Solid Waste and Its Interference on The Water Quality of The *Igarapé*[1] *do Quarenta* Educandos Basin - Manaus/Am

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[1] Igarapé: Stream that rises in the forest and flows into the river (an indian word in Tupi-guarani)

Summary

The "Igarapé do Quarenta", a *stream in Educandos basin, is categorized today as the "worst" and most polluted of the city Manaus, Amazonas, due to the accumulation of solid waste and contamination by heavy metals along its course. The main objective of this research was to verify the influence of solid waste in critical points of the Igarapé do Quarenta, on the water quality of the stream. The area of solid waste accumulation ("garbage") and the water quality in the stream and around and under the bridges of the Igarapé do Quarenta, between the springs (Armando Mendes and Zumbi neighborhoods) and the mouth (Educandos), in the Amazon "summer" and "winter"," were quantified. Water quality was evaluated at each sampling site. The macroscopic analysis demonstrated its importance for the feasibility diagnosis, finding that two of the three springs found are degraded and disturbed. The pH and electrical conductivity values in the sample sites visited, in the upper and middle, of the Igarapé do Quarenta, were very high values in relation to the maximum values recorded in a natural environment in other water streams of Manaus.*

Keywords: Pollution; Garbage; Macroscopic; Accessibility; Flow;

1. Introduction

On planet Earth there is only 3% fresh water, the remaining is salt water and non-drinking water for human consumption. In the statistics of 3%, about 2.5% is contained in glaciers and another plot is frozen in the Antarctic region (Nunes et al. 2009). Thus, we depend on 0.3% of fresh water with an accessible surface (rivers and lakes) on the planet to supply our needs, which means that of the total volume of water circulating on the planet, only 0.075% is fresh water (Rebouças et al., 1999) and can be accessed more easily. The United Nations (UN) report on the Joint Monitoring Program for Water Supply and Sanitation, prepared by UNICEF and WHO in 2010 (WHO and UNICEF, 2010), concluded that 92% of the world's population does not have access to fresh water, which equates to an approximate total of 800 million citizens in need of water. Brazil is one of the countries with the highest water availability (53% of the South American continent and 12% of the world), although this water is distributed unevenly in relation to population density (Rebouças et al. 1999). The state of Amazonas is one of the most privileged, with water potential of 1.848.3 k^3/year, water demand of 0.14 k^3/year and water availability of 773,000 m^3/inhabitant/year (Tundisi and Tundisi 2011). However, factors such as poor sanitary sewage, lack of treatment and impact mitigation measures, caused by solid materials in urban drainage, have a direct influence on water quality, quality of life of the population and quality of aquatic life (Marinho and Nascimento 2014). With the emergence of the Manaus Free Trade Zone there was a strong population growth, disordered, from the mid-1970s. Without adequate infrastructure, this growth of the city created a set of deficiencies and urban problems that increased the occupation of the banks of the streams (Benchimol 1981), which led to the change in water quality (Nogueira et al. 2007). In this aspect, it is worth mentioning the *Igarapé* do Quarenta, because in addition to housing people's homes, it received the effluents from the industries installed in its basin. Another very prominent factor, over the years (being the subject of international reports, such as, for example, in South Korea), is the accumulation of solid waste ("garbage") in some parts of the streams, being responsible for the flooding of public roads, besides granting the locals unpleasant smell (Pascoaloto et al. 2015).

Previous studies have indicated the *Igarapé* do Quarenta (Educandos basin) as the "worst" (most polluted) stream of Manaus (Melo et al. 2005; Pascoaloto and Soares 2015), mainly due to heavy metal contamination (Silva et al. 1999). Thus, it is important to verify how this interruption in the drainage of the streams affects the quality of the water and the most critical points, in order to suggest/indicate which places need more emergency attention. Siqueira et al. (2010), in their research on the microbiology of drinking water used in feeding units, states that fresh water ends up being the main means of transmitting pathogens of diseases that cause infections, because of this the authors evaluated whether there was the presence of coliforms in localities around the Federal Rural University of Pernambuco, in which it was identified disagreement with the pre-established standards in legislation, attributing the results by the poor hygienic and sanitary conditions of the study sites. In the last decade, Brazil has been marked by the insertion of several regulatory laws and environmental standards, which currently directly and indirectly influence the use of natural resources (Buriti and Barbosa 2014). The environmental importance shaped the structure of the way of governing, in which technical and scientific knowledge about environmental issues and their scope is necessary, and environmental education should exist formally and informally, from an interdisciplinary view (by Fátima Wolkmer and Pimmel 2013).

