Conceptually, the descriptive level (p-value) is defined as the lowest level of significance ( $\alpha$ ) that can be assumed to reject the null hypothesis ( $H_0$ ).

After the consistency analysis of the data, we proceeded to the elaboration of descriptive statistics with graphs for the physical-chemical and biological parameters that presented non-normal distribution. Box plots were drawn up, showing the values of the first quartile (25%), the median, and the third quartile (75%) of the data.

The Hydrogen potential (pH) is one of the most critical parameters and is often used to evaluate the effluent, as all phases involving wastewater treatment are pH-dependent.

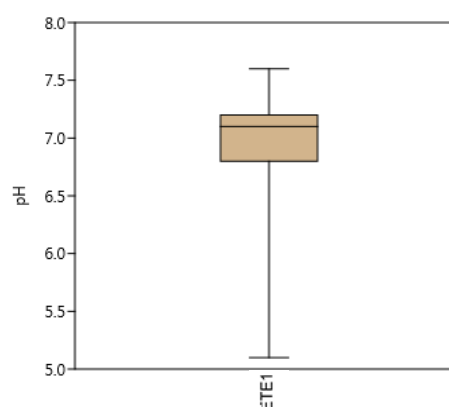
When comparing the results with the limits defined in CONAMA Resolution 430/2011, it is noted that, in general, the pH values of STP1, STP2, and STP3 follow the established by the Resolution, whose limit is between 5 and 9, as shown in figures 1 and 2. According to Santos (2020), the Ipojuca River presents, on average, waters closer to neutrality.

Figure 1 - Effluent pH values in STP2 and STP3



Source: Prepared by the authors, 2023.

Figure 2 - Effluent pH values in STP1

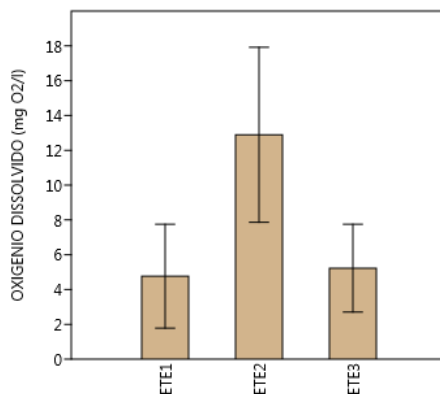


Source: Prepared by the authors, 2023.

Oxygen is one of the main parameters for evaluating the liquid medium, as it is used to determine the impact of pollutants on water bodies. What determines the concentrations of DO in surface waters are the processes of oxygen production, associated with the reaeration of the atmosphere, photosynthesis, and its forced entry into effluents, in addition to the processes of oxygen consumption, organisms, oxidation of organic matter and benthic demand (MENDES *et al.*, 2021).

Resolution CONAMA nº 357/2005 establishes that the DO value for the waters classified in class 3 is not less than 4 mg/L. Figure 3 shows the DO concentration in the effluents of the STPs when released into the Ipojuca River. In the sampling period, the levels of DO were above the minimum limit required by the Resolution for the river with framing in Class 3. That is, they meet the established parameter.

Figure 3 - Dissolved Oxygen Values in the effluents of STP1, STP2 and STP3

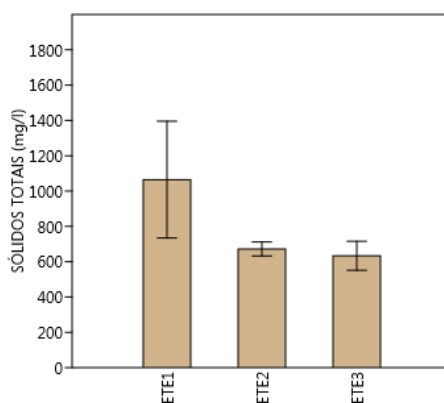


Source: Prepared by the authors, 2023.

The solid charge of the liquid medium consists of all contaminants except gases. Size, state, chemical characteristics, and decantability can classify these solids. According to the chemical characteristics, total solids (TS) can be classified into volatile solids (VS) and fixed solids (FS). Volatile solids represent an estimate of organic matter in solids, whereas fixed solids represent inorganic matter (VON SPERLING, 2005).

Resolution CONAMA nº 357/2005 does not establish limits for total, fixed, and volatile solids, only for total dissolved solids up to 500 mg/L for classes 1 to 4. The results of the TS analysis in the STPs under study are shown in Figure 4.

Figure 4 - Values of Totais solids



Source: Prepared by the authors, 2023.

The behavior of total solids in STP1 presented an average value of 1,064.00 mg/l, while STP2 and STP3 presented values of 672.0 mg/l and 633.0 mg/l, respectively. It is admitted that higher concentrations of total solids observed in the STP1 are due to the release of solid waste in the urban area or urban drainage discharge in the sewage collection networks, contributing

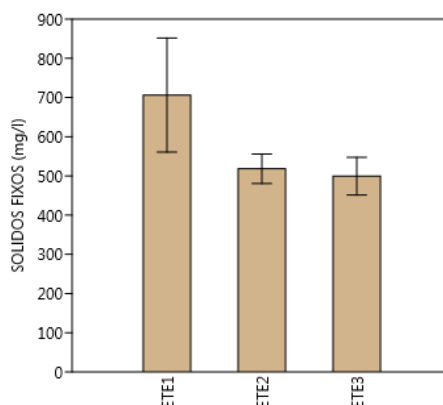


significantly to the increase of total solids.

Figure 5 shows the results of the analysis of fixed solids in the STPs under study. The behavior of fixed solids presented average values of 706.2 mg/l, 518.3 mg/l, and 499.4 mg/l for STP1, STP2, and STP3, respectively. Higher concentrations of fixed solids in STP1 come from environmental degradation, such as erosive processes due to rainfall in areas not yet urbanized or degraded environments in the city, so that most inorganic or mineral matter can be carried to the reception boxes or maintenance holes of the sewage network to cause higher concentrations of fixed solids.

The STP3 presented average values of fixed solids within the established limit, while the STP2 average value was slightly close to that recommended in the legislation. In this way, it can be analyzed that the effluent treatment is efficient for removing the load of solid pollutants, and it can also be inferred that the region has a more preserved natural environment.

Figure 5 - Fixed Solid Values in the effluents of the STPs



Source: Prepared by the authors, 2023.

Regarding volatile solids, STP1 pointed to the mean value of 358.3 mg/l, while STP2 and STP3 showed mean values of 153.4 mg/l and 134.0 mg/l, respectively. Higher concentrations of volatile solids, as in the case of STP1, are due to the form of organic matter from the treatment process existing in the plant.

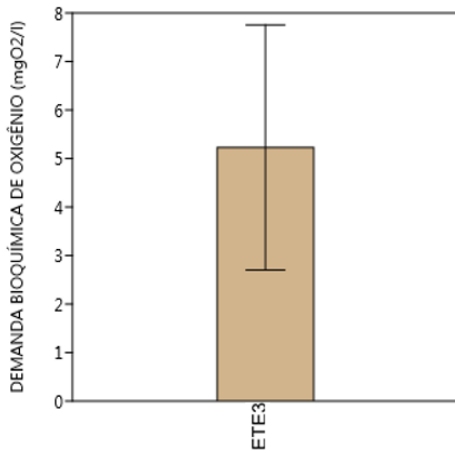
Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed to stabilize (decompose) the organic matter in a sample through biochemical processes. Thus, it is considered an indirect indication of the amount of biodegradable carbon (VONSPERLING, 2005).

The values for the BOD samples at the disposal points of the STPs in the Ipojuca River are shown in Figures 6 and 7. The stations presented the results of the BOD, much lower than the value recommended by CONAMA nº 430/2011 and CPRH, with a maximum value of 120 mgO<sub>2</sub>/L. STP1, STP2 and STP3 presented means of 80 mgO<sub>2</sub>/L, 19 mgO<sub>2</sub>/L and 5.2 mgO<sub>2</sub>/L, respectively. Therefore, we conclude that the systems operate satisfactorily regarding organic matter removal. In the case of STP1, the BOD value shows greater variability and can reach values higher than the reference values (CONAMA and CPRH). This variation is probably due to



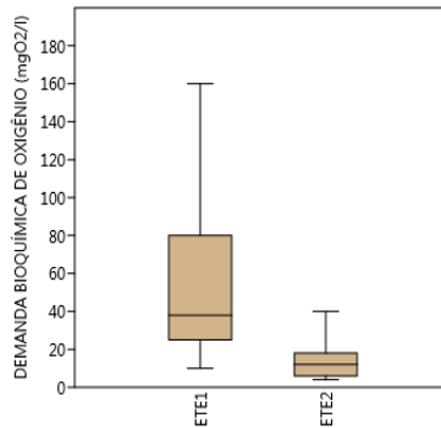
the collection period, when the treatment systems were operating less efficiently, allowing the effluent to contain still organic matter, which led to such variability.

Figure 6 - BOD value in STP3 effluent



Source: Prepared by the authors, 2023.

Figure 7 - BOD values in STP1 and STP2 effluents

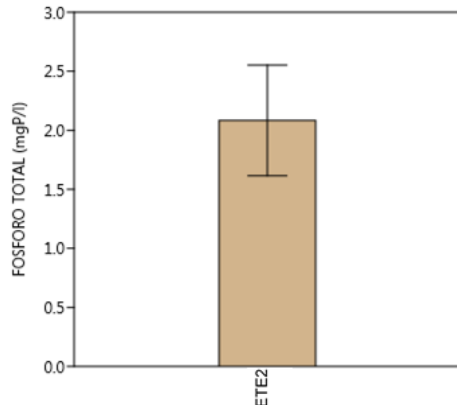


Source: Prepared by the authors, 2023.

Phosphorus is an essential nutrient for the growth of microorganisms responsible for stabilizing organic matter. Domestic sewage can usually contain an excessive load of this nutrient (VON SPERLING, 2005).

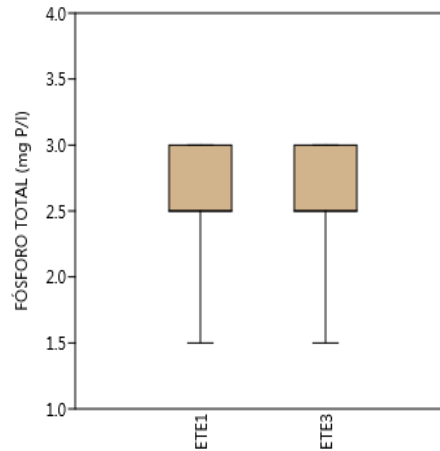
According to CONAMA Resolution 357/2005, the maximum total phosphorus concentration for release in class 3 rivers is 0.15 mg/L for lotic environments—figures 8 and 9 show phosphorus concentrations in STP1, STP2, and STP3 along the Ipojuca River.

Figure 8 - Total Phosphorus Values in STP2



Source: Prepared by the authors, 2023.

Figure 9 - Total Phosphorus Values in STP1 and STP3



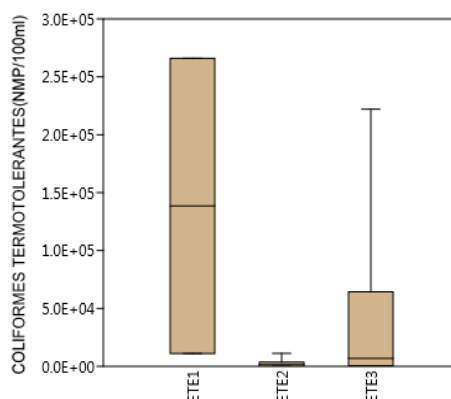
Source: Prepared by the authors, 2023.

The phosphorus values in STP1, STP2, and STP3 are above the value recommended by CONAMA Resolution 357/2005, which shows the presence of this element in the effluents, fecal organic matter, and household washing powders, which are the primary sources of phosphorus. The phosphorus index is an essential aspect of the stages of the treatment system at each of the STPs, which should be taken into account, indicating the need for a tertiary treatment stage to reduce the concentration of this nutrient in the sewage.

Total coliforms are a large group of bacteria present in the feces of humans and animals that can be found in water samples and soils, whether polluted or not (VON SPERLING, 2005).

STPs showed total coliform concentrations above the limit proposed by the CPRH technical standard 2007 (20000 NMP/100 mL) for Class 3 rivers, including CPRH effluent pattern parameters, reaching maximum values of  $2,5 \times 10^5$  NMP/100 mL in STP1;  $1.10 \times 10^4$  NMP/100 mL in STP2 and  $2.2 \times 10^5$  NMP/100 mL in STP3.

Figure 10 - Total Coliform values in STP1, STP2 and STP3



Source: Prepared by the authors, 2023

Still, in these same stations, the average values of total coliforms over the twelve months of collections were  $4.1 \times 10^4$  NMP/100 mL in STP1,  $2.3 \times 10^3$  NMP/100 mL in STP2 and  $4.7 \times 10^4$  NMP/100 mL in STP3. From these results, the average recorded by the STP2 ( $2.3 \times 10^3$  NMP/100 mL) is the one that points to a lower value than the index recommended in the resolutions ( $4.0 \times 10^3$  NMP/100 mL).

Table 2 presents the matrix of the results referring to the eigenvalues for extracting components of the correlation matrix of the effluent quality data corresponding to the STPs studied. According to the latent root criterion, the first three components explain 72.29% of the total Variance of the data.

Table 2 - Explanation of each component of eigenvalues and percentage of Variance.

Eigenvalue components		% of Variance explained Eigenvalues cumulative		% of Variance explained
1	8.44	49.67	8.44	49.67
2	2.45	14.40	10.89	64.08
3	1.40	8.21	12.29	72.29
4	1.36	8.02	13.65	80.31
5	1.00	5.90	14.66	86.21
6	0.58	3.43	15.24	89.64
7	0.54	3.20	15.78	92.83
8	0.44	2.59	16.22	95.42
9	0.27	1.62	16.50	97.04
10	0.19	1.09	16.68	98.13
11	0.14	0.83	16.82	98.95
12	0.08	0.48	16.90	99.43
13	0.05	0.32	16.96	99.76

Source: Prepared by the authors, 2023.

Table 3 shows the factor matrix of the component analysis, expressing the relationship between factors and variables, which allows the variables with the greatest interrelationships in each component to be identified.

Table 3 - PCA factorial matrix of effluent quality data of STPs

Variables	MAIN COMPONENTS		
	CP1	CP2	CP3
TEMP	-0.081	0.625	0.116
pH	-0.396	0.619	0.275
ALCAL.	-0.200	-0.132	<b>0.823</b>
Chloride	0.409	-0.372	0.138
OD	-0.388	0.628	-0.162
BOD	<b>0.908</b>	0.132	0.130
COD	<b>0.960</b>	0.092	0.130
Sedimentable solids	<b>0.929</b>	0.145	0.064
TS.	<b>0.949</b>	-0.049	-0.159
FS.	<b>0.863</b>	-0.044	-0.209
VS.	<b>0.947</b>	-0.049	-0.106
SS.	<b>0.959</b>	0.194	0.041
FSS	<b>0.966</b>	0.063	0.037
VSS	<b>0.852</b>	0.374	0.044
P	-0.039	<b>-0.836</b>	-0.242
O& G	0.005	0.280	-0.495
TOTAL COLIFORM	0.439	-0.333	0.397
Eigenvalue	8.44	2.45	1.40
Variance (%)	49.67	14.40	8.21
Cumulative Variance (%)	49.67	64.08	72.29

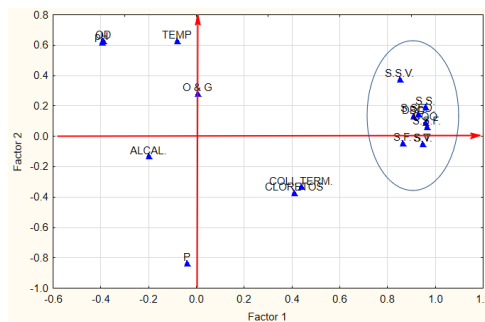
Source: Prepared by the authors, 2023.

Table 3 shows no cross-loadings or accumulation of loadings in just one component, so we decided not to perform varimax rotation. Component 1 explains 49.67% of the total Variance in the data and is strongly represented by the solids component (S. Sed.; TS; FS; VS; SS; FSS; VSS) and biochemical (BOD) and chemical (COD) oxygen demand. CP2 explains 14.40% of

the data and is strongly related to the input of organic matter (P). PC3 explains 8.21% of the total Variance of the data and is related to alkalinity.

Figure 11 shows the relationship between the variables, which form sets grouped by factors. The variables that best represent the class formed by the solids groups, BOD and COD, are located far from the origin, and these are the ones with the greatest representativeness concerning the organic matter (P) class. The other variables have low representativeness because they are close to the origin of the two axes.

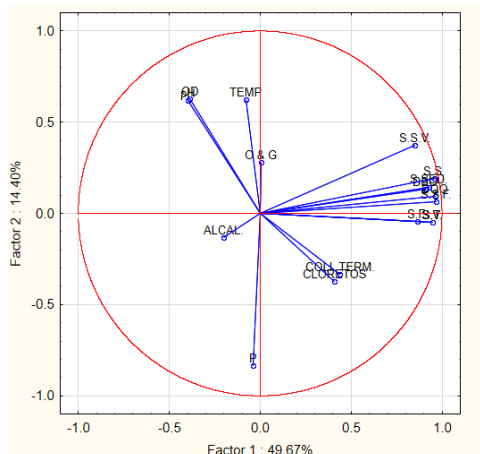
Figure 11 - Graph representing the relationship between factors 1 and 2 and variables



Fonte: Elaborada pelos autores, 2023.

