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ANALYSIS OF THE BIOPHYSICAL-CHEMICAL PARAMETERS OF THE BENFICA RIVER IN THE MUNICIPALITY OF BENEVIDES, STATE OF PARÁ (BRAZIL) – 2025

ANÁLISE DOS PARÂMETROS BIOFÍSICO-QUÍMICOS DO RIO BENFICA NO MUNICÍPIO DE BENEVIDES, ESTADO DO PARÁ (BRASIL) - 2025

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ABSTRACT

Justification: The Benfica River and its hydrographic basin, in the Metropolitan Region of Belém, have suffered various anthropogenic impacts, necessitating monitoring research to assess the river's health and preserve water quality. **General objective:** the analysis of the biophysicochemical parameters of the Benfica River in the stretch of the Benfica district in the city of Benevides in the state of Pará – Brazil, from March to December 2025. **Specific objectives:** to identify biophysicochemical risks that may endanger human and environmental health; To predict potential impacts on human health from the degradation of limnological resources; to produce educational material with an emphasis on environmental chemistry; to develop diagnoses to support public policies; to encourage efficient and effective low-cost *in situ* environmental chemistry research; to identify risk agents for local environmental degradation. **Methodology:** exploratory-explanatory field research, quantitative-qualitative laboratory analysis using biophysicochemical parameters, carried out *in situ* in the Benfica River, in the stretch of the Benfica district, in the municipality of Benevides in the state of Pará, Brazil, in 2025. **Conclusion:** Urban development has drastically impacted the Benfica River, with many houses blocking its passage and view, and hindering its use by wildlife. Another factor is the intense use of motorised canoes and jet skis, as well as cooking oil, in some places where floating oil slicks can be observed on the river. This highlights the need for public policies focused on environmental education, efficient actions for the use and preservation of the Benfica River and its tributaries, and the urgent implementation of effective processes for removing oil slicks and monitoring and intervening in their sources. It should be noted that the trace element lead was identified in the collected samples, which needs to be traced to identify the source.

Keywords: Environmental chemistry; Biophysical-chemical analysis; Limnology; Benfica River - state of Pará (Brazil); City of Benevides - state of Pará (Brazil); Amazonian rivers.

RESUMO

Justificativa: O Rio Benfica e sua bacia hidrográfica, na Região Metropolitana de Belém, tem sofrido diversos impactos antrópicos, necessitando pesquisas de monitoramento para avaliar a saúde do rio e preservação da qualidade da água. **Objetivos:** geral, A análise dos parâmetros biofisioquímicos do Rio Benfica no trecho do distrito de Benfica na cidade de Benevides no estado do Pará – Brasil, no período de março a dezembro de 2025; objetivos específicos: identificar riscos biofisioquímicos que possam pôr em risco a saúde humana e ambiental; prognosticar possíveis impactos a saúde humana pela degradação dos recursos limnológicos; produzir material didático com ênfase a química ambiental; elaborar diagnóstico para fundamentar políticas públicas; incentivar pesquisas de química ambiental *in situ* com eficiência e eficácia a baixo custo; identificar agentes de riscos para degradação ambiental local. **Metodologia:** pesquisa exploratória-explicativa, quantiqualitativa laboratorial por parâmetros biofísico-químicos, realizada *in situ* no Rio Benfica, no trecho do distrito de Benfica, no município de Benevides no Estado do Pará no Brasil, em 2025. **Conclusão:** O desenvolvimento urbano tem impactado o rio Benfica drasticamente, onde muitas casas fecham a passagem e visão do rio, e o uso pela fauna. Outro fator é o intenso uso de canoas motorizadas e jet-ski, bem como, óleo de cozinha, em alguns pontos onde pode-se observar placas de óleos flutuantes sobre o rio, mostrando a necessidade de políticas públicas de educação ambiental de ações eficientes para o uso e preservação do Rio Benfica e seus tributários e, implantação urgente de processos

eficazes de remoção de placas de óleo e monitoração e intervenção em suas fontes. Cabe ressaltar que o elemento traço chumbo foi identificado nas amostras coletadas, sendo necessário rastreá-lo para identificar a sua origem.
Palavras-chave: Química ambiental; Análise físico-química; Limnologia; Rio Benfica - estado do Pará (Brasil); Cidade de Benevides - estado do Pará (Brasil); Rios da Amazônia.

