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Chemical and biological monitoring of water quality on a hydrographic basin in the State of Santa Catarina

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SUMMARY

The inappropriate destination of urban effluents, deforestation along the banks of watercourses, expanding agricultural activities, as well as the lack of public management plans for the prevention and adequacy of the use of urban rivers, compromise the efficiency of basic sanitation services and consequently the health of the population. The objective of this research is to monitor the water quality of the Itajaí-Açu river, the largest watercourse in the Itajaí hydrographic basin, located in the State of Santa Catarina, based on the seasonal chemical and biological indicators, in addition to verifying the statistically significant difference between the sample points. For this purpose, five collection points were allocated along the river, for the aforementioned indicators, in the seasons, spring and summer (2019); autumn and winter (2020), totaling 80 samples. To verify the statistically significant difference between the sample points, the Statistical Software R, version 3.6.3 was used. The results pointed to the chemical and biological contamination along the entire length of the Itajaí-Açu river, regardless of the seasonal aspect. There is an urgent need to implement Municipal Basic Sanitation Plans in all the municipalities that are part of the Itajaí watershed. The absence or precariousness of a planning instrument for the provision of public sanitation services in the municipalities, in addition to violating the legal principle of human dignity of access to clean water and adequate sanitation, contributes to the increase of the environmental degradation of the territory as well as the health of its population.

KEYWORDS: Watershed, Indicators, Water quality

1. INTRODUCTION

The water quality of a hydrographic basin is directly related to the balance between the natural and man-made factors to its territory (CORNELLI et al., 2016). The inappropriate destination of urban effluents, deforestation along the banks of the watercourses, expansion of agricultural activities, as well as the lack of public management plans for the prevention and adequacy of the use of the urban rivers, compromise the efficiency of basic sanitation services and consequently the health of the population.

In Brazil, the Federal Constitution of 1988 in Item IV, of art. 200, establishes the attribution of SUS (Unified Health System) to "[...] participate in the formulation of policies and the execution of basic sanitation actions" (BRASIL, 1988). The document gives the area of basic sanitation as a social activity to prevent and protect the health of the population. In this context, the legal concept for basic sanitation was published in 2007 by Law No. 11,445, which addresses a set of services, infrastructures and operational facilities for the supply of drinking water; sanitary sewage; urban cleaning and solid waste management; and drainage and management of urban rainwater (BRASIL, 2007). Subsequently, the National Basic Sanitation Plan (PLANSAB) approved in December 2013, ensured access to clean water and adequate sanitation as a human right, essential for the full enjoyment of life and other rights (BRASIL, 2013).

To comply with the rights guaranteed by the aforementioned law, since 1997 Brazil has had a water resources policy under Law 9.433 / 97 and with Resolution No. 357/2005 of the National Environment Council (CONAMA) that establish quality standards which are appropriate to the respective uses of water, assuring water potability to the population (BRASIL, 1997; 2005). However, the growing urban expansion combined with the inappropriate occupation of the territory and the neglect of sanitation has weekend and further weakening the water quality in the water resources.

In this regard, the present work is a partial result of a research project that aims to monitor the water quality of the Itajaí-Açu river, the largest watercourse and hydrographic basin of the Itajaí river, located in the State of Santa Catarina, seeking to establish precepts for the urban public management taking in view the prevention and adaptation of possible environmental impacts that compromise the environmental health and health of the population of the territory under study.

2. OBJECTIVES

The objective of this research is to monitor the water quality of the Itajaí-Açu river, using seasonal chemical and biological indicators, in addition to verifying the significant statistical difference between the sample points, aiming to establish the precepts for the management of urban public taking in view the prevention and adequacy regarding the possible environmental impacts that compromise the water quality and public health.

3. METHODOLOGY

In this section, the description of the study area and the chemical and biological monitoring of water in this research will be addressed.

3.1 Study Area

The hydrographic basin of the Itajaí River has a total area of 15,000 km², which corresponds to 16.15% of the Santa Catarina's territory, with approximately 1,466,885 inhabitants, according to IBGE data. This population portion of the basin, which makes the 18.6% of the state's inhabitants, produces approximately 234,701.67 m³ of domestic effluents daily (IBGE, 2020).

Covering 52 municipalities in its territory, the Itajaí basin naturally divides into seven main hydrographic sub-basins. The largest watercourse in the Itajaí basin is the Itajaí-Açu river, formed by the junction of the Itajaí do Oeste and Itajaí do Sul rivers, in the municipality of Rio do Sul. With 12 municipalities on its banks, the Itajaí-Açu river economically moves the agriculture and livestock in the state of Santa Catarina, along its length of 188.0 Km and area of 2,780.0 Km^2 (PLAN OF WATER RESOURCES OF THE ITAJAÍ BASIN).

For the monitoring of water quality, five collection points were allocated along the Itajaí-Açu river, the first point (P1) being selected in the formation of the river in the municipality of Rio do Sul and the last point (P5) at the mouth, in the municipality of Navegantes. The choice of the other collection points was made to follow each other in order from the first one. (P2) was chosen in the area of vegetation, municipality of Apiúna, (P3) was in the urban area, municipality of Blumenau and (P4) in the open field area of the municipality of Ilhota.

To consolidate the objective proposed in this research, i.e, to monitor the water quality of the Itajaí-Açu river by using the chemical and biological indicators and to verify the statistically significant difference between the sample points, we used the support of Statistical Software R (R Development Core Team, 2020), version 3.6.3, for the descriptive statistics and data normality test (Shapiro-Wilk), which was followed by the significance analysis between the variables (Kuskall Wallis test).

3.2 Chemical and biological water monitoring

The parameters used as variables in monitoring the water quality of the Itajaí-Açu river were selected according to the CONAMA Resolution No. 357/2005, in the chemical indicators:

nitrite and nitrate; and biological indicators: thermotolerant coliforms and total coliforms, in the seasons like spring, summer (2019); and autumn, winter (2020).

The predilection of analysis of the nitrite and nitrate indicators in surface waters, acts as a design, respectively, in the occurrence of the active biological processes that are influenced by the presence of organic pollution and by the flow of agricultural land to the rivers due to the use of fertilizers in agriculture (FONSECA, 2017). On the other hand, the coliform biological group, since it inhabits the intestines of mammals, including humans, its presence in the aquatic environment is indicative of the fecal contamination by the inadequate effluent discharge, which is considered as a basic bioindicator in the parameter of the legislation related to the monitoring of water quality for drinking and bathing (NUNES, 2019).

According to the sampling plan, in the aforementioned indicators, four collections were carried out covering the four seasonal spaces, totaling 80 samples along the Itajaí-Açu river. The samples were analyzed by the Central Laboratory of Analytical Tests, UNIVALI - CLEAn, in the municipality of Itajaí - SC, which followed the normative references Standard Methods for the Examination of Water and Wastewater (GREENBERG; CLESCERI; EATON, 1992).

4. RESULTS

Performing the descriptive analysis of the study of the chemical and biological parameters at the five water collection points, covering the four seasons, with the R Statistical Software (R Development Core Team, 2020), we obtained the results shown in **figure 1**. The line represented in red in the figures corresponds to the water potability standards established by the CONAMA resolution No 357/2005.

According to the graphs of the chemical indicators, nitrate values ranged from 0.31 mg / L at point 2 - summer, to 24.61 mg / L at point 5 - spring ($\overline{X}$ = 3.057 ± 5.34; mean and standard deviation respectively), **figure 1a**. The non-conformity of water potability standards with Resolution No. 357/200 of CONAMA observed in the spring season in P5, the region of the mouth of the Itajaí-Açu river can be attributed to the agricultural areas of point 4, being the most representative territory for this sector. According to the IBGE's agricultural census, this indicative leachate arises due to the high rainfall in the season (accumulated precipitation 21.4 mm). According to Fonseca, (2017, p.15) “the increase in the levels of nitrate ions in drinking water, especially in rural areas; where the main source of this nitrate is the runoff that occurs from the agricultural lands to the rivers and streams is due to the use of fertilizers”.

