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Performance analysis of large wastewater treatment plants in Aracaju

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Abstract

One of the biggest impacts on the country's water resources is the discharge of raw wastewater into rivers, which can be minimized with wastewater treatment. In this work, both the treatment systems performance used in four Wastewater Treatment Plants (WWTPs), which treat the domestic wastewater of Aracaju, and the compliance with the requirements of the current environmental legislation for the release of effluents were evaluated. To do so, physical-chemical, and bacteriological monitoring bulletins of the WWTPs were evaluated through the period of 1 year and 3 months. The WWTPs almost fully complied with all the conditions set out in the legislation for the parameters analyzed. Data analysis showed, in general, a better quality of the effluent from WWTP Orlando Dantas, with pollutant removal efficiencies very close to those found in the literature. However, the other stations, WWTP ERQ Norte, WWTP ERQ Sul and WWTP ERQ Leste, even fulfilling the legislation almost throughout all the studied period, achieved performance below expectations, due to the type of treatment technology adopted. With the evaluation of the results and the operating and maintenance conditions of the stations, it was concluded that there is a need to allocate resources for investments in a greater frequency of laboratory analysis and in the operation and maintenance of the infrastructure of the WWTPs. Furthermore, continuously training professionals involved in the operation of the systems will increase the performance of wastewater treatment structures. Consequently, there will have the improvement in the quality indices of treated wastewater, reduction of pollution and public health problems.
KEYWORDS: Domestic wastewater. ERQ. WWTP.

INTRODUCTION

One of the biggest impacts on Brazil's water resources occurs through the discharge of wastewaters into water courses, which, in most Brazilian cities, do not receive adequate treatment before their release. In 2019, only 49.1% of the wastewater generated in the country received some type of treatment (SNIS, 2020).

Due to the growth of urbanization and human activities, an increasing number of pollutants are dumped into the water, bringing many risks to the environment and human health (LU; YU, 2018).

Water pollution drastically affects environment development. At the same time, it is also a strategic economic resource, vital to a nation's economy. With the rapid increase of the population and the accelerated development of the economy all over the world, the global consumption of water has increased dramatically and in the meantime water pollution has become more and more serious (YANG et al., 2020).

Wastewater treatment emerges as a solution by removing pollutants from the wastewater and helping to preserve not only public health but also the environment (ZHANG et al., 2010). When raw wastewater is released, it contains suspended solids, colloids, and soluble substances. When released into water bodies, they destroy the ecosystem and cause water related diseases (KIM et al., 2017).

In the process of removing contaminants from wastewater, physical, chemical, and biological processes take place to eliminate the pollutants, so that the treated wastewater can finally be discharged into the water body (DERMIBAS et al., 2017).

Therefore, wastewater treatment is a widespread concern throughout the world, as the release of wastewater is increasing. For this reason, many wastewaters treatment plants operate at the limit of their capacity, a common problem in developing countries, where the volume of treated wastewater is very low (BENVENUTI et al., 2018). This reality is associated with several reasons, such as the lack of awareness of public agents and the high costs of wastewater treatment (FORSTINUS, 2016).

In addition to these factors, aging wastewater infrastructure increasingly threatens water quality as the gap between investments and the deterioration of wastewater collection and treatment systems widens (MCLELLAN et al., 2018).

Specifically in the case of Wastewater Treatment Plants (WWTPs), they have the function of ensuring that the concentration of pollutants in treated wastewater reaches acceptable limits, before being discharged into lakes and rivers. A main issue for these systems is their efficiency, both in terms of quality of the wastewater discharged and economic cost involved in operating the plants (BARBU et al., 2017).

OBJECTIVES

The present study aimed to evaluate, through physical-chemical monitoring, the performance of four wastewater treatment plants from Aracaju city, capital of the state of Sergipe, operated by the state sanitation company.

METHODOLOGY

The capital of Sergipe has 1,070.06 km of wastewater collection network that, in 2019, collected approximately 21.5 million cubic meters of liquid waste, leading them to four treatment stations, where they were treated and released into bodies receivers (SNIS, 2020).

The study was based on data related to the monitoring of the four stations (WWTP ERQ Norte, WWTP ERQ Sul, WWTP ERQ Leste and WWTP Orlando Dantas) that treat wastewater collected in public networks in the city of Aracaju. The first three stations are called quality recovery station (ERQ in Portuguese).

The data were obtained from the state sanitation company that provided information on the following physicochemical and bacteriological parameters: BOD, COD, ammoniacal nitrogen, sulfides, oils and greases, pH, settleable solids and thermotolerant coliforms. These values corresponded to the parameters of the influent and effluent of each station, with the exception of the concentrations of ammoniacal nitrogen, sulfides, oils, and greases, referring only to the effluent. The monitoring period of the WWTPs ranged from January 2017 to March 2018.

It should be noted that, despite the WWTP ERQ Norte being located on the left bank of the *Sal* River, in *Nossa Senhora do Socorro* city, from which it receives part of its evictions, its largest wastewater supply comes from the capital, in addition to receiving contributions from clean-pit trucks. This station features a stabilization pond system consisting of seven facultative ponds followed by six maturation ponds.

The WWTP ERQ Sul and WWTP ERQ Leste have their facilities sequentially composed of grating, sandbox and Parshall flume, Upflow Anaerobic Sludge Blanket reactor (UASB), oxidation ditches and chlorine disinfection.

At WWTP Orlando Dantas, its treatment system is composed of two oxidation ditches in orbital format, with two mechanical aerators for each one, preceded by grating, sandbox and Parshall flume. After passing through the ditches, the wastewater goes to four decanters and is subsequently disinfected with chlorine.

From the monitoring data analysis of the WWTPs, their efficiencies were measured to compare with the performance values of these wastewater treatment technologies present in the literature. In addition, compliance with CONAMA Resolution 430/2011 was verified. This resolution provides information about the release of effluents from sanitary wastewater treatment systems, whose established limits are presented in Table 1.

Table 1. Conditions and standards for effluents from sanitary wastewater treatment systems - Resolution 430

pH	Temperature	Settleable Materials	BOD	Oils and greases	Floating Materials
Between 5 and 9	**< 40°C**	**≤ 1 mL/L**	**≤ 120 mg/L***	**≤ 100 mg/L**	**Absent**

*: Admit concentration superior to 120 mg/L since the removal efficiency is at least 60%.
Source: Adapted from CONAMA, 2011.

Data were organized in Microsoft Office Excel version 2016 and analyzed using R (Project for Statistical Computing) software, version 3.5.0. For parameters whose inlet and outlet concentrations were known, efficiency calculations were performed and the ability to remove pollutants from the treatment systems was obtained. Data normality was tested by applying the Shapiro-Wilk test (RAZALI; WAH, 2011), with a confidence level of 95%.

After the application of the normality test, the influence of non-standard data in the determination of the results was verified. In view of this, the need to verify points that differ from the sample data set (outliers) has become indispensable.

This analysis was performed using the outlier identification method, by applying Thompson's Modified Tau Test (CIMBALA, 2011).

The significance level adopted was 5%. After removing the outliers, removal averages closer to reality were obtained, without the influence of outliers.

It is worth noting the impossibility of calculating efficiency for parameters whose data availability referred only to treated wastewater (ammoniacal nitrogen, sulfides and oils and greases). Regarding the WWTP ERQ Sul data for any parameter for April and December 2017 were not available, hence the lack of points in the graphs referring to the season for these months.

In addition to obtaining the data, information was collected for the research through technical visits. During the visits, the state of conservation of the treatment units and equipment in the WWTPs was observed, as well as the form of control of the wastewater treatment processes.

RESULTS

With the monitoring data from the stations, it became possible to verify compliance with current legislation and to compare their removal efficiencies when treating raw wastewater.

The average values of removal efficiency in the four evaluated WWTPs are presented in Table 2.

Table 2. Average removal efficiency in the Aracaju WWTPs

Parameter	WWTP			
	ERQ Norte	ERQ Sul	ERQ Oeste	Orlando Dantas
BOD (%)	45,2	54,3	73,1	90,4
COD (%)	31,3	49,3	55,5	81,2
Settleable Solids (%)	100,0	85,0	48,1	100,0
Thermotolerant coliforms (%)	60,3	92,4	77,0	96,9

Source: Prepared by the authors, 2022.

It is worth noting that the parameters in Table 2 were evaluated monthly, monitoring the standards quality of the WWTPs wastewater. For a closer characterization of wastewater, the parameters analysis of BOD, COD and thermotolerant coliforms should be performed at least weekly and, in the case of settleable solids, at least once a day (TARDIVO, 2009), due to the variation in flow and concentrations of polluting loads over the course of hours, days and months.

According to the results obtained in Table 2, marked differences are observed in the removal efficiencies in the evaluated treatment modalities. The WWTP ERQ Norte, despite presenting lower influent concentrations of the parameters BOD and COD in relation to the WWTP Orlando Dantas, showed lower efficiency for these parameters. A probable cause to contribute to this low performance of the WWTP ERQ Norte is due to sludge discharge from cesspool clean trucks directly into the facultative ponds, without first going through a preliminary treatment, with the consequent silting of the ponds, increase in the organic load and effective reduction of system performance. These trucks launch their load in the first optional lagoon, that is, downstream of the raw sewage sampling point of the ERQ Norte, since the collection of the influent sample occurs before the grating.

The construction of an equalization tank, interconnected to the lagoon system, to homogenize the sludge released by the cesspool clean trucks and then conduct it to the preliminary treatment, would be a way of evaluating the real performance of the ERQ Norte.

The ERQ Sul and ERQ Oeste, equipped with UASBs followed by oxidation ditches, showed lower than expected efficiencies, mainly related to BOD and COD, if compared only to the performance values of oxidation ditches present in the literature that would be greater than 90% (LI et al., 2014; LUO et al., 2020).

Since these two stations have undergone through expansions in recent years and consequently not having reached the number of connections in the network, a possible justification for the low performance is their operation under hydraulic underloads, with values of organic matter in the raw sewage below the specified in project.

Another hypothesis would be the inefficiency of the preliminary treatment, as it allows the transport of sediments to the secondary treatment devices. The accumulation of sand and coarse/floating solids causes obstruction and irregular distribution in the UASB branches and consequent appearance of preferential paths and dead zones. In both ERQ Norte and ERQ Sul, the screw pump, a constituent part of the preliminary treatment system of the two stations and responsible for removing the sand concentrated at the bottom of the desander, was inoperative.

Among the four stations analyzed, WWTP Orlando Dantas obtained the best removal efficiencies and those closest to the ones found in the literature.

Chaves et al. (2018) also evaluated the efficiency of treatment plants in Aracaju, including ERQ Norte, ERQ Sul, ERQ Oeste and WWTP Orlando Dantas. By measuring the

parameters in both influent and effluent of the stations, resulting from the monitoring data of the WWTP, whose coverage period ranged from January 2013 to December 2014, it was possible to perform a comparative analysis of the performance of the systems over the years.

Comparing the values presented in Table 2 with those obtained by Chaves et al. (2018), there was a significant increase of 67.6% in BOD removal in the ERQ Norte, when varying its performance from 27% to 45.2%. However, efficiency was still low, once in well-operated stabilization pond systems, the BOD removal performance ranges from 80 to 95% (BANSAH; SUGLO, 2016; OBERLIN, 2018; SUNARSIH et al., 2020: ALVES et al., 2021).

Differently from what was observed in the ERQ Norte, the ERQ Sul and ERQ Oeste showed little oscillation in the BOD removal rates, compared to the values obtained by Chaves et al. (2018). In the ERQ Sul, the change went from 53% to 54.3% and in the ERQ Oeste, from 77% to 73.1%.

Both the ERQ Sul and the ERQ Oeste did not reach minimum efficiency values for the BOD parameter when using oxidation ditches only, even though these stations were composed of oxidation ditches preceded by UASB. Silva et al. (2018), when analyzing, for thirteen months, the efficiency of an WWTP composed of an UASB reactor followed by a dissolved air float, obtained an average efficiency in the removal of BOD of 71.5% only in the anaerobic digester.

At ERQ Sul, in addition to a possible condition of hydraulic underload of the system, interruptions caused by failures in the functioning of the aerators of the oxidation ditches interfere with the development of aerobic bacteria, responsible for the degradation of organic matter and consequent reduction of the concentration of BOD.

Even with a higher influent concentration of BOD, compared to the concentrations of ERQ Sul and ERQ Oeste, WWTP Orlando Dantas managed to be more efficient by using only oxidation ditches as a way of treating sewage, while the other two stations dispose of an UASB system followed by oxidation ditches.

Comparing the period studied by Chaves et al. (2018), at WWTP Orlando Dantas, there was a 13% increase in the BOD removal rate, by varying its efficiency from 80% to 90.4%. This performance is compatible with the average values of 92% to 95% of oxidation ditches in BOD removal (LI et al., 2014; LUO et al., 2020).

That said, the importance of the level of operation, maintenance conditions and hydraulic aspects of the facilities observed at the WWTP Orlando Dantas becomes evident, in order to obtain high efficiency, since from the evaluated WWTPs, this station presented better treatment system maintenance.

Regarding the COD, after calculating the efficiencies, for the ERQ Norte, the efficiency in relation to the observed period of 31.3% was obtained, with emphasis on the month of January 2017, where the COD value went from 180 mg/L in raw sewage, to 276 mg/L in treated effluent. A punctual discharge of cesspool clean trucks close to the time of collection of the wastewater samples may have caused this increase.

A treatment system composed of four stabilization ponds, similar to the ERQ Norte, when treating wastewater, obtained a COD removal efficiency variable between 86.2 and 90.5% (K'OREJE et al., 2018).

For ERQ Sul, in February 2017 alone, there was a 25% increase in the COD value of treated sewage in relation to raw sewage. On average, the removal efficiency was 49.3% for the

observation period. In the ERQ Oeste, in all months observed, there was a removal of COD in relation to raw sewage. In December 2017, there was the lowest efficiency for the system, corresponding to 16%. The highest efficiency occurred in April of the same year, with a value of 94.6%. During the observed period, this station reached an average efficiency of 55.5%.

In the evaluation of a domestic wastewater treatment plant composed of two UASB reactors, without post-treatment, unlike the ERQ Sul and ERQ Oeste, the COD removal rates in the reactors varied between 55 and 75% (ROSS et al., 2018).

Finally, at the Orlando Dantas station, an average COD removal efficiency of 81.2% was obtained. This showed the efficiency of the treatment system regarding the degradation and removal of organic matter from the sewage. Although this station had a very high removal, in April 2017, there was an increase in the COD of treated wastewater in relation to the raw wastewater of approximately 45.8%.

Regarding the removal of organic matter, only the WWTP Orlando Dantas presented satisfactory results. The others, even not exceeding the limit stipulated by the legislation of 120 mg/L of BOD for the treated wastewater, in most of the evaluated period, it was below the specified in the literature. Better operating conditions and better functioning of electromechanical equipment would result in considerable gain in the performance of these systems in terms of carbonaceous matter degradation.

For the thermotolerant coliform parameter, when comparing the data from this work with those from the research by Chaves et al. (2018), there was a significant negative oscillation in the performance of ERQ Norte, as it decreased its removal efficiency from 90% to 60.3%. The gradual silting of the ponds, notably in the maturation ones, implies this low removal efficiency, since under good operating conditions, the removal of thermotolerant coliforms for this type of treatment approaches 99.999% (BANSAH; SUGLO, 2016; LEITE et al. al., 2017; MENDONÇA; MENDONÇA, 2018; OBERLIN, 2018).

In order to increase the effectiveness of pathogen removal in the maturation ponds, some steps can be taken, among which, the installation of deflectors, for providing an increase in the detention time, adequate proportions in the dimensions of the pond, good maintenance conditions (sludge accumulation) and upstream treatment (SHELUDCHENKO et al., 2016).

In the ERQ Oeste, in relation to the thermotolerant coliforms parameter, an oscillation from 87% to 77% was observed. Issues related to an inefficient preliminary treatment, similar to those found in the ERQ Norte and Sul, compromise the removal efficiency of the ERQ Oeste treatment system. In addition, about the disinfection step, the concentration of the disinfectant (chlorine), the time of contact with wastewater, its degree of dispersion in the sewage and its physicochemical characteristics can negatively impact the removal rate of pathogens.

It is worth noting that the release of treated sewage into water bodies without proper disinfection, contributes with a significant number of organisms of the so-called coliform group, including specific agents of waterborne diseases (RIBAS; FORTES NETO, 2008).

In the ERQ Sul, there was an increase in efficiency corresponding to 4.8%, varying from 88% to 92.4%. At WWTP Orlando Dantas, performance remained practically the same, going from 95% to 96.9%.

As for settleable solids, the ERQ North and ERQ South, throughout the analyzed period, remained within the limit stipulated by the resolution. Their average removals were 100 and

85%, respectively. An average of settleable solids in the influent was obtained for the ERQ Norte corresponding to 0.71 mL/L. As for the ERQ Sul, the mean value of settleable solids was 1.41 mL/L.

The ERQ Oeste showed an average efficiency in the removal of settling solids of only 48.1%. In January and February 2018, the station did not comply with CONAMA Resolution 430, as the values of settleable solids in the effluent were 4.0 and 3.5 mL/L, respectively, exceeding the maximum allowed limit.

During these months, there was an increase in terms of settleable solids in the treated effluent. Even when complying with the legislation for most of the analyzed period and treating raw sewage with an average of settleable solids equal to 1.43 mL/L, considered of low concentration (METCALF; EDDY, 2015), low performance was observed in the ERQ Oeste, when removing this parameter.

A possible insufficient separation between the liquid fraction of the sewage and the solids during the decantation stage, together with the irregular shutdown of the aerators, may justify not only the low efficiency but also the loss of solids in the treated sewage.

Finally, at the Orlando Dantas station, there was efficient removal of settleable solids, with 100% removal throughout the evaluated period.

With regard to ammoniacal nitrogen, average concentrations of 23.7 mg/L, 30.4 mg/L, 32.0 mg/L and 12.0 mg/L were observed, respectively, in the effluent from ERQ Norte, ERQ Sul, ERQ Oeste and WWTP Orlando Dantas. At ERQ Norte, the highest concentration of ammoniacal nitrogen in the effluent was verified in November 2017, corresponding to 52.0 mg/L.

Through data analysis, Chaves et al. (2018) observed an average ammoniacal nitrogen removal efficiency of 25% in ERQ Norte.

Although the facultative ponds do not show expressive efficiency in the removal of nutrients, when associated with the maturation ponds, they should present concentrations of ammoniacal nitrogen in the treated sewage lower than those verified in the ERQ Norte. In a system composed of anaerobic, facultative and maturation ponds, analyzed by Fujioka et al. (2020), an overall ammoniacal nitrogen removal efficiency of 43% was obtained.

In eighty-nine facultative lakes evaluated separately, Espinosa et al. (2017) found an average ammoniacal nitrogen removal performance equal to 57% and an average concentration in the effluent of 13 mg/L.

