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Physicochemical Parameters Of The Waters Of The Caraparu River In The District Of Caraparu In Santa Izabel Do Pará (Brazil)

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Abstract
Justification: *The main river in the district of Caraparu, in the municipality of Santa Izabel do Pará, is the Caraparu River, which originates in the city of Santa Izabel and flows into the Guamá River, which is of great importance for agriculture, tourism and, in some cases, consumption. Therefore, there is a need for monitoring to ensure water quality.*
Objective: *analysis of the physiochemical parameters of the waters of the Caraparu River along the course of the Caraparu district in Santa Izabel do Pará.*
Methodology: *Water samples were collected from the Caraparu River in Santa Izabel do Pará, at different times and tide situations (high and low), always in the morning and with on-site analysis. The pH was measured in the samples using a portable electronic pHmeter and compared with multiparameter strips as a control. The electrical conductivity values of the water samples were measured using a portable electronic conductivity meter, expressed in µS/cm-1, as well as the sample temperature and Total Dissolved Solids. For environmental temperature, an environmental thermometer was used. The samples were subjected to multiparameter test strips with 3 tests for each sample to identify: alkalinity, lead, bromine, nitrate, nitrite, iron, chromium (VI), copper, mercury, fluorine, among others. The Secchi disk was used to evaluate turbidity, visibility in centimetres, among others. The qualitative observational method was used to obtain information on anthropogenic environmental pollution in the studied river and its surroundings and the presence of wild flora and fauna. Conclusion: The aquatic compartmental environment is the one that suffers most from pollution, because what is in the air and soil can somehow reach the water. In this sense, there is a need for investments in biorefineries and biofuels, sustainability projects, solid residue management, reuse of agricultural residues, incentives for recycling and reusing industrial materials, biopolymers and biomonomers and other biodegradable materials, improvement of urban sanitation technologies, education for conscious consumption, efficient and effective environmental management programs, production of renewable energy, adequate treatment of residual water, public policies to guide the conscious use of water, among others, in addition to controversial measures such as combating consumerism and reproductive education, etc. These measures are largely costly, but the cost of restoring a river and the impact on human and environmental health result in much greater losses.*
Keywords: *Environmental chemistry, Chemophysical analysis, Limnology, Santa Izabel do Pará, Caraparu River.*

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I. Introduction

The municipality of Santa Izabel do Pará is located at latitude: 01º 17' 55" S, longitude: 48º 09' 38" W, with altitude: 24m.[1] It has an area of 720.9 km², with a population of 73,019 inhabitants, with a diarrhoea rate of 0.2% per 1000 people. It has only 10.7% of households with adequate sewage, 19.9% of urban households on tree-lined public roads and 6.3% of urban households on public roads with adequate urbanization (presence of drains, sidewalks, paving, etc[2].

The main river in the district of Caraparu, in the municipality of Santa Izabel do Pará, is the Caraparu River, which has the source in the city of Santa Izabel and flows into the Guamá River, with great importance for agriculture, tourism and, in some cases, consumption.

For recreational water users, the risks associated with chemical hazards will depend on the type and concentration of chemical contaminants and the characteristics of the area. River flows and tidal and wave action can dilute and disperse chemical discharges. In contrast, slow-flowing lowland rivers and lowland lakes may be more susceptible to contamination and provide low levels of dilution or dispersion. Water bodies subject to continuous or intermittent discharges may accumulate contaminated sediments. Potential sources of chemical hazards include industrial discharges and spills; wastewater discharges; discharges from contaminated sites; local use of motorised vessels; petroleum receiving stations; pesticides; mining waste; and natural chemicals, including algal toxins[3].

The chemical quality of water must be assessed by identifying its components using specific laboratory methods. Two important groups of chemical substances, each with specific origins and effects on human health, are inorganic chemical substances, such as heavy metals, organic substances and solvents[4].