1. INTRODUCTION

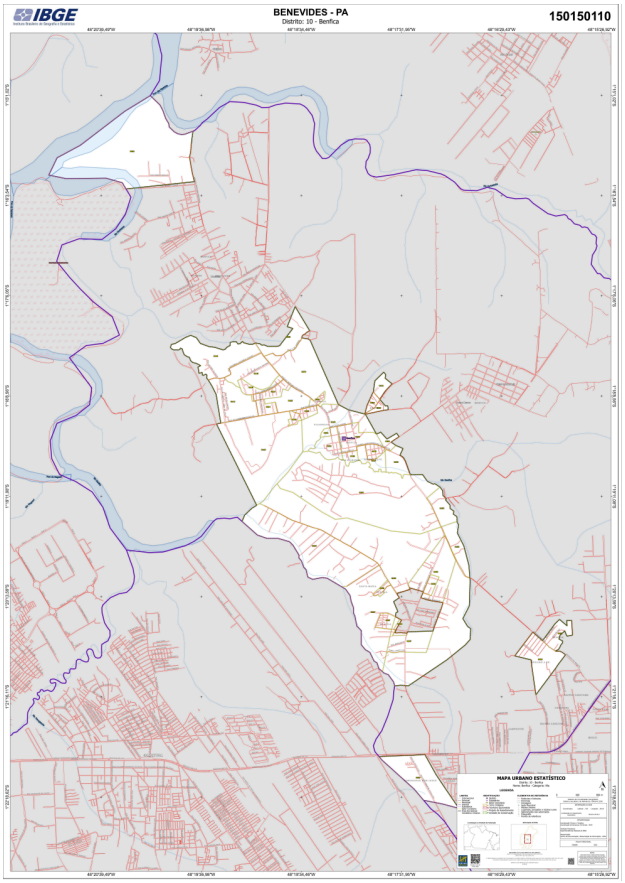
The municipality of Benevides belongs to the Metropolitan Region of Belém in the state of Pará (Brazil), and is considered part of the Northeast region of the state of Pará in Brazil, bordering the municipalities of Marituba to the South, Santa Barbara do Pará to the North, Santa Isabel do Pará to the West, and Ananindeua to the East. One of its districts is Benfica, which features the Benfica River as a prominent feature in its river basin.

Benfica River with high tide. Photo by Aureliano da S. Guedes, PhD

According to the Brazilian Institute of Geography and Statistics (2025), in the last population census carried out in 2022, the municipality of Benevides had a population of 63.567 people, with an estimate of 68.191 inhabitants for 2024. Showing that 17.4% of households have adequate sanitation, 38% of urban households are located on streets with trees, and 0.9% of urban households are located on streets with adequate urbanisation (presence of drainage, sidewalks, paving, and curbs)[1].

The climate of the municipality of Benevides, in the section of the Benfica district through which the river of the same name flows, is characterised as warm and humid tropical, with a period of lower rainfall between the months of June and December and higher rainfall from January to May. However, it is observed that there is rainfall in all months.

The Benfica River has several tributaries, most notably the Uriboca River in the municipality of Marituba, the Mocajuba River, and the Santo Amaro River, as well as numerous springs and streams. Its mouth is the Maguari River in the municipality of Ananindeua, which in turn flows into the Acará River in the district of Icoaraci in Belém, in the state of Pará (Brazil).



Benfica district - Benevides-PA – Instituto Brasileiro de Geografia e Estatística, 2022[2].

The Benfica river basin encompasses the municipalities of Belém, Marituba, and Benevides; however, the basin is mostly located within the municipality of Benevides, corresponding to 32.20% of the municipality's area. In the urban context, one of the most noticeable aspects in the Benfica River basin is the establishment of numerous industries along the BR 316 highway[3].