Facing this problem, this work has as main objective to verify the influence of solid waste in critical points of the Educandos Basin, on the water quality of the streams.

2nd. Study and Characterization of the Area

In the mid-18th century the economy of Manaus was expanding, due to the commercialization of rubber, and for the urbanization of the city to accompany the development, there were significant changes in the structure of the city, where the streams of the city center came to be seen as a stalemate for development, thus initiating a restructuring, such planning was inspired by French urbanizations, backfilling springs and replacing with the works of mansions, water works, luxurious architectural buildings, building of galleries for the urban drainage system (FONSECA, 2008; VALE, 1999). The global population increase was higher between the years 1950 and 1970, and the city of Manaus was no different, being one of the Brazilian cities with the highest population growth rate, where it increased by 79.71%. Such growth is derived from immigration from other states and rural exodus, both in search of new job opportunities, added to the decrease in mortality rate, made the city of Manaus present such an increase (FONSECA E CORREIA, 1972; GOES, 2016). Fonseca (2008), says that the city of Manaus had its highest population growth in the 1990s, because, when compared to the 1960s, it shows a population increase of 582%.

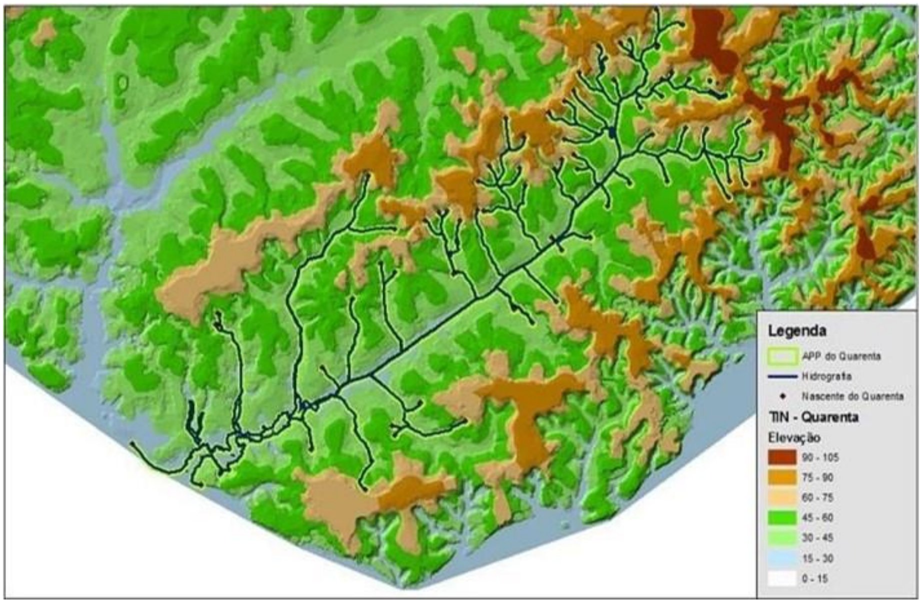

Figure 1. Digital Model of Elevation of the Educandos Basin (Manaus - AM).
Source: (GONÇALVES et al. 2014)

The study was developed in the Educandos basin, according to Figure 01. About 27 sampling sites were selected, based on the ease of access and stability of the substrates. According to Oliveira et al. (2003) apud Frota (2016), the microbasin of the *Igarape do Quarenta* comprises an area of approximately 38 km long, an average width of 6 meters and an average depth of 50 cm, which constitutes the main trainer of the Educandos watershed, which has a total area of approximately 4,320 hectares. The *Igarapé do Quarenta* watershed, is located between latitudes 3º 04´ 16.95" and 03º 08´ 83.51" South, and Longitude 59º 55´ 62.35" and 60º 01´ 31.42" West. Its bed, in relation to the areas of the city of Manaus, runs from northeast to southwest and meets with *Igarapé da Cachoeirinha* and *Igarape do Mestre Chico*, which together form the watershed of Educandos that flows into the Negro River. The study lasted 6 months (January/2021 - June/2021) and had as main objective, to verify the issue of solid waste associated with bridges in the *Igarapé do Quarenta.*

