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Water Quality of the Capibaribe River, Municipality of Recife, State of Pernambuco, Brazil: A Case Study

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ABSTRACT

In view of the constant growth of urban, agricultural, and industrial demands, it is possible to notice that the uncontrolled use of aquatic environments has caused the acceleration of degradation processes in lotic systems and environmental quality. Thus, there has been a growing need to assess environmental changes and their effects on water resources. This study aimed to assess the physical-chemical quality of the water at six different collection stations, in the Capibaribe River, Recife, Pernambuco, Brazil, around the Caranguejo/Tabaiares Community, complementing it with socioeconomic data from the community. The results were compared to the Brazilian quality standards for Class 1 saline waters, according to CONAMA n.357/2005, observing that the studied parameters indicate low water quality in the six studied points. Therefore, there is a need to adopt appropriate mitigation measures, including the improvement of the community's living conditions.

Keywords: *Water assessment, River monitoring, Urban water resources, Socioeconomic survey.*

INTRODUCTION

First of all, it is worth noting that this article is a consequence of the Research Project of Catholic University of Pernambuco, participating in the Network of the International Federation of Catholic Universities (FIUC), under the coordination of Teacher Arminda Saconi Messias, with a General Project entitled “Gestión del Água. Água, Medio Ambiente, Salud. Contribuición de las Universidades Católicas Latinoamericanas a la Proteción del Água y la Reducción de los Riesgos Relacionados con este Recurso”.

And that the increasing contamination of water resources, caused by several sources, among which the domestic and industrial effluents stand out, the urban and agricultural diffuse load, has been compromising the use of these resources for its various purposes. Each of these sources has its own characteristics regarding pollutants. Water pollution by domestic and industrial effluents is a major cause of the reduction in water quality, increasing treatment costs for human consumption. Thus, water assessment and monitoring are essential to monitor the behavior of physical-chemical parameters, in addition to providing subsidies to assess the conditions of the source and contribute information for decision-making in the management of water resources [1].

The increasing use of water resources, according to [2], has resulted in problems, not only of lack, but also in the degradation of its quality. According to [3] it is clear that in the last decades there has been a quantitative and qualitative decrease in surface waters, a fact that can be attributed to the activities developed in hydrographic basins, being directly linked to the imbalance found in these environments.

According to [4], Pernambuco has hydrographic basins that have two strands: the São Francisco River and the Atlantic Ocean. Those that flow into the São Francisco River form the so-called interior rivers, the main ones being: Pontal, Garças, Brígida, Terra Nova, Pajeú, Moxotó, Ipanema and groups of small inland rivers. The basins that flow into the Atlantic Ocean constitute the so-called coastal rivers, and the main ones are: Goiana, Capibaribe, Ipojuca, Sirinhaém, Una and Mundaú and groups of basins of small coastal rivers.

The name Capibaribe comes from the Tupi language and means river of capybaras or wild pigs. It was in the riverside region of Capibaribe where the culture of sugar cane was first consolidated in Northeast Brazil, due to the fertile and suitable soil for sugarcane agriculture; livestock has also developed on its banks. Capibaribe contributed to the evolution of the State of Pernambuco, which occurred not only from the center to the periphery, but also from the mills to the commercial center. In the 19th century, there were places in Recife, where people bathed in Capibaribe and vacationed on its banks [5].

The Capibaribe River is located in the north - eastern portion of the State of Pernambuco, Brazil. The Capibaribe River basin is limited to the North with the State of Paraíba, with the Goiana River basin and with groups of basins of small coastal rivers. To the south it is limited by the Ipojuca river basin and the group of small coastal rivers basins. To the east with the Atlantic Ocean and the group of small coastal rivers basins, and to the west, with the State of Paraíba and the Ipojuca River basin[4].

Still according to [4] the Capibaribe River rises on the border of the municipalities of Jataúba and Poção, passing through several urban centers and serving as a receiving body for industrial and domestic waste. The Capibaribe River basin has an area of 7,454.88 km² (7.58% of the State's area), covering 42 municipalities in Pernambuco.

