EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Análise ambiental do rio Tracunhaém atrelada ao ensino de Geografia

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RESUMO
Esta pesquisa teve como objetivo realizar a análise ambiental do Rio Tracunhaém no município de Bom Jardim- PE buscando reafirmar a importância das águas para os ecossistemas terrestres e usos para os seres humanos atrelado ao Ensino de Geografia. Para isso, foi realizado um levantamento bibliográfico, com o qual foi possível caracterizar a bacia hidrográfica da área de estudo e argumentar sobre a importância do tema nas aulas de Geografia. Um trecho da área banhada pelo rio foi escolhido e realizadas fotografias com o intuito de expor os impactos ambientais negativos. Com base nessas imagens, foi construído, um mapa temático para os estudantes do ensino médio, numa escola do município. Foi possível constatar a vulnerabilidade do Rio Tracunhaém e analisar a sua biodiversidade. Com a aplicação da atividade pedagógica, foi possível promover a educação ambiental, contribuindo para a construção do pensamento crítico, fortalecendo o Ensino de Geografia.

PALAVRAS-CHAVE: Educação Ambiental. Impactos ambientais. Interdisciplinaridade. Monitoramento Ambiental.

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Environmental analysis of the Tracunhaém river linked to the Geography Education

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ABSTRACT
This research aimed to conduct an environmental analysis of the Tracunhaém River in the municipality of Bom Jardim, PE, with the goal of reinforcing the significance of water for terrestrial ecosystems and its relevance to human activities, particularly within the context of Geography Education. A comprehensive literature review was carried out to characterize the hydrographic basin of the study area and emphasize the importance of this subject in Geography classes. A specific section bathed by the river was selected capturing negative environmental impacts through photography. Utilizing these visual records, a thematic map was developed for high school students at a local school. The investigation unveiled the vulnerability of the Tracunhaém River ecosystem and facilitated an in-depth analysis of its biodiversity. Through the implementation of a pedagogical exercise, environmental education was effectively advanced, fostering the cultivation of critical thinking and the enhancement of Geography Education.

KEYWORDS: Environmental education. Environmental impacts. Environmental monitoring. Interdisciplinarity.

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Análisis Ambiental del Río Tracunhaém Vinculado a La Enseñanza ae La Geografía

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RESUMEN
Esta investigación se dedica en un análisis ambiental del Río Tracunhaém en el municipio de Bom Jardim- PE y busca reafirmar la importancia del agua para los ecosistemas terrestres y sus usos para los seres humanos junto a la enseñanza de la geografía. Para eso, se realizó un levantamiento bibliográfico, con el cual se logró medir la importancia del agua para la vida terrestre, caracterizar la vasija hidrográfica del área de estudio y argumentar acerca de la importancia del tema en las clases de geografía. Para el desarrollo de la investigación se delimitó una área bañada por el río, donde se tomaron fotografías de varias partes con el fin de exponer los impactos ambientales negativos en estas áreas. A partir de estas imágenes se construyó un mapa temático a estudiantes de la secundaria de uma escuela del municipio. De esta manera, fue posible verificar la vulnerabilidad del Río Tracunhaém y analizar su biodiversidad. Con la aplicación de la actividad pedagógica se logró promover la educación ambiental, contribuyendo para la construcción del pensamiento crítico, fortaleciendo la enseñanza de la geografia.

PALABRAS CLAVE: Educación ambiental. Impactos ambientales. Interdisciplinariedad. Vigilancia ambiental.

Introduction

The importance of water for the survival of ecosystems and societies is undeniable. However, demographic explosion combined with technological advancement has enabled the intensive use of this resource, thereby increasing pressure on it and intensifying its degradation.

In this regard, Martins et al. (2016) state that "in recent years, the unplanned exploitation of its multiple uses has devalued this resource, leading to disputes and conflicts in regions that, until recently, had a relative abundance of water." Many of these unsustainable uses result from a lack of information and environmental awareness, or from negligence and disregard for environmental legislation.

As a consequence of these actions, not only the quality but also the very existence of water resources is at risk. In 2022, a study published in an international journal revealed alarming results regarding the high levels of pollution in rivers across all continents (UOL, 2022). Furthermore, many of these human-induced actions contribute to the increase in global temperatures, which in turn alters rainfall patterns, affecting water availability and causing increasingly frequent extreme weather events such as heatwaves, storms, hurricanes, and droughts. With reduced water volume, there is a significant increase in pollutant concentrations (Ecodebate, 2022).