Figure 12 shows the unit correlation circle, displaying the point cloud of variables with two-dimensional representation in the PCA analysis of the effluent quality parameters of the STP1, STP2, and STP3 plants.

Figure 12 - Two-dimensional representation of the variables in the analysis



Source: Prepared by the authors, 2023.

As can be seen in Figure 12, some variables are superimposed on each other. The overlap shows that these variables have the same representativeness in the graph, mainly those

related to solids and biochemical and chemical demand of effluent quality.

The solid load may be related to surface runoff, solid waste deposits in the sewage basin, and the natural weathering process of the geological components of the soil (ANDRADE *et al.*, 2007; SILVA *et al.*, 2008).

Figure 12 shows that the variables behaved differently from the main components. The variables about Factor 1 and Factor 2 were responsible for the most excellent dispersion of the results according to the quality parameters of the effluents analyzed and are those related to water pollution.

## 5. CONCLUSIONS

According to the descriptive statistics, only the Tacaimbó STP showed average values for the pH parameter within the standard defined by CONAMA Resolution 430/2011. It should be noted that this parameter may be influenced by anthropogenic actions, considering that the municipality's main economic activity is agriculture.

As for total solids, TSS1 and TSS2 showed values above the limits defined in the legislation. These indices may be associated with sediment from urban drainage entering the sewage system even though the state of Pernambuco only allows the implementation of absolute separator systems.

Regarding BOD, we found that all the STPs operated satisfactorily during the period studied, with values lower than those recommended by the legislation. The Tacaimbó STP showed significant variations, possibly because, in some periods, it operated less efficiently, allowing the effluent still to contain organic matter at certain times of the year.

The concentration of phosphorus, in values above those recommended by CONAMA Resolution 430/2011 for the STPs studied, indicates the need for adjustments to the treatment processes, such as extending the aeration of the activated sludge or including a chemical coagulation stage so that the effluent can reach the level of quality required by the legislation.

It can be seen that the effluents studied had high concentrations of total coliforms, indicating the pollution of the environment and, consequently, the need to adapt the disinfection stage, either through the concentration of chlorine or radiation or the time of exposure to these disinfecting agents.

By analyzing the descriptive statistics of the effluent quality parameters, it is generally concluded that the STPs studied meet the requirements defined by the environmental agencies, especially regarding organic matter removal. The treatment technologies adopted are, therefore, suitable for the region. As for solids removal, the Tacaimbó STP shows some variation; however, this is not always related to a deficiency in treatment but may be associated with areas of environmental degradation in the region.

At the same time, it is also possible to suggest actions for the environmental recovery of areas in the municipalities to minimize the erosive processes that can influence the quality of the effluent, as well as education and inspection actions to inhibit clandestine connections to the sewage network.

There is also a need to improve the process of removing nutrients such as phosphorus.

Multivariate statistics showed that the parameters relating to solids (settleable, total, fixed, and volatile), BOD, and COD accounted for 49.67% of the total Variance in the data, representing principal component 1 (PC1). These results corroborate the analysis of descriptive statistics.

Flaws in the sample collection, storage, and transportation procedures can also explain the Variance. BOD and COD analyses, in particular, require that the sample's collection and storage (refrigeration) and the time taken to conduct the analysis be carefully followed. Inadequate procedures can strongly influence the analysis results.

Principal component 2 (PC2) explains 14.40% of the Variance in the data. It is strongly related to the input of organic matter, in this case phosphorus, once again linking the results to pollution of the liquid environment. Principal component 3 (PC3) explains 8.21% of the total Variance in the data and is related to alkalinity.

The most significant variation in the data is regarding to the parameters that represent pollution (organic matter). These parameters are the most important for identifying environmental pollution, and therefore, those that the Company emphasizes in its control. The Variance can either represent flaws in the collection and storage procedures or inefficient operation at certain times of the year.

The Gravatá STP showed the best results in removing organic matter, inorganic solids, and nutrients.

Periods of less efficient system operation do not necessarily mean that the system does not meet the requirements or must be appropriately designed for the demand. External factors such as the intrusion of urban drainage into the sewage system, environmental degradation, rainfall intensity, and clandestine connections can alter the composition of the effluent, making the designed system ineffective at treatment.

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