In the metropolitan region of Recife it is divided into two branches: the southern branch, also called the dead branch due to the numerous landfills that occur in the area, and which flows into the Pina Basin; and the North branch, at the mouth of which is the Port of Recife. The Capibaribe River estuary is a highly eutrophic region, due to the excess of nutrients, attributed mainly to domestic sewage, urban runoff, and sugar cane cultivation regions. Other biological indicators, such as fecal coliforms, biochemical oxygen demand and species that indicate organic pollution, also demonstrated that the water quality of this estuary is compromised; due to the high pollution load it receives [5].

On the Recife route, the Capibaribe River receives a load of residues from an estimated population of 430 thousand inhabitants, due to the disorderly urban growth. There was a deterioration of the environmental resources that surrounded the river, reflecting on the quality of life of the riverside populations. Because of this reality, the waters that suggested the title of Brazilian Venice to Recife resemble any polluted canal [6].

Thus, water treatment consists of applying techniques that can make it drinkable. According to Ordinance MS 518 [7, 8], drinking water is water intended for human consumption whose microbiological, physical, chemical and radioactive parameters meet the potability standard and which do not offer health risks. The objectives of the treatment are of a sanitary order when it comes to the removal of pathogenic organisms and chemical substances that represent a health risk; aesthetic and organoleptic when it comes to removing turbidity, color, odor and taste; and, of an economic nature when it seeks to eliminate corrosivity, hardness and iron. The aforementioned aesthetic standards are linked to the acceptance standard for human consumption, in order to avoid rejection of use [9, 10].

In most developing countries, the water used for human consumption and for domestic use is taken from rivers, which generally have a high turbidity, due to the presence of a large amount of solid material in suspension, mainly in the rainy season, bacteria and other microorganisms [11]. In CONAMA resolution no. 357 [12] only Class 4 fresh water cannot be used in a Water Treatment Plant (ETA); however, if you consider technology, water of any quality can be transformed into drinking water; what this process entails are the costs involved.

According to its basic characteristics, impurities present in water can be divided into chemical, physical and biological. The main impurities found in surface waters are: solids dissolved in ionized form, dissolved gases, dissolved organic compounds and suspended matter, such as microorganisms (bacteria, algae and fungi) and colloids. Most of these impurities have a stable suspension for long periods of time [13, 14].

In view of this reality, the present study sought to find out through the analysis of the physical and chemical characteristics, whether the water from the Capibaribe River consumed by the residents of the Caranguejo Tabaiares Community in Recife-PE, meets the potability standards required by Ordinance MS 518/04, indispensable for health promotion, as well as the socioeconomic situation of the surrounding community.

Materials and Methods

The water was collected in six previously defined collection stations, around the Caranguejo/ Tabaiares Community, on the Capibaribe River, Recife, Pernambuco, Brazil, with five replications:

- ✓ **Collection Station 1 -** (8°04’42, 84”S 34°54’08, 61”W): Imperial Street with Realeza Street, on the Motocolombó bridge, near a car workshop.

- ✓ **Collection Station 2 -** (8°03'55, 24"S 34°54'28, 47"W): Felipe Moreno Street with Remédios Road, in Caranguejo/Tabaiares Community.
- ✓ **Collection Station 3 -** (8°03'52, 28"S 34°54'15, 20"W): Tabaiares Street on the bridge next to the Sport Clube do Recife stadium parking lot exit.
- ✓ **Collection Station 4 -** (8°03'42, 99"S 34°54'02, 39"W): Prof. Lima de Castilho Bridge on Abdias de Carvalho Avenue, near the Chico Science tunnel.
- ✓ **Collection Station 5 -** (8°04'03, 85"S 34°54'02, 29"W): Beira Rio Avenue at the entrance bridge of the Caranguejo/Tabaiares Community.
- ✓ **Collection Station 6 -** (8°04'03, 22"S 34°54'49, 08"W): Bridge on the Joana Bezerra Viaduct near the metal walkway.