Given this scenario, conducting research and analysis to assess the current conditions of various watercourses becomes exponentially important. These efforts should aim to diagnose impacts and propose necessary interventions to mitigate or solve the problems identified. Moreover, it is crucial to expand such research and disseminate the information to educational institutions and the general public, since much environmental damage results from the lack of environmental awareness among local residents (Albuquerque & Ribeiro, 2018).

In light of the above, the objective of this study was to conduct an environmental analysis of the Tracunhaém River in the municipality of Bom Jardim, Pernambuco, seeking to reaffirm the importance of water for terrestrial ecosystems and its uses for human life, in connection with the teaching of Geography.

In this context, the research emphasizes the importance of water, discusses the negative environmental impacts on Brazilian rivers caused by anthropogenic activities, presents aspects of water resource management in Brazil and the characteristics of the watershed in the study area. Additionally, it contributes to the teaching of Hydrogeography in schools by analyzing the

environmental impacts occurring in the Tracunhaém River, particularly in the urban area of the municipality of Bom Jardim-PE.

Moreover, recognizing that the teaching of water-related topics especially within the discipline of Geography is essential for building environmental awareness, this research expanded the debate by bringing it into the classroom. An educational activity was developed and implemented during Geography classes with first-year high school students at a state school in the municipality of Bom Jardim, with the aim of enhancing environmental awareness within the school community.

The Importance of Water

The existence of water is one of the most essential elements for life on the planet. In fact, the emergence of the first life forms is directly linked to water, which is present in the composition of all living beings. This natural resource, in association with other factors, enables the development of life in all its forms, from the smallest to the most complex. Moreover, the water cycle is fundamental for maintaining Earth's climate stability (Magossi; Bonacella, 2013).

Approximately 70% of the Earth's surface is covered by water. However, of all the water on the planet, 97.5% is found in seas and oceans. Of the remaining 2.5%, 68.9% is contained in glaciers and polar ice caps, 29.9% is underground, 0.9% is in other reserves such as the atmosphere and wetlands, and only 0.3% is found in rivers and lakes. Although the total volume of freshwater available is sufficient for human survival, its uneven distribution across continents results in a large portion of the global population still suffering from water scarcity (Cassarin & Santos, 2011).

According to Pena (2022), Brazil holds 12% of the world’s available freshwater. In addition, Brazil (2022) states that freshwater resources are distributed according to the national hydrographic division established by the National Water Resources Council (CNRH), which defines 12 hydrographic regions with similar characteristics.

In this context, rivers play a fundamental role in the survival of both ecosystems and human society, as they flow through continental lands providing one of the essential resources for life (Ono, 2022). This statement is reinforced when we consider the importance of river systems in various societies around the world for example, the Nile River in Africa, which brings fertility to the desert soils of the Sahara through its annual floods, making agriculture possible and supplying water to plants, animals, and people(Macedo, 2019).

The Ganges River, located on the Asian continent, supplies hundreds of millions of people and serves multiple purposes, including religious rituals, for example (Matias, 2022). The Colorado

River, in North America, is considered one of the most heavily exploited rivers in the world, with nearly 90% of its water diverted to irrigate more than two million hectares (Souza, 2018). In Brazil, the São Francisco River is regarded as one of the most important rivers in the country, sustaining riverside communities that depend entirely on this watercourse for their survival (Castro & Santana, 2016). Moreover, this river is responsible for bringing water to semi-arid areas in the Northeast, which suffer from severe water scarcity (Brito; Silva, 2008).

Environmental Impacts on Brazilian Rivers

It is a fact that rivers have been essential to the survival and development of civilizations throughout history. However, as societies developed, environmental impacts on rivers increased significantly. Along with population growth came the intensified multiple uses of rivers, which accelerated the deforestation of riparian forests, the invasion of floodplain areas, and the increase in the volume of effluents discharged into rivers. As a result, water quality has been severely compromised (Baptista; Cardoso, 2013).

According to Instituto Prominas (2017, p. 5), "Environmental impact is the consequence of a natural or anthropic action or activity that causes abrupt changes to the entire environment or to some of its components." These anthropic actions can result in both positive and/or negative impacts on nature. Agricultural activities, housing construction, and waste production, for instance, lead to various negative impacts such as the extinction of fauna and flora species, pollution, and water scarcity, among others (Santos, 2022).

Therefore, it is necessary to analyze the excessive exploitation to which water resources are subjected, as such use often leads to situations of water stress and environmental degradation (Cassarin & Santos, 2011). Law No. 6,938 of August 31, 1981, which established the National Environmental Policy, defines in Article 3, item II, the degradation of environmental quality as "the adverse alteration of the characteristics of the environment."

Conexo Sanches (2008, as cited in Scalco & Ferreira, 2013, p. 2) points out that:

> With regard to impact studies, it is necessary to understand how human actions can affect natural processes. Through prior studies and the characterization of already existing impacts, it is possible to identify the causes and effects of an impacting event, thus allowing for interventions aimed at mitigating these impact.

In this context, there are various human activities that directly and negatively affect the dynamics of Brazilian rivers, such as the disposal of waste and effluents, the use of agrochemicals,

deforestation of riparian vegetation, alteration of watercourses, mining, dam construction, excessive water use, among others.

Waste is understood as any material, regardless of its nature, that is discarded as a result of domestic, social, or industrial human activity. It refers to everything that is thrown away because it no longer holds value for its owner (Yoshitake, 2012, as cited in Hempe & Noguera, 2010, p. 5). According to Montensanti (2022), "effluents are liquid discharges resulting from human and industrial activities."

Regarding the dumping of waste into valley bottoms, streets, and rivers, Belline and Mucelin (2008) explain that: *"These habitual practices can lead to, among other things, the contamination of water bodies, sedimentation, flooding, and the proliferation of disease-carrying vectors."* As a case in point, an analysis was conducted in the urban area of the Itapecuru River, in the state of Maranhão, where, according to Pereira et al., it was found that(2020, p. 60):

> With regard to the disposal of solid waste, it was observed that during the rainy season (flood period), due to the increased flow velocity in the lotic environment, the river carries and disperses a wide variety of waste most notably plastic materials, with a predominance of plastic bags and wrappers. These are either retained along the riverbanks or deposited within the river channel, contributing to the sedimentation process, which was also observed at the site.

Effluents from households and industries, when discharged into water bodies without prior treatment, cause imbalances in aquatic ecosystems (Jesus, 2017). Among the main consequences of domestic sewage discharge into these environments is an increase in the number of decomposing organisms and, consequently, a reduction in the amount of dissolved oxygen in the water—a fact observed in the study of the Camandoica River in São Paulo (Alberto & Filho, 2012). Furthermore, the disposal of industrial waste can lead to changes in the natural color of the water, the formation of foam, a decrease in oxygen levels, and the death of aquatic animals. In the Capibaribe River, along the stretch that crosses the municipality of Toritama-PE, water analyses conducted during both dry and rainy seasons revealed the presence of chemical contaminants from local textile industries (Oliveira, 2007).

In agricultural and livestock-raising areas, pesticide residues reach water bodies along with sediments and rainwater. In this process, heavy metals and nutrients such as phosphorus and nitrogen are carried into aquatic environments. Although these nutrients are essential for the functioning of

aquatic biota, when present in excess they increase water turbidity, cause water pollution, and contribute to the eutrophication of aquatic ecosystems (Mathiesen, 2017). Water pollution occurs when the original characteristics of water are altered. Eutrophication is a phenomenon in which an excessive amount of organic compounds leads to the overgrowth of autotrophic organisms such as algae and pathogenic microorganisms, resulting in decreased oxygen levels in the aquatic environment and a deterioration of water quality (Magossi & Bonacella, 2013).

Additionally, in polluted aquatic environments, pollutants accumulate in sediments, animals, and plants throughout the entire food chain, leading to a process known as bioaccumulation. Since some species are more sensitive to this phenomenon, they are often used in research as bioindicators to quantify pollutant levels in a given environment. An example is a study conducted in the reservoir of the Itaipu Binational Hydroelectric Plant, in which the golden mussel species was used to assess aquatic conditions (Marengoni, 2013).

Moreover, the abnormal concentration of nutrients such as phosphorus and nitrogen in water bodies promotes the excessive growth of algae and aquatic plants, causing ecological imbalances. In many cases, the uncontrolled spread of aquatic plants covers the entire water surface, obstructing sunlight penetration (Santos, 2015). According to Silva, Mello, and Almeida (2019), rivers polluted with high levels of organic matter have direct and indirect consequences for public health and also affect beach water quality.

Another human activity that directly affects watercourses is the removal of riparian vegetation, which, according to Filho (1994) (apud Bruno, 2014, p. 8)

> These are forest-type vegetation formations associated with water bodies, along which they may extend for dozens of meters from the riverbanks and exhibit significant variations in floristic composition, depending on the interactions established between the aquatic ecosystem and its surroundings.

In this regard, Castro, Mello, and Poester (2012, p. 7) state that:

> Riparian forests are important because they perform a set of ecological functions that are extremely relevant to quality of life, especially for local human populations and the river basin. They are essential for conserving the diversity of native animal and plant species, both terrestrial and aquatic. Riparian forests influence water quality, regulate the hydrological regime, stabilize riverbanks, reduce riverbed sedimentation, and are themselves influenced by flooding, nutrient input, and the aquatic ecosystems they border.

Furthermore, Lima (2010) explains that these riparian forests are capable of retaining and filtering the water that flows into the river channel, preventing sediments, toxic substances, and nutrients such as phosphorus and nitrogen from reaching the river. As a result, riverbanks are stabilized by the roots that protect the slopes, and together with the leaf litter, they enhance the soil's infiltration capacity and reduce riverbed sedimentation. Additionally, they have a positive influence on atmospheric humidity.

However, according to Oliveira et al. (2022, p.168)

> These forests have been subjected to ongoing devastation over the years, as irrational land use has caused negative environmental impacts, leading to deforestation and serious environmental problems such as the extinction of fauna and flora species, local climate change, soil erosion, and the sedimentation of riverbeds and their tributaries.

In this regard, Martins (2007, as cited in Bruno, 2014, p. 14) adds that:

> The main causes of riparian forest degradation are deforestation for the expansion of agricultural areas on rural properties; urban expansion; logging; natural or human-induced fires; sand extraction from rivers; poorly planned tourism ventures, among other.

As a case study, a research project was conducted on the Jacarecica River in Maceió, Alagoas, where areas of the river with and without riparian vegetation were monitored, analyzed, and compared. The study found that most of the riparian areas had been removed and replaced by housing developments. These residences, located in environmentally sensitive zones, are exposed to the river's polluted water and also discharge sewage directly into the riverbed, further degrading water quality. Additionally, the study revealed that the stretches of the river where riparian vegetation was still present showed smaller temperature variations between dry and rainy periods. In terms of water turbidity, the sections with vegetation exhibited more consistent and stable data (Souza, 2012).

In addition to riparian forests, environmental damage in spring areas is also a major concern. "A spring is understood as the emergence of the water table that gives rise to a water source (reservoir) or watercourses (streams, creeks, and rivers)" (Silva, 2015). In other words, springs are essential for supplying rivers with water. According to the same author, in addition to deforestation and contamination, many people living near these areas or engaging in activities nearby lack awareness about the importance of preserving natural resources.

In this regard, Gomes, Melo, and Vale (2006, p. 102) state that: "*The spring system must be preserved and is composed of the vegetation, soil, rocks, and topography of the adjacent and upstream areas surrounding the springs*."

Teaching Hydrogeography

Hydrogeography can be defined as a scientific branch of Geography that conducts research on surface and groundwater. It is responsible for analyzing aspects related to the morphology of watersheds, river channels, and the factors that may alter water dynamics, such as the various uses of water throughout a basin (Lopes, 2018).

Rivers are extremely important to society; however, they are under significant pressure due to human activities. In this context, Geography education can play a key role in educating and raising students' awareness through Hydrogeography-related topics, such as water resource management, water usage, wastefulness, the discharge of effluents into waterways, among other issues that are part of everyday lif (Oliveira, et al, 2019).

In this context, Fogaça (2017, p. 29) argues that

> The environmental degradation we observe today is the result of the model of nature exploitation implemented over the past centuries. What remains are the consequences of growth achieved at the expense of the belief in infinite resources and the ongoing effort to develop techniques and technologies capable of reversing this damage and minimizing the future exploitation of natural resources.

