Chapter 121

WQI of the source of the Sussuapara stream in the dry and rainy months in the city of Palmas - TO

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Abstract

Springs are important environmental systems for the maintenance of hydrological, geomorphological and biological balance. However, in urban areas, these springs have been intensely modified by human action. One of the main consequences of urban interventions on the dynamics of springs is changes in water quality. One of the main consequences of urban interventions on the dynamics of springs is changes in water quality. In addition, periods of greater precipitation can interfere with this dynamic. Therefore, the present study aimed to evaluate the water quality index - WQI at the source of the Sussuapara stream in the municipality of Palmas-TO in the year 2021. Nine parameters were studied to assess water quality; four samples were collected in the dry months and four in the rainy months. The results obtained were compared with Conama Resolution no. 357 and showed that the WQI of the headwaters of the Sussuapara stream in the dry months was higher than in the rainy months, being classified as "Good" and "Regular", respectively. The results showed that the impacts caused by surface runoff and location of the spring are significant in the water quality index.

Keywords: Water quality; Springs; Urban perimeter.

1 INTRODUCTION

Water is essential for the maintenanceof life. All metabolic reactions that occur inside cells are in the presence of water. In the case of plants, water is a fundamental *input* in the photosynthesis process, which ensures its growth and, in turn, is the essential basis of food chains. In addition, water is used in the form of leisure, industry, food production and electricity generation (Braga et al., 2005).

According to Braga et al. (2005), The earth's surface has 71% water. Of this percentage, 97% are formed by oceans and seas, 2% is in solid phase (glaciers) and 1% consists of lagoons, lakes, rivers and groundwater. Since the consumption of water by human society comes from the freshwater reserve, which corresponds to 1% of the surface water then has a limited amount of available water.

According to the National Water Agency (Brasil, 2010), Brazil has a considerably high reserve of freshwater, both surface and underground, in the form of water sources (groundwater, effluents, emerging or water deposits) that have high usable potential for public supply. However, its use should be considered and aware, since the demand for water increases due to the population increase, which requires even more availability of drinking water.

Therefore, it has become necessary not only to rationalize the amount of water consumed, but also to treat water in order to make it suitable for human consumption, especially of springs, which are fundamental systems for the maintenance of watersheds (Galatto et al., 2011). It is commonly understood that the springs are outcrops of the groundwater level on the surface of the ground and are the starting points of waterand water courses (Pereira et al., 2011). The springs are found on slopes or terrain depressions or at the base level represented by the local watercourse. They can be perennial (continuous flow), temporary (flow only in the rainy season) and ephemeral (arise during rain, remaining for only a few days or hours).

Currently, inadequate land use, deforestation and indiscriminate application of fertilizers and pesticides have caused numerous environmental problems, especially in areas of springs, changing the quality and quantity of water drained by the basin (Manoel and Carvalho, 2013). In addition, human activities such as solid waste disposal have become an additional problem.

The National Water Agency (Ana, 2004) and the U.S. National Health Foundation, National Sanitation Foundation, developed studies in 1970 to qualify water use, whether for direct consumption (ingestion) or other purposes. From this study, the Water Quality Index (WQI) was established, which is a parameter that indicates for which purposes the body of water can be used. Santos et al. (2014) point out that the analysis of water quality represents a subsional instrument for the various decision-making within the hydrographic basin, especially with regard to the management of land and surface water use and occupation.

The WQI is calculated according to nine parameters considered important to qualify water, indicating better quality as it approaches the maximum value (IQA 100). This reference value is used to estimate the quality of raw water, aiming at the use for public supply after treatment (Conama, 2005).

The variation of water quality parameters as well as the WQI are related to the modification of the type of land use and occupation, and this deterioration can occur both due to natural and anthropic modifications (Alves et al., 2012). Another component that can alter water quality is the rainfall regime (Borges, 2009; Silva et al., 2008). However, other authors justify not having a climate influence on water quality dynamics on a regular basis (Gharibi et al., 2012).

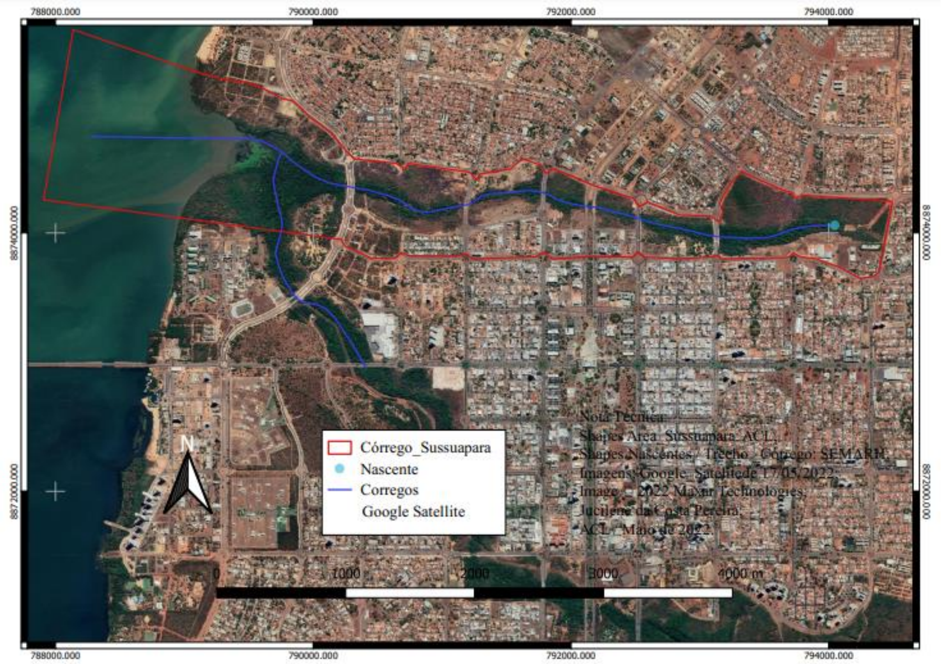
Thus, the present study aimed to monitor water quality in dry and rainy months, by monitoring the associated parameters, at the source of Córrego Sussuapara, palmas, Tocantins, in 2021.