The parallel drainage pattern of the Benfica River basin is associated with its geological formation, consisting of Tertiary terrains of the Barreiras and Pós-Barreiras formations and current sediments resulting from erosion that occurred in the terrains of the Barreiras and Pós-Barreiras groups found along the river plains, low plateaus, and floodplains. The tableland (most prominently located on the eastern edge of the basin) and hills mark the steepest slopes and altimetric amplitudes (between 30 and 40 m)[4].

Benfica Riverside - Benfica district in the City of Benevides.

Source: Google Earth, 2025[5].

Aerial photo of Benfica. Photo by Aureliano da S. Guedes II.

The Benfica River and its hydrographic basin have suffered various anthropogenic impacts from constructions along its banks, siltation, lack of adequate sewage treatment, industrialisation, soil impermeability due to asphalt sheeting and soil cementation, small-scale agricultural production, deforestation, among others, requiring constant research to assess the river's health and preserve the quality of its water.

The chemical quality of water is measured by identifying the component in the water, using specific laboratory methods. Such chemical components must not be present in water above certain concentrations determined with assistance of epidemiological and toxicological studies. Tolerable limit concentrations mean that the

substance, if ingested by an individual with an average physical constitution, in a certain daily amount, during a certain period of life, added to the expected exposure of the same substance through other means (food, air, etc.), subjects this individual to an unacceptable risk of developing a resulting chronic illness. Two important groups of chemical substances, each with specific origins and effects on human health, are inorganic chemicals, such as heavy metals, and organic chemicals, such as solventes[6].

Biological contamination also results in serious environmental health problems, notably *Klebsiella*, *E. coli*, and *thermoresistant coliforms*, which, identified as total coliforms, can cause various waterborne diseases, including cholera, haemorrhagic colitis, diarrhoea, abdominal pain, severe gastroenteritis, hepatitis A, among others, and can even cause the patient's death[7].

Given this, the overall objective of this research was to conduct an analysis of the main biophysicochemical parameters of the Benfica River in the stretch within the Benfica district of the city of Benevides in the state of Pará – Brazil, during the year 2025; and the specific objectives were: To identify biophysicochemical risks that may endanger human and environmental health; to predict possible impacts on human health from the degradation of limnological resources; to produce teaching materials for subjects such as "Environmental Chemistry," "Environment," "Limnology," and others related, with an emphasis on environmental chemistry; to prepare a partial diagnosis of the river in question to support public policies; to encourage high-quality, efficient, and effective *in situ* environmental chemistry research at low cost; to identify risk agents for local environmental degradation.

2. METODOLOGIA

This is a quantitative-qualitative exploratory-explanatory laboratory field research, using biophysical-chemical parameters, carried out *in situ* in the Benfica River, in the stretch of the latitude 1°18'46.89"S and longitude 48°18'11.51"W that crosses the district of Benfica, municipality of Benevides, state of Pará, Brazil, from March to December 2025.

Benfica Riverside - Benfica district in the City of Benevides.

Source: Google Earth, 2025[5].

The pH was measured using a portable electronic pH meter and compared with test strips as a control. Electrical conductivity values were obtained using a portable electronic conductivity meter, expressed in $\mu S/cm^{-1}$ (micronSiemens per centimetre), which was also applied to the measurement of sample temperature and Total Dissolved Solids. A portable ambient thermometer was used to measure ambient temperature. All samples were subjected to 3 tests with multiparameter reagents *in situ*, to identify alkalinity and analyse possible presence of lead, bromine, nitrate, nitrite, iron, chromium (VI), copper, mercury, fluorine, among others. The Secchi disk was only used where the riverbed was not clearly visible; its purpose was to assess turbidity, visibility in centimetres, among other factors[7,8,9,10].

Microbiological analyses were performed using chromogenic culture tests for *Escherichia coli* and thermotolerant coliforms (formerly known as faecal coliforms), always employing both initial and confirmatory tests to ensure the quality of the results[7].

Observational research was conducted in the environment to identify the colour of the river water at the time of sample collection, as well as to identify the predominant flora and fauna observed and classified.