In this regard, according Brasil (1998, p. 46)

> The analysis of environmental problems involves political, historical, economic, ecological, and geographical issues—in short, it involves a variety of processes. Therefore, it is not possible to understand and explain them through the lens of a single science. However, since the object of study in Geography concerns the interactions between society and nature, a broad range of environmental topics necessarily falls within its scope.

Moreover, according to Gomes and Filho (2018, p.2-3)

> Therefore, it is evident that Hydrogeography lessons are of utmost importance for shaping citizens who are aware of water resources and their significance. They also contribute to the understanding of the role of activities such as basic sanitation for both life and the environment. The result is a student who is committed to water resources and to the well-being of society.

An analysis of the Base Nacional Comum Curricular (BNCC) shows that topics related to river waters appear in elementary education as specific learning objectives for the 2nd, 3rd, 4th, 5th, 6th, and 8th grades. In the 2nd grade, it is addressed in the following competency: (EF02GE11) Recognize the importance of soil and water for life by identifying their different uses (such as agriculture and material extraction, among other possibilities) and the impacts of these uses on daily life in both urban and rural settings."

In the 3rd grade, it appears in the following competencies:

> (EF03GE09) *Investigate the uses of natural resources, with emphasis on water use in daily activities (such as food preparation, hygiene, plant cultivation, etc.), and discuss the environmental problems caused by these uses.* (EF03GE10) *Identify the necessary precautions for using water in agriculture and energy generation in order to ensure the continued supply of potable wate*.

For the 4th grade, it appears in: (EF04GE11) *Identify the characteristics of natural and human-made landscapes (relief, vegetation cover, rivers, etc.) in the local environment, as well as human actions in the conservation or degradation of these areas.* For the 5th grade, in: (EF05GE10) *Recognize and compare attributes of environmental quality and some forms of watercourse and ocean pollution (such as sewage, industrial effluents, oil spills, etc*.)."

For the 6th grade, it appears in:

> (EF06GE04) Describe the water cycle by comparing surface runoff in urban and rural environments, recognizing the main components of basin and hydrographic network morphology and their role in shaping the Earth's surface and vegetation cover.

Finally, in the 8th grade,

> (EF08GE15) Analyze the importance of the main water resources in Latin America (such as the Guarani Aquifer, the Río de la Plata, Amazon, and Orinoco basins, and cloud systems in the Amazon and Andes, among others) and discuss the challenges related to water management and commercialization.

With regard to high school education in the state of Pernambuco, the *Formação Geral Básica* (FGB – General Basic Education) document is used to guide the sequencing of content from the 1st to the 3rd year. Topics related to watercourses are addressed in the 1st year under Specific Competency 3:

> Critically analyze and assess the relationships between different groups, peoples, and societies and nature (production, distribution, and consumption), as well as their economic and socio-environmental impacts, with a view to proposing alternatives

> that promote awareness, socio-environmental ethics, and responsible consumption at the local, regional, national, and global levels.
>
> .

Through the knowledge object:

> Planet Earth: formation and evolution of the Earth; internal structure of the Earth; continental and oceanic relief; soil formation; atmosphere: weather and climate; biomes and vegetation formations; groundwater and river basins.

Thus, it becomes evident that Hydrogeography-related topics can be addressed at various stages of schooling, thereby fostering effective content delivery.

In addition, at the high school level, Hydrogeography lessons should prioritize understanding the multiple uses of water resources and the impacts caused by their inappropriate use. This should take into account students' lived experiences and perceptions of the subject, in such a way that this approach focused on understanding geographic space at different scales contributes to the formation of critically engaged citizens (Gomes; Filho, 2018).

In line with this perspective, Cavalcanti (2008, p. 43, as cited in Meneghesso & Lastória, 2016, p. 389) states that:

> For students to understand the spaces of their daily lives which have become extremely complex it is necessary that they learn to look simultaneously at the broader and global context to which they belong, and at the elements that characterize and distinguish their local context. I believe that, in order to achieve the objectives of this education, it is essential to consider the local the student's own place but with the aim of enabling them to build a broader frame of reference that allows for more critical analysis of that realit.

In this context, the issue of water is addressed within environmental education, due to growing concerns about human activities that negatively impact natural resources especially water, such as the discharge of effluents, which results in a series of environmental and public health problems. In this situation, the role of schools and educators is emphasized in the systematization and dissemination of knowledge related to environmental issues (Mattos, 2009).

