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LIMNOLOGICAL CHARACTERIZATION OF THE JAGUARIBE RIVER IN THE MUNICIPALITY OF TABULEIRO DO NORTE, STATE OF CEARÁ

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ABSTRACT

The ecological study of rivers is essential for informing decisions about environmental dynamics. This approach can contribute positively to the preservation of river resources and ecosystems while promoting and disseminating the concept of sustainability. Disorderly population growth, combined with the increasing development of various human activities, exerts negative impacts on the environment, particularly on water resources, affecting both the quality and quantity of water available for consumption. The aim of this study was to assess the water quality of the Jaguaribe River in Tabuleiro do Norte, Ceará state. Water samples were collected monthly, and the following parameters were measured: temperature, pH, conductivity, dissolved oxygen, and turbidity. Our results show that the river is moderately impacted by human activities on the banks, as well as changes associated with the seasonal transition period.

KEYWORDS: Sustainable Development, Water Resources, Semiarid Region.

CARACTERIZAÇÃO LIMNOLÓGICA DO RIO JAGUARIBE NO MUNICÍPIO DE TABULEIRO DO NORTE, ESTADO DO CEARÁ

RESUMO

O estudo ecológico de rios é essencial para a tomada de decisões sobre a dinâmica ambiental. Essa abordagem pode contribuir positivamente para a preservação dos recursos e ecossistemas fluviais e, ao mesmo tempo resgatar e difundir o conceito de sustentabilidade. O crescimento desordenado da população, somado ao desenvolvimento de várias atividades humanas, exercem impactos negativos sobre o ambiente, particularmente sobre os recursos hídricos, afetando tanto a qualidade quanto a quantidade de água disponível para consumo. Esse trabalho objetivou avaliar a qualidade da água do Rio Jaguaribe em Tabuleiro do Norte, estado do Ceará. Amostras de água foram coletadas mensalmente e os seguintes parâmetros foram medidos: temperatura, pH, condutividade, oxigênio dissolvido e turbidez. Nossos resultados mostram que o rio é moderadamente impactado pelas atividades humanas nas margens, bem como mudanças associadas ao período de transição sazonal.

Palavras chave: Desenvolvimento Sustentável, Recursos Hídricos, Semiárido.

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1 INTRODUCTION

The ecological study of rivers is essential for informing decisions about environmental dynamics. This approach can contribute positively to the preservation of river resources and ecosystems while promoting and disseminating the concept of sustainability, which is vital for modern society. The inadequate occupation and irregular management of riverbanks raise major concerns because of their potential environmental impacts. Therefore, improving water resource management is imperative to achieve sustainable development.

Disorderly population growth, combined with the increasing development of various human activities, exerts a negative impact on the environment, particularly on water resources, affecting both the quality and quantity of water available for consumption (TÁVORA, 2010).

Recent research indicates that the richness or decline of ichthyofauna serves as a reliable indicator of water quality in rivers and lakes (SANTOS and HELBEL, 2008). Teixeira and Gurgel (2005) highlight the importance of understanding the life cycle of certain species and their role in different trophic levels. This knowledge is essential for guiding the conservation and management of aquatic ecosystems.

The study of water resources associated with aquatic fauna involves a profound interaction between various areas of knowledge. This is because water resources constitute a territorial unit that supports and responds to all interactions within its environment, functioning as a living system.

Water management is an extremely complex multidisciplinary undertaking that encompasses physical and behavioral components. Additionally, it is closely linked to environmental management and the promotion of sustainable development, a reality that needs to be recognized and embraced (VIEIRA, 2003).

The rivers in the semi-arid region act as intermittent water reservoirs that mitigate the impacts of drought. In many cases, these reservoirs serve as refuges for wildlife, especially because many rivers and streams in the region are intermittent. Additionally, these rivers provide water and food, as well as foster local economic activities. For example, the Jaguaribe River is a perennial river of great importance to the municipality of Tabuleiro do Norte. Various commercial and recreational activities occur along its banks. Therefore, preserving river ecosystems is essential to ensure the sustainable provision of environmental services.

The findings of this research serve as a basis for the development of environmental management and education initiatives in the studied river. The development of an analytical support tool to facilitate river management is essential for ensuring the sustainability of this area. Therefore, the methodology developed in this research can be a valuable tool to guide the development of public policies aimed at improving the quality of life in the micro-watersheds of the semi-arid region of Ceará. Thus, studies on aquatic ecosystems become crucial for acquiring the necessary knowledge to propose water resource management programs and conserve an important natural resource in the semi-arid region.

In this study, we assessed the water quality of the Jaguaribe River in the municipality of

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Tabuleiro do Norte (state of Ceará) during the dry-wet season transition. We aimed to establish relationships between seasonal aspects and human activities conducted on the riverbanks.

2 BIBLIOGRAPHIC REVIEW

To be classified as high-quality, water must possess specific characteristics that consider the natural characteristics of the region in which it is located and its intended purpose. In Brazil, Resolution 357/2005 by the Conselho Nacional do Meio Ambiente (CONAMA) establishes standards and criteria for classifying water quality. This resolution also defines environmental guidelines for water classification. However, the parameters established by CONAMA resolution derive from international experiences and may not always align with the specific conditions of a particular water body.

Several characteristics of high-quality water can be affected by human activities. The natural ability of water resources to dilute, assimilate, and depurate pollution is constrained by the quantity and quality of water, which are closely related. In areas where the natural assimilation capacity is exceeded, ecological imbalances occur (TCHOBANOGLOUS, 1993). As cities expand, the demand for water increases, leading to conflicts and unsustainable use of this resource.

Water quality can also fluctuate under natural conditions because of the interactions between environmental components. Moreover, the extensive use of water in urban, agricultural, and industrial areas substantially impacts the quality of water resources. Therefore, effluents discharged into streams and rivers must be treated beforehand because certain substances can accumulate in the water and pose risks to public health, fauna, and flora. Incorrect and unsustainable use of water resources causes several negative impacts (TORRES, 2019).

The term "water quality" does not denote an absolute or near-absolute level of purity, but rather a standard that is as close as possible to the "natural" state found in springs before being affected by human activities (Branco, 1991). In addition, achieving a desirable level of purity is essential and depends on the specific purpose for which the water is used, such as supply, irrigation, industrial processes, and fishing.

Water quality can be assessed using various parameters that reflect its physical, chemical, and biological characteristics. From a health perspective, the chemical characteristics of water are particularly important because the presence of certain elements or chemical compounds can make certain treatment technologies impractical. These parameters have broad applications and serve to characterize water supplies, wastewater, springs, and receiving bodies.

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3 METHODOLOGY

The study was conducted in the Jaguaribe River (Figure 1), located in the municipality of Tabuleiro do Norte (approximately 210 km from Fortaleza municipality), in the eastern region of the state of Ceará. The sampling site (5°12'34" S, 38°07'36" W) was situated in the Middle Jaguaribe River, next to a popular riverside resort widely used for recreational activities (Figure 2). Water samples were collected monthly from August 2018 to March 2019 to compare water quality during the dry-wet season transition.

Figure 1: Jaguaribe River in the municipality of Tabuleiro do Norte, state of Ceará, Brazil.

Figure 2: Water sampling point in the Jaguaribe River, in the municipality of Tabuleiro do Norte, state of Ceará, Brazil. Note the riverside resort tents in the background.

Temperature, pH, and conductivity were measured *in situ* using water quality probes. The pH probe had a detection range of 0 to 14, while the conductivity probe had a detection range of 0 to 1,000 µS/cm. Samples for the assessment of dissolved oxygen and turbidity were collected in duplicate, stored in appropriate containers, and immediately transported to the Instituto Federal

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de Educação, Ciência e Tecnologia do Ceará, Limoeiro do Norte Campus, for analysis.

Data analysis was conducted according to the standards outlined in the Brazilian legislation for the control of environmental water quality, as established by the Conselho Nacional do Meio Ambiente (CONAMA Resolution No. 357/2005), and in the relevant literature.

4 RESULTS AND DISCUSSIONS

The Jaguaribe River is of great importance to the municipality of Tabuleiro do Norte. Many commercial and recreational activities are conducted along its riverbanks, resulting in the discharge of waste into the river.

The water temperature ranged from 29.7 to 33.0 °C, with the minimum recorded in September 2018 and the maximum in January 2019 (Table 1). The variation in water temperature reflected the variation in environmental temperature, which was consistent with this geoclimatic particularity. Water temperature is an important factor influencing the growth of microorganisms and the rate of chemical reactions. According to Von Sperling (2005), an increase in temperature accelerates physical, chemical, and biological reactions and decreases solubility, thus increasing gas transfer rates in the water, which can generate unpleasant odors. Temperature and dissolved oxygen in water showed an inverse relationship.

Table 1: Water temperature at the sampling point in the Jaguaribe River between August 2018 and March 2019.

PERIOD	TEMPERATURE (ºC)
August/2018	30.5
September/2018	29.7
October/2018	31.8
November/2018	32.0
December/2018	30.2
January/2019	33.0
February/2019	32.2
March/2019	30.0

Turbidity is an indicator for assessing the concentration of solid organic matter in water. CONAMA Resolution 357/05 stipulates that the turbidity levels of class 2 freshwater bodies should not exceed 100 nephelometric turbidity units (NTU). Turbidity levels ranged from 0.32 NTU in September 2018 to 1.79 NTU in March 2019 (Table 2), which fall within the limits established by the legislation. The gradual increase in turbidity over the months can be attributed to the onset of the rainy season in the region. This results in the revolving of particulate matter that had settled in the riverbed because of the influx of colder water from precipitation.

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Table 2: Turbidity levels at the sampling point in the Jaguaribe River between August 2018 and March 2019.

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PERIOD	TURBIDITY (NTU)	CONAMA RESOLUTION 357/2005
August/2018	0.40	Permissible values should not exceed 100 NTU
September/2018	0.32	
October/2018	0.46	
November/2018	1.03	
December/2018	1.28	
January/2019	1.34	
February/2019	1.47	
March/2019	1.79	

The pH indicates the concentration of hydrogen ions in a solution and is used to express the acidity or alkalinity of a given solution. The pH of pure water at 25 °C is 7.0, which is considered neutral. Values above 7.0 indicate alkalinity, whereas values below 7.0 indicate acidity (SAWYER et al., 2003). The pH of the water in the sampled stretch of the river ranged from 6.2 in November 2018 to 8.7 in January 2019 (Table 3). These values align with CONAMA Resolution 357/2005, which establishes the pH range for class 2 freshwater bodies at 6.0–9.0.

Table 3: pH at the sampling point in the Jaguaribe River between August 2018 and March 2019.

PERIOD	pH	CONAMA RESOLUTION 357/2005
August/2018	7.6	Permissible values range from 6.0 to 9.0.
September/2018	8.3	
October/2018	8.2	
November/2018	6.2	
December/2018	8.1	
January/2019	8.7	
February/2019	8.4	
March/2019	8.1	

Water conductivity was another parameter analyzed (Table 4). The conductivity of natural waters ranges from 10 to 100 µS/cm. However, in environments contaminated by domestic or industrial sewage, conductivity tends to increase, reaching up to 1,000 µS/cm (BRASIL, 2006). In semi-arid regions, the conductivity of natural waters can be even higher, often exceeding 1,000

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µS/cm. This is because of the high rates of water evaporation, which result in a higher concentration of mineral salts, often regardless of any diffusive pollution load.

Conductivity refers to the ability of a material to conduct electric current. It is influenced by the local climate. The conductivity values increased gradually over the study period, ranging from 288.35 µS/cm in September 2018 to 552.00 µS/cm in March 2019 (Table 4). According to CONAMA Resolution 357/2005, permissible conductivity values range from 10 to 100 (µS/cm).

Table 4: Conductivity at the sampling point in the Jaguaribe River between August 2018 and March 2019.

PERIOD	CONDUCTIVITY (µS/cm)	Piratoba *et al*., 2017; Von Sperling, 2005
August/2018	324.75	Recommended values range from 10 to 100 µS/cm.
September/2018	288.35	
October/2018	324.65	
November/2018	308.25	
December/2018	338.00	
January/2019	395.00	
February/2019	405.00	
March/2019	552.00	

As the dry season progresses, riverside resorts (particularly in inland towns) become popular destinations because of the environmental services they offer to alleviate the heat. However, in these resort areas, human activities such as bars and restaurants occupy the riverbanks and attract more people. During the study, we observed an increase in the number of individuals bathing and using the resort's restaurants. Moreover, solid and liquid waste is left on the riverbanks, which may explain the gradual increase in conductivity values observed.

Dissolved oxygen is a highly important parameter for assessing water quality in aquatic ecosystems. The lack of dissolved oxygen in water promotes the proliferation of anaerobic organisms, whose metabolism releases substances that give the water an unpleasant odor and appearance. Moreover, fish depend on dissolved oxygen to survive. More generalist species can tolerate O_2 concentrations as low as 2 mg/L, but more demanding species require at least 4 mg/L of O_2 (BRAGA et al., 2005).

Dissolved oxygen levels ranged from 6.9 mg/L in February 2019 to 9.6 mg/L in December 2018 (Table 5). These values align with CONAMA Resolution 357/2005, which sets the threshold at above 5 mg/L for class 2. However, as observed in the study by Silva (2013), the lowest levels of dissolved oxygen in the water occurred during rainy months (February and March) because of the increase in organic matter carried by rainwater.

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Table 5: Dissolved oxygen levels at the sampling point in the Jaguaribe River between August 2018 and March 2019.

PERIOD	DISSOLVED OXYGEN (mg/L)	CONAMA 357/2005
August/2018	9.0	Permissible values should not exceed 5.0 mg/L.
September/2018	8.1	
October/2018	8.8	
November/2018	8.4	
December/2018	9.6	
January/2019	7.6	
February/2019	6.9	
March/2019	7.0	

5 CONCLUSION

Our study shows that the local climate and human activities on the riverbanks influence the Jaguaribe River. Among the various parameters examined, conductivity was the single one that accurately reflected the gradient of influence and deviated from the values recommended in CONAMA Resolution 357/2005. The other parameters were within the recommendations outlined in this resolution, although reflecting the dynamic nature of the local environmental conditions.

It is essential to broaden the analysis and include additional sampling points along the Jaguaribe River to obtain a more comprehensive assessment of its water quality in Tabuleiro do Norte. These findings can assist the local population, especially those frequenting the riverside resort, in adopting practices and engaging in activities that have a minimal impact on the local environment.

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