Several variables must be considered when collecting material for limnologic research, including: ambient temperature; odour; colour; transparency; turbidity; dissolved oxygen; chlorophyll; deep current; surface current; total suspended solids; total dissolved solids; current speed; wind speed, among others[7].

It is important to note that lotic systems, due to their flow and permanent interaction with their tributaries, their waters can present significant variables between the collection of one sample and another, given their transport capacity, decomposition of organic and inorganic matter, difference in water temperature by area and depth, among others[7,8,9,10].

3. RESULTS AND DISCUSSIONS

Benfica River					
Parameters	**Sample 1 27/03/2025**	**Sample 2 28/06/2025**	**Sample 3 30/09/2025**	**Sample 4 02/12/2025**	**Tolerability in recreational waters/Source**

Environmental visibility	Normal	Normal	Normal	Normal	-
Environment temperature C°	30,2	28,5	29,9	30,9	-
Wind	Absent	Absent	Absent	Absent	-
Ciliary forest	Yes	Yes	Yes	Yes	Varies depending on the type and width of the river
Tide	Low	Low	Low	High	-
Aquatic macrophyte presence	No	No	Yes	No	Must not present eutrophication
pH	6,2	6,0	6,0	<6,0	6-9
Temp C° - Sample	26.4	24,1	26,6	25,6	-
Secchi disk depth	74 cm	Not applicable	79 cm	69 cm	-

Colour	Brown	Brown	Brown	Brown	True colour: natural colour level of the water body in mg Pt/L – CONAMA[11]
Turbidity	Normal	Normal	Normal	Normal	**≤** 40 nephelometric turbidity units (NTU) – CONAMA[11]
Odour	Normal	Normal	Normal	Normal	Absent odour
Electrical conductivity- (mS/cm).	0.040	0,030	0,396	1,700	Depends on ions, geological aspects, pH and others
TDS (Total Dissolved Solids)	0.020	0,015	0,196	0,850	< 500 mg/litre – CONAMA[11]

Carbonate	0	0	0	0	Observe pH, presence of macrophytes and other factors.
Water Hardness	100	250	250	250	500mg/l Review
Lead	5	10	20	10	0,01mg/L – CONAMA[11]
Bromine	0	0	0	0	0,5mg/l (500 µg/l) WHO[12]
Nitrate	0	0	0	0	10,0 mg/L – CONAMA[11]
Nitrite	0	0	0	0	1,0 mg/L – CONAMA[11]
Iron	0	0	0	<5	0,3 mg/L – CONAMA[11]
Chromium (VI)	0	0	0	0	0,1 mg/l
Copper	0	0	0	0	0,009 mg/L – CONAMA[11]

Mercury	0	0	0	0	0,0002 mg/L – CONAMA[11]
Fluoride	0	0	0	0	1,4 mg/L – CONAMA[11]
Free Chrorine	0	0	0	0	
Total Alkalinity	0	0	0	0	
Escherichia coli	Yes	Yes	No	Yes	
Thermotolerant coliforms	Yes	Yes	Yes	Yes	

Based on determination for fresh water salinity ≥ 0.5 ‰ CONAMA [11]

The odour of the water qualitatively analysed in the samples, taking into account the presence of mangroves on the banks of the Benfica River, was considered normal. Environmental olfactory chemical reception did not show any concern at the time of the research.

The turbidity is important to check for suspended particles that, in excess, can hinder the passage of light, damaging phytoplankton, some types of important bacteria, photosynthesis of macrophytes, among others[7,8,9,10]. In Benfica River, at the sample collection site in different periods, it presented ≤ 40 nephelometric turbidity units (NTU), as normal, without harming photosynthesis and other important actions.

Secchi disc depth is a qualitative value because it depends on the observer's vision and the solar radiation in the probed environment, in addition to the influence of organic and inorganic materials that make up the water. In this research[9]. In the Benfica river, when possible, the use of the Secchi disk allowed visibility between 69 cm and 79 cm, always presenting the water colour brown, both in normal river visibility and in environmental visibility, being normal or cloudy, with normal turbidity.

The brown colour of the water of Benfica River in the stretch within the Benfica district reflects the presence of sediments carried from the riverbanks by leaching from Amazonian rains and the current that acts by lifting and carrying sediments along its course.

Benfica river at low tide. Photo by Aureliano da S. Guedes, PhD

Benfica river at high tide. Photo by Aureliano da S. Guedes II.

A water source that is in contact with minerals containing lead sulphide, or due to natural, industrial or anthropogenic contamination of this metal, where penetration via the gastrointestinal, dermal and/or respiratory tract can have cumulative effects on individuals, which, when reaching levels above the tolerability threshold, can cause pathologies related to the transport of calcium in the body, in the gastrointestinal tract and problems in the central nervous system (CNS) and peripheral nervous system (PNS) in a diffuse manner[7].

Exposure to lead has decreased significantly since the use of leaded gasoline was phased out, but there are still multiple sources of this metal, resulting in adverse health and economic effects, particularly in low and middle-income countries[13]. Improper disposal by industries is a significant source in these cases.

In general, inorganic lead salts have low solubility in water, except for nitrate, chlorate and, to a lesser extent, lead chloride. Lead forms stable organic compounds, that is, when its atom is bonded to a

carbon atom, such as tetraethyl lead and tetramethyl lead. These compounds, both colourless liquids, have low solubility in water and are volatile.

In the all sample collections, in the Benfica River in the Benfica district in Benevides city in the state of Pará, trace elements of lead were identified. which, being a bioaccumulative trace element, poses a risk to human and animal health. requiring tracking to identify the origin[14].

A water source that is in contact with minerals containing lead sulphide, or through natural, industrial or anthropogenic contamination of this metal, where penetration via the gastrointestinal, dermal and/or respiratory tract may have cumulative effects on individuals, which, when reaching a level above the tolerability threshold, may cause pathologies related to the transport of calcium in the body, in the gastrointestinal tract and problems in the central nervous system (CNS) and peripheral nervous system (PNS) in a diffuse manner[7].

Other researchers in 2006 already indicated the presence of the trace element lead in the Benfica River. For example, Porto (2006) stated that a concentration of lead (Pb) was detected at the source of the Benfica River, exceeding the limit permitted by CONAMA Resolution 357 in effect at the time. Nearby agricultural activities may be using fertilisers or pesticides in cultivation, concentrations that could be reaching the river's source[15].

In the last sampling in December 2025, the tide was high, and trace element iron <5 was detected in the samples. Since this was not reflected in other samples, it was considered an isolated event.

Chromium (VI), copper, mercury, and other trace-elements were not detected in any sample collected during the period. Carbonate, free chlorine, fluoride, nitrate, and nitrites were not identified in any sample collected.

Floods can increase the transmission of viral diarrheal diseases, hepatitis A and E, cholera, and vector-borne diseases such as yellow fever, West Nile fever, and dengue fever. In these cases, contaminated waters often contain bacteria from faeces, such as *Escherichia coli* and *Enterococcus spp.*, which can cause gastrointestinal illnesses and various infections, including skin infections[16].

Flood-related skin diseases encompass a range of conditions related to exposure to contaminated floodwater and subsequent environmental changes. Floods can increase the risk of skin infections, traumatic skin diseases, reactions to insect bites, primary skin diseases aggravated by psycho-emotional factors, among others[17].

Thermotolerant coliforms were identified in all samples. As for *Escherichia coli*, it was only absent in the samples collected on September 30, 2025, indicating biological contamination. It is necessary to identify the source, as it can occur through soil leaching by rain, domestic sewage discharged directly into the river, or even livestock farming, among other factors that may be associated. Identifying the source requires public policies for both mitigation and environmental education, among others.