3rd. Methodology

This is a quali-quantitative research, in which is the understanding between "theoretical and practical dynamic, a navigation map with a guiding structure of a process, continuously open to questioning about the key points of the problem raised and possible to be evaluated under criterion of scientific validity" and then apply the descriptive methodology (Ensslin et al. 2007). The area of solid waste accumulation ("garbage") and the water quality in the streams in the bridges of the *Igarapé do Quarenta*, between the springs (Armando Mendes and Zumbi neighborhoods) and the mouth (Educandos), in the Amazon "summer" and "winter", were quantified. The number of sampling sites was defined after the initial visit to find out which bridges over the stream are accessible. To determine the critical points, we used the analysis of the photographic records of the visited bridges, to better visualize the sampling and identify the main types of apparent solid residues (organic matter - branches, leaves, roots; glass, metal, paper and plastic). Water quality was evaluated at each sampling site. The water samples were collected with the aid of a collector and packed in polyethylene bottles

(1000ml), to determine the environmental variables pH and electrical conductivity, according to Rice et al. (2012). The variation in the types of solid waste, was verified over the hydrological period; the interference of "drainage obstruction" on water quality at each sample site investigated. It was also verified, in each sampling site, if there was variation in water quality between the periods of flood and drought and if there was a relationship between this variation and the presence of solid residues. The data, for the execution of the analyses performed, were grouped and organized in the Microsoft Excel spreadsheet, in which they were made even the preparation of a graph for better visualization of the evaluated data. The classification of urban interferences in the springs occured through on-site visits and macroscopic analysis. The execution of the respective method occurred by physical-chemical and biologicalanalysis, the collected data are organized into categories according to Rocha et al. (2017), considering their respective macroscopic characteristics. After collection, the information obtained was analyzed and structured in a statement chart, and the evaluation of the parameters was applied using the quantification method used by Moreira Gomes et al. (2005). This method functions as a score, in which it determines the class that each source analyzed is as to its degree of environmental preservation.

3rd. Results

The results obtained in this work showed that all the analyzed sites are altered, so that it was identified that the entire stream is vulnerable and environmentally weakened, based on the photographic records and observations raised, and it is not possible to identify specific critical points, characterizing the basin so far as in critical situation, for presenting both solid residues and excess organic matter decomposition. According to Silva Milanezi and Pereira (2016), both vulnerability and environmental fragility are directly associated with the fragility of an area, due to suffering environmental damage when subjected to a certain action, ranging from the change of the characteristics of the physical and biotic environment such as slope, altitude, temperature, aridity, vegetation, soil and even exposure to certain sources of environmental pressure, such as population density, land use, directly linked to environmental impacts. According to the World Health Organization (WHO 2008), the management of municipal solid waste plays a prominent role in this world scenario, because in its decomposition process they emit greenhouse gases, directly affecting the environment and population health, which should have special attention, since the data indicate constant growth in waste generation. The action of the health sector to create or practice an environmental surveillance model, related to the quality of water for human consumption, which takes into account health and well-being, is extremely important. In addition, it is important to be aware of the need for current legislation in order to implement national models and programs related to water quality (Brazil 2016).

According to the World Health Organization report data, 1.1 billion people remain without sewage networks or with poor distribution, about 4,000 children die daily from diarreic diseases caused by poor water quality, only 63% of the world population would have access to quality sanitation, which includes treatment of sewage treatment plant, efleunt treatment plant, garbage collection etc. it also addresses a forecast that in 2015 this percentage would be 67%.

The constant population growth, which in its consequences, the economic and technological developments and the lack of change in the consumer lifestyle, help to build results as the constant growth of solid waste generation, in quantity and diversity, highlighting urban and metropolitan areas, as they go on reducing the quality of life of this population, since, such waste from new technologies, have in their composition synthetic and dangerous elements to the ecosystem and human health (Gouveia 2012).

When the population dumps solid waste on the surface of the streets and gutters (Figure 2 – A), it contributes directly to the pollution of the water course, because through the urban surface runoff, it transports such waste through the river networks to the stream, characterizing it as a diffuse form of pollution of urban rainwater. Studies on diffuse pollution in the rainwater of an urban drainage basin analyzed the rates of solid waste load in the washes of an urban basin in the city of Natal-RN, quantifying the pollutant loads in the defoliion due to nine rainfall events, which occurred in 2013 (Righeto et al. 2017). The authors identified that the analysis of diffuse pollution in the streets is complex and difficult to measure, but concluded that rainfall events present great polluting potential of water bodies.

Figure 2. Disposal of Solid Waste in the banks and surrounding areas in the *Igarapé do Quarenta*

The rainflow of cities can lead from solid waste, soil sediments to pollutants from areas near the point of recollection, besides having clandestine connections of residential sewers, where such rates of diffuse pollution are directly linked to economic, social and public interest aspects.

It has been identified that it is not only a one-off pollution of residents near the *Igarapé do Quarenta*, in which solid waste pollution comes from the entire vicinity of the body of water, where such waste is dragged through the surface runoff to the drainages following to the stream, agreeing with Takano et al. (2006), whose study in the Tarumã basin, the population established on the banks of the *Igarapé do Pedreira* stated that the waste came from the stream and intensified with rain.

The water analysis revealed that none of the sample sites is in a natural state, when compared to the data recorded by Costa et al. (2016).

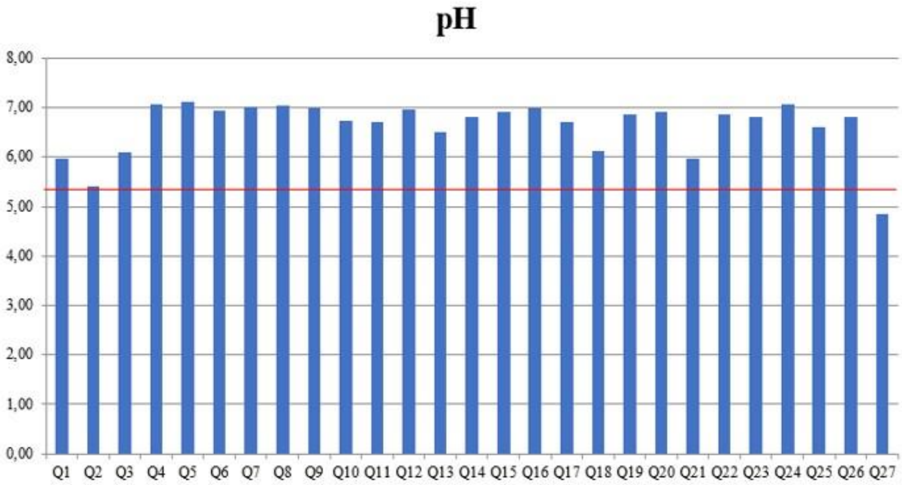

Figure 3. PH values in the sampling sites in the upper and middle of the *Igarapé do Quarenta* basin in relation to the maximum values recorded in the natural environment of the city of Manaus (line in red) by Costa *et al.* (2016).

However, when comcommencing the results obtained for the two variables presented in this report (pH and electrical conductivity), it is noticed that the sample sites least impacted was Q2, that is, the low quality of the *Igarapé do Quarenta* comes from the headwaters. It is emphasized that it was not possible to collect water in the main spring, located in the *Sauim Castanheira* Wild Refuge (SEMMAS 2016) – which is closed for the works of the future "Parque das Nascente do Igarapé do Quarenta". The Q2 sampling site is located next to the *Sauim Castanheira* Wild Refuge.

Electric conductivity

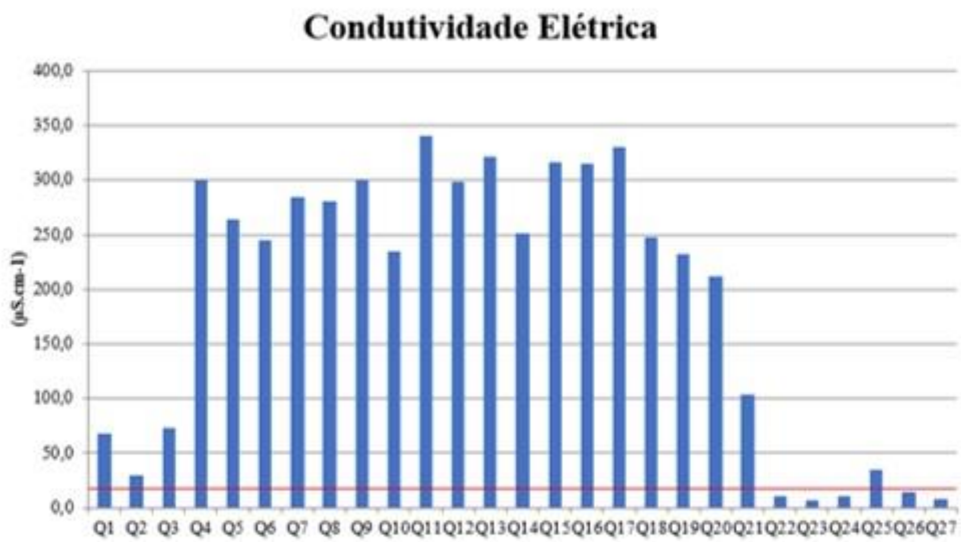

Figure 4. Values of electrical conductivity in the sample sites visited in the upper and middle of the *Igarapé do Quarenta* basin in relation to the maximum values recorded in natural environment in the city of Manaus water streams (line in red) by Costa et al. (2016).

The classification regarding the degree of preservation of the 3 (three) springs of *Igarapé do Quarenta*, was carried out by summing up the current situation of the indicators prearranged, being characterized as springs in the conditions: Great (A: 31 – 33), Good (B: 28 – 30), Reasonable (C: 25 – 27), Bad (D: 22 – 24) and Bad (E: Below 21).

In the present study, nomenclatures from 01 to 03 were used for the cataloguing of springs, each number referring to one of the springs analyzed. In the spring N1- (Q 12 - 03º07'51.2" S / 59º94'35.3" W) by collecting the physical parameters of the present spring, it was found that it has the color ation of dark water, with the presence of solid residues around the water body and odor, this spring is already suppressed by urban buildings, being characterized in a stream, in which it receives loads of both solid waste and domestic sewage. S 03.08084 W 59.93721.

Table 1. The capitals, assets and revenue in listed banks

SPRINGS	COLOURING	SOLID RESIDUOS	MAT. FLOATING	OILS	SITE PROTECTION	INSERTION AREA	ODOUR	SEWAGE	FOAM	VEGETATION	HUMAN USE	ANIMAL USE	PUNCTUATION	LEVEL OF PRESERVATION
N1	1	1	1	2	1	1	1	1	3	1	1	2	16	Lousy
N2	2	2	3	3	1	2	3	3	3	2	1	2	27	Reasonable
N3	3	2	3	3	1	3	3	3	3	3	1	2	30	Good

Description for the above table.

The Spring N2 (Q 23 - 03º08'08.4" S / 59º93'72.1" W), was whistling due to recreational use, mainly affecting its water body. According to Silva et al. (2018) the disordered growth of communities around protected areas causes social and environmental problems, mainly contributing to the degradation of water bodies and green areas.

It was found that the accessibility in the springs N2 and N3 is ofmild degree, with no protection in its surroundings. The Proximity to homes and establishments is a factor that influences their environmental degradation. In this indicator, Leal et al. (2017) points out in his study that 33% of the detected outcrops of then springs are less than 50 meters from urbanized areas, not obeying the limits established by the legislation. The analyses carried out in two springs by Silva et al., (2014) found the direct influence on the springs due to the proximity of urban equipment.

Despite the presence of solid residues, the color of the water from the N3 spring was classified as clear, being considered in good condition. The research presented by Leal e Oliveira (2017) informs that 08 of its 15 springs analyzed fit the light color, considering that five springs did not have access. Von Sperling (1996) states that the parameter of water color ation is the result of the existence of substances in solution that can be caused by elements such as iron or manganese, by the decomposition of the organic matter of water (mainly vegetables), by algae or by the introduction of industrial and domestic sewage. The springs N1 and N2 were classified as low preservation condition (chart 1). They are areas located near patios and residences and do not have protection. Both showed critical degree regarding the presence of solid residues, floating materials, presence of sewage and human use.

Thus, applying the preservation index adapted by Moreira Gomes et al., (2005) through the sum of points, N1 obtained a score of 16 and N2 obtained a score of 27, being classified respectively in Class E and C, as poor and reasonable.

However, N3 is in a good condition of preservation, because the analysis of its macroscopic characteristics was median, obtaining the classification B, as good. It should be emphasized that these data are considered alarming, since the one of the springs is located in a conservation unit of integral protection. Considering also that one of the main functions of conservation units is to fully protect the natural areas of interest for future generations (Tozzo, 2014).

5th. Conclusion.

The water analysis revealed that none of the sample sites is in a natural state, equalizing with the visual situation of the basin, where it was shown as a whole in a critical state of pollution. Studies are necessary for the qualitative identification of solid residues that arise in the water streams in a diffuse way. The study of the springs found in the *Igarapé do Quarenta* was necessary, because one of the springs was in a conservation unit of integral protection and the others in private areas, and are in a vulnerable situation in the face of urban growth in its surroundings. Thus, methods for analysis of their susceptibilities were developed in order to diagnose the degree of criticality of the outcrops. In this research, the application of macroscopic analysis demonstrated its viability, finding that two of the three springs found are degraded and disturbed. It is of paramount importance to tighten and comply with existing environmental legislation, meeting the unique needs of these areas and it is also important to increase safety around the park. In this study, it is suggested to send the analysis to the public secretariat responsible for the environmental management of the studied locations.

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