Thus, when environmental education is developed across all levels of education, it enables the articulation of educational environmental practices that raise students' awareness and encourage the adoption of more sustainable habits in harmony with the natural environment. This awareness process, in turn, is not limited to the school setting it can extend to the neighborhoods where students

and staff live, thereby contributing to the conservation of natural resources (Effting, 2007). In other words, these actions go beyond the boundaries of formal and non-formal education, integrating the school with the community (Alcântara; Silva; Nishijima, 2012).

Methodological Procedures

Study Area

The study area focuses on the Tracunhaém River, specifically the section that flows through the urban area of the municipality of Bom Jardim, located in the microregion of Northern Agreste in the state of Pernambuco. This watercourse is part of the Goiana River Basin, situated in the northeastern portion of the state of Pernambuco.

The Goiana River Basin covers an area of 2,847.53 km², which corresponds to 2.90% of the total area of the state of Pernambuco. Its main rivers are the Capibaribe-Mirim, the Siriji, the Tracunhaém, and the Goiana. The Tracunhaém River originates in Umburetama, a district of the municipality of Orobó-PE, and extends for approximately 127 kilometers. Its main tributaries on the left bank are the Orobó River, Pajé Stream, Ribeiro River, Paissandu Stream, and the Acaú River. On the right bank, it receives waters from the Gabioé Stream, Itapinassu River, and Caraú River. The Tracunhaém sub-basin drains the waters of the municipalities of Orobó, Bom Jardim, João Alfredo, Limoeiro, Lagoa do Carro, Buenos Aires, Carpina, Tracunhaém, Nazaré da Mata, Araçoiaba, Itaquitinga, Igarassu, Condado, and Goiana.

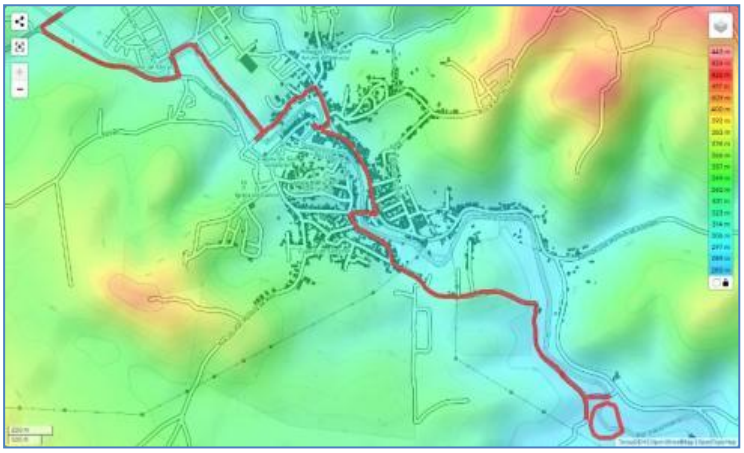
The municipality of Bom Jardim is located in the Northern Agreste Mesoregion and the Médio Capibaribe Microregion of the state of Pernambuco. It lies on the Borborema Plateau, at an average altitude of 333 meters, and is characterized by a landscape of deeply incised and narrow valleys, shallow to moderately deep soils with natural fertility, and numerous rocky outcrops (Beltrão et al., 2005).

According to data from the Climate Data Organization (2021), the climate is tropical and classified as Aw under the Köppen system. The average temperature is 24.1°C, and the average annual rainfall is 652 mm, with the wettest months being March, April, May, June, and July. The region encompasses both the Atlantic Forest and Caatinga biomes.

Development of Didactic Material

The first stage in the development of the didactic material consisted of field research. During this phase, a route was taken along the banks of the Tracunhaém River, and images were captured using a mobile phone camera. The route covered approximately 4.080 km (Figure 1).