Lotic systems present permanent flows and interactions with their tributaries, their waters can present significant variations between the collection of one sample and another, given their transport capacity, organic and inorganic composition of materials, difference in water temperature by area and depth, among others.

The objective of this research was to analyse physiochemical parameters of the waters of the Caraparu River along the Caraparu district in Santa Izabel do Pará.

II. Methodology

Water samples were collected from the Caraparu River at different times and tide situations (high and low), always in the morning and with on-site analysis from January to December 2024.

The pH was measured by a portable electronic pH meter and compared with multiparameter test strips as a control. The electrical conductivity values were measured by a portable electronic conductivity meter, expressed in µS/cm-1 (micronSiemes per centimetre), and the sample temperature and Total Dissolved Solids. For the environmental temperature, an environmental thermometer was used. Multiparameter test strips were used with 3 tests for each sample to identify: alkalinity, lead, bromine, nitrate, nitrite, iron, chromium (VI), copper, mercury, fluorine, among others. The Secchi disk was used to evaluate turbidity, visibility in centimetres, etc. The qualitative observational method was used to obtain information regarding anthropogenic environmental pollution in the river and its surroundings and the presence of wild flora and fauna.

It is worth mentioning that the climate in most areas of the Amazon is hot and humid, with a predominance of rain during six months and occasional rain in the remaining months. Because it is largely located in the equatorial region, the high temperature and vapours from lakes, rivers, ocean, etc., will contribute to the high humidity in the Amazon, which, combined with the evapotranspiration of plants that extract moisture from the soil that makes up the forest, will result in high atmospheric humidity and a significant level of annual precipitation[5]. This humidity, due to rainfall aspects, will influence the analysis of the samples; in this sense, some data such as winds, environmental visibility, local temperature, tide, among others, were considered in the sample collections.

Several variables must be considered when collecting samples in limnology, including: temperature; odour; pH; colour; transparency; turbidity; divided oxygen; electrical conductivity; chlorophyll; deep current; surface current; total suspended solids; total distributed solids; current speed; wind speed, among others[5]

III. Results And Discussions

The chemical quality of water is measured by identifying the component in the water using specific laboratory methods. Such chemical components should not be present in the water above certain concentrations determined with the help 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 quantity, during a certain period of life, added to the expected exposure to the same substance through other means (food, air, etc.), subjects this individual to an unacceptable risk of developing a resulting chronic disease. 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 solvents. (BRAZIL, 2006)

The predominant dark coloration in the waters of the Santa Izabel do Pará hydrographic basin is characterized by the large contribution of organic compounds from trees that fall and rot, flowers, fruits, leaves and roots of the riparian forest and aquatic macrophytes, influencing the turbidity, colour and pH of the waters of rivers, streams, among others[6].

Chemically pure water does not conduct electricity; however, if acids, bases or salts are dissolved in it, the solution will conduct electric current and chemical transformations will occur[7].

In the case of waters of a limnological nature, these will be chemically influenced by sediments, substances transported by leaching, rainwater, aquatic and terrestrial biota, anthropogenic and natural pollution, among others, therefore presenting in their chemical composition substances that have a greater or lesser degree of electrical conductivity.

The electrical conductivity of water is one of the most important variables in limnology, since it can provide information both on the metabolism of the aquatic ecosystem and on important phaenomena occurring in its drainage basin. Among the information that can be provided by electrical conductivity values is information on the magnitude of the ionic concentration. The ions most directly responsible for electrical conductivity values in inland waters are the so-called macronutrients (calcium, magnesium, potassium, sodium, carbonate, sulphate, chloride, etc.), while nitrate, nitrite and especially reactive soluble phosphorus have little influence. The ammonium ion can only have an influence at high concentrations; daily assessment of the electrical conductivity of water provides information on important processes in aquatic ecosystems, such as primary production (decrease in values) and decomposition (increase in values); electrical conductivity can help to detect sources of pollution in aquatic ecosystems; geochemical differences in the tributaries of the main river or a lake can be easily assessed with the help of electrical conductivity measurements[8].

It is important to know that the electrical conductivity of water can also be related to the presence of salts, tide and elements leached into the river by rain.

Water temperature in lotic systems varies daily and seasonally due to factors such as climate, altitude, type and extent of ciliary forest, and groundwater input. This temperature sets limits on the geographic distribution and physiology of organisms, influencing reproduction, survival, and the life cycle of organisms[9].

In terms of water temperature in tropical regions, conductivity values in aquatic environments are more related to the geochemical characteristics of the region where they are located and the climatic conditions (dry and rainy season), but they can also be influenced by the trophic state, especially in environments under anthropic influence[8].

Temperatures, both environmental and aquatic, are important, being related to water density, preservation of microfauna and microflora, mainly nitrifying bacteria, among others, and are important in measuring pH. In this sense, the variation in temperature of water samples and the environment highlights the characteristics of the hot humid climate of the studied region, therefore with a strong influence on the characteristics of the flora, fauna, hardness and pH of the samples[6].

The pH and plant and animal communities in aquatic ecosystems are closely interdependent. Aquatic communities and affect pH, just as pH affects the metabolism of these communities in different ways. In communities, pH acts directly on the permeability processes of the cell membrane, thus interfering with intra and extracellular ionic transport and between organisms, for example, through the assimilation of CO2.[10]

The presence or absence of carbonate ions defines hard water rivers or acidic water rivers with a low concentration of carbonate ions[9].

Carbonate ($CO3^{2}$), considered an inorganic carbon ion, related to the pH of the water, may be related to minerals leached from riverbanks, type of sediment, among others, making the water even more acidic due to carbonic acid; however, the processes of decomposition of plant and animal remains by microorganisms, eutrophication of plants, organic components of domestic sewage, respiration of fish and other molluscs, animal and plant decomposition, among others, in these rivers and their banks, will generate organic carbon, also making the water more acidic. Acid rain, resulting from, among others, the burning of fossil fuels, fires, industrial chimneys, among others, also contributes to the acidity of the limnological waters.

In limnic waters (rivers, lakes, ponds, wells, etc.) it may contain barium, bicarbonate, calcium, chlorides, strontium, fluorides, phosphates, magnesium, nitrates, potassium, sodium, sulphates, among others, originating from the soil through leaching, air, anthropic influences, among others[5].

The main natural sources of trace elements for the continental aquatic environment are the weathering of rocks and the erosion of soils rich in these materials. Recently, other sources of trace elements have assumed great importance: industrial activities, through solid effluents that are released directly into the atmosphere and liquids that are released into small streams or directly into rivers and lakes; Hg in mining activities; domestic effluents and surface water from areas cultivated with chemical fertilizers and especially from those where agricultural pesticides are used (these contain the most varied trace elements such as: Cd, Hg, Pb, Cu, etc.). The atmosphere is also an important source of trace elements for aquatic ecosystems. There are several sources that enrich the atmosphere with trace elements, which through wet and dry precipitation can reach the aquatic environment. Among these sources, marine and biogenic aerosols stand out, resulting from the disintegration and dispersion of plants and animals, natural fires, particles of volcanic origin, and others carried by the wind (dust) and mainly industrial emissions directly into the atmosphere (anthropogenic source)[11].

The simple change in the valence of the metal transforms the slightly toxic trivalent chromium into the aggressive and carcinogenic hexavalent chromium[12]. Hexavalent chromium [Cr(VI)], among the various ionic forms of Cr, is the most toxic. This is generally an industrial byproduct widely used for pigment production, leather tanning, wood processing, chromium plating, metallurgical and chemical industries, stainless steel manufacturing, welding, cement production, ceramics, glass, etc. Cr(VI) levels have increased in soil, water and air, mainly due to increased use by industries and improper disposal of these residues in the environment[13].

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[14].

However, 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 a level 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[5].

Because lotic systems present permanent flow and 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 materials, difference in water temperature by area and depth, among others[6].