In the water samples, sulfate and turbidity (nephelometry), chloride (precipitation titrimetry - Mohr method), hardness, calcium and magnesium (complexation titrimetry), acidity (titrimetry), iron (photocolorimetry), pH (potentiometry) and color (compared to platinum-cobalt standard) were determined, according to Standard Methods of Water and Waster water [15].

The historical rescue of the Caranguejo/ Tabaiares Community was carried out through a bibliographic survey and, mainly, through informal conversation with the residents.

Results and Discussion

Physical-Chemical Analysis of the Water in the Capibaribe River

The results found in the six collection stations were obtained by means of five replications. It was used as a comparative parameter resolution CONAMA no. 357 [12] and the water was classified as Class 1 saline, for all water collection stations on the Capibaribe River. Table 1 shows the results of the chemical and physical determinations of the water.

Table1. *Some chemical and physical parameters of the water in the Capibaribe River, Recife, Pernambuco, Brazil (averages of five samples)*

Determination	CS1	CS2	CS3	CS4	CS5	CS6
Sulfates (mg/l SO_4^{2-})	1536	62	212	713	869	1609
Chlorides (mg/l Cl^-)	4565	94	895	2446	2678	4646
Total Hardness (mg/l $CaCO_3$)	1665	163	590	1201	993	1572
Calcium (mg/l Ca^{2+})	101	36	33	67	61	90
Magnesium (mg/l Mg^{2+})	344	18	124	251	204	327
Acidity (mg/l CO_2)	40	88	112	28	36	22
Total Fe (mg/l Fe^{3+})	1	1	1	0	1	1
pH	7.3	7.4	7.5	7.8	7.8	7.8
Real color (mg/l Pt-Co)	37	46	92,5	40	45	45
Turbidity (UNT)	32.2	26.0	585.8	21.9	19.9	19.2

*Where: **CS1** = 8°04'42,84"S 34°54'08,61"W; **CS2** = 8°03'55,24"S 34°54'28,47"W;*

***CS3** = 8°03'52,28"S34°54'15,20"W; **CS4** = 8°03'42,99"S 34°54'02,39"W;*

***CS5** = 8°04'03,85"S 34°54'02,29"W; **CS6** = 8°04'03,22"S 34°54'49,08"W.*

High levels of sulfate (Table 1) were found in all Collection Stations, except in CS2, which obtained the minimum sulfate value, with 62mg/l, and the maximum values were obtained in CS1 and CS6, with 15.356mg/l and 1.609mg/l of sulfate respectively.

As for chloride, all collected water samples showed high values, except CS2, obtaining a minimum value of 94mg/l, with a maximum value of 4.646 mg/l in CS6.

Considering water as Class 1 saline and using CONAMA resolution no. 357 of 2005, it is established that the maximum value for sulfate is 0.002mg SO_4^{--}/l and for chloride it is 0.01mg Cl^-/l.

Like sulfate, it is known that chloride also interferes in the anaerobic treatment of industrial effluents, constituting an interesting field of scientific investigation as well. High levels of mineral salts, particularly sulfate and chloride, are associated with the tendency of corrosion in distribution systems, in addition to adding flavor to the waters. Under anaerobic conditions, sulfates are reduced to sulfides; and in effluent treatment stations (ETS), they cause odor problems [16, 17]. An increase in chloride content in the water is an indicator of possible pollution by sewage (through excretion of chloride in the urine), industrial waste and water used for irrigation [18, 19].

Still in Table 1, the maximum values for Ca^{2+} were found in CS1 and CS6, with 100.8 mg/l and 90.18 mg/l, respectively, and the minimum in EC3, with 32.665 mg l.

