

Analysis of the Bathing Area of the main recreation points of the Grajaú-MA River

Análise da Zona Balnear dos principais pontos de recreação do Rio Grajaú-MA

Análisis de la Zona de Baño de los principales puntos de recreación del Río Grajaú-MA

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Abstract

Deficiency in sanitary sewage services, mainly in sewage collection and treatment services, results in inadequate sewage disposal in receiving water bodies. This work analyzes the physicochemical and microbiological conditions of Grajaú river for the preponderant bathing conditions established for bathing defined by CONAMA Resolution 274/00. Grajaú, Prainha (P1), Canecão (P2) and Porto do Limoeiro (P3). Physicochemical analyzes of color, chloride, total hardness, alkalinity, pH and microbiological were carried out, through the indicators of the group of total coliforms and (*E. coli*), using the ALFAKIT methodology in the points. The result was close to 3uH, which allows us to say that the color of the water is within the references required by Conama 357/05. The total alkalinity was 300 mg.L⁻¹ CaCO₃, which allows us to conclude that the water of the Grajaú river is hard. The pH in the three samples did not change, it remained 8.0 in the three points, in view of this, these parameters are in accordance with the references of CONAMA n° 274/00. Through this study it was possible to observe that the river waters, based on the indicator, are within the accepted standards for bathing. Still, through this study, it was possible to conclude that it becomes increasingly necessary to monitor the public power facing the Grajaú river, considering that it can be observed that leisure spots are much sought after by the population.

Keywords: Conama 274/00; Grajaú river; Chemical-physical analysis.

Resumo

A deficiência nos serviços de esgotamento sanitário, principalmente nos serviços de coleta e tratamento de esgoto, resulta em disposição inadequada de esgoto nos corpos hídricos receptores. Este trabalho analisa as condições físico-químicas e microbiológicas do rio Grajaú para as condições balneares preponderantes estabelecidas para balneabilidade definidas pela Resolução CONAMA 274/00. Grajaú, Prainha (P1), Canecão (P2) e Porto do Limoeiro (P3). Foram realizadas análises físico-químicas de cor, cloreto, dureza total, alcalinidade, pH e microbiológica, através dos indicadores do grupo de coliformes totais e (*E. coli*), utilizando a metodologia ALFAKIT nos pontos. O resultado foi próximo a 3uH, o que permite afirmar que a cor da água está dentro das referências exigidas pelo Conama 357/05. A alcalinidade total foi de 300 mg.L⁻¹ CaCO₃, o que permite concluir que a água do rio Grajaú é dura. O pH nas três amostras não se alterou, permaneceu 8,0 nos três pontos, em vista disso, esses parâmetros estão de acordo com as referências do CONAMA n° 274/00. Através deste estudo foi possível observar que as águas do rio, com base no indicador, estão dentro dos padrões aceitos para banho. Ainda, por meio deste estudo, foi possível concluir que se torna cada vez mais necessário o monitoramento do poder público voltado para o rio Grajaú, tendo em vista que pode-se observar que os locais de lazer são muito procurados pela população.

Palavras-chave: Conama 274/00; Rio Grajaú; Análise físico-química.

Resumen

La deficiencia en los servicios de alcantarillado sanitario, principalmente en los servicios de recolección y tratamiento de aguas servidas, se traduce en una disposición inadecuada de las aguas servidas en los cuerpos de agua receptores. Este trabajo analiza las condiciones fisicoquímicas y microbiológicas del río Grajaú para las condiciones de baño preponderantes establecidas para el baño definidas por la Resolución CONAMA 274/00. Grajaú, Prainha (P1), Canecão (P2) y Porto do Limoeiro (P3). Se realizaron análisis fisicoquímicos de color, cloruro, dureza total, alcalinidad, pH y microbiológicos, a través de los indicadores del grupo de coliformes totales y (*E. coli*), utilizando la metodología ALFAKIT en los puntos. El resultado fue cercano a 3uH, lo que nos permite decir que el color del agua está dentro de las referencias exigidas por Conama 357/05. La alcalinidad total fue de 300 mg.L⁻¹ CaCO₃, lo que permite concluir que el agua del río Grajaú es dura. El pH en las tres muestras no cambió, se mantuvo en 8,0 en los tres puntos, por lo que estos parámetros están de acuerdo con las referencias de CONAMA n° 274/00. A través de este estudio se pudo observar que las aguas del río, con base en el indicador, se encuentran dentro de los estándares aceptados para el baño. Aún así, a través de este estudio, fue posible concluir que se hace cada vez más necesario monitorear el poder público frente al río Grajaú, considerando que se puede observar que los lugares de esparcimiento son muy buscados por la población.

Palabras clave: Conama 274/00; Río Grajaú; Análisis químico-físico.

1. Introduction

The water is a natural resource that exists in large quantities on the planet, making it essential for the life of everyone living on Earth, whether men, animals or plants (Silva et al., 2011). This water resource is very important for the maintenance of life, being essential for all organic functions such as digestion, blood circulation, breathing, urinary excretion, perspiration, among others. In this sense, the industry has been looking for resources that minimize the contaminants present in the water, aiming to make them more useful and renewable in order to improve the quality of life of human beings and consequently make the ecosystem less polluted (Lima & Medeiros, 2008).

Currently, water resources have become one of the main issues of environmental issues, due to the misuse of water bodies (Lopes, 2012; Pacheco, 2021). The deficiency in sanitary sewage services, mainly in the services of collection and treatment of sanitary sewage, results in the inadequate disposal of sewage in receiving water bodies, and for being directly released into water courses without undergoing adequate treatment, further worsens the environmental conditions of areas affected by sewage discharges (Almeida, 2017; Silva, 2021). In this way, the interference of basic and environmental sanitation can be defended as a limiting factor of this process, as it generates negative effects on its three pillars, affecting present and future generations. (Santos *et al.*, 2021).

Water pollution is an aggravating factor, as rivers are excessively polluted, altering the physical-chemical properties of the water, thus causing a great waste of this water resource. The release of liquid and solid effluents of urban and industrial origin into rivers has a great influence on the quality of the water found in the city's river, affecting the availability of this natural resource and generating serious problems of environmental imbalance (Lima & Medeiros, 2008). Such imbalances can

cause the scarcity of these resources, generate an energy and economic crisis, in addition, regions with a concentration of housing close to water bodies transform them into open sewage corridors, thus producing numerous diseases (Prestes, 2019).

Currently, in Brazil, the assessment of water quality in rivers, lakes and seas for activities that involve primary contact, that is, bathing, must meet the standards established by CONAMA Resolution 274, of November 29, 2000. In this resolution, freshwater bathing conditions are evaluated in categories, defined according to the levels of fecal coliforms (thermotolerant) (Souza *et al.*, 2016).

Bathing analysis assesses the quality of water bodies for primary contact recreation, being used both on coastal beaches and in inland waters (Souza *et al.*, 2016). For bathing water, the primary concern for sanitary factors is the public is fecal contamination of human and animal origin, cleaning products, hospital waste, among others, which are thrown directly into the river, in addition, another aggravating factor is untreated sewage, bags and plastic packaging irregularly discarded on the banks of the river, thus, the recovery of polluted water becomes more difficult, and environmental factors can influence the presence and distribution of microorganisms (Hong *et al.*, 2010; George *et al.*, 2004).

The impacts on aquatic environments are multiple in terms of pollution source and dynamics in time and space, comprising a series of consequences, including oxygen depletion due to the degradation of the high load of organic matter brought by sewage and soil leaching, increased concentration of some micropollutants and concentration of metals and pathogenic microorganisms. Thus, considering that water for recreational purposes can compromise the health of bathers, there is a need to evaluate the physical-chemical and microbiological parameters of bathing in the river in the Municipality of Grajaú. For that, information was generated about the sanitary conditions of the city that can contribute to the adoption of preventive measures and legal inspections, which allow proposing adequate strategies to maintain this aquatic environment with healthy environmental quality (Passerat *et al.*, 2011; Hamza *et al.*, 2011).

In this city, in addition to the deficiency in basic sanitation services, there is the construction of houses very close to the Grajaú river and public baths, thus, the final destination of sewage and other types of pollutants, which run through culverts or even in the open, has the river as a final destination, thus, there is a contribution to water pollution that is also consumed by part of the population, as already documented in studies by Rodrigues (2015).

Regarding the use of water from the Grajaú river for recreational activities such as bathing, barbecue, commercial activities such as bars and restaurants on the banks of the river, the contamination of the river by these domestic effluents and waste produced in leisure is excessive. Furthermore, it is a fact that human activities, which are based on a lifestyle and development, have defined significant changes in the environment, influencing the availability of a series of resources (Brasil, 2006). And in the river it is possible to detect that garbage is a constant, considering that the city does not have sewage treatment for the entire domestic network, nor basic sanitation. In this way, the work makes an analysis of the physical-chemical and microbiological conditions of the Grajaú river for preponderant bathing established for bathing purposes defined by CONAMA Resolution 274/00.

2. Methodology

2.1 Monitoring Points

This study was carried out in the municipality of Grajaú in the state of Maranhão, on the banks of the Grajaú river. Three points were selected for water collection: Prainha, Canecão and Porto do Limoeiro, to carry out the physical-chemical and microbiological analyses. With the aid of the GPS device – ETREX 10 GARMIN, three sampling points were determined in sections of the Grajaú river, whose distance between Prainha and Canecão is 686 meters, between Canecão and Ponto do Limoeiro is 1,037 meters and, finally, between Prainha and Ponto do Limoeiro 1,723 meters.

The analyzed points were chosen due to the search for bathers and possible risk areas due to the influence of water

quality, that is, possible sources of contamination. Table 1 presents the geographic coordinates of each water sample collection point.

Table 1. Geographic location and altitude of the six collection points on the Grajaú river.

Analyze with Etrex 10 GARMIN GPS			
Location	Latitude	Longitude	Altitude
Prainha	5° 49' 29.6" S	46° 08' 26.1" W	129 m
Canecão	5° 49' 11.1" S	46° 08' 39.1" W	127 m
Limoeiro	5° 48' 41.1" S	46° 08' 22.0" W	128 m

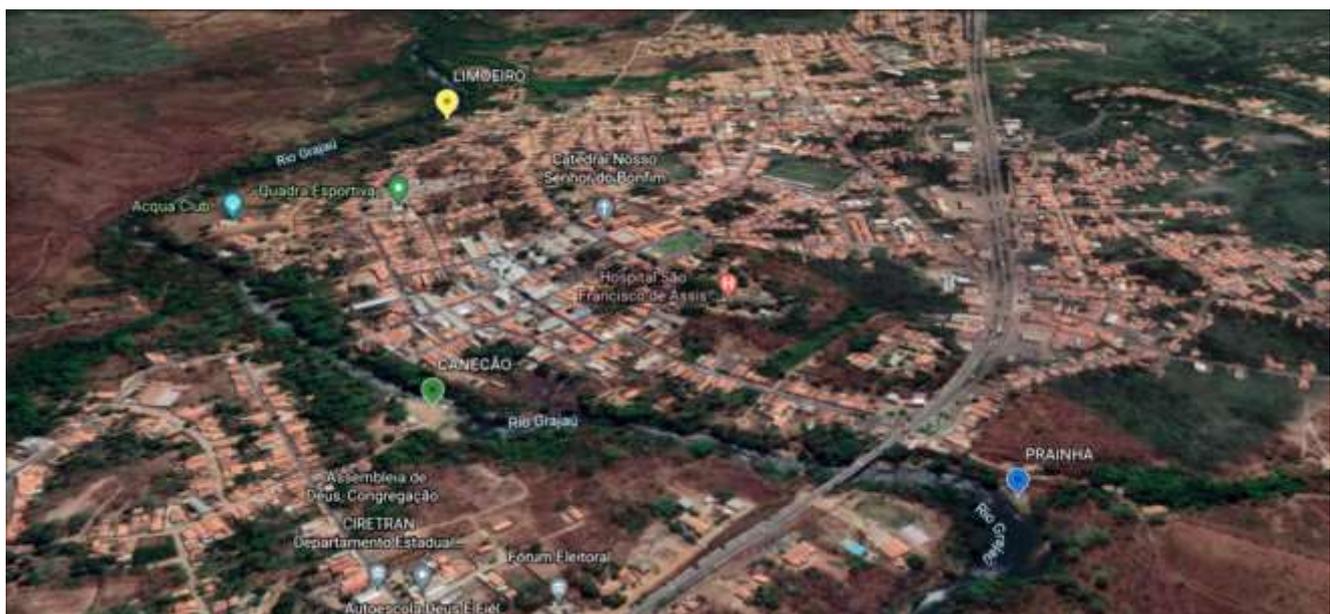
Source: Authors (2022).

In Figure 1 we can see the monitoring points demarcated upstream and downstream on the perimeter of the Grajaú river. The points were delimited to facilitate the analysis of bathing conditions and follow the following characteristics: (PI) – Delimited area for bathing; (PII) – Delimited area for bathing; (PIII) – Delimited bathing area.

The research was carried out in two seasons: summer and winter. On October 20, 2019, the summer stage was held and on March 23, 2021, the winter stage. The visits were carried out at three leisure and recreation points on the Grajaú river in the urban area, namely: Prainha, Canecão and Porto Limoeiro. Such places were chosen because they gather a greater number of bathers during the summer period.

References from the CONAMA Ordinance 274/2000 were used for the analyses, which establishes the procedures and responsibilities related to the control and surveillance of the quality of the bath and other measures. For the physicochemical analysis of color, chloride, total hardness, alkalinity, pH and microbiological analysis, through the indicators of the group of total coliforms and *Escherichia coli* (*E. coli*), the ALFAKIT methodology was used. The presence or absence of floating materials and odor-producing substances has been verified.

Figure 1. Geographical identification of the Grajaú river in the urban perimeter of the city of Grajaú – MA.



Source: Google (2022).

2.2 Procedures

The water samples collected for the chemical analyzes were carried out in previously sanitized 300 mL pet containers, then transferred to beakers identified for each type of analysis. For microbiological analysis, samples were collected in two 250 mL glass containers, properly identified and sterilized in an autoclave. After collection, the samples were placed in a thermal container for further analysis in the laboratory.

The research was carried out in the chemistry laboratory of the Federal University of Maranhão, Campus Grajaú, in which the following parameters were examined: total alkalinity, chlorides, total hardness, pH, color and total coliforms. The Alfakit® potability kit was used for the evaluations, following the methodology and bench protocol of this kit.

3. Results and Discussion

The results of the microbiological analysis with the Alfakit® colipaper method were elucidated. In which, the quantification of the results consisted of counting the blue points (fecal coliform colonies), counting the blue and red points (total coliform colonies) and multiplying them by 100, obtaining the results in CFU/100 mL.

At the end of the research, the results obtained in the laboratory were presented and compared with the values determined by CONAMA Resolution n° 274/00 for the classification of bathing waters as proper (excellent, very good and satisfactory) or unsuitable, according to the density of bacteria *E. coli*. The table below shows the results of the analysis for *E. Coli* from Rio Grajaú at the points: Prainha (P1), Canecão (P2) and Limoeiro (P3), in the winter phase (Table 2).

Table 2: Average of the microbiological parameters of the 3 points of the Grajaú river in the winter phase.

Parameter	P1	P2	P3
<i>E. coli</i>			
(<i>Thermotolerant Coliforms</i>)	400	400	400
Total Coliforms	1200	800	800

*(UFC/100 mL). Source: Authors (2022).

According to Table 2, the results obtained are within the limits of the parameters required as own water, in relation to the values established by CONAMA resolution 274/00. The microbiological analyzes showed the same results for the three (3) analyzed points, 400 CFU/100 mL of *E. coli* (*Thermotolerant Coliforms*) and 1,200 CFU/100 mL of total coliforms in P1 and 800 CFU/100 mL of total coliforms in P2 points and P3. A large extension of the Grajaú river crosses the urban center of the municipality, which allows and facilitates contamination with waste produced by the population, industries and agricultural products, leading to the presence of fecal and total coliforms (SOUSA, 2016). Water is considered unsuitable when the value obtained in the sampling is greater than 2,500 fecal coliforms (thermotolerant) or 2,000 *E. coli*, according to CONAMA 274/00. Thus, by the results obtained in this study, the waters of the Grajaú river are within the parameters of bathing, thus being suitable for primary recreation. The physical-chemical analyzes were carried out "in loco" on the banks of the Grajaú river, in the summer and winter phases, at points P1, P2 and P3, as illustrated in Tables 3 and 4.

Table 3: Mean of the physicochemical parameters of the three points of the Grajaú river in the winter stage.

PARAMETERS	LIMITING	PRAINHA	CANECÃO	LIMOEIRO
Color	15	3 uH	3 uH	3 Uh
Chloride	250	200 mg.L ⁻¹	200 mg.L ⁻¹	200 mg.L ⁻¹
Total hardness	500	300 mg.L ⁻¹	300 mg.L ⁻¹	300 mg.L ⁻¹
Alkalinity	**	370 mg.L ⁻¹	200 mg.L ⁻¹	200 mg.L ⁻¹
pH	6 A 9,5	7,5	8	7,5

*uH - Hazen unit. Source: Authors (2022).

Table 4: Mean of the physicochemical parameters of the three points of the Grajaú river in the summer stage.