As for mercury, the ability of organomercury compounds to efficiently cross cell membranes significantly increase their retention in organisms (long biological half-life) and results in their bioaccumulation and biomagnification along food chains. Most of the mercury present in the tissues of aquatic organisms is in the form of methylmercury, although levels of inorganic mercury are much higher than organomercury forms. It is believed that the formation of methylmercury in the aquatic environment occurs mainly through a reaction mediated by microorganisms (e.g. sulphate-reducing bacteria). However, other abiotic mechanisms (photochemical methylation, transalkylation, etc.) are also capable of producing methylmercury in the environment[14].

Mercury toxicity in the body can result in several pathologies, both acute and chronic, mainly in the Central Nervous System, Respiratory Tract, Urinary Tract, Gastrointestinal Tract and Hematopoietic System, resulting in dementia, depression, stomatitis, insomnia, among others[5].

The nitrite concentration is always very low (< 60mg N-NO–2. ℓ–1), because this chemical can be reduced chemically and/or by the activity of bacteria that reduce nitrate or oxidize ammonium. Especially in tropical waters, this concentration is very low and is often below the detection limit of the method. Nitrite can occasionally accumulate in bags with oxygen tensions below 1mg O2.ℓ-1 and in conditions of low stratification[9]. Inorganic nitrate is highly soluble and abundant in waters that receive high concentrations of nitrogen, resulting from the discharge of domestic sewage or agricultural activities[9].

Nitrogen, when oxidized, will result in nitrites and nitrates which, as a nutrient for plants, can cause eutrophication of aquatic plants, resulting in increased oxygen consumption, causing competition with aquatic fauna, resulting in migrations or extinction of certain species of fish, crustaceans, etc., and attracting other species that are better adapted to the low presence of oxygen.

In addition, water levels and rainfall variations, biomass, primary productivity and, consequently, the population dynamics of aquatic macrophytes are affected by several other abiotic factors, among which physical factors (e.g. ecosystem morphometry, water, temperature and underwater radiation), chemical factors (e.g. water and sediment nutrients, and inorganic carbon) and physicochemical factors (e.g. pH) can be highlighted. However, these factors affect each biological type of aquatic macrophyte differently. In addition to the effects of abiotic variations, aquatic macrophyte populations are also affected by biological interactions, especially competition (intra and interspecific), herbivory and facilitation[15].

Lotic systems are affected by the following changes: pumping of water for irrigation or public or private supply (farms), which alters the flow and structure of rivers; organic and inorganic pollution from industrial and agricultural sources (point and diffuse sources). Pesticides, herbicides, heavy metals and the discharge of untreated sewage are some of the threats to the integrity of rivers; intensive land use, which leads to an increase in suspended matter and the release of substances and elements in large quantities into lotic systems; introduction of exotic species, which alter the food web and the natural process of community interaction; removal of riparian vegetation, which is extremely important in maintaining the buffer conditions of rivers. This removal, in addition to reducing the organic matter available to fish and invertebrates, fails to protect the banks and slopes of rivers, altering their morphometry; construction of dams for hydroelectricity and public supply; alteration of floodplains and wetlands associated with dams for agriculture, construction of canals or urbanisation; construction of canals, bridges and passages, which interfere with the functioning of rivers, alter the substrate (physical and chemical compositions) and remove and affect organisms; construction of large areas for irrigation, with considerable withdrawals of water for this activity, contaminated by domestic (sewage) and industrial waste, are the two greatest threats to lotic systems[9].

In the case of anthropogenic pollution, the main sources are caused by population growth, in many cases with disorderly urban growth, therefore, without planning, with the main consequences: alteration of river flows, cemeteries, deforestation of ciliary forests, industrialisation, among others. The population needing food will reflect the pollution in rural areas, through extensive agricultural activities, where chemical products for soil correction, if misused, will generate nutrients that, when falling down the gradient into lakes, rivers, Amazonian wells, among others, causing eutrophication, as well as deforestation and the introduction of exotic species, etc. To generate energy for consumption by these populations and their industries, there is a need for large-scale energy production, whether through charcoal and/or mineral coal, burning of fossil fuels, construction of hydroelectric plants, among others, resulting in damage to surface and underground water resources; Another factor is clandestine mining, which, without production criteria, silts up rivers and lakes, as well as contaminating them with heavy metals; among many others[5].