2 METHODOLOGY

2.1 CHARACTERIZATION OF THE STUDY AREA

The study was conducted in the area of the sussuapara stream, located in the municipality of Palmas, in 2021 (Figure 1). The area is 5,945 $m^{2\ \text{long}}$, with approximately 806 ha, 230 m of altitude and water in the lake formed by the Luís Eduardo Magalhães Plant. The main watercourses that cut through the urban area are Córrego Água Fria, Córrego Sussuapara, Córrego Brejo Comprido, Córrego do Prata, Taquaruçu Grande and Taquari (Palmas, 2014).

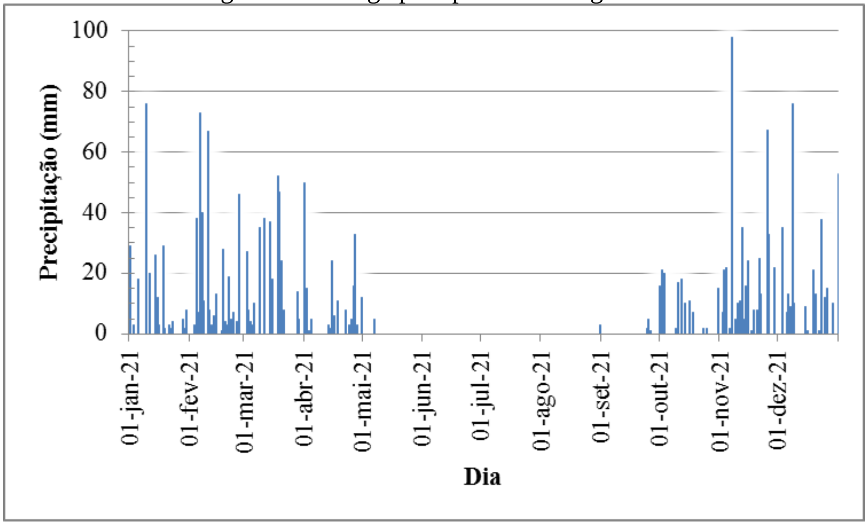
Figure 1: Location of the Study Area



The soils of the region are classified as: Percressionary Pétric Plinthsol, Dystrophic Yellow Red Latosol, Dystrophic Fluorium Neosol and Corthenic Yellow Latosol (Embrapa, 2013).

The climatic data collected during the study period were obtained from a conventional meteorological station during 2021 (Figure 2).

Figure 2: Average precipitationduring 2021.



Source: Inmet (2021).

The climate in the region, according to the köeppen climatic classification is humid tropical type with two well-defined seasons, presenting annual average temperature and precipitation of 27.5º C and 1600 mm respectively (Inmet, 2015).

2.2 DATA COLLECTION

For water quality monitoring, eight samples were collected during 2021, four in the months of highest precipitation (MC) and four in the dry months (DM), distributed according to Table 1.

Table 1: Rainfall for 24 hours prior to the date of collection

Samples	Date	Rainfall (mm)
MC	26/02/2021	46
	27/04/2021	33
	25/11/2021	67
	19/12/2021	37,6
MS	18/06/2021	0
	21/07/2021	0
	23/08/2021	0
	24/09/2021	5

* MS: dry months; MC: rainy months.

It is possible to observe in Table 1 that between June and September there was no precipitation. In the months of higher precipitation, the samples were not carried out continuously, because the rainy season in the municipality usually happens between the months of October and March and the collections were carried out within the same year.

The samples were collected in triplicate, packed in refrigerated thermal boxes and transported to the Solid Waste Laboratory of the Federal University of Tocantins. 1000 mL plastic material bottles were used for physicochemical analyses and sterilized 100 mL vials for bacteriological. In the rainy season, the collections were always performed on the day after precipitation.

The physical-chemical and microbiological parameters were analyzed with theAmerican Public Health Association (2005), based on the attributes of water quality indicators suggested by the National Sanitation Foundation (NSF) (Table 2).

Table 2 :Parameters used to assess Water Quality

Parameters	Method	Reference
ph	Potentiometric	APHA (2005)
Turbidity (NTU) Reading	Turbidimetric	APHA (2005)
Total Nitrogen (mg/L)	Spectrophotometry	APHA (2005)
Totalphoro (mg/L)	Spectrophotometry	APHA (2005)
Dissolved Oxygen (mg/L) O2	Oxymetry	APHA (2005)
Biochemical Oxygen Demand (mg/L) O2	Titulometry	APHA (2005)
Total Solids (mg/L)	Gravimetry	APHA (2005)
Thermotolerant Coliforms (NMP/100 mL)	Colilert	APHA (2005)
Temperature (^{0}C)	Thermometry	APHA (2005)

Source: National Sanitation Foundation

2.3 CÁLCU LO DO INDICIE WATER QUