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Domestic sewage treatment an analysis of the North Station of domestic sewage treatment of Presidente Venceslau – SP

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SUMMARY

The release of domestic sewage, without treatment directly into water bodies, contributes to public and environmental health impacts, and investment in basic sanitation by Brazilian municipalities in domestic sewage treatment systems is essential. In general, biological treatment is used to reduce the organic load of domestic sewage and improve its quality, before its release into the environment. In this context, the present study sought to survey the operations performed at the Domestic Sewage Treatment Station (ETE) North of the municipality of Presidente Venceslau, located in the west of the State of São Paulo, for the treatment of domestic sewage and to evaluate the quality of the treated sewage and their impacts on the water body of release. Thus, the adopted domestic sewage treatment process was monitored, through fieldwork at the North ETE and a preliminary assessment of self-purification in a stretch of the stream after the release of the treated sewage. It was verified that the domestic sewage treatment technology adopted at the ETE Norte de Presidente Venceslau is a compact and effective treatment plant, with a series of equipment for the removal of organic matter and disinfection of domestic sewage before its release into the water body. In this way, ETE Norte must seek permanent efficiency, monitoring and control of the treatment of domestic sewage in the municipality studied, since the release of this effluent into water bodies can affect the quality of water, the local fauna and flora, as well as human health if it does not meet quality and legal requirements.

KEYWORDS: Domestic Sewage. Treatment. Management of Water Resources.

1Introduction

Several regions of Brazil have water quality problems resulting from the release of untreated domestic sewage, which causes economic, environmental and public health impacts (FORNARI et al., 2018).

The composition of the domestic sewage is approximately 99% water and low concentrations of organic and inorganic material, dissolved or suspended, which vary in quantity and quality, including carbohydrates, lignin, fats, soaps, detergents, proteins, natural or synthetic substances, pathogenic microorganisms, among others (MANNARINO et al., 2013).

Conventional domestic sewage systems involve the collection, transport, treatment and disposal of treated domestic sewage in the environment. The use of treatment levels will depend on the characteristics of the domestic sewage to be treated, volume and final quality needs of the effluent (OLIVEIRA JÚNIOR, 2013).

Installing a reliable sewage collection and treatment system improves overall health and sanitation, and consequently reduces the spread of waterborne diseases, which helps alleviate the health system (MUGA et al., 2009).

The municipality of *Presidente Venceslau* is located in the Water Resources Management Units - UGRHI 21 and UGRHI 22, whose consultative and deliberative management bodies of these UGRHI are, respectively, the Hydrographic Basin Committee (HBC) of the *Aguapeí* and *Peixe* rivers (HBC-AP) and *Pontal do Paranapanema* (HBC-PP).

As for domestic sewage, the Situation Report of the *PontaldoParanapanema* Hydrographic Basin – base year 2012 identified that UGRHI 22 had good rates of collection, treatment and reduction of polluting organic load. However, the indicators of treatment and reduction of organic load had regular classification, as the municipality of Presidente Venceslau did not have domestic sewage treatment. The beginning and completion of works on domestic sewage treatment plant in *Presidente Venceslau*was indicated as a guideline for management (CBH-PP, 2013).

In the Situation Report of the *Pontal do Paranapanema* Hydrographic Basin – base year 2014, it was pointed out that the hydrographic basin still had some problems regarding the treatment and reduction of the polluting organic load. It had been highlighted that the municipality of *Presidente Venceslau* had concluded the works of the North domestic sewage

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treatment plant (HBC-AP), object of study in this paper, and the plant was in operation. The Southdomestic sewage treatment plant(HBC-PP) was still in progress with the financial support from the Clean Water State Program (CBH-PP, 2015).

According to the 25th diagnosis of water and domestic sewage services – 2019, the urban population served by domestic sewage networks in the country was 108.1 million inhabitants (2.5% more than in 2018). The domestic sewage treatment rate in the country was 49.1% in relation to the estimate of generated domestic sewage and 78.5% in relation to the estimate of collected domestic sewage. The volume of treated domestic sewage increased by 5.1% compared to 2018 (BRASIL, 2020).