Calcium may be involved in a series of chemical reactions, including ion exchange, precipitation, and fixation, but its function is not yet well defined. Apparently, they reduce the toxic effect of other ions, notably sodium and magnesium [20, 21, 22].

For Mg^{2+} the maximum value found was 343.625 mg/l in CS1 and the minimum value was 17.625 mg/l in CS2.

For potability purposes, relatively high values of total hardness - TH, predominantly caused by the presence of calcium and magnesium salts (temporary hardness) and possibly also iron, chloride and sulfate (permanent hardness), are allowed. In Brazil, the Ministry of Health ordinance no. 2,914 of December 14, 2011, establishes the maximum limit of 500 mg $CaCO_3$/l for water to be admitted as potable. The objection is due to taste, which can eventually be considered an unpleasant feature of very hard waters [16, 23].

From what can be seen in Table 1, higher values of acidity occurred in CS2 and CS3, respectively 88mg CO_2/l and 112mg CO_2/l, and the lowest results for CS5 and CS6, each with respectively 36mg CO_2/l and 22mg CO_2/l.

Acidity is a measure of the water's ability to resist the pH changes caused by the bases. It is mainly due to the presence of free carbon dioxide, in addition to dissolved solids and gases (CO_2 absorbed from the atmosphere or resulting from the decomposition of organic matter and H_2S). It can also be influenced by industrial dumping and water associated with mining activities [19].

Analyzing Table 1, one can also perceive low levels of total iron, with a value of 1mg Fe^{3+}/l in the Collection Stations, except for CS4, where the presence of total iron was not detected. Considering saline water as Class 1 in CONAMA resolution no. 357 [12], the water must contain a maximum value of 0.3 mgFe^{3+}/l.

In surface waters, the level of iron increases in rainy seasons due to the carrying of soils and the occurrence of erosion processes on the banks. Iron, despite not being a toxic element, poses several problems for the public water supply. It provides color and flavor to the water, causing stains on clothes and sanitary utensils. It also poses the problem of the development of deposits in pipes and iron bacteria, causing biological contamination of water in the distribution network itself. For these reasons, iron is a standard of potability [16, 17].

It can also be seen, from Table 1, that there was a small pH variation in the different Collection Stations, being approximately between 7.4 and 7.9, being within the standards for Class 1 water of CONAMA resolution n.357 [12], where the pH has to be in the range between 6.0 and 9.0. According to [20, 24], for the vast majority of water bodies, the pH varies between 6.0 and 8.0.

pH influences natural aquatic ecosystems due to its effects on the physiology of several species [21, 25]. It is an important characteristic to be controlled in a spring, since it influences the biological processes that occur in the aquatic environment, as well as the toxicity of some compounds present in it [26].

Table 1 also shows that for the real color, CS3 presented the highest value, 90 mgPt-Co/l, and CS4 the lowest value, 40 mgPt-Co/l.

It was observed that all points showed high values for turbidity, being higher than drinking water (5.0 Nephelometric Turbidity Units - UNT), with a maximum value of 58.75 UNT, in CS3, and a minimum value of 19.24 UNT in CS6. Considering Class 1 of CONAMA resolution no. 357 [12], the turbidity parameter can present up to 40 UNT. Therefore, CS3 (585.8 UNT) is out of the standard.

The presence of suspended materials and the color of the liquid mass decrease the transparency of the water, which can significantly reduce the light energy available for photosynthesis. The decrease in transparency negatively affects the aesthetic aspect of the waters, especially the polluted ones, which are now compromised, including for industrial purposes [26]. This color in the water is due to the presence of humic acids and tannin, originated from the decomposition of vegetables, as well as also of anthropogenic origin, coming from industrial residues [27, 28].

Socioeconomic Survey

The city of Recife, capital of Pernambuco, comes over time, going through a process of occupation of urban land, in which environmental degradation is closely related.

The degradation of the Capibaribe River estuary has been affecting the living conditions of the Caranguejo/Tabaiares community in terms of access to and use of water.