IV. Analysis Of Results

Caraparu River					
Parameters	**Sample 1 22/11/23**	**Sample 2 19/03/24**	**Sample 3 25/06/24**	**Sample 4 10/09/24**	**Tolerability in recreational waters/Source**
Environmental visibility	Normal	Normal	Cloudy	Normal	-
Environmental Temperature in C°	35.1	31.4	31.5	33.1	-
Wind	No	No	No	Weak	-
Ciliary forest	Yes	Yes	Yes	Yes	Varies depending on the type and width of the river
Tide	Low	High	High	Low	-
Aquatic Macrophyte Presence	Yes	Yes High	Yes High	Yes High	Must not present eutrophication
pH	6,2	6,2	6,2	6,2	6-9
Temp. C° - samples	27.9	26	25.5	27.2	-
Depth visibility with Secchi Disc	95cm	78cm	Not applied	Not applied	-
Colour	Dark brown	Dark brown	Dark brown	Dark brown	True colour: natural colour of the water body in mg Pt/- CONAMA
Turbidity	Normal	Normal	Normal	Normal	≤ 40 nephelometric turbidity units (NTU) - CONAMA
Odour	Normal	Normal	Normal	Normal	Absent odour
Electrical Conductivity (mS/cm).	0.046	0.024	0.042	0.040	Depends on ions, geological aspects, pH and others
TSD (Total Dissolved Solids)	0.023	0.012	0.021	0.020	< 500 mg/L – CONAMA
Carbonate	0	0	0	0	Observe pH, presence of macrophytes and other factors
Water Hardness	25	100	50	50	500mg/L Review
Lead	20	10	20	0	0,01mg/L – CONAMA
Bromine	1	0	0	0	0,5mg/l (500 µg/L) -WHO
Nitrate	0	0	0	0	10,0 mg/L – CONAMA
Nitrite	0	0	0	0	1,0 mg/L – CONAMA
Iron	5	0	0	0	0,3 mg/L – CONAMA
Chromium (VI)	1	1	0	0	0,1 mg/L
Copper	0	0	0	0	0,009 mg/L – CONAMA
Mercury	0	0	0	0	0,0002 mg/L - CONAMA
Fluoride	0	0	0	0	1,4 mg/L - CONAMA

(*) Determination of fresh water salinity ≥ 0.5% CONAMA

Turbidity is important to check suspended particles that, in excess, can hinder the passage of light, damaging phytoplankton, some types of important bacteria, photosynthetic macrophytes, among others. In the case of the Caraparu and Maguari rivers, at the sample collection site in different periods, it was presented ≤ 40 nephelometric turbidity units (NTU), as normal, without harming photosynthesis and other important actions.

The depth of the Secchi disc 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 the organic and inorganic materials that make up the water. In the Caraparu River, when possible, the use of the Secchi disc allowed visibility between 78cm and 95cm, always presenting a dark brown coloration of the water, both in normal visibility of the river and in environmental visibility, which can be normal or turbid, with normal turbidity.

The electrical conductivity in the Caraparu River varied from 0.024 to 0.046, influenced by the Total Dissolved Solids, which were between 0.012 and 0.023, also being influenced, among others, by the rainiest period in the region and by the tide, as the data were higher at high tide.

The temperatures of the water samples from the Caraparu River varied, in the different collection periods, between 25.5ºC and 27.9ºC, while the environmental temperature varied between 31.4ºC and 35.1ºC in the different measurement periods. These temperatures, among other factors, influence the increase in the acidity of the water by breaking down some water molecules, generating carbonic acid (H CO) that mixes with the water.

