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Monitoring of water Quality in the São João River Hydrographic Basin in the Municipality of Porto Nacional – Tocantins

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Abstract— *The world today faces a major problem that is the pollution of water resources, occurring a huge loss of water quality. The quality monitoring is of utmost importance for obtaining physical, chemical, biological and ecological information of water resources through sampling. However, this research will cover a study of the waters of São João river, an important water resource for the municipality of Porto Nacional-TO, to meet the demands of the city in relation to supply, fishing, leisure, among others. This project will be directed in three stages: study and demarcation of three points of the hydrographic basin, field methodology and then laboratory methodology. The parameters to be analyzed are: temperature, oxygen, pH, total nitrogen, total phosphorus, electrical conductivity, total of coliforms, total of solids and turbidity. The project will examine the quality of the water, verifying if the basin has the necessary parameters determined by Resolutions 274/2000 and 357/2005 of the National Environmental Council (CONAMA).*

Keywords— São João river, Water Quality. CONAMA.

I. INTRODUCTION

One of the main natural resources for the existence of the human being is water. It would be difficult to imagine any kind of life in the absence of this vital resource. Water is a natural resource that encompasses all aspects of human civilization, from agricultural and industrial development to cultural and religious values rooted in the society.

This resource covers a series of important factors, such as ecosystem conservation, human consumption, recreational use, among others. Speaking of human survival, it is important to note that water is essential for living beings, and as a way of life for vegetal and animal species. A large part of the world's territory is occupied by water, with 97% of them salted and only 3% fresh, and among it only 0.01% comes from lakes and rivers that are the main sources of supply for the population (CETESB, 2007).

Philippi Junior and Martins (2005) affirm that one third of the Earth's population is currently estimated to live in areas with water scarcity because of degradation. These conditions are related to the precarious nature of water systems and sanitary and industrial sewage, the abusive use of pesticides, inadequacy of the solutions used for waste disposal, the absence or insufficiency of measures to protection against flooding, erosion and depletion of water sources, pollution levels and water, atmospheric, soil, subsoil and food contamination.

Several indices were developed based on physical-chemical characteristics of the water or from biological indicators, with adjustments in weights and parameters to suit regional realities. These water quality indexes are usually based on a few variables (Gergel et al., 2002), whose definition must reflect the potential or actual natural or anthropogenic changes that occur with the water (Toledo & Nicolella, 2000).

The monitoring of water quality, through a sampling process, seeks to obtain qualitative and quantitative information, reaching purposes such as knowledge of biological, chemical and physical conditions, framing a body of water in classes or for inspection purposes. São João river is located in the state of Tocantins, which is the newest one of the federation and so has a low development level, being created in 1988, with vast water availability, thus providing good agricultural activity, irrigable areas,

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and great hydroelectric potential in the municipality of National Harbor.

The water basin area of São João river is the only source of water supply in the city, and it is suffering from several aggressions, such as agricultural activities, where it is clear the necessity to use the water with rationality to improve the quality of life of the population and sustainability. In view of the above, the present work has the objective of evaluating the water quality of São João river in Porto Nacional, through the determination of a water quality index - IQA NSF, through the indicative parameters.

Currently, a huge problem is faced in relation to water quality, mainly due to the anthropic actions. The water basin area of São João river, which is located in the municipality of Porto Nacional-TO, is a major source of distribution that has undergone changes in water quality in its water body.

São João river presents a variation in the quality of the water that is used to supply the municipality. With this, it is necessary to evaluate the quality of the basin water, to correct it, looking for its necessary parameters.

With water being a resource of great necessity for life, it is indispensable to be provided with good quality. Due to the changes in water quality, it was interesting to analyze the water resource addressed to identify whether it meets the conditions of public supply, with this resource being the only source of supply of the municipality.

II. MATERIAL AND METHODS

Study area

The São João river Basin has an area of approximately 82 km2, which is located in the State of Tocantins, between parallels 10° 46'43 "and 20° 41'20" of south latitude and between meridians 48° 14'16 "and 48° 24'51" of west longitude, southeast of the municipality of Porto Nacional-TO (Fig. 1), with its river mouth in the urban area, being a direct contributor of the Tocantins River.

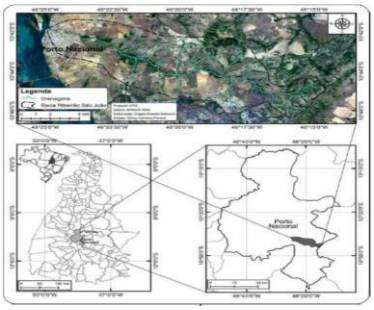

Fig. 1 – Location map of the Water Basin
Source: BALDUINO, 2018.

São João river has its source in the rural area, in Pilões Farm (coordinates S 10°46'08 "and W 48°15'57"), with direction for the municipality of Porto Nacional, crossing several rural properties and some representative neighborhoods, such as: Jardim Querido, Jardim Umuarama, Santa Helena and Vila Nova, with its river mouth (coordinates S 10°42'10 "and W 48°23'47") in the Tocantins river lake (BALDUINO, 2016).

Diagnosis of the river basin

The diagnosis of the river basin was made through field visits, where the conditions of preservation in its extremities were observed, such as the ciliary forests that run from the source, analyzing if they will be in agreement with the new forest code, Law 12651/2012, that affirms that the Permanent Preservation Area (APP) for source and water eyes is of the order of 50m radius in the surroundings. The basin under study, related to the new forest code, is classified as a natural perennial watercourse and, in this case, its APP covers a minimum width of 30 meters, so it is a watercourse of less than 10 meters wide.

Field methodology

The field methodology for sample collection was performed according to NBR 9897 for the demarcation of points and for sample collection. To begin the study, three (3) collection points were defined for analysis. The location of the points is shown in Table 1.

Table 1. Coordinates of water collection points for analysis of São João river in Porto Nacional, Tocantins.

Collection Points	Latitude (S)	Longitude (W)	Place of reference
PI	10° 46’08’’	48°15’57’’	Near the source (Pilão Farm)
PII	10°43’02’’	48°22’21’’	Saneatins Dam
PIII	10°42’10’’	48°23’47’’	Near the river mouth

It was also used satellite images for better understanding (GPS map 60CSx Garmin) and visualization of the collection points of the São João river basin (Fig. 2).

Fig. 2 - Collection Points
Source: Google Earth (2018)

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For the determination of the IQA NSF (Water Quality Index), the parameters that were analyzed are:

• Water temperature (°C);
• Dissolved Oxygen (OD)
• Biochemical Oxygen Demand (BOD);
• Hydrogen Ionic Potential (pH);
• Turbidity;
• Electric Conductivity;
• Total of Dissolved Solids (SDT);
• Total Nitrogen;
• Total Phosphorus;
• Fecal Coliforms

Collection of water samples

The water samples for the analyzes were collected in a weekly basis in the period of six weeks at three different points, from November 2017 to April 2018, using 100 ml containers for microbiological and 2000 ml for the physicochemical ones, being then labeled and packaged in iceboxes and taken to be processed in the laboratory of the Federal Institute of Education, Science and Technology of Tocantins, in Porto Nacional and LAPEQ - Research Laboratory in Environmental Chemistry, Federal University of Tocantins (UFT) - Palmas Campus - TO In total, 18 water samples (microbiological and physicochemical) were collected at the three analyzed points.

Laboratory Methodology

Fecal coliforms (CF) were analyzed according to the filter membrane technique, in according to the methodology described by Standard Methods; Total Nitrogen: was analyzed by the micro Kjeldahl method; Total Phosphorus: through the ascorbic acid method after digestion with ammonium persulfate; Total of Solids: were analyzed by the porcelain capsule method; Turbidity: determined by the nephelometric method; Biochemical Oxygen Demand (BDO): was determined by the A standard method. (APHA, 2005).

Calculation of the NSF Water Quality Index (IQA)

The IQA was calculated by the multiplicative weighted mathematical formula of the water quality corresponding to the following parameters: sample temperature, pH, dissolved oxygen saturation percentage, biochemical oxygen demand (5 days, 20° C), fecal coliforms, total nitrogen, total of phosphorous, total of solids and turbidity. Being exposed by the equation:

Equation (1):

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

Where:

IQA: Water Quality Index, a number between 0 and 100;
qi: quality of the i-th parameter, a number between 0 and 100, obtained from the respective average curve of quality variation for each parameter, depending on its concentration or measure;
wi: weight corresponding to the i-th parameter or sub-level, a number between 0 and 1 (Table 2), attributed according to its importance for the global conformation of quality, where:

Equation (2):

$$\sum_{i=1}^{n} Wi = 1$$

Where:
n: number of parameters in the IQA calculation

Table 2. Parameters and weights for the calculation of IQA – NSF

PARAMETERS	UNIT	WEIGHT (wi)
CF	NMP/100ml	0,15
pH	-	0,12
DBO	Mg/L	0,10
Total of nitrogen	Mgn/L	0,10
Total of phosphate	$MgPO_4$/L	0,10
Temperature	°C	0,10
Turbidity	NTU	0,08
Total of solids	Mg/L	0,08
OD	%saturation	0,17

Source: Yisa et al. (2012).:

The water quality classification of the river stream was performed according to the levels specified in Table 3.