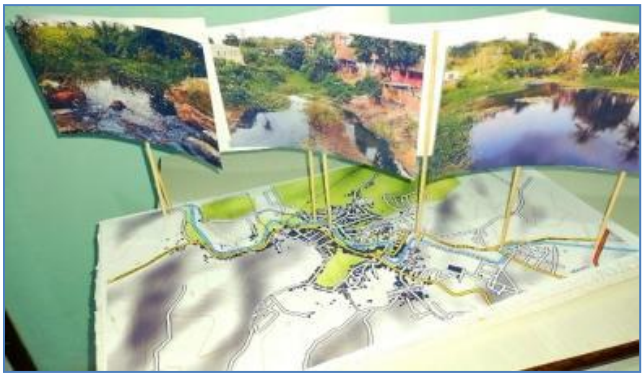
Figure 1: Route covered along the banks of the Tracunhaém River, municipality of Bom Jardim-PE



Source: Topographic map, 2023.

In the second stage, the observation and analysis of the environmental impacts on the river, as identified during the field research, were carried out with the support of photographs and theoretical references. In the third stage, a thematic map was created (*Figure 2*), using Styrofoam as a fixed base, an altimetric image of the municipality, and photographs of strategically selected points along the river.

Figure 2: Thematic Map



Source: The authors, 2023

It is important to note that the use of thematic cartography in Geography classes in basic education is essential for the construction of geographic knowledge, especially because thematic representations allow for the visualization and localization of geographic phenomena, thereby enhancing the development of geographic reasoning (Castro, Soares, & Quaresma, 2015).

Furthermore, the inclusion of photographs in Geography classes serves as a didactic resource capable of helping students develop their abilities to read and interpret geographic space, resulting in positive outcomes for learning. With just one click, a photograph becomes an object of study, allowing students to visualize concepts materialized in the landscape (Mussoi & Santos, 2008).

In the fourth stage, a worksheet with four reflection questions was created for the students. The four questions developed were:

1º) In your opinion, what can be done to solve or minimize the environmental problems affecting the Tracunhaém River?

2º) In your daily life, how can you help the river?

3º) Had you noticed these problems in the river before? If so, when?

4º) Do you live near the banks of the Tracunhaém River?

In this way, the proposed questions take into account students' environmental perceptions as an important factor for the development of environmental education in schools (Castoldi; Bernardi; Polinarski, 2009).

In the fifth stage, the activity was implemented with the presentation of the thematic map during Geography classes for 1st-year high school students at a school located in the city. Finally, the results obtained through the implementation of the pedagogical activity were presented and discussed.

It is important to highlight that the activity was carried out in alignment with the school's Environment Week, with the agreement of the school's coordination team.

Results and Discussion

Environmental Analysis of the Tracunhaém River

During the field research, several sections of the river were observed where environmental damage was clearly visible. In most of the urban area, the absence of riparian vegetation was evident, with this vegetation having been replaced by the construction of houses, businesses, and even public squares. *Figure 3* presents a photo mosaic of the research area.

Figure 3: Images of the research area

Source: The authors, 2023

An analysis of *Figure 3* reveals the absence of riparian vegetation and the occupation of riverbanks; construction in Permanent Preservation Areas (PPAs); sewage being discharged directly into the watercourse; sedimentation; livestock raised within the riverbed; and, in several sections, the river water shows high turbidity and a foul odor. In certain areas, a large amount of aquatic vegetation covers the entire water surface, which may be directly related to the excessive accumulation of nutrients in the water due to pollution. Waste is another recurring issue observed in most sections, with numerous plastic materials such as bags, packaging, and PET bottles, as well as tires and household objects. The various negative impacts on the river presented here clearly indicate that the studied watercourse is facing significant environmental degradation.

Pedagogical Practice

The pedagogical activity was carried out with first-year high school classes, following planned stages aimed at engaging students and fostering critical reflection on water pollution. Initially, an introduction and discussion were held on the topic of water resource pollution, with a specific focus on the situation of the Tracunhaém River in the municipality. The thematic map developed for the

project was used to illustrate the problem and facilitate a visual understanding of the observed environmental impacts.

Next, a questionnaire with four reflective questions was distributed, encouraging students to consider what could be done to solve or minimize the environmental problems affecting the river. During the discussion, many students expressed concern about the accumulation of waste, water pollution, and the lack of vegetation along the riverbanks, sharing their own experiences and suggesting possible solutions.

The analysis of the photographs displayed on the thematic map provided an opportunity for students to develop skills in reading and interpreting landscapes and geographic locations. By observing the images, they identified issues such as deforestation, the construction of housing in Permanent Preservation Areas, and the high turbidity of the water, discussing visible differences in the river's condition between urban and rural areas.