Better performances were obtained by Bastos et al. (2018), in a study carried out with four maturation ponds in series, which individually presented a performance of 40.6%, 39%, 49.4% and 53%. The efficiency of the four ponds in removing ammoniacal nitrogen was 91.4%.

Factors such as the reduction of depth due to silting, turbidity, and mixing conditions, especially in the maturation ponds, may have a negative effect on the removal performance of this parameter.

The lowest and highest concentration of ammoniacal nitrogen verified in the ERQ Sul were 17.1mg/L and 40.7 mg/L, respectively, in May and November 2017.

Ammoniacal nitrogen concentrations in sewage treated by ERQ Oeste were always higher than 22 mg/L, with the exception of April 2017, when the value was 14.3 mg/L. This lower concentration obtained may have as a probable cause the collection of the sample for analysis after high precipitation with consequent sample dilution. Lopes (2015), when characterizing

domestic sewage in WWTPs, located in the west of Paraná state, observed the influence of high precipitation during the sampling period, in the decrease of the concentration of ammoniacal nitrogen in the samples collected.

As for the nitrogen values, the need for subsequent treatment steps is evident, as the excess of ammoniacal nitrogen reduces the concentration of dissolved oxygen and the pH in the water body, causing its eutrophication.

Out of the four stations evaluated, WWTP Orlando Dantas reached the lowest average concentration of ammoniacal nitrogen in the effluent. Only in August, October and November of 2017 and March of 2018, concentrations exceeded the value of 20.0 mg/L. On average, the ammoniacal nitrogen concentration was 12.0 mg/L.

Regarding the pH, the raw sewage and the effluent from the four stations presented pH values close to neutrality. As they are close to the pH range between 6 and 9, they favored the existence of greater biological diversity and, consequently, better conditions for the biological treatment (METCALF; EDDY, 2015). It was found that the stations met the established criterion (between 5 and 9) by CONAMA Resolution 430, in the four observed WWTPs, in all verified measurements.

At ERQ Norte, the pH of raw sewage ranged from 6.9 to 8.1. These values were similar to those obtained by Smyth et al. (2018) and Campos et al. (2016), when they evaluated the efficiency of facultative ponds in the treatment of domestic sewage. In relation to the ERQ Sul, there was also a slight alkalinization of the wastewater.

The pH variation of raw sewage in the ERQ Sul remained close to the optimal pH range, from 6.6 to 7.4. The pH values of the treated sewage from the ERQ Sul were close to those obtained by Rocha et al. (2017) and Ross et al. (2018), when using UASB reactors in the treatment of domestic sewage.

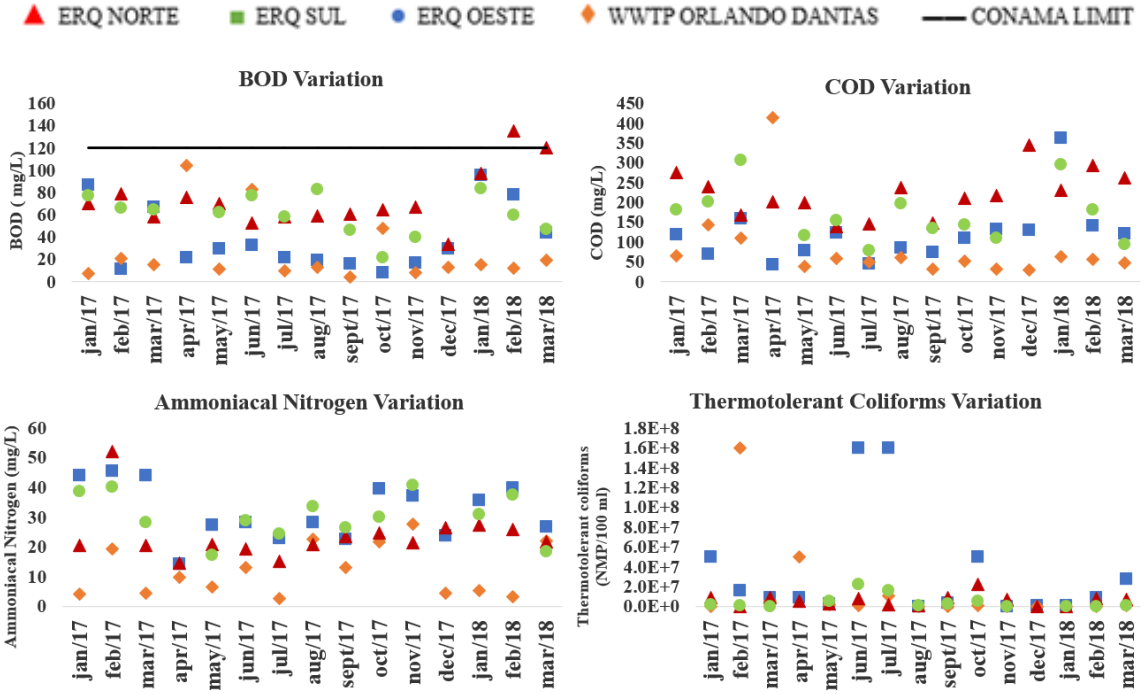
Unlike the ERQ Norte and ERQ Sul, in the ERQ Oeste there was a small reduction in the sewage pH. Before the treatment, it varied from 7.2 to 8.3 and after, it ranged from 7 to 7.8.

In the pH analysis at the WWTP Orlando Dantas, a variation of the pH value of the influent from 7.2 to 8.1 was verified and in the effluent, it ranged from 7.1 to 8.1, remaining slightly alkaline.

Regarding oils and greases, no station exceeded the limit of 100 mg/L in the treated sewage, established by CONAMA Resolution 430. Averages were much lower than those established by legislation, of which: 2.5 mg/L for the ERQ Norte, 2.9 mg/L for ERQ Sul, 2.8 mg/L for ERQ Oeste and 2.6 mg/L for the Orlando Dantas station. One way to contribute to the reduction of the input of fatty substances in the public sewage collection network and its consequent arrival at the WWTP is the adoption, in the sanitary sewage systems of single-family or multi-family buildings, of oil and grease retaining devices, called grease traps. These, when built according to appropriate projects, combined with periodic maintenance and removal of grease residues, have their efficiency greatly increased.

Figure 1 shows the variation of parameters (BOD, COD, ammoniacal nitrogen and thermotolerant coliforms) analyzed in the effluent from the WWTPs.

Figure 1. Parameters analyzed in the WWTPs effluent



Source: Prepared by the authors, 2022.

In the case of sulfides, concentration values of 1.6 mg/L for the ERQ Norte, 1.5 mg/L for the ERQ Sul, 2.7 mg/L for the ERQ Oeste and 0 mg/L for WWTP Orlando Dantas were found in the treated sewage. Although Brazilian legislation does not set limits for sulfide concentration values, its presence, in the predominant form of H_2S (odorant gas), during sewage acidification, implies the occurrence of complaints from the resident community in the vicinity of WWTPs, caused by the emanation of odors produced in the generation of hydrogen sulfide (GOSTELOW et al., 2001; JIANG et al., 2013).

With regard to the requirements of CONAMA Resolution 430, the ERQ Sul, ERQ Oeste and WWTP Orlando Dantas fully complied with all the conditions for the parameters analyzed. Only ERQ Norte failed to comply with the legislation, as it exceeded the tolerated limit of 120 mg/L of BOD in the effluent and did not present a minimum efficiency of 60% of removal.

CONCLUSION

In relation to the requirements of CONAMA Resolution 430, the WWTPs almost fully complied with all the conditions for the parameters analyzed. Only WWTP ERQ Norte did not comply with the legislation, in relation to the BOD parameter.

Regarding the removal efficiencies of other pollutants, it was observed that, apart from the WWTP Orlando Dantas, the three other analyzed stations presented values lower than

expected for BOD, settleable solids and thermotolerant coliforms parameters, for the type of treatment adopted.

In the WWTP ERQ Norte, the lowest efficiency in the removal of BOD corresponding to 45.2% was verified, and the WWTP ERQ Leste had the lowest efficiency of settleable solids equal to 48.1%.

Therefore, it can be concluded that resources need to be allocated for investments in a greater frequency for both laboratory analysis and infrastructure operation and maintenance of the WWTPs. Intervention actions to remove the sludge accumulated in the WWTP ERQ Norte lagoons will provide improvements in its operational performance. Likewise, it is essential to return the preliminary treatment to full operation, through the grating, to avoid the entry of coarse and floating solids in the following treatment stages.

Continuous training of professionals involved in the operation of the systems will lead to an increase in the performance of wastewater treatment structures.

BIBLIOGRAPHICAL REFERENCES

ALVES, M. S., SILVA, F. J. A., ARAÚJO, A. L. C., PEREIRA, E. L. Performance evaluation and coefficients of reliability for waste stabilization ponds in northeast Brazil. **Revista Ambiente & Água**, v. 16, 2021.

BANSAH, K. J., SUGLO, R. S. Sewage treatment by waste stabilization pond systems. **Journal of Energy and Natural Resource Management (JENRM)**, v.3, n.1, 2016.

BARBU, M., VILANOVA, R., MENESES, M., SANTIN, I. On the evaluation of the global impact of control strategies applied to wastewater treatment plants. **Journal of Cleaner Production**, v. 149, p. 396-405, 2017.

BASTOS, R. K. X., RIOS, E. N., SÁNCHEZ, I. A. Further contributions to the understanding of nitrogen removal in waste stabilization ponds. **Water Science and Technology**, v. 77, n. 11, p. 2635-2641, 2018.