The results for the indicative nitrite ranged from 0.01 mg / L at points P1 to P5 in spring, to 0.44 mg / L at point P4 in summer ($\overline{X}$ = 0.08 ± 0.10), **figure 1b**. Despite the variations shown in the indicative at some collection points, the values are still within the water consumption potability standards set at 10.0 mg / L, according to CONAMA. Considering the biological indicatives, the thermotolerant coliforms alternated from 49 NMP / 100 ml at point P2 in autumn, to 16,000 NMP / 100 ml at points P1 and P3 in spring and P5 in summer ($\overline{X}$ = 3575 ± 5,713,079), **figure 1c**. According to CONAMA Resolution No. 357/2005, values of up to 1000 NMP / 100 ml are acceptable for water intended for human consumption, a recreation of primary contact and vegetable irrigation, after conventional treatment, however, it was observed that Point 2 was the only point which did not present any non-compliance with the legislation. According to Nunes et al. (2019) in a study of the Salgadinho-CE river, the presence of

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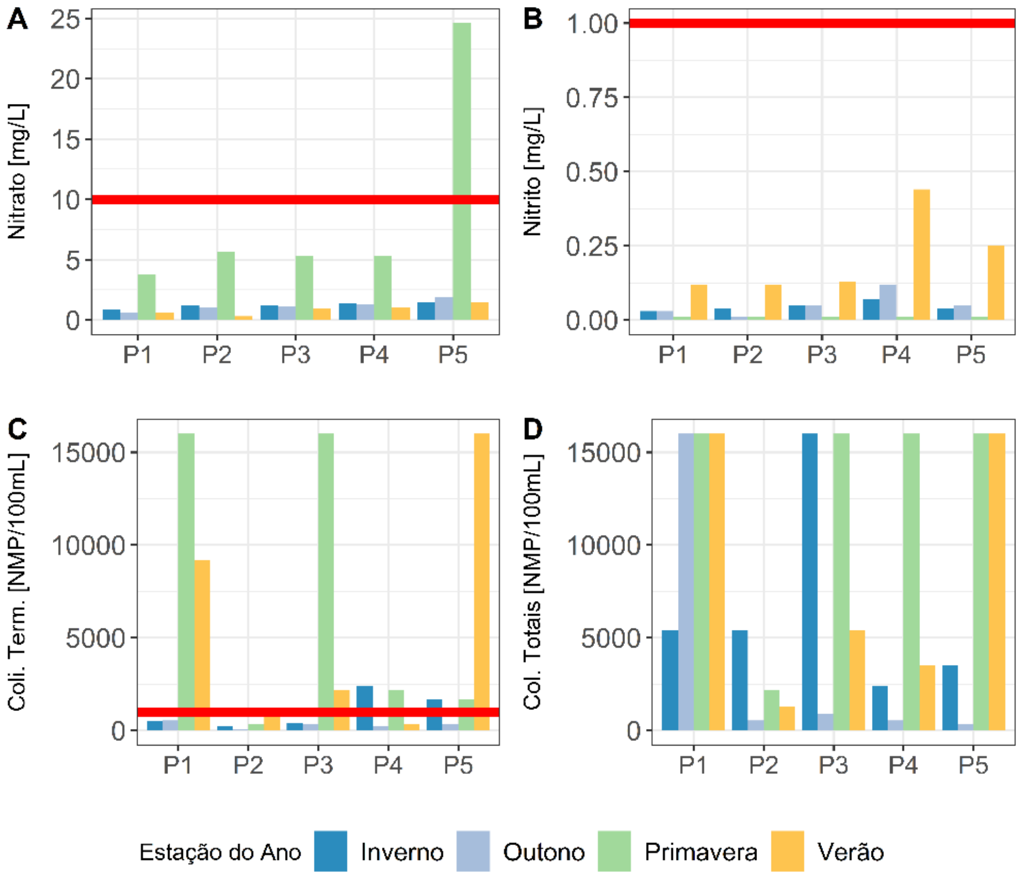
thermotolerant coliforms in the aquatic environment is indicative of human fecal contamination, which would result in the lack of basic sanitation in the region.

According to the information from the National Sanitation Information System (SNIS), data of the sampled points analyzed along the Itajaí-Açu river in 2018, only the municipality of Blumenau has 43% of the population served by the sewage collection network, the other municipalities still use septic tanks or do not present destination information of their effluents. The potability of the water at Point 2 can be attributed to the vegetation (which according to the IBGE agricultural census, covers 22.56% of its territory), considering that forested areas on the banks of the rivers attenuate the load of the pollutants released by the effluents (VIEIRA, 2019).

The total coliforms ranged from 350 NMP / 100 ml at P5 autumn, to 16,000 NMP / 100 ml at P1, P3, P4, P5 in spring, where we repeated P1 and P5 in summer; P1 in autumn and P3 only in winter ($\overline{X}$ = 7972 ± 6,892.43), **figure 1d**. The legislation does not establish a standard of values for the indicative, it only points out that the presence of bacteria in the coliform group is an indicator of pathogenic microorganisms characterizing the discharge of urban waste in the watercourse (BRASIL, 2005). As shown, P2 remained with the lowest values in the different seasons for the call sign, already described above as a forested area. P1 is alerted, which represents the formation of the Itajaí-Açu river, demonstrating that the water is already contaminated by the pathogenic waste coming from the head of the Itajaí basin.

Figure 1. Descriptive analysis of the chemical and biological parameters of water in the Itajaí-Açu river



Source: ORGANIZED BY THE AUTHORS, 2020.

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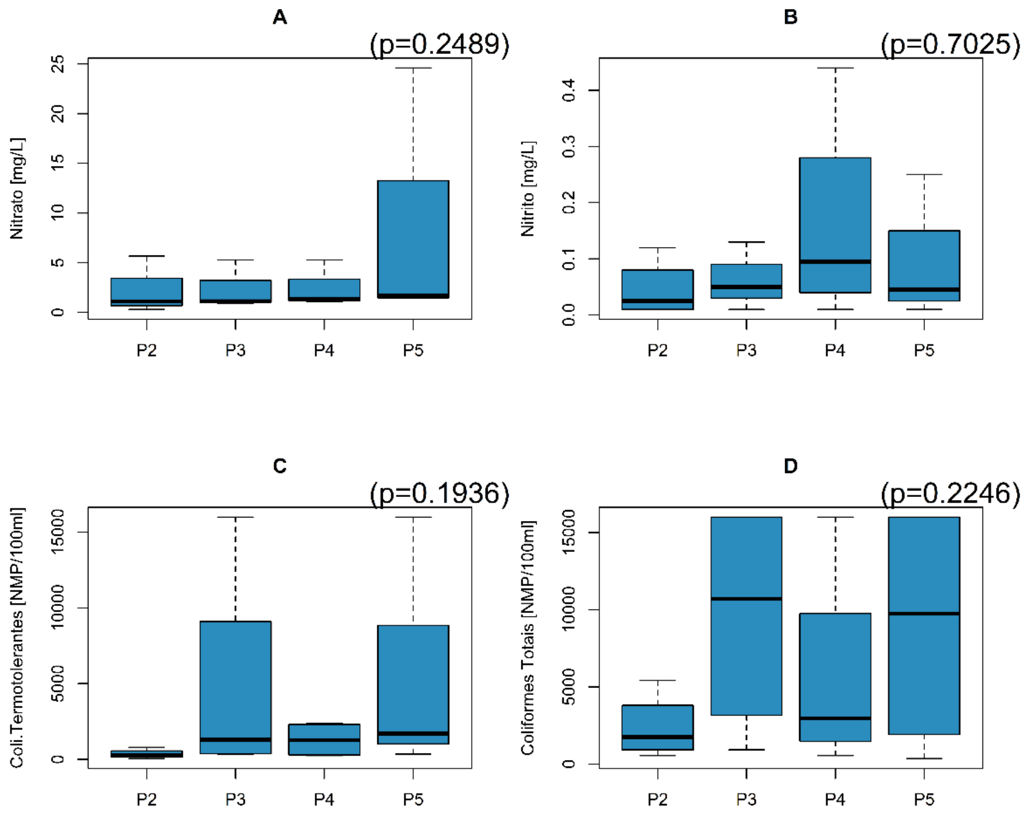
Applying the Shapiro-Wilk test, for the normality of chemical and biological indicatives, it was found that the data that do not follow the normal distribution and is non-parametric, showed the significance level to be below 0.001 ($p < 0.001$). Nitrate values resulted in p = $1{,}649^{-7}$; nitrite in p = $2{,}076^{-5}$; thermotolerant coliforms in p = $3{,}65^{-6}$ and total coliforms in p = $0{,}021^{-2}$, which shows a very small probability that the value will appear again in relation to the others. Non-parametric results were also found by De Melo (2020) in the study of a hydrographic basin located in the State of Mato Grosso; Freire (2020), with interannual (2013 to 2018) and seasonal differences in the water quality monitored in the stretches of 11 hydrographic basins in the Brazilian semiarid region, in the state of Ceará.

To verify whether there is a statistically significant difference between the results of the analysis of the chemical and biological indicators and the different sample points, the Kuskall Wallis test was applied, which corroborates with the non-parametric data (**figure 2**).

Considering the result of the "p" values in the application of the Kuskall Wallis test for the space-seasonal frequencies, it is revealed that there is no significant difference between the chemical indicators; nitrate p = 0.2489 (**figure 2a**) and nitrite p = 0.7025 **(figure 2b**); and biological; thermotolerant coliforms p = 0.1936 (**figure 2c**) and total coliforms p = 0.2246 (**figure 2d**) at different sample points, as they have values greater than 0.05 ($p > 0.05$).

Figure 2. Test of seasonal significance on chemical and biological indications



Source: ORGANIZED BY THE AUTHORS, 2020

These data unfortunately, point to the chemical and biological contamination along the entire length of the Itajaí-Açu River, regardless of the season. In research on a river in the state of Amapá, Abreu, and Cunha (2020), chemical results for the nitrogen and biological results for the coliform group were reported that corroborate the study in question for the water quality, pointing to the strong anthropic impacts of the urban, agricultural and industrial sectors on the basin.

5. CONCLUSION

The results obtained through the use of the statistical technique are reliable for monitoring the water quality indicators, elucidating the effect of human activities on the quality of waters of a hydrographic basin. Despite pointing to the contamination influenced by the agricultural areas and by the discharge of effluents throughout the Itajaí-Açu river, it was observed that the vegetation present in one of the sampling points, located in the municipality of Apiúna (P2), was still able to attenuate part of the chemical and biological load dumped in the watercourse.

Identifying only the municipality of Blumenau along the Itajaí-Açu River, with the adequate partial treatment of sewage (43%), an urgent need for the implementation of Municipal Basic Sanitation Plans in all municipalities that are part of the Itajaí watershed was observed. We emphasize that, due to the confluence of the water resource (P1), it has been biologically contaminated and lies outside the standards of water potability established by the law, hence it compromises the health of the population.

The absence or precariousness of a planning instrument for the provision of public sanitation services in the municipalities, in addition to violating the legal principle of human dignity of access to clean water and adequate sanitation, contributes to the increase of the environmental degradation of the territory as well as the health of its population. Challenging the rhetoric of laws and the contours of public management is an effort to be continued in the sense of carrying out concrete actions, exercising criticism in the face of environmental management conflicts, between social life and the environment, between territory and city, thus intervening, fully in defense of the environment and the dignity of the Brazilian citizen.

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