Specifically, for the municipality of *Presidente Venceslau*, in 2019, the total population of the municipality was 39.516 inhabitants and the urban population of the municipality was 37.809 inhabitants. The urban population served with sanitary domestic sewage was 37.098 inhabitants and the extension of the domestic sewage network was 210 km. The volume of domestic sewage collected was 1.453 (1.000 m^3/year) and the volume of domestic sewage treated was 581 (1.000 m^3/year) (SNIS, 2019).

The effects of sanitation interventions are generally positive, as they constitute a service that ensures the improvement and well-being of the population. Investments in sanitation must meet the dimensions of sustainable development and seek to preserve and conserve the environment and particularly water resources (LEONETI; PRADO; OLIVEIRA, 2011).

In addition, knowing the self-purification capacity of the water body is one of the ways to control the pollution of water bodies, estimating the amount of treated effluents that the river is capable of receiving without jeopardizing its natural characteristics and observing the relevant laws (GUEDES; TERAN; GUEDES, 2019).

According to Von Sperling (2005, p. 137) before the release of domestic sewage, the ecosystem of the watercourse is generally in balance and after the entry of the polluting source, communities are affected to a high degree, resulting in disorganization initial trend, followed by a later trend towards reorganization.

Cornelli et al. (2014) raised in the literature that domestic sewage treatment methods that use both anaerobic and aerobic processes are in greater numbers than those that use only anaerobic or only aerobic processes and the most used treatment methods were anaerobic treatment/UASB, wetlands and activated sludge.

The CONAMA Resolution n. 357, of March 17, 2005, deals with the classification of bodies of water and environmental guidelines for their classification, as well as establishing the conditions and standards for the discharge of effluents, and other measures. In addition, the CONAMA Resolution n. 430, of May 13, 2011, deals with the conditions and standards for the release of effluents, complements and amends the Resolution n. 357, of March 17, 2005. Both Resolutions must be evaluated in cases of discharge of effluents from sewage treatment systems.

That way, it is of fundamental importance to understand and guarantee the efficiency of thedomestic sewage treatment plant over time, so that the benefits can be evaluated in the context of the sustainability of water resources. Moreover, the discussion of this theme is of great relevance for the management of water resources, especially for the River Basin Committees involved with the management of water resources.

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2 Objectives

This article aims to analyze the treatment of domestic sewage carried out at the Northdomestic sewage treatment plant in the municipality of *Presidente Venceslau* and the water quality of a section of the stream that receives the treated sewage, classified as class 2.

3 Methodology

The methodology adopted for the development of the present study involved technical visits to the North domestic sewage treatment plantin the municipality of *Presidente Venceslau - SP*, as well as office work to understand and describe the project adopted for the domestic sewage treatment. Information was gathered to characterize theNorthdomestic sewage treatment plant and describe its operation.

Parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), among others, were also surveyed in laboratory analysis reports carried out by Northdomestic sewage treatment plant, in order to analyze the efficiency of the plant studied.

To determine the self-purification capacity of the analyzed section of the stream where the treated sewage from the North domestic sewage treatment plantof *Presidente Venceslau*is released, the mathematical modeling of Streeter and Phelps was adopted, according to the methodology described by Von Sperling (2006).

For the calculations, it had been takenvalues presented in the North domestic sewage treatment plantproject, as well as physical-chemical parameter data available in laboratory analysis reports.

The stream flow (Qr) upstream of the sewage release is 0.353 m^3/s; the average depth of the stream is 0.3 m, the average speed of the stream is 0.35 m/s and the distance traveled until reaching the confluence with the main river is 1,200 m. The class of the stream studied is class 2 and the minimum allowed value of dissolved oxygen, in this case, according to CONAMA Resolution n. 357/2005, is 5.0 mg/L.

The flow of treated sewage released into the stream (Qe), as well as the values of biochemical oxygen demand from the river (BODr), from the treated sewage (BODe), of dissolved oxygen from the river (Or) and of dissolved oxygen from sewage treated (Oe) were obtained through analysis of laboratory reports from outsourced laboratories hired by the municipality for these analyses.

With the values of these parameters, it was possible to calculate the BOD of the river/treated sewage mixture (BOD5o) and the dissolved oxygen value of the river/treated sewage mixture (Co).

According to Köppen and Geiger, the climate classification in the municipality is Aw and the average temperature in *Presidente Venceslau* is 22.1° C. The average annual rainfall is 1,173 mm (https://pt.climate-data.org/ south-america/brazil/sao-paulo/presidente-venceslau-52300/#climate-graph). As the water temperature value was not available, in this study, the water temperature was adopted as the average temperature in *Presidente Venceslau* of 22.1º C.

The altitude of the municipality of Presidente Venceslau is 422 meters (https://pt.wikipedia.org/wiki/Presidente_Venceslau).

The temperature and altitude data, mentioned above,were used to determine the oxygen saturation concentration (Cs). For the calculation of Cs, a temperature of 22º C was

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used and the altitude interpolated between 0 and 500 m (422 m). With the value of Cs and the value of Co, it was possible to calculate the oxygen deficit (Do).

The deoxygenation coefficient (K1) depends on the type of organic matter and the degree of treatment, in addition to the temperature and the presence of inhibitory substances. Treated effluents, for example, have a slower degradation rate, due to the fact that most of the more easily assimilated organic matter has already been removed, leaving only the slower stabilization portion. For the determination of K1 in the present study, the tabulated value for the average of secondary effluent was adopted. Afterwards, the K1 value was corrected, since the K1 value depends on the temperature, which exerts a great influence on the microbial metabolism.

The value of the reaeration coefficient (K2) of a body of water can be determined using statistical methods. The selection of the value of the K2 coefficient has a greater influence on the results of the dissolved oxygen balance than the K1 coefficient, due to the factof the variation ranges of the latter being narrower. For the study, the average value of K2 was adopted considering slow rivers, large lakes. The reaeration coefficient also depends on the temperature and needed to be corrected.

It was also necessary to calculate the transformation constant from BOD5 to ultimate BOD (KT). The ultimate demand for oxygen, right after mixing (Lo) was calculated for later determination of the critical time (tc), critical distance (dc), critical deficit (Dc) and critical concentration of dissolved oxygen (Cc). Thus, the dissolved oxygen profile over time and distance, which makes it possible to plot the dissolved oxygen profile over time (in days) and distance (in kilometers) on a diagram, could be determined.

4 Results

The Northdomestic sewage treatment plant is located on *Rodovia PSV - 060, km 25*, plus 850 meters, in the rural neighborhood of *Aymoré (Rodeio resort) in Presidente Venceslau – SP*. The Figure 1 presents an image with an aerial view of the plant. The Northdomestic sewage treatment plant has been in full operation since September 2015, receiving domestic sewage from the North Basin of the municipality of *Presidente Venceslau*, thus around 18,000 inhabitants are being served by Northdomestic sewage treatment plant.

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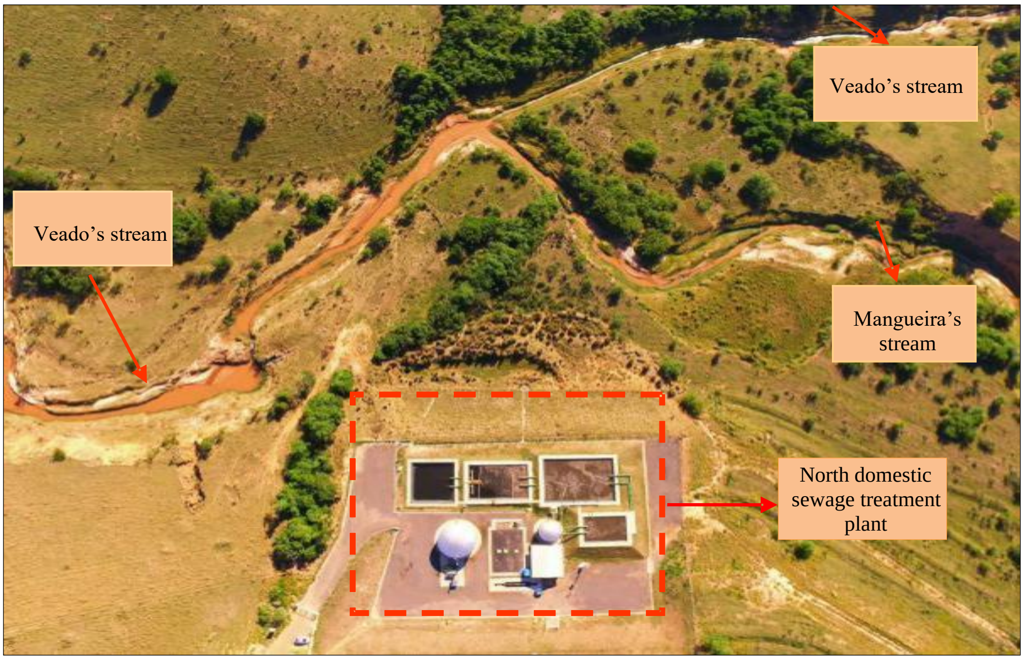
Figure 1 – Aerial view of the North domestic sewage treatment plant of *Presidente Venceslau – SP*.



Source: The authors (2017).

The Figure 2 shows an image of the equipment used in the treatment of domestic sewage at the studied plant.

Figure 2 – Domestic sewage treatment equipment at the North domestic sewage treatment plant of *Presidente Venceslau – SP*.

Source: The authors (2016).

The plant studied is composed of a treatment system that includes a preliminary domestic sewage treatment consisting of grating (removal of coarse solids), sandbox (removal of sand), Parshall gutter (flow measurement and speed control) and tank primary decantation (removal of sedimentable suspended solids and floating solids).

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Afterwards, the domestic sewage goes to a secondary treatment, in which it passes through a buffer tank (storage of domestic sewage before secondary treatment), an anaerobic tank (decomposition of biodegradable organic matter through the action of anaerobic microorganisms). After, the domestic sewage goes to an anoxic tank (reduction of the total nitrogen present in domestic sewage by denitrification), an aeration tank (injection of dissolved oxygen into the tank for the decomposition of biodegradable organic matter through the action of aerobic microorganisms), and a secondary settling tank (removal of solids formed in the aeration tank by sedimentation). Finally, the domestic sewage goes to a sludge digester tank/centrifugal decanter (drying of previously digested sewage sludge in high-performance equipment).

Subsequently, the domestic sewage undergoes a tertiary disinfection treatment in the contact tank with chlorine dripping (mainly elimination of thermotolerant bacteria and Escherichia coli through the disinfection reaction with chlorine), to finally be forwarded to the final outfall for disposal in the water body.

The primary decanter, for decanting the sand, is expected to be dredged every five years and the solid waste extracted must be sent to the municipal sanitary landfill.

The operating system of the Northdomestic sewage treatment plantacts with the recirculation of sludge from the anaerobic tank, and the sludge deposited in the secondary decantation tank is sent to the sludge digester tank, where it accumulates water with excess bacteria and these go to the centrifuge decanter, where there is the separation of water from organic matter. The water returns to the treatment system and the organic matter (sludge) is deposited in buckets to be sent to the sanitary landfill.

The Northdomestic sewage treatment plantanalyzed presents some important technological aspects to be highlighted in the domestic sewage treatment, unlike the simplified conventional systems commonly adopted. It included, for example: aeration by electronic injection of oxygen into the system; digestion of the sludge generated in the secondary decanter that undergoes centrifugation/drying; chlorination of domestic sewage at the end of treatment; size compact with an area of 11,135 m², smaller than the Australian lagoon system. These aspects, among others, contributed to the implementation of a modern and effective domestic sewage treatment system.

The Table 1 presents the domestic sewage results analyzes carried out in 2018 and provided by the studied plant.

Table 1 – Parameters analyzed at the North domestic sewage treatment plant of Presidente Venceslau – SP.

Parameters	Raw domestic sewage (mg/L)	Treated domestic sewage (mg/L)	Efficiency (%)
COD Total (mg/L)	490	87	82.24
BOD (mg/L)	89	4.1	84.39
DO (mg/L)	0.87	not analyzed	not determined

Source: The authors (2018).

The North domestic sewage treatment plant showed an efficiency of removal of organic matter of around 85%, indicating a good performance of the operational process of domestic sewage treatment.

The Table 2 presents the data used for the self-purification calculations, obtained, as previously mentioned, from the North domestic sewage treatment project and from analysis of data available in laboratory reports provided by the studied plant.

Table 2 – Flow, BOD and DO values of the stream and treated domestic sewage.

Parameters	Stream upstream of launch	Treated domestic sewage
Q (m^3/s)	0.353	0.0375
BOD (mg/L)	2.80	41.42
DO (mg/L)	7.23	6.00

Source: The authors (2019).

That way, following the calculations, according to the methodology described by Von Sperling (2006), the BOD value of the river/treated domestic sewage mixture (BOD5o) was 6.5 mg/L and the dissolved oxygen value of the river/domestic sewage mixture treated (Co) was 7.1 mg/L.

Continuing with the calculations, according to the methodology described by Von Sperling (2006), the values presented in Table 3 were obtained.

Table 3 –Values calculated for the variables that determined self-purification.

Determined variables	Values
K_1 $(day)^{-1}$	0.18
K_1adjusted $(day)^{-1}$	0.20
K_2 $(day)^{-1}$	3.08
K_2adjusted $(day)^{-1}$	3.24
Travel time (d)	0.04
Oxygen saturation concentration (C_s) (mg/L)	8.38
Oxygen deficit (D_O) (mg/L)	1.3
K_T (transfer constant from theBOD_5toBOD_u)	1.59
BOD last (L_O) (mg/L)	10
Critical time (T_c) (dias)	*
Critical distance (d_c) (km)	*
Critical Dissolved Oxygen Deficit (D_c) (mg/L)	*
Critical Dissolved Oxygen Concentration (C_c) (mg/L)	*

* Not determined

Source: The authors (2019).

As the value of the last BOD (LO) (mg/L) was very low, 10 mg/l, it was not possible to calculate the values of the critical time, critical distance, critical deficit of dissolved oxygen and critical concentration of dissolved oxygen. It was not determinate because the calculation of the critical time presented a negative value due to the low value of the last BOD and as the other parameters depended on the time, it was not possible to calculate.

It can be seen, with the results presented in Figure 3, that over the distance and time the OD values remained constant, around 7 mg/l. This demonstrates the efficiency of the domestic sewage treatment used in the North domestic sewage treatment plant of *Presidente Venceslau - SP*.

That way, the DO value was above 5.0 mg/l, legal requirement, along the 1.2 km of distance until reaching the main river.

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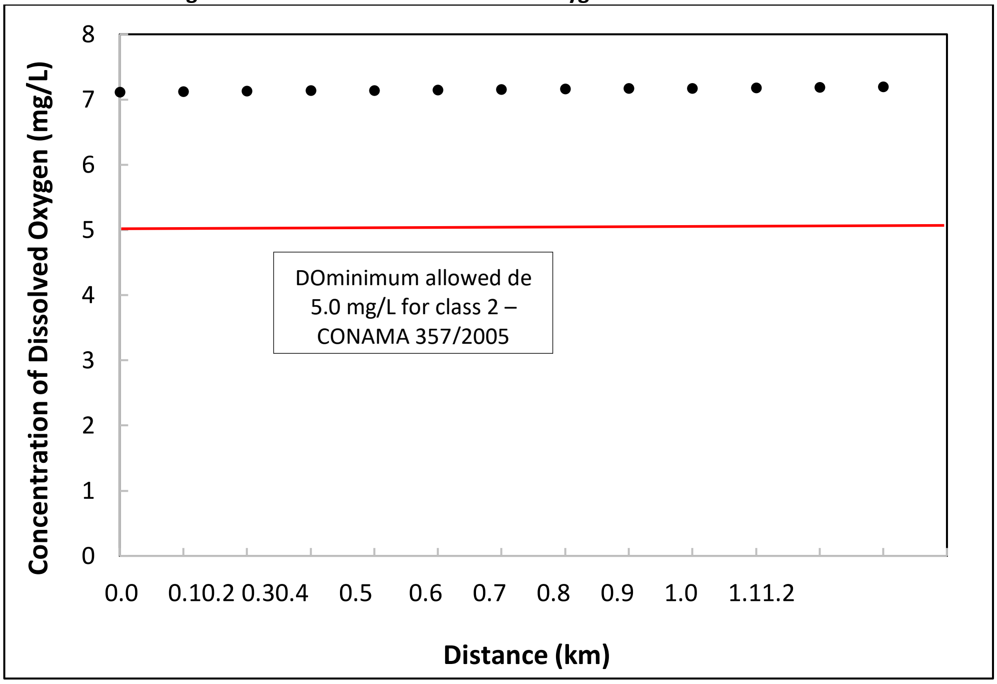
Figure 3 – Concentration of dissolved oxygen as a function of time.



Source: The authors (2019).

Von Sperling (2005) points out that when the river receives a high organic load, the self-purification profile is divided into four zones. In the first, degradation, downstream of the launch point, there is an initial decrease in DO (dissolved oxygen); in active decomposition, the DO reaches the minimum value; in the recovery zone, the stage of restoring the balance prior to pollution begins, with an increase in DO; and in the clean water zone, there is a high concentration of dissolved oxygen.

In general, when domestic sewage treated is launch into the water body, dissolved oxygen is consumed in the receiving body due to the stabilization processes of organic matter carried out by decomposing bacteria, which use the DO for their respiration. However, as shown in Figure 3, this profile was not observed, since the BOD released into the water body had a very low value, due to the domestic sewage treatment capacity of the plant, thus, the environment was not disturbed until after the equilibrium was reestablished.

5 Conclusion

The launch and dilution of domestic sewage in water bodies demand considerable attention and adequate monitoring by the Government through its management bodies, carrying out due monitoring of domestic sewage and the repercussion on the quality of water in the receiving body.

The dilution capacity of a receiving body must take into account the preliminary conditions of water quality and the hydrological regime, which prevent the release of polluting loads that go beyond the self-purification capacity.

The impact caused by the release of domestic sewage from the treatment plants into water bodies is a reason for considerable concern. So that the establishment of public policies and environmental rules to outline environmental criteria for discharge and level of treatment

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must ensure that, the environmental impacts of the disposal of such effluents do not harm the quality of water resources.

However, it is concluded that the North domestic sewage treatment plant has been efficient and that the treatment technology adopted is of good quality.

Finally, among the legally defined water resources management instruments, aiming to provide multiple use in appropriate quality and quantity standards, both for current users and for future generations, we can cite the granting of the right to use water resources and inspection, in which the environmental agencies must act for the proper management of water resources.

In addition, it is extremely important that the municipality guarantee compliance with the universalization of basic sanitation and implement articulated and efficient short, medium and long-term actions to improve the domestic sewage treatment system as a whole. So, it can be possible to generate not only environmental gains, but also in the area of health, mainly in relation to the most vulnerable groups of contagion by diseases related to inadequate environmental sanitation.

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