Table 3 - Quality level or water classification according to the IQA-NSF result

Quality level	Rate
Excellent	90 < IQA ≤ 100
Good	70 < IQA ≤ 90
Average	50 < IQA ≤ 70
Bad	25 < IQA ≤ 50
Very Bad	00 < IQA ≤ 25

Source: Yisa et al. (2012).

III. RESULTS AND DISCUSSIONS

Water Quality Index (IQA)

The results of the physical, chemical and bacteriological parameters of the surface waters of the São João River were used to calculate the IQA in the period corresponding from November 2017 to April 2018. The classification of the waters quality of São João River was performed according to the values recommended by the NSF. The data collection took place during the rainy season and at the beginning of the dry season. In the rainy season the

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water presented a dark coloration that is a result of the solids carried to the river bed, and in the period of drought the water presented a transparent coloring. It is important to note that the darker color of the water does not indicate contamination, since the colorless water may also be contaminated. With the results obtained, it was observed that the São João River Basin presented a variation of the IQA from 51.98 to 63.07. The study showed that according to the IQA values, water quality can be classified as "medium". With the results presented, it is possible to affirm that the area where a low water quality is presented is also where urban activities are predominant, in every season (dry and rainy). Similar studies such as those of GAZZAZ et al. (2015), Liu et al. (2015), OCAMPO-DUQUE et al. (2015) and RUBIO-ARIAS (2015) associated the variations in IQA values with contributions from industry, domestic activities, and drainage of the basin, which in turn affect water bodies.

According to Carvalho et al. (2016), it was observed that the behavior of the IQA in the same three points presented a variation of 49.74 to 80.72, during a different period of collection. In the Carvalho study, it was shown that according to the values obtained for the IQA, water quality can be classified as "good" for most of the period.

Of the nine parameters, three (dissolved oxygen, total of phosphorus and total of coliforms) were in disagreement with the values established by the NSF resolutions. However, the variations presented showed that they were not significant to reflect the final results, demonstrating that such variations were absorbed by other parameters.

Table 3. Water Quality Index (IQA NSF) in the three collection points.

Points **Dates**	**PI**	**PII**	**PIII**
November/2017	**63,07**	**59,67**	**57,70**
December/2017	**61,8723**	**60,16**	**56,89**
January/2018	**54,35**	**57,70**	**56,71**
February/2018	**56,65**	**57,54**	**54,55**
March/2018	**51,98**	**61,16**	**54,40**
April/2018	**55,27**	**60,67**	**56,16**

IV. CONCLUSIONS

The results obtained in the period under study regarding the degradation level allow us to conclude that the waters of São João River did not meet all of the quality parameters determined by the CONAMA Resolution 357/2005 for class two waters. In the NSF IQA calculation, of the nine parameters (dissolved oxygen, biochemical oxygen demand, pH, total nitrogen, total of phosphorus, turbidity, total of coliforms and total of dissolved solids), three (dissolved oxygen, total of phosphorus and total of coliforms) were in disagreement. The bathing conditions, Resolution CONAMA 274/2000, specifically in point three (PIII), presented values above the recommended ones, making it improper for recreation of primary contact.

As a result of these continuous processes of degradation affecting the hydrographic basin under study, and of its social, economic and ecological importance for the municipality of Porto Nacional, high investments should be made in the management of water resources for the prevention, recovery and preservation of this great environmental patrimony, São João River, to increase the IQA (Water Quality Index), which currently classified as "average".

The use of IQA is therefore essential for the monitoring of water resources, due to its low costs, as well as the importance for the decision-making process. In the case of São João River, it is observed that the IQA proposed by the NSF does not satisfactorily describe the quality in some specific uses, such as water bathing. Specifically, this index presents limitations in Point III, since the coliform parameter is absorbed by the other parameters, diluting its effect, which may lead to an overestimation of the quality of this water.

Therefore, preventive measures are necessary and must be taken to ensure safety, restore and preserve the quality of the waters of this valuable resource for present and future generations. This can be done through an environmental education program for the communities living in the surroundings of this water resource and revitalization of the ciliary forest, among others.

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environmental guidelines for their classification, as well as establishing the conditions and standards for effluent discharge, and other measures.

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