According to personal reports, the referred Community is an urban settlement that occupies an area of approximately 7.4 hectares, part of which belongs to the Ilha do Retiro neighborhood and another part to the Afogados neighborhood and is inserted in the margin of the dead arm of the Capibaribe River.

In 1910, the first residents of the Caranguejo community arrived, forming a community of fishermen, whose subsistence came from the Capibaribe River, which provided a large abundance of crabs due to the mangroves. Hence the name of the community: “Caranguejo”.

The Tabaiares Community emerged in 1970, with the appropriation of the land where a Tabaiares Futebol Clube football field was located. So much so that, initially, the name of the community was Campo Tabaiares and over the years, it started to be called “Tabaiares”. The population of the Tabaiares community was formed by those excluded from housing programs, since in the 60s and 70s, the population that was not part of the official programs for obtaining a home, due to the intense political and ideological repression experienced by the military period the country, which stifled any and all forms of claims, had no choice but to occupy empty or little used land.

The first people who occupied the Caranguejo and Tabaiares communities were without electricity, water supply, garbage collection, sewage, and any housing infrastructure. In this way, the houses were "raised" on stilts and built with pieces of wood, cardboard, plastic, iron plates, among other elements obtained in the streets of Recife. Due to the low purchasing power of the population of the referred communities, it is evident the impossibility of buying or renting a property in another location, making them remain in the Caranguejo / Tabaiares community, which is protected by Law 16113 of 1995, as a Special Zone of Social Interest (Zeis).

The interest in preserving the banks of the Capibaribe River, in the municipality of Recife, came to show itself effectively in 2002, when Caranguejo and Tabaiares had existed for over 30 years. In the formation of the Caranguejo and Tabaiares territories, processes of social appropriation of nature related to the Capibaribe River estuary were developed.

The importance of estuaries is due to the fact that they are areas where the reproduction and growth of most marine species occur and function as a natural protection of the coastline against invasion by the tides. In addition, they house an ecological complex formed by several species of fauna and flora, widely adapted to soil conditions.

It is noteworthy that the actions of deforestation, landfills and pollution carried out by the residents of the Caranguejo/Tabaiares community were induced, in a way, by the lack of urban infrastructure and housing supply for the low-income population of Recife. In this scenario, the population itself becomes both a victim and an offender at the same time, because while contributing to pollution in the Capibaribe River, by throwing waste into the river, it also depends on the river itself to survive, through fishing. In this way, their subsistence is compromised, due to the food offered by the mangrove, which is becoming increasingly scarce and/or contaminated, due to the lack of an environmental development process.

The issue of water presents itself as one of the main difficulties experienced by the Caranguejo/ Tabaiares community. The “Housing Need of the Low Income Population” versus “Protection of Ecologically Fragile Areas”, that is, the need for basic sanitation versus intervention by the public authorities in the aforementioned community shows the residents' struggle with the public authorities over the use and use of the waters of the Capibaribe River, the existing pollution due to the dumping of waste directly into the river and the precarious basic sanitation conditions in the community.

Despite living on the banks of water bodies, the Caranguejo/Tabaiares community faces problems in accessing quality water. As a way to survive and try to overcome this type of limitation, the population turns to clandestine pipe connections that pass through the area, introducing taps or hoses to serve the community. In addition to this form of irregular water supply, there are also conducting networks made by residents to reach their homes.

CONCLUSION

The water samples collected at the six stations surrounding the Caranguejo/ Tabaiares

Community showed normal pH values. For the turbidity parameter, the only sample that showed a high value was CS3, with values greater than 40 UNT. The CS1, CS3, CS4, CS5 and CS6 samples showed high values of sulfate and chloride, which can cause problems such as bad odor and taste in the water.

Therefore, it is clear that the population of the Caranguejo/Tabaiares Community is exposed to the damage and risks caused by the poor conditions of basic sanitation, inadequate housing, lack of access to drinking water and water supply.

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