The area studied exhibits a diversity of animal, plant, bacterial, and other populations that interact to form a large community, each

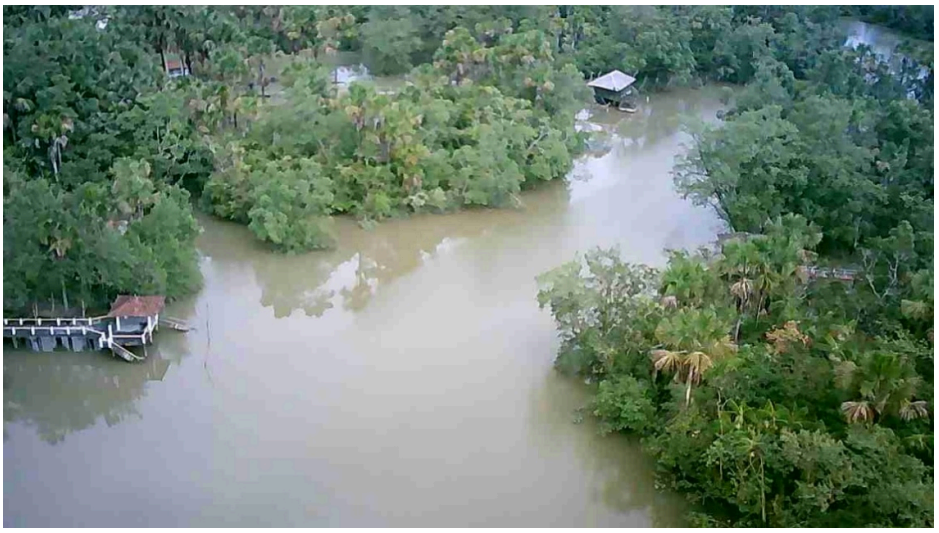
dependent on the others in some way.

In this case, populations are understood to be individuals of the same species that inhabit, interact, and reproduce in a given area; the community presents different species that inhabit and relate in some way to other species in a harmonious or disharmonious manner, depending, to some extent, on the environment to survive[7].

Several species of fauna were observed during the collection of water samples, among which stand out: *Armases benedicti*, *Berlepschia rikeri*, *Bothrops atrox*, *Bradypus tridactylus*, *Bradypus variegatus*, *Cebus apella*, *Iguana iguana*, *Melanosuchus niger*, *Minuca vocator*, *Pitangus sulphuratus*, *Ramphastos toco*, *Ramphastos tucanus*, *Saimiri sciureus*, *Tamandua tetradactyla*, *Turdus rufiventris*, *Tyrannopsis sulphurea*, among others.

Several plant species from the Amazon region, including the Metropolitan Region of Belém in the state of Pará, where the municipality of Benevides and the district of Benfica are localised, are still unknown. However, many of those that have been identified show great economic potential for the pharmaceutical, cosmetic, and food industries, etc[7].

As for flora, several species were observed, including: *Bactris gasipaes*, *Bertholletia excelsa*, *Carapa guianensis*, *Aubl*, *Caladium bicolor*, *Carica papaya*, *Capsicum chinense*, *Cedrela fissilis*, *Ceiba pentandra*, *Copaifera langsdorffii*, *Euterpe oleracea*, *Heliconia bihai*, *Hevea brasiliensis L*, *Mauritia flexuosa*, *Montrichardia linifera*, *Spondias mombin*, *Swietenia macrophylla*, *Symphonia globulifera*, *Vouacapoua americana*, among others.



Aerial photo of Benfica river at high tide with emphasis on the ciliary forest.
Photo by Aureliano da S. Guedes II.

4. CONCLUSION

Urban development has drastically impacted the Benfica River. Many houses are being built along the riverbank, including horizontal residential condominiums, blocking access to the river and hindering views of wildlife. This negatively affects tourism, particularly for lower-income populations, and is detrimental to the natural environment. Another factor harming the river is the extensive use of motorised canoes and jet skis, as well as the dumping of cooking oil in some areas, where floating oil slicks can be observed on the Benfica River. The trace element lead was identified in the samples, which is concerning due to its cumulative effects on human and animal health.

This scenario highlights the urgent need for the creation of public policies for environmental education and efficient actions for the use and preservation of the Benfica River and its tributaries, as well as the urgent implementation of effective processes for removing cooking oil deposits and monitoring and intervening in their sources; and the tracking of lead sources reaching the river for

guidance and removal of the contaminant, preserving and improving the river's quality.

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