BENVENUTI, T., HAMERSKI, F., GIACOBBO, A., BERNARDES, A. M., ZOPAS-FERREIRA, J., RODRIGUES, M. A. Constructed floating wetland for the treatment of domestic sewage: a real-scale study. J**ournal of environmental chemical engineering**, v. 6, n. 5, p. 5706-5711, 2018.

BRASIL. Resolução CONAMA nº 430, de 13 de maio de 2011. Dispõe sobre as condições e padrões de lançamento de efluentes, complementa e altera a Resolução nº 357, de 17 de março de 2005, do Conselho Nacional do Meio Ambiente-CONAMA. **Diário Oficial da União. República Federativa do Brasil**, Poder Executivo, Brasília, DF, 16 mai. 2011.

CAMPOS, A. T., SOUZA, C. V., SOUZA, F. A., SILVA, E. Tratamento de dejetos líquidos de suínos por meio de lagoas de estabilização visando uso agrícola. **Engenharia Ambiental**, v. 13, p. 107-120, 2016.

CHAVES, V. S., SCHNEIDER, E. H. M., LIMA, A. S. P., MENDONÇA, L. C. Desempenho das estações de tratamento do esgoto de Aracaju. **Revista DAE**, v. 66, p. 51-58, 2017.
CIMBALA, J. M. **Outliers**. Penn State - A Public Research University, Department of Mechanical and Nuclear Engineering, 84p, 2011.

DERMIBAS, A., EDRIS, G., ALALAYAH, W. M. Sludge production from municipal wastewater treatment in sewage treatment plant. **Energy Sources, Part A: Recovery, Utilization, and Environmental Effects**, v. 39, n. 10, p. 999-1006, 2017.

ESPINOSA, M. F., VON SPERLING, M., VERBYLA, M. E. Performance evaluation of 388 full-scale waste stabilization pond systems with seven different configurations. **Water Science and Technology**, v. 75, n. 4, p. 916-927, 2017.

FORSTINUS, N. O., IKECHUKWU, N. E., EMENIKE, M. P., CHRISTIANA, A. O. Water and waterborne diseases: A review. **International Journal of Tropical Diseases and Health**, v. 12, n. 4, p. 1-14, 2016.

FUJIOKA, A. M. A., CARVALHO, E. H., CARILHO, S. M. A. V., BITTAR, K. H., PFEIFFER, S. C. Avaliação da eficiência da remoção de nitrogênio e fósforo em lagoas de estabilização no tratamento de lixiviado e esgoto sanitário. **Brazilian Journal of Development**, v. 6, n. 3, p. 12049-12058, 2020.

GOSTELOW, P., PARSONS, S. A., STUETZ, R. M. Odour measurements for sewage treatment works. **Water research**, v. 35, n. 3, p. 579-597, 2001.

HONGWEI, L. U., SEN, Y. U. Spatio-temporal variational characteristics analysis of heavy metals pollution in water of the typical northern rivers, China. **Journal of Hydrology**, v. 559, p. 787-793, 2018.

JIANG, G., KEATING, A., CORRIE, S., O'HALLORAN, K., NGUYEN, L., YUAN, Z. Dosing free nitrous acid for sulfide control in sewers: results of field trials in Australia. **Water research**, v. 47, n. 13, p. 4331-4339, 2013.

KIM, H. J., YOU, J. Y., PARK, C. J. Review of sewage and sewage sludge treatment in Korea. **Int. Proc. Chem. Biol. Environ. Eng**, v. **101**, p. 67-73, 2017.

K'OREJE, K. O., KANDIE, F. J., VERGEYNST, L., ABIRA, M. A., VAN LANGENHOVE, H., OKOTH, M., DEMEESTERE, K. Occurrence, fate and removal of pharmaceuticals, personal care products and pesticides in wastewater stabilization ponds and receiving rivers in the Nzoia Basin, Kenya. **Science of the Total Environment**, v. 637, p. 336-348, 2018.

LEITE, V. D., OLIVEIRA, A. G., CAMPOS, A. R. C., SOUSA, J. T., LOPES, W. S., OLIVEIRA, E. G. Tratamento conjugado de lixiviado de aterro sanitário e esgoto doméstico em lagoas de estabilização. **Revista DAE**, v. 65, n. 207, p. 77-93, 2017.

LI. J., CAI, A., WANG, M., DING, L., NI, Y. Aerobic granulation in a modified oxidation ditch with an adjustable volume intraclarifier. **Bioresource technology**, v. 157, p. 351-354, 2014.

LOPES, T. R. **Caracterização do esgoto sanitário e lodo proveniente de reator anaeróbio e de lagoas de estabilização para avaliação da eficiência na remoção de contaminantes***,* Dissertação de mestrado. Medianeira (PR): Universidade Tecnológica Federal do Paraná, Medianeira. 122 pp, 2015.