Finally, the students answered the questionnaire, and their responses were analyzed collectively. The suggestions for addressing the river's environmental issues reflected a growing sense of critical awareness and an understanding of the impacts of human actions on the environment. The activity, in the end, not only reinforced the content discussed in class but also allowed students to connect theoretical knowledge with real-world observations, strengthening critical thinking and environmental education.

These responses demonstrate that students have a critical perspective regarding the river's environmental situation and are capable of reflecting on and proposing alternatives for the resolution or mitigation of environmental problems. Moreover, some students specifically mentioned the need to address waste disposal as a way to solve the river's environmental impacts, indicating an awareness of the harm caused by such waste and its connection to environmental degradation.

Moreover, the fact that students mentioned several mitigation alternatives reveals their understanding that the various negative environmental impacts are not caused by waste alone, demonstrating their awareness that multiple human actions result in damage to ecosystems.

From this perspective, Castoldi, Bernardi, and Polinarski (2009) argue that human behavior stems from individuals' perceptions of the world, with each person reacting according to their conceptions and relationship with the environment, based on prior representations developed throughout their lives.

In response to the second question regarding everyday actions that can help minimize the damage caused to the river students mentioned not discarding waste and other residues in the

Tracunhaém River or in the streets, removing trash from the river channel, and creating awareness campaigns to alert the population about the mistreatment of the river.

Thus, the actions proposed by the students reveal that they are able to recognize how their daily behaviors influence the environmental health of the river. Once again, proper disposal of solid waste was the most frequently mentioned solution to address environmental damage. Regarding the perception of waste, Oliveira (2006) suggests that the environmental perception of urban waste does not involve all of our sensory organs. The perception of waste is not auditory, gustatory, or tactile urban waste is primarily a visual and olfactory problem. Most of the time, we do not see the waste, but we can smell its stench from a distance.

In response to the third question, students reported that they had already observed the large amount of waste whenever they passed by the river. This indicates that the river's environmental issues are clearly perceptible to most students, who turned their attention to the river and noticed the environmental pressure being exerted on the watercourse.

It is worth emphasizing that environmental perception is essential for the development of critical awareness and a worldview processes that are closely linked to environmental education (Castoldi; Bernardi; Polinarski, 2009).

Through the fourth question, it was found that although only 1% of the students live near the river, this proximity did not limit their understanding of the environmental issues faced by the Tracunhaém River. Even students living farther away demonstrated a significant understanding of the challenges and environmental impacts, reflecting the effectiveness of the classroom discussions and activities in broadening critical awareness on the topic.

Final considerations

This research gathered significant information for addressing environmental problems that threaten the quality and availability of water resources in Brazil, particularly in the municipality of Bom Jardim–PE.

Based on the literature review, a wide range of anthropic activities were identified as causes of environmental degradation in Brazilian rivers. This underscores the importance of this study in understanding the scale of environmental damage and, therefore, in developing actions to solve, minimize, or compensate for such impacts on water resources, ensuring the conservation of ecosystems and the availability of water since this resource is essential for life on planet Earth.

In addition, the environmental analysis of the Tracunhaém River within the municipality shows that, like many other watercourses in Brazil, it is affected by a series of negative environmental impacts caused by human activities. This highlights the need for research that can identify environmental problems resulting from such impacts and develop actions that support efforts to mitigate them and conserve the river and its biodiversity.

In this regard, the pedagogical practice led the debate on the importance of water resources and the environmental vulnerability of the Tracunhaém River into the classroom. It expanded discussions to the students' own reality and, by considering each individual's environmental perception, promoted environmental education within the school environment. Moreover, it contributed to the construction of knowledge and critical thinking through the incorporation of teaching methodologies that strengthen the teaching of contemporary Geography.

Photographs were fundamentally important to the development of this research, as they enabled the identification of environmental impacts through the reading and interpretation of landscapes and geographic space. Furthermore, the use of these images in constructing the thematic map provided meaningful support for classroom discussion and helped students develop skills such as landscape reading and interpretation and the construction of geographic reasoning.

Based on this, it is possible to affirm that this study presented results that highlight the importance of further research on environmental analysis within Brazilian rivers and point to teaching methodologies capable of expanding the debate on this topic in school settings, supporting efforts to address environmental problems through environmental awareness in Geography classes.

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