In the Caraparu River, the carbonate rate identified was 0.00. The presence of carbonates at the sample collection sites was insignificant in terms of risks to human and environmental health. However, lotic waters should always be monitored, especially because there are small and medium-sized industries and agricultural activities nearby, in addition to the urbanisation of the studied district.

The pH is also related to water hardness. In the Caraparu River, in the perimeter of the Caraparu district in the municipality of Santa Izabel, all sample collections showed a pH of 6.2 and a water hardness of 25 to 100, which is classified, in terms of Hardness, as soft water, in addition to presenting homeostasis, even with changes in tides, rainy season, sample collection period, among others. This can also be proven by the absence of carbonates in water samples collected at different times. Therefore, the hardness of the water in the Caraparu River does not pose environmental risks and/or risks to human and livestock health.

The transition metal Hexavalent Chromium was identified in the first samples in the Caraparu River. In nature, Hexavalent Chromium is rare, and some bacteria can process it in small quantities; in large quantities, the processing bacteria will not be able to perform their task, and it is suspected that the origin is of industrial or agricultural processes. The presence of Hexavalent Chromium appeared in the first two sample collections in the Caraparu River and was not repeated in sample collections at other times. However, there is a need for monitoring to identify whether it is related to the rainy season in the region, where it may originate from residues from agricultural processes, contaminating the soil and reaching the river by leaching and/or possible contamination by industrial processes. In any case, monitoring is necessary given the toxicity of Hexavalent Chromium, which causes dermatitis, contact allergies, kidney disease, poisoning, cancer and other diseases. However, there is also a need for domestic sewage treatment to ensure better water quality; And industries should always be monitored and recommended to carry out efficient and effective maintenance of heavy metal residue filtration processes; the same recommendation applies to automotive paint shops.

In the first three sample collections in the Caraparu River, trace elements of lead were identified, with only the last sample showing a negative result, requiring tracking to identify the origin and whether this could happen again, given the risk to environmental and human health.

In the samples collected and analysed in the Caraparu River, in the Caraparu District area, in the municipality of Santa Izabel, the presence of mercury was not identified.

Nitrites, nitrates and fluorides did not present significant quantities for the sensitivity of the method used. Therefore, they do not present risks to environmental and human health.

It is worth mentioning that a large quantity of free-floating macrophytes of the species *Pristia stratiotes* were observed in the Caraparu River, characterizing eutrophication. It is worth noting that during some of the team's incursions into that river, city workers were observed removing large quantities of these macrophytes from the water to facilitate the tourist use of the area. However, this mechanical removal of the large excess of this species reduces the shading for other species and the silting of certain areas of the river, already close to the district of Caraparu, by foliage of this species and contributes to better oxygenation of the Caraparu River and its tributaries. The main negative point is the reduction of shelter for some types of fish and the availability of food and nutrients for other species, for example, macro-invertebrates and micro-invertebrates, among others. There is a need to identify whether eutrophication is natural or artificial, if artificial, to track the source, diagnose the causes and develop projects to minimise or contain the harmful impacts on the Caraparu River and its tributaries and effluents, such as the Maguari River, which is already beginning to show eutrophication by *Pristia stratiotes* in the areas influenced by the Caraparu River.

V. Conclusion

The aquatic compartmental environment is the one that suffers most from pollution, since what is in the air and soil can somehow reach the water. In this sense, there is a need for investments in biorefineries and biofuels, sustainability projects, solid waste management, use of agricultural waste, incentives for recycling and reusing industrial materials, biopolymers and biomonomers and other biodegradable materials, improvement of urban sanitation technologies, education for conscious consumption, efficient and effective environmental management programs, production of renewable energy, adequate treatment of wastewater, public policies to guide the conscious use of water, among others, in addition to controversial measures such as combating consumerism and reproductive education, etc. These measures are largely costly, but the cost of restoring a river and the impact on human and environmental health result in much greater losses.

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