LUO, Y., YAO, J., WANG, X., ZHENG, M., GUO, D., CHEN, Y. Efficient municipal wastewater treatment by oxidation ditch process at low temperature: Bacterial community structure in activated sludge. **Science of The Total Environment**, v. 703, p. 135031, 2020.

MCLELLAN, S. L., SAUER, E. P., CORSI, S. R., BOOTSMA, M. J., BOEHM, A. B., SPENCER, S. K., BORCHARDT, M. A. Sewage loading and microbial risk in urban waters of the Great Lakes. **Elementa: Science of the Anthropocene**, v. 6, 2018.

MENDONÇA, L. C., MENDONÇA, S. R. **Sistemas sustentáveis de esgotos: orientações técnicas para projeto e dimensionamento de redes coletoras, emissários, canais, estações elevatórias, tratamento e reúso na agricultura**. São Paulo: Blucher; 348 pp, 2018.

METCALF, L., EDDY, H. P. **Tratamento de efluentes e recuperação de recursos**. Porto Alegre: McGraw Hill Brasil; 1980 pp, 2015.

OBERLIN, A. S. Performance Evaluation of Waste Stabilization Ponds in Mwanza City, Tanzania. **Performance Evaluation**, v.8, n. 4, 2018.

RAZALI, N. M., WAH, Y. B. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. **Journal of statistical modeling and analytics**, v. 2, n.1, p. 21-33, 2011.

RIBAS, T. B. C., FORTES NETO, P. Disposição no solo de efluentes de esgoto tratado visando à redução de coliformes termotolerantes. **Ambiente & Água-An Interdisciplinary Journal of Applied Science**, v. 3, n. 3, 2008.

ROCHA, J. M., FALEIRO, G. G. V., MAGALHÃES, J. S. F., PEREIRA, J. O. Avaliação da retenção de sólidos em inovadora configuração de reator UASB tratando esgoto doméstico. **Revista DAE**, 2017.

ROSS, B. Z. L., GUERRA, A. C. S., PAULA, A. C., FUGANTI, M. F., COSTA, F. J. O. G. Proposta de recuperação de reator anaeróbio tipo UASB tratando esgotos domésticos–Estudo de caso/Proposal of recovery of anaerobic reactor type UASB treating domestic sewage-Case study. **Brazilian Journal of Technology**, v. 1, n. 1, p. 35-48, 2018.

SHELUDCHENKO, M., PADOVAN, A., KATOULI, M., STRATTON, H. Removal of fecal indicators, pathogenic bacteria, Adenovirus, Cryptosporidium and Giardia (oo) cysts in waste stabilization ponds in Northern and Eastern Australia. **International journal of environmental research and public health**, v. 13, n. 1, p. 96, 2016.

SILVA, E. M., SILVA, G. G., QUEIROZ, S. C. B., OLIVEIRA JUNIOR, K. C., PASCHOALATO, C. F. P. R., MARTINS, F. M. S., OLIVEIRA, L. R. A., PEDROZA, M. M. Eficiência de uma estação de tratamento de esgotos composta por reator anaeróbio tipo UASB, seguido de um flotador por ar dissolvido. **Revista AIDIS de Ingeniería y Ciencias Ambientales. Investigación, desarrollo y práctica**, v. 11, n. 2, p. 220-237, 2018.

SMYTH, K., VENDRAMELLI, R., DANKEWICH, D., YUAN, Q. Seasonal variations in cold climate nutrient removal: A comparison of facultative and aerated lagoons. **Journal of environmental management**, v. 214, p. 224-231, 2018.

SNIS, Sistema Nacional de Informações sobre Saneamento. **Diagnóstico dos Serviços de Água e Esgoto - 2019**. Brasília, 183 pp, 2020.

SUNARSIH, S., SASONGKO, D. P., SUTRISNO, S., PUTRI, G. A., HADIYANTO, H. Analysis of wastewater facultative pond using advection-diffusion model based on explicit finite difference method. **Environmental Engineering Research**, v. 26, n. 3, p. 190496, 2020.

TARDIVO, M. **Considerações sobre o monitoramento e controle dos parâmetros físicos, químicos e biológicos de estações de tratamento de esgotos e proposta para sistema integrado de gestão com enfoque ambiental, controle de qualidade, segurança e saúde**, Tese de doutorado. São Carlos (SP): Universidade de São Paulo. 119 pp, 2009.

YANG, J., LIU, X., YING, L., CHEN, X., LI, M. Correlation analysis of environmental treatment, sewage treatment and water supply efficiency in China. **Science of the Total Environment**, v. 708, p. 135128, 2020.

ZHANG, L. Y., ZHANG, L., LIU, Y.D., SHEN, Y. W., LIU, H., XIONG, Y. Effect of limited artificial aeration on constructed wetland treatment of domestic wastewater. **Desalination**, v. 250, n. 3, p. 915-920, 2010.