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SANITATION AND WATER QUALITY IN THE PACIÊNCIA RIVER BASIN, MARANHÃO ISLAND, BRAZIL

Saneamento e qualidade das águas na bacia hidrográfica do rio Paciência, Ilha do Maranhão, Brasil.

Saneamiento y calidad del agua en la cuenca del río Paciência, Isla de Maranhão, Brasil

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SUMMARY

Sanitation has great influence on the quality of life of the population, because in the absence of the same, increases the incidence of cases of disease and, in General, causes impacts on the environment. In this context, water as a resource of the utmost importance for maintaining life, became the primary vehicle of contamination and proliferation of disease due to inadequate sewage discharges (effluent release household in natura and waste solids), which in your time, intensifies the process of degradation of watersheds. Therefore, the development of evaluation studies and monitoring the quality of watersheds makes if necessary, and in this way, actions for the management team and conservation of waters. Thus, this study aimed to analyze the basic sanitation in the catchment area of the River Patience, on the island of Maranhão. Specifically, the objectives were: to assess the performance indicators of the basic sanitation; assess the quality of water through the analysis of physical, chemical and biological parameters and finally determine the water quality Index- IQA. It was noted that data on the incidence of sanitation along with IQA, the study area is compromised, indicating water bodies pollution making it unfit for use. This situation mainly associated to the use and occupation of the soil and the deficiency of sanitation in the basin.

Keywords: Sanitation. Water quality. Hydrographic basin.

RESUMO

O saneamento tem grande influência na qualidade de vida da população, pois na ausência do mesmo, aumenta a incidência de casos de doenças e, de forma geral, acarreta impactos no ambiente. Neste contexto, a água como um recurso de extrema importância para manutenção de vida, se tornou o principal veículo de contaminação e proliferação de doenças, devido aos descartes inadequados (lançamento de esgotos domésticos, efluentes in natura e resíduos sólidos), que por sua vez, intensifica o processo de degradações dos mananciais. Deste modo, esta pesquisa objetivou analisar o saneamento básico na bacia hidrográfica do rio Paciência, na Ilha do Maranhão. Especificamente os objetivos foram: avaliar os indicadores de desempenho do saneamento básico; avaliar a qualidade das águas por meio da análise de parâmetros físico, químicos e biológicos e por fim determinar o Índice de Qualidade da Água – IQA. Constatou-se que diante dos dados dos índices de saneamento juntamente com IQA, a área de estudo encontra-se comprometida, indicando poluição dos corpos hídricos tornando-se impróprios para uso. Está situação associa-se principalmente ao uso e ocupação do solo e a deficiência do saneamento básico na bacia.

Palavras-chave: Saneamento. Qualidade da água. Bacia hidrográfica.

RESUMEN

El saneamiento tiene una gran influencia en la calidad de vida de la población, ya que, en ausencia de ella, aumenta la incidencia de casos de enfermedad y, en general, tiene impactos en el medio ambiente. En este contexto, el agua como recurso de extrema importancia para el mantenimiento de la vida se ha convertido en el principal vehículo de contaminación y proliferación de enfermedades, debido a la eliminación inadecuada (liberación de aguas residuales domésticas, efluentes frescos y residuos sólidos), lo que a su vez intensifica el proceso de degradación de los manantiales. Por lo tanto, esta investigación tuvo como objetivo analizar el saneamiento básico en la cuenca del río Paciência, en la isla de Maranhao. Específicamente, los objetivos eran: evaluar los indicadores de rendimiento del saneamiento básico; evaluar la calidad del agua a través del análisis deparámetros físicos, químicos y biológicos y, finalmente, determinar el índice de calidad del agua (AQI). Se encontró que, en vista de los datos de los índices de saneamiento junto con AQI, el área de estudio se ve comprometida, lo que indica que la contaminación de las masas de agua se vuelve inadecuada para su uso. Esta situación se asocia principalmente con el uso y la ocupación de la tierra y la deficiencia de saneamiento básico en la cuenca.

Palabras-clave: Saneamiento. Calidad del agua. Cuenca.

1 INTRODUCTION

Environmental issues have become one of the greatest challenges today, through changes in the environment, where man seeks to meet their needs. In this context, one of the biggest deficiencies, especially in developing countries, is the lack of sanitary infrastructure, which in turn compromises the well-being of the population and degrades the environment.

To this end, sanitation has been implicitly present in society since the oldest civilizations, the first precautions arose with storage, filtering water and waste dumps in vacant places. The high rates of population growth in urban centers triggered a series of diseases, which prompted the government to seek corrective measures.

Thus, the guidelines for Brazilian sanitation began to be defined by the National Sanitation Plan (PLANASA) in the 1971s, but due to the crises in the country, the plan ended. Under new leadership, the government implemented new programs, such as the Sanitation Program for Urban Centers - PRONURB, which in turn followed the same path as PLANASA.

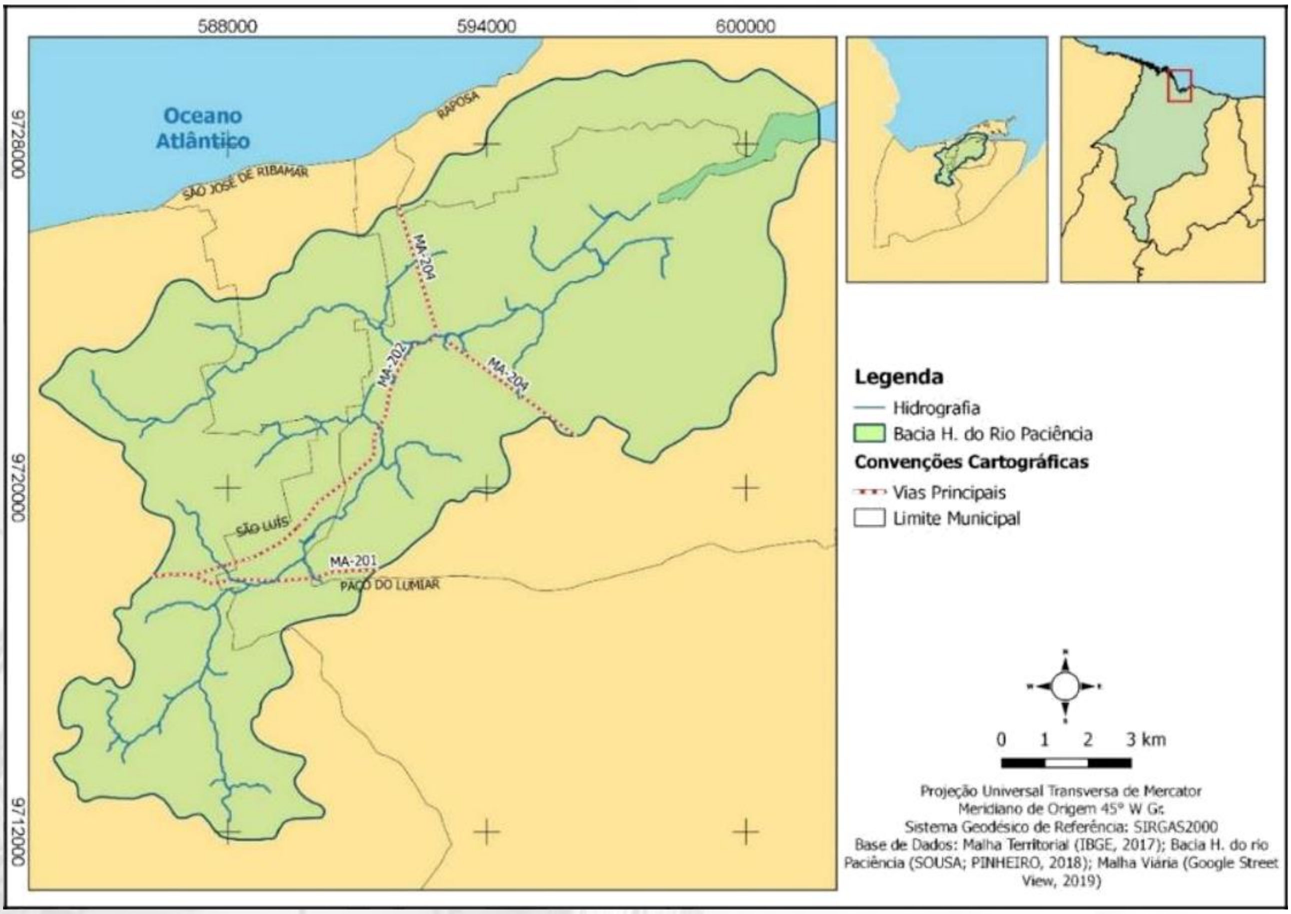
In 2007, Law Nº. 11,445 with the function of managing basic sanitation in Brazil, later that regulation was revoked in July 2020 for Law Nº 14,026, which went on to establish a new paradigm for planning in the sector in question. This legal framework provided significant changes in the basic sanitation policy, with goals of universalization and qualification of the services provided.

The lack of health management affects all social aspects of the population, with health being the most affected. As a result, water resources, which are sources of life, have become sources of domestic and industrial sewage disposal, solid waste, resulting in numerous waterborne diseases. In this way, it is necessary to monitor the quality of water to assess the sanitary conditions of the watersheds and provide information for the management and maintenance of water resources.

Water quality is characterized by physical, chemical and biological parameters described in resolutions, ordinances and laws that establish a set of conditions and water quality standards to meet its use. In view of this, it is of great importance to monitor the water quality of watersheds, water resources planning units, according to the Water Law, No. 9,433 of 1997, mainly with regard to public consumption, since the economic and social development of the population is based on the availability of good quality water.

In this context, the study area inserted in the Island of Maranhão, is located in the northeast region of Brazil, and covers the municipalities of São Luís, São José de Ribamar, Paço do Lumiar and Raposa, being an intermunicipal basin comprised between the geographic coordinates 02º 25' 30” to 02º 37' 30” South Latitude and 44º 07' 30” to 44º 16' 30” West Longitude (as shown in figure 01).

Figure 01-Location map of the research area.



Source: SOUSA (2019).

The process of degradation of a watershed is directly related to the processes and forms of occupation over time. “On the Island of Maranhão, made up of several river basins, this process accelerated, especially from the second half of the 20th century onwards, when investment in the industrial and housing sector intensified (PEREIRA, 2006 p.58)."

In this way, the population development of the São Luís capital began with the concentration of the textile factory located in Vila Anil and the commerce sector. Subsequently, the arrival of the companies ALUMAR (Consórcio de Alumínio do Maranhão SA), Porto do Itaqui, Ferrovia Carajás and Companhia Vale do Rio Doce brought service providers, which led to the migration of people to the city, causing a population swelling, which which results in the gradual increase of occupations in the city.

From these perspectives, in the 1980s, the city of São Luís had accommodation located to the south of the basin from the beginning of industrialization and expansion of commerce. Then, given the urbanization process developed from the construction of large housing complexes, the occupations in the entire area of the basin expanded to the municipalities of Paço do Lumiar, São José de Ribamar and Raposa, triggering serious environmental problems.

It should be noted that the Paciência River is in a constant state of environmental degradation due to the in natura discharge of sewage, mainly from domestic sources. Thus, water quality is affected, considerably increasing the risk of water contamination, triggering a problem with basic sanitation, especially with regard to public supply.

In this context, this work had as general objective to analyze the basic sanitation in the watershed of the Paciência River, in the Island of Maranhão. Specifically, the objectives were to evaluate performance indicators for basic sanitation; evaluate the water quality through the analysis of physical, chemical and biological parameters and finally determine the Water Quality Index - IQA.

2 METHODOLOGY

The study consisted of three stages: office, field and laboratory following some methodological procedures and based on some research, such as CORREA (2018); SALGADO et al. (2013) who developed studies in the area of the Paciência river watershed. The information base used to compose the basic sanitation data for the municipalities covered by the basin was the National Sanitation Information System (SNIS), which is currently the most complete database on the sector in Brazil.

The years of 2015 and 2017 were taken into account for the municipalities of São Luís, São José de Ribamar and Paço do Lumiar. Part of the territory of these municipalities is part of the basin. The SNIS platform does not yet have information on the municipality of Raposa, for this reason, it was not considered. To complement the data, the information made available in the ANA Sewage Atlas was also considered.

With regard to the field, sampling is one of the most relevant steps and therefore prudence and technique are needed at this stage so that there is no contamination or losses that could interfere with the results. Thus, the collection was carried out in accordance with the National Guide for Collection and Preservation of Samples (CETESB, 2011) and the Technical Standard of ABNT No. 9,898/97.

At first, the collection area was recognized at previously selected sample on Google Earth, which were later confirmed in the field on 12/22/2017, in the morning, with the aid of GPS (Global Positioning System), model Garmin. It should be noted that nine sample were collected, these represent the situation of the basin.

Soon after, the material was collected in sterile plastic conteiner (1000 ml), with all the asepsis care and identified according to the sample, matrix and parameters to be performed, thus being considered a simple collection.

The temperature, pH and DO parameters were determined in loco using the AKSO multiparameter probe, model AK87, calibrated before carrying out the analytical tests and the others (BOD, ST, Thermotolerant Coliforms, Total Nitrogen, Total Phosphorus and Turbidity) started analyzes within 24 hours.

The BOD determination consists of measurements of the dissolved oxygen concentration in the samples, diluted or not, before and after the 5-day incubation period at 20ºC. by Thermo in the Orion 3STAR model and then the samples were incubated at 20±1°C, according to the criteria of the Standard Methods for the Examination of Water and Waste water; 23rd edition, 2016.

Total solids were determined by the gravimetric method, in which all substances remain in the capsule after complete drying of a given volume of samples. In this method, porcelain capsules were used, all of which were tared before adding 100 ml of samples and weighed after drying on an Ohaus semi-analytical scale in the model PA214CP. These samples were dried in the Nova Ética oven using the 400/4ND model at a temperature of 94°C; after drying, they remained for another 1 hour at a temperature of 103 - 105°C.

The parameter of thermotolerant coliforms was determined by counting, using the filtering membrane technique, which consists of inoculating the sample in specific culture media (mFC Agar) for the development of bacteria from the coliform group.

The samples were diluted with buffered water due to the matrix and concentration of odors, turbidity and among other characteristics. Soon after, the samples were filtered to retain the possible microorganisms present, through a specific filtering membrane of 0.45µm porosity. The membrane was placed in a Petri dish containing culture medium and subsequently incubated in a culture oven at 44.5±0.2°C for 24 hours. The reading was made by the growth of blue colored colonies, which developed in the culture medium.

To determine the total nitrogen parameter, the Alfakit Photocolorimeter AT 10P equipment was used, where 5ml of the sample was measured and transferred to a photocolorimeter tube, which in parallel was carried out a blank test using distilled water, after calibrating the equipment, the samples were read.

Total phosphorus was determined through colorimetry performed by the Vanodomolybdic Method as indicated by the Spectrokit from Alfakit, purchased for this work, with the aid of a UV/VIS spectrophotometer, model DR 200, from the HACH brand, at the

Laboratory of Food and Water Analysis at the Veterinary Building. (CCA/UEMA). The selected wavelength was 415 nm (nanometer). This method is described in Standard Methods for the Examination of Water and Wastewater; 21st edition, 2005.

Turbidity was determined using an Alfakit bench turbidimeter, based on the nephelometric principle, with a pre-programmed turbidity calibration curve for readings in the range of 0 to 1000 NTU. First, a blank test was carried out, filling a cuvette with distilled water; after reading the blank test, the samples were read.

3 BASIC AND ENVIRONMENTAL SANITATION

Sanitation comes from the Latin "sano" which means the action of sanitizing, of making clean and habitable an area that provides living conditions for a population. Nowadays sanitation has gained a broader concept.

According to the National Health Foundation:

> The concept of sanitation has been socially constructed throughout human history, depending on the material and social conditions of each era, the advancement of knowledge and its appropriation by the population. The notion of sanitation assumes different contents in each culture, due to the relationship between man and nature and also in each social class, relating, in this case, to the material conditions of existence and the level of information and knowledge (FUNASA, 2015, p.18.).

According to Law No. 14.026 / 2020, in its 3rd. Art, basic sanitation is defined as a set of services, infrastructures and operational installations considering: supply of potable water, sanitary sewage, urban cleaning and management of solid waste, drainage and management of urban rainwater.

According to the World Health Organization (WHO, 2000), "sanitation constitutes the control of all factors in the physical environment, which exert or may exert deleterious effects on their state of physical, mental or social well-being". By adding the environment where there are social relations, man's way of life, the concept of basic sanitation was expanded to environmental, conceptualizing as:

> The set of socioeconomic actions aimed at achieving levels of environmental health, through the supply of potable water, collection and sanitary disposal of solid, liquid and gaseous waste, promotion of sanitary discipline in land use, urban drainage, disease control transferable goods and other services and specialized works, with the purpose of protecting and improving urban and rural living conditions (FUNASA 2015, p. 19).

The environmental insertion in the sanitary aspects gave a new perspective in the social and environmental relation. However, the picture of access to sanitation is not so far from the reality of the last century, according to the latest report released by the World Health Organization (WHO, 2017), about 4.5 billion people in the world do not have access to safe sanitation (the one that is connected to a treated sewage network), and more than 2.3 billion do not even have access to bathrooms.

From this perspective, it is worth emphasizing that “Brazil, in a basic issue such as sanitation, remains among the most backward, having numerous deficiencies in relation to the guarantee of treated water, collection and treatment of sewage for the population. It should be noted that the parts of the population that suffer most from the large deficits in coverage of basic sanitation services are the rural population and the low-income population” (LANDAU, 2016).

In order to monitor the development of sanitation in the country, in 1996 the National Information System on Sanitation (SNIS) was created by the federal government in order to assist in the planning and execution of sanitation policies. This system comprises an operational, managerial, financial and quality database on the provision of Water and Sewage, Urban Solid Waste and Urban Rainwater services.

“SNIS has established itself as the largest and most important database in the Brazilian sanitation sector. The historical series (1995-2011) allows the identification of trends in relation to the data, the elaboration of inferences regarding the trajectory of the variables and the design of public policies with greater foundation” (COSTA et. al. 2013).

Data on water and sewage services are provided to the SNIS by state companies, municipal companies and autarchies, private companies and, in many cases, by the municipalities themselves, all named in the SNIS as service providers (SNIS, 2016). This information makes it possible to monitor the management and services provided in Brazilian municipalities.

In the study in question, indicators were used that portray services related to public water supply, sanitary sewage and solid waste management, therefore, the analysis carried out is related to basic sanitation in the Paciência river basin, and not to the environmental sanitation, which involves a set of technical and socioeconomic actions, with the objective of achieving increasing levels of environmental health, as previously defined. The indicators studied were:

• **Sewage Collection Index (IN015):** this index portrays the percentage of sewage collected without treatment.

• **Sewage Treatment Index (IN016):** monitors the percentage of collected sewage that is treated before final disposal.

• **Average per capita water consumption index (IN022):** monitors the amount of water in l/inhab./day of the total population of the municipality served with water supply.

• **Urban water service index (IN023):** monitors the percentage of the population in the urban area of the municipality that benefits from public drinking water supply services.

• **Urban Sewage Service Index in Relation to Water Supply Service (IN024):** This Index monitors the percentage of the municipality's urban population that benefits from public sewage services that are connected to sewage collection networks in relation to the urban population that is served with water supply.

• **Water consumption index (IN052):** monitors the percentage of the population in the urban area of the municipality that consumes this resource.

• **Total Water Service Index (IN055):** monitors the percentage of the total population of the municipality that consumes this resource.

Sanitary Indicators have been widely used to assess sanitation conditions and these may represent the effects of inefficiency on human health. According to Teixeira et. al. (2004), sanitation has a profound impact on the quality of life of a population, interacting with cultural, economic and political issues in a given region. The lack of investment in this sector ends up often causing, among other things, an increase in the incidence of cases of diseases related to sanitary conditions in general, negatively interfering in the well-being of the population.

The lack of sanitary infrastructure mainly affects individuals from the poorest layers of society, which is evidenced by the high incidence of diseases such as cholera, typhoid fever, diarrhea, hepatitis A, among others, which contributes to the decrease in the quality of life of the population.

According to the survey "Inadequate Sanitary Sewage and Impact on Population Health" carried out by the Trata Brasil Institute, diseases related to inadequate water and sewage systems and deficiencies in hygiene cause the death of millions of people every year. Children are more affected, with diarrhea as the second leading cause of death in children under 5 years of age according to (TRATAR BRASIL, 2013, s.p)

Therefore, “diseases that affect human health cause not only harm to people, but also reduce the collective security of the population and produce economic impacts due to numerous interactions, increased mortality and activity dysfunction” (TUNDISI et al 2006 p.251).

3.1 Pollution and water quality

In a context of lack of basic sanitation or its inefficiency, surface sources are directly affected, where the lack of planning in the use of water resources generates degradation, such as pollution and contamination of watercourses, silting and among others that influence in quality of life.

Water resources, as an important part of the physical environment, are easily compromised, whether in terms of quality and/or quantity, or due to characteristics such as alteration of watercourses or reduction of drainage channels, making the current scenario of degradation and neglect worrisome (SILVA, 2003 p. 43).

Water pollution is understood as “the addition of substances or forms of energy that, directly or indirectly, alter the nature of the body of water in such a way as to jeopardize the legitimate uses to which it is put” (SPERLING, 1996). , p.32).

However, not every ecological alteration can be considered pollution, since it is classified based on the modification of the aspect of the original system in a way that interferes with the lives of beings that inhabit a certain environment. On the other hand, the contamination, is distinguished by affecting the environment without changing the physical characteristics of ecological relationships over time (SANTOS, 2014, p.22).

In the scenario of water depreciation, it is necessary to clarify that the existing quality of a certain water is different from the desirable quality for it, since the desirable quality concerns its foreseen use.

In this way, water quality is the result of natural phenomena and human action, in general, it can be said that the quality of a given water is a function of the use and occupation of the soil in the watershed (SPERLING, 1996). In view of this, each use will require specific assessments regarding the physical, chemical or biological characteristics of the water.

For water characterization, several parameters are used which represent its particularities, these parameters are quality indicators and constitute impurities when they exceed higher values established by current legislation for a given use.

The indicators emerged as a tool for assessing water and social impacts caused by the multiple uses of water. It is worth emphasizing that the indicators are essential in public policy decisions and it is through them that the monitoring of water resources takes place.

As presented by the National Water Agency:

> Monitoring is the set of practices aimed at monitoring certain characteristics of a system. When monitoring the quality of natural waters, changes in the physical, chemical and biological characteristics of the water, resulting from human activities and natural phenomena, are monitored. Practices related to monitoring include the collection of data and samples in specific locations, carried out at regular intervals of time, in order to generate information that can be used to define the current conditions of water quality (ANA, 2016, s.p.).

To monitor changes in water bodies, "various quality indicators were developed by different entities and with different purposes, and all of them have in common the weighted combination of a set of factors" (BRAGA et. al., 2005). In this context, such indices were developed, the Aquatic Life Preservation Index (IVA), Trophic State Index (TSI), Water Quality Index (IQA), among others, each for a specific purpose.

However, the most known and used index is the Water Quality Index. (IQA), which was developed in 1970 by the National Sanitation Foundation (NSF) in the United States, but it was only from the 1975s onwards that it began to be used in Brazil by the Environmental Company of the State of São Paulo (CETESB). This index was developed to mainly assess the quality of raw water, aiming at public supply, and was adapted from the original version.

The structure of the IQA was established through opinion polls of several specialists in the area, which among 35 proposed variables, only nine parameters were chosen, namely, temperature, hydrogen potential (pH), turbidity, Dissolved Oxygen (DO), Biochemical Demand of Oxygen (BOD5,20), total nitrogen, total phosphorus, total residues and thermotolerant coliforms.

"The indices can be interpreted as grades, which portray the water quality of a given point through a single value, which facilitates the understanding of the general public and the comparison between the evaluated points" (SPERLING, 2005). In this sense, the parameters have a weight as shown in table 01.

Table 01 -Weights (W) of the IQA parameters

parameters	Weights (w)
Dissolved oxygen - DO	0.17
Hydrogen Potential - pH	0.12
turbidity	0.08
Temperature	0.10
total residue	0.08
thermotolerant coliforms	0.15
Biochemical Oxygen Demand - BOD5, 20	0.10
total nitrogen	0.10
total phosphorus	0.10

Source: ANA (2009).

With data adequacy, Water Quality Index is determined by the following Equation:

$$IQA = \prod_{i=1}^{n} q_i^{w_i}$$

IQA: Water Quality Index, a number between 0 and 100;

qi: quality of the ith parameter, a number between 0 and 100, obtained from the respective "average quality curve variation", depending on its concentration or measure and,

wi: weight corresponding to the ith parameter, a number between 0 and 1, attributed according to its importance for the overall quality conformation. n: number of variables included in the calculation of the IQA.

The IQA value is composed of categories, in which the classification varies from poor to excellent quality, receiving values from 0 to 100 (Table 02).

Table 02 -IQA classification

Category	weighting
Excellent	79< IQA ≤ 100
Good	51 < IQA ≤ 79
Regular	36 < IQA ≤ 51
Bad	19 < AQI ≤ 36
terrible	IQA ≤ 19

Source: CETESB (2008).

Faced with changes in the water system, the importance of indicators and indices for monitoring the evolution of water quality is notorious, even though their representation is small on the national scale of impacts.

4 RESULTS AND DISCUSSIONS

In the study area, the management of sanitation and public supply in the municipality of São Luís is the responsibility of the Environmental Sanitation Company of Maranhão – CAEMA; BRK Ambiental is responsible for the municipalities of Paço Lumiar and São José de Ribamar e Raposa, which is coordinated by the Autonomous Service, supervised by the municipal government. These companies annually (or should) forward information to the SNIS, which uses primary data to calculate operational sanitation rates.

In view of this, the results are presented by municipality that makes up the watershed of the Paciência River, based on the years of 2015 and 2017 with information available on the SNIS platform, for the indicators studied, as well as through the information contained in the ANA’s Sewage Atlas.

- **Municipality of São Luís**

With regard to water consumption and service in the city of São Luís, the performance indexes shown in table 03 were taken into account.

Table 03 -Operational Performance of Water Consumption and Service in the Municipality of São Luís.

Year	POP _TOT	IN022 - Consumption average per capita of water (l/hab./day)	IN023 - Index service urban water (%)	IN052 - Index consumption of Water (%)	IN055 - Index service total water (%)
2017	1,091,868	130.51	88.12	36.47	83.23
2015	1,073,893	130.64	90.33	33.80	85.31
Average		**130.57**	**89.22**	**35.15**	**84.27**

Source: National Sanitation Information System, adapted by the author (2019).

Based on what is shown in the table, it appears that between 2015 and 2017, the average per capita water consumption (IN022) practically remained around the average of

130 l/person/day. Corroborating this sense, it appears that the percentage of urban service (IN023), as well as the water consumption rates (IN052) and the percentage of total water service (IN055) varied little.

It is understood that despite the population growth in this municipality, there was not a significant increase in the performance of water supply in the same proportion. These results indicate that, even in the municipality, there is no universality of access to water by the population, through the local distribution network, that is, the lack of access to piped water is still a reality for the population, or even part of it. of this population opted for other alternative sources, such as supply through tube wells.

The operational performance of sewage collection, service and treatment in the municipality was analyzed considering the indicators presented in table 04.

Table 04 -Sewage collection and treatment performance in the city of São Luís.

Year	POP_TOT	IN015 - Index of collection of Sewer(%)	IN016 - Index of treatment of Sewer(%)	IN024 - Index of urban care of sewage referred to municipalities served with Water (%)
2017	1,091,868	71.60	22.02	51.60
2015	1,073,893	62.49	14.04	51.19
Average		**67.05**	**18.03**	**51.40**

Source: National Sanitation Information System, adapted by the author (2019).

In this table, it is observed that despite a decrease in relation to the sewage collection index (IN015), in the years of 2015 and 2017, an improvement can be seen in relation to sewage treatment. However, the urban sewage service does not present a significant growth.

The behavior verified through the index (IN024) portrays that the benefit of public sewage services in the municipality is still deficient, that is, not the entire population in São Luís served with water supply is connected to sewage collection networks Restroom. This is a worrying fact, which leads us to reflect that the population is looking for other alternatives, and that may cause damage to the environment and for themselves, such as the improper disposal of raw sewage in the environment, among other “solutions”. Clandestine sewage connection causes overwhelming environmental damage, taking waste to streams, rivers and seas.

- **Municipality of São José de Ribamar**

With regard to the municipality of São José de Ribamar, table 05 presents the results on the performance of water consumption and service in the municipality.

Table 05 -Operational performance of water consumption and service in the municipality of São José de Ribamar.

Year	Population (IBGE)	IN022 - Consumption average perch of Water (l/hab./day)	IN023 - Index of attendance urban water (percentage)	IN052 - Index consumption of Water (percentage)	IN055 - Index of attendance total water (percentage)
2017	176,008	171.52	90.00	41.22	58.76
2015	174,267	127.79	90.00	33.80	56.17
Average		**149.66**	**90.00**	**37.41**	**57.47**

Source: National Sanitation Information System, adapted by the author (2019).

It is understood that the maintenance of the IN023 index at 90% indicates that there was not universality for the urban water service, or that possibly occurred, on the part of the population, it was an alternative search for supply, which is not necessarily connected to the water supply network. It must also be considered that the percentage added to the IN055 may include service to rural areas.

Regarding the operational performance of sewage in the municipality of São José de Ribamar is represented in table 06:

Table 06 -Performance of urban sewage collection, treatment and service in the municipality of São José de Ribamar.

Year	Population (IBGE)	IN015 - Index collection of Sewer (%)	IN016 - Index of treatment sewage (%)	IN024 - Attendance rate urban sewage referred to municipalities served with Water (%)
2017	176,008	46.19	67.07	31.62
2015	174,267	38.09	84.5	18.43
Average		42.14	75.79	25.03

Source: National Sanitation Information System, adapted by the author (2019).

The results in table 06 show a small increase of 21.1% in relation to the sewage collection index (IN015) for the years 2015 and 2017, however, there is a reduction in relation to sewage treatment (IN016) evidence of improper disposal. São José de Ribamar had an increase of approximately 70% in the respective period referring to the urban sewage service in relation to the other municipalities served with water (IN024) and, regarding the sewage index, it is observed that there was a reasonable reduction.

It appears that although there has been an increase in urban sewage services, the same proportion of growth has not occurred in relation to its treatment, on the contrary, there has been a decrease, that is, the sewage is collected, but not treated.

It should be noted that the lack of sewage treatment has negative and often irreversible consequences for human health, as an efficient sewage system eliminates sources of contamination and pollution, reduces costs in treating water for supply, conserves natural resources and even improvement in the economy, because most illnesses are associated with lack of exhaustion.

- **Municipality of Paço do Lumiar**

With regard to the municipality of Paço do Lumiar, table 07 shows the percentage of the municipality's population that is served or not with water.

Table 07 -Performance of water consumption and service in the municipality of Paço do Lumiar.

Year	Population (IBGE)	IN022 - Consumption medium per capita of water (l/hab./day)	IN023 - Index of attendance urban water (percentage)	IN052 - Index consumption of water (percentage)	IN055 - Index of attendance total water (percentage)
2017	122,420	345.29	0	56.41	11.19
2015	117,877	141.92	0	100	9.76
Average		307,616	0	91,282	22,976

Source: National Sanitation Information System, adapted by the author (2019).

In this context, the average per capita consumption of water (IN022) had a relevant increase. Considering that the national average, according to SNIS data (2014) is 162.00 l/person/day, and also that the average in the State of Maranhão is 154.2 l/person/day, a value of 345.29 l/inhab./day as registered for the year of 2017 is high, or rather, it indicates a bad use of water. Accompanying this growth, the IN055 index increased by 1.43%.

The water consumption index (IN052) showed a decrease. If it did not occur, an error in the transfer of this data to the SNIS, this indicates the possibility of clandestine water connections, which, in addition to jeopardizing the supply and causing waste of a natural resource, burdens the bodies responsible for its distribution.

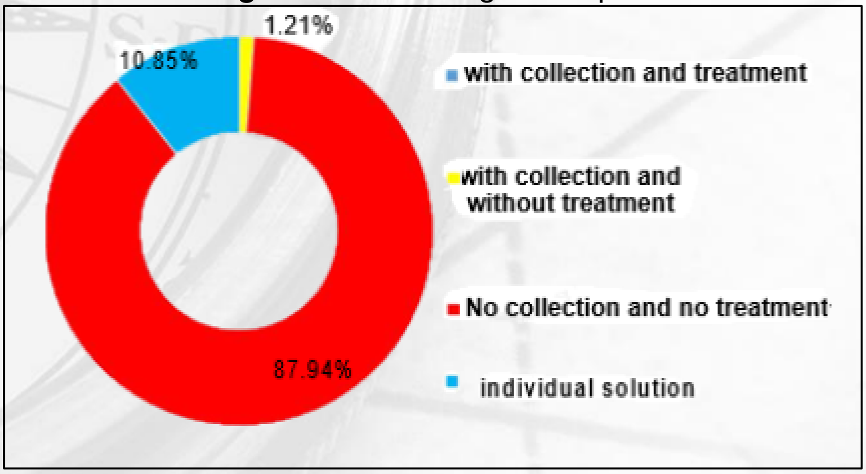
Regarding the performance of sewage systems, the municipality of Paço do Lumiar does not have information on the SNIS platform, as well as on the ANA Sewage Atlas, making it impossible to analyze these services.

- **Municipality of Raposa**

According to the research area, it was not possible to generate sanitation indices for the municipality of Raposa, as the health care data was not transferred to the National System, which makes it difficult to characterize the local situation. However, through the ANA sewage atlas portal it is possible to have a small general view of reality (Figure 02).

The situation in the municipality of Raposa is quite alarming, as the figure above shows that more than 80% of sewage is neither collected nor treated, as already mentioned. The main objective of basic sanitation is to promote human health in the environment in which they live and, given the data, it is clear that the right guaranteed by the constitution and defined by Law No. 14,026 / 2020 is a disregard for the authorities, lack of management and commitment to society, since many diseases proliferate due to the absence of these services.

Figure 02 -Sewerage in Raposa



Source: Atlas de esgotos, ANA (2013).

Another factor that contributes to the lack of sanitation in the study areas is the rapid growth of the urban population, in which there are occupations in inadequate areas resulting in the accumulation of waste, inadequate disposal and the increase in the consumption of natural resources, which favors mainly with landslides and flooding in the areas due to lack of urban drainage.

It should be noted that industrial growth also has its co-participation with environmental pollution (highlighting water pollution), as these often circumvent the legislation by releasing their effluents into the Hydrographic Basin without any treatment. In this circumstance, the entire population is affected by the lack of sanitation, however, the low-income class is more vulnerable to this situation. At this juncture, sanitation is an important tool in mitigating or reversing the negative impacts caused by anthropic actions and economic activities.

4.1 Quality of surface water in the Paciência River Basin

Water quality is determined by the use and occupation of the watershed area, as it is a reflection of natural conditions and human activities. In this way, the waters of the Paciência River were evaluated in line with the CONAMA Resolution N0. 357/05 for each parameter, taking into account fresh waters in classes 2 and 3 (Table 08).

Table 08 -Parameter results correlated with CONAMA 357/2005.

parameters	P01	P02	P03	P04	P05	P06	P07	P08	P09	Class 2	Class 3
Temp. °C	26.9	27.5	26.5	26.8	27.3	26.8	26.7	27.4	26.7	-	-
pH	7.37	6.64	7.32	7.32	7.38	7.43	7.25	7.26	7.34	In between 6.0 and 9.0	In between 6.0 and 9.0
OD (mg. L-1)	0.19	0.23	0.28	0.14	0.18	0.16	0.28	0.31	0.24	Not bottom to 5 mg.L O2	Not bottom to 4 mg.L O2
Turbidity (NTU)	495	365	520	660	684	610	480	520	415	Until 100 NTU	Until 100 NTU
ST (mg. L-1)	277	181	390	398	475	364	361	328	335	-	-
BOD (mg. L-1)	3.7	1.4	1.1	30.8	75.9	21.7	12.2	6.1	0.67	Up to 5 mg.L O2	To 10 mg.L O2
total nitrogen (mg. L-1)	7.25	2.29	1.65	6.26	7.01	6.38	1.50	1.10	0.95	2.18 mg/L	-
Phosphor (mg. L-1)	0.42	1.11	0.79	1.22	1.92	1.25	0.79	0.97	0.82	0.1 mg.L	0.15 mg.L

coliforms thermotolerant	960	100	430	1810000	1040000	153000	5400	1050	320	≤1000	≤2500

Source: Elaborated by the author (2019).

In view of the results in Table 08, the temperature of the sampling points did not show a very large variability (26.5° to 27.5°C) and the highest points were P02, P06 and P08, thus, the temperature of the area is not in disagreement with the regional history, it is emphasized that the water temperature oscillation interferes with the behavior of aquatic life since it has an ideal temperature for its development, in this way, the increase / decrease can cause migration or deaths of ichthyofauna.

The total solids parameter does not have a value determined by the resolution assigned to the study, however it provides important information on the concentration of suspended solids that in a river can compromise the production of food in the food chain (due to turbidity) and hide microorganisms pathogenic (the process of disinfection is compromised). In this way, P04, P05 and P06 have the highest concentration of solids as shown in Table 08.

In this context, turbidity measures the level of clarity of the water and the more particles (inorganic and organic debris) in suspension, the more turbid the water becomes, making it difficult for light to penetrate. All sampling points are outside the standard established by legislation as shown in Table 08, points P04, P05 and P06 show that they are more critical and this situation can be explained by the intense erosion process and mainly by the release of effluents into the watershed associated with accumulation of solid waste on the banks.

The pH is in compliance with the legislation for all classes of fresh water, since the maximum value is between 6 and 9. The points are neutral, highlighting only the P02 with a slightly acidic pH.

Dissolved oxygen (DO) at all points is outside the standard established by legislation for Class 2 (not less than 5 mg. L-1) and Class 3 (not less than 4 mg. L-1), as shown in Table 08. Regarding this parameter, points P04, P05 and P06 are the most critical, since the DO content is the main indicator for characterizing the effects of water pollution by organic discharge (probably from sewage), as unpolluted water must be saturated with oxygen and, on the contrary, indicates anaerobic conditions. The low concentration of oxygen in the Paciência river basin is verified through the sanitation indices, which demonstrates the high rate of untreated sewage.

The Biochemical Oxygen Demand corroborates the data above, since this variable demonstrates the oxygen content consumed by the microorganisms for the decomposition of organic matter, thus points P01, P02, P03 and P09 meet the water class 2 that Is up to 5 mg.L-1 O2 and points P04, P05, P06, P07 and P08 are not in compliance with the water classification, which means the higher the BOD, the lower the amount of oxygen available in the Paciência River.

In the result achieved for the Phosphorus parameter, all points were outside the standards according to CONAMA Resolution No. 357/2005, since it establishes values lower than 0.15mg. L-1. It appears in natural waters mainly due to sanitary sewage discharges and in this research it was identified that the main cause of inclusion of this compound was through domestic sewage from the neighborhoods adjacent to the points. In this follow-up, nitrogen was also evaluated and according to the results, P01, P02, P04, P05 and P06 are high, not meeting the desirable quality standard

It should be noted that excess phosphorus in surface water causes eutrophication and it Is very common in fertilizers and cleaning products, as well as nitrogen, both known as macronutrients because they are the main nutrients for biological processes.

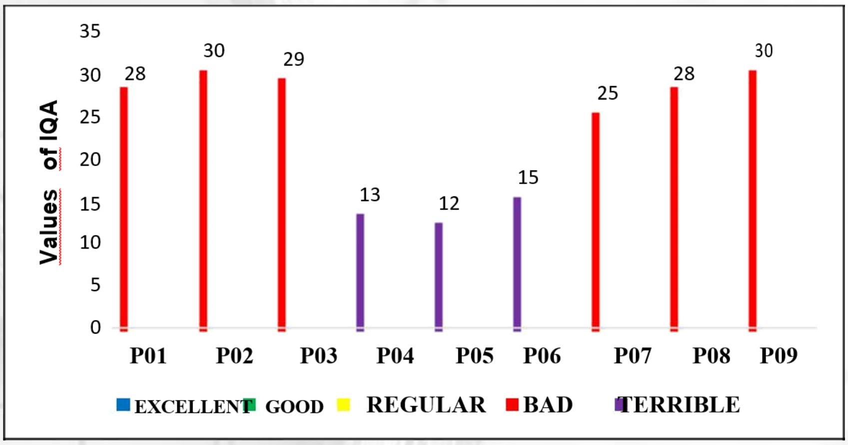
The microbiological variable demonstrates that P04, P05, P06, P07 and P08 do not meet the maximum permissible value in any of the freshwater classes, since it establishes values ≤ 2500 per 100 ml. It should be noted that they are not pathogenic, but their presence in large numbers indicates the possibility of the existence of pathogenic microorganisms that are responsible for the transmission of waterborne diseases such as, for example, bacillary dysentery, typhoid fever and cholera (ANA, 2019).

In view of all these variables, it is possible to have a preliminary view that the water available in the source of the Paciência River has compromised quality and this situation is caused by the release of domestic sewage and the accumulation of solid waste around the basin. The most critical points before the analytical tests are P04, P05, P06 of the Turu creek, tributary of the Paciência river on the left bank, the other points are not in an adequate situation, but less critical than the highlighted ones.

The relationship between the variables can be considered as a starting point for evaluating the quality of the water, thus, as the concentration of turbidity in the water increases, the consumption of dissolved oxygen increases, possibly for the decomposition of the organic matter and, the same trend may apply for coliforms to thrive, as the particles serve as shelter for them.

The Water Quality Index (IQA) indicator that evaluates the contamination of surface water bodies due to organic and fecal matter, solids and nutrients, attributing scores to the parameters individually, with the weight of each element being visible in the final acquisition of results of the IQA. In this context, the IQA of the source was calculated by point according to the CETESB model and among the variables oxygen has the greatest weight in the equation which, in view of the analytical results, compromises the index a lot. Therefore, the study area presented a bad classification for sampling points P01, P02, P03, P07, P08 and P09 and very bad for points P04, P05, P06 of the Paciência River basin (Figure 03).

Figure 03 -Graph of the behavior of the Water Quality Index-IQA.



Source: Prepared by the author (2019).

Poor/or terrible water quality means unfit for use and for conventional treatment of public supply. Thus, the pollution of the aquatic environment, caused directly or indirectly by human activities, causes deleterious effects on human health, on subsistence, mainly on riverside families and on economic activities in the region.

5 FINAL CONSIDERATIONS

The quality of life of living beings is directly related to the quality of the environment in which they live. As a result, urban sanitation goes beyond waste collection, as this indicates a set of socioeconomic actions that aim to achieve environmental health. However, population growth together with the lack of public policy applications led to disorderly occupations, turning the sources of water resources into discards.

In view of the work, the importance of basic sanitation in the environmental, social and economic scope was observed, which in its application results in long-term health, guaranteeing quality of life for citizens. It is worth noting the importance of water resources for water supply and sewage services.

Through the data of the Sanitation indices, the neglect around the watershed of the Paciência River is notorious, since the data portray that there is sewage collection, but there is no treatment for it, or else, when the population increases and there is a reduction in the water supply and sewage collection. Also noteworthy is the average consumption per capita of water that indicates poor distribution/use of water. These data corroborate the water assessment, through the variables that make up the Water Quality Index – IQA.

In this context, the analytical tests of the sampling points indicate intense degradation of the study area, caused by the release of in natura effluents in its waters, certified by the low DO content, high concentration of turbidity, high content of BOD, nitrogen, phosphorus and thermotolerant coliforms where these concentrations along with the other parameters classified the water from bad to terrible. Based on this information, it can be said that the water quality at the sampling points is compromised, indicating the pollution of water bodies making them unfit for use.

Therefore, all stretches are in a delicate situation, the most critical being points 04, 05 and 06 located in the municipality of São José de Ribamar. The current environmental situation of the Paciência river basin is mainly associated with the use and occupation of the soil around the basin, which have intensified as a result of investments in the housing sector.

There are some caveats, considering that only one collection was carried out, in the month of December, due to the lack of possibility of accessing the area in the period of more intense rains.

It is believed, therefore, from the study carried out, that the objectives were achieved, at the same time, that it contributed to the knowledge of the environmental conditions of the basin, to the theme of characterizing the sanitation and quality of the surface waters of the island, as well as how, important information is generated for the water management process in Maranhão, and especially for the Island of Maranhão.

REFERENCES

AGÊNCIA NACIONAL DAS ÁGUAS. **Portal da qualidade das águas-redes de monitoramento. 2016.** Available at: <http://pnqa.ana.gov.br/rede-nacional-rede-monitoramento.aspx>. Accessed on: 10 feb. 2019

AGÊNCIA NACIONAL DE ÁGUAS - ANA. **Indicadores de qualidade - Índice de qualidade das águas (IQA).** Available at: <http://portalpnqa.ana.gov.br/indicadores-indiceaguas.aspx>. Accessed on: 16 may. 2019

AGÊNCIA NACIONAL DE ÁGUAS (Brasil). **Atlas esgotos: despoluição de bacias hidrográficas** / Agência Nacional de Águas, Secretaria Nacional de Saneamento Ambiental, Brasília: ANA, 2017.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 9648**: Estudo de concepção de sistemas de esgoto sanitário. Rio de Janeiro, 1986.

BRAGA et. al. **Introdução a Engenharia Ambiental- o desafio do desenvolvimento sustentável.** 2 ed. São Paulo: Pearson Prentice Hall, 2005**.**

BRASIL. **Lei Federal n.11.445**, de 05 de janeiro de 2007. Institui a Lei Nacional de Saneamento. Brasília, 2007.

BRASIL. Ministério da Saúde **Manual de Saneamento**. 4 ed. Brasília: Fundação Nacional de Saúde, 2015.

BRASIL. **Portal do Sistema Nacional de Informações sobre Saneamento.** Available at: <http://www.snis.gov.br/>. Accessed on: 07 jan. 2019

CETESB - Companhia Ambiental do Estado de São Paulo. Qualidade das águas superficiais no estado de São Paulo 2011. Série Relatórios. Apêndice D: **Variáveis de Qualidade das Águas**. Available at: <http://www.cetesb.sp.gov.br/userfiles/file/agua/aguas-superficiais/aguas interiores/documentos/índices/02.pdf>. Accessed on: 05 mai. 2019.

CORRÊA, E. L. S. **Qualidade das águas e nível trófico da bacia do Rio Paciência na Ilhado Maranhão, Brasil. São Luís, 2018**. 113 f. Monografia (Graduação em Geografia Bacharelado). Universidade Estadual do Maranhão, 2018.

COSTA, S. A. B; CÔRTES, L. S.; COELHO, T.; FREITAS, M. M. **indicadores em saneamento: avaliação da prestação dos serviços de água e de esgoto em Minas Gerais** rev. UFMG, Belo Horizonte, v. 20, n.2, p. 334-357, jul. /dez. 2013. Available at: <https://www.ufmg.br/revistaufmg/downloads/20-2/16-indicadores-em-saneamento-samuel-costa-larissa-cortes-taiana-netto-moacir-freitas-junior.pdf>. Accessed on: 05. Nov. 2018

LANDAU, E. C.; MOURA, L. **Variação geográfica do saneamento básico no Brasil em 2010: domicílios urbanos e rurais**. Brasília, DF: Embrapa, 2016.

ONUBR: **OMS pede aumento de investimentos para atingir meta global de banheiro para todos** Available at: <https://nacoesunidas.org/oms-pede-aumento-de-investimentos-para-atingir-meta-global-de-banheiro-para-todos/>. Acesso: 04 nov. 2018

Resolução CONAMA 357- Ministério do Meio Ambiente. Available at: <www.mma.gov.br/port/conama/res/res05/res35705.pdf>. Accessed on: 29 mar. 2019.

SALGADO, M. E. R; PEREIRA C. R. P; SOUZA, U. D. V. **Dinâmica socioambiental da área da bacia do Rio Paciência, porção nordeste da Ilha do Maranhão/MA**. Anais XVI Simpósio Brasileiro de Sensoriamento Remoto - SBSR, Foz do Iguaçu, 13 a 18 abr. 2013, INPE.

SANTOS, H. C.**Poluição Hídrica. 2014.** UNOPAR - Universidade Norte do Paraná, Palmas. Available at: <www.trabalhosfeitos.com/topicos/diferença-poluição-e-contaminação/0>. Accessed on: 25 nov. 2018.

SILVA, M. A. R. **Economia dos recursos naturais**. In: Economia do meio ambiente: Teoria e prática. Rio de Janeiro: Editora Campos, 2003.

SPERLING, M. V. **Introdução à qualidade das águas e ao tratamento de esgotos** – 2ªed. Departamento de Engenharia Sanitária e Ambiental**,** Universidade Federal de Minas Gerais; 1996.

SPERLING, M. V. **Introdução à qualidade das águas e ao tratamento de esgotos**. 3. Ed. Princípios do tratamento biológico de águas residuárias. Editora da Universidade Federal de Minas Gerais – UFMG – Belo Horizonte, 2005.

TEIXEIRA, A. L. F. et al. **Análise espacial de indicadores socioeconômicos aplicada a gestão na área de saneamento.** 2004. Available at: <http://hidro.ufrj.br/pet/artigos/%20Artigo-%20RBRH.pdf>. Accessed on: 20 feb. 2019

TRATAR BRASIL. **Saneamento básico x Saúde no Brasil. 2013** Available at: <http://www.tratabrasil.org.br/blog/2013/04/09/saneamento-basico-x-saude-no-brasil/>. Accessed on: 22 feb. 2019.

TUNDISI, J. G. "**Novas Perspectivas para a Gestão dos Recursos Hídricos".** Rev. USP (Superintendência de Comunicação Social da Universidade de São Paulo). **Volume** 1. Número 70. p. 24-35. jul. /ago. 2006.

PEREIRA, E. D. **Avaliação da vulnerabilidade natural à contaminação do Solo e aquífero do reservatório Batatã - São Luís (MA***)* 2006. Tese (Doutorado). Universidade Estadual Paulista Instituto de Geociências e Ciências Exatas. Campus de Rio Claro.

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