PARAMETERS	LIMITING	PRAINHA	CANECÃO	LIMOEIRO
Color	15	3 uH	3 uH	3 uH
Chloride	250	104 mg.L ⁻¹	140 mg.L ⁻¹	84 mg.L ⁻¹
Total hardness	500	200 mg.L ⁻¹	200 mg.L ⁻¹	200 mg.L ⁻¹
Alkalinity	**	200 mg.L ⁻¹	460 mg.L ⁻¹	400 mg.L ⁻¹
Ph	6 A 9,5	8	8	8

*uH - Hazen unit. Source: Authors (2022).

Color is a very important parameter for the detection of contamination in rivers, as it allows the verification of materials suspended in the water. It also provides important preliminary indications for the characterization of the physicochemical quality (Souza, 2000). In the two stages (Summer and Winter) at points P1, P2 and P3, the result found was close to 3 uH (Hazen unit), which allows us to affirm that the color of the water is within the references required by CONAMA 357/05. In the chemical parameter total alkalinity, expressed in mg.L⁻¹ of calcium carbonate (CaCO₃), none of the six collection points in the Grajaú river presented values above 500 mg.L⁻¹ of CaCO₃, remaining in the range of 93.3 to 190 mg.L⁻¹ of CaCO₃ (Sousa, 2016).

As for the alkalinity test, the samples at points P1, P2 and P3 in the two stages, allowed to reach an average of 400 mg.L⁻¹ CaCO₃ which allows to say that the water is within the standard of the resolution of CONAMA 274/00. Water hardness is classified as: soft or mild (<50 mg.L⁻¹ of CaCO₃); moderate hardness (50 mg.L⁻¹ to 150 mg.L⁻¹ of CaCO₃); hard (150 mg.L⁻¹ to 300 mg.L⁻¹ of CaCO₃); and very hard (> 300 mg.L⁻¹ of CaCO₃) (Brasil, 2006). Grajaú is a city with a soil rich in minerals such as gypsum, and the exploitation of this mineral has contributed to the increase in the increase of calcium carbonate in the river. According to resolution n° 356 of the Ministry of the Environment, water is considered hard up to 300 mg.L⁻¹ of CaCO₃.

In the analysis at points P1, P2 and P3, the average was 300 mg.L⁻¹ CaCO₃, which allows us to conclude that the water of the Grajaú river is hard. It is recommended that the pH of the water in the distribution system is between 6.0 and 9.5. In all analyzed samples, the pH was between the levels recommended by Brazilian legislation, which will not cause any harmful effect on the health of consumers (Brasil, 2011). (Sousa, 2016) The pH in the three samples did not change, it remained at 8.0 in the three points, in view of this, these parameters are in accordance with the references of CONAMA n° 274/00. The waters of the Grajaú river are collectors of untreated domestic sewage and solid waste, which were found in large quantities, mainly in Balneário Canecão. The creation of spas on the banks of the river has caused serious impacts on the life of the river, causing silting, pollution, removal of riparian vegetation, among other interferences that modify the landscape and alter the quality of the water.

4. Final Considerations

The Grajaú River is one of the essential natural resources for the Grajaúenses, as it has the practice of fishing, one of the main sources of income for many families in the municipality, in addition to being used to supply drinking water to a large part of the population of the city and as tourist spot historic. Through this study it was possible to observe that the river waters, based on the indicator, are within the accepted standards for bathing (primary contact recreation). It is necessary to analyze the dimension of the impacts that the economic activities carried out on the banks of the river have caused, in view of the importance of preserving this natural resource.

The evidence collected and discussed in this work demonstrates that the visual pollution of the area is a reality that results from the absence of environmental education programs with visitors and residents who frequent the analyzed areas of the Grajaú da Prainha (P1), Canecão (P2) and Porto rivers. Lemon tree (P3), places for visitors to circulate. This observed pollution is characterized as punctual and can be reversed with corrective and preventive measures.

It is also important to highlight that through this study it was possible to conclude that it is increasingly necessary to monitor the public power facing the Grajaú River, considering that it can be observed that leisure spots are highly sought after by the city's population from grajaú. Therefore, care should be taken with the bathing areas of this natural resource, because in addition to the river having economic importance as a means of subsistence, it could also be explored as a means of leisure and tourism for the municipality in a conscious way.

Thus, annual studies of the physical-chemical properties of the waters of the Grajaú river in bathing places are essential to assess the quality of water in recreational activities in the municipality. In which, charges in the public sector for the maintenance of treatment and care for these areas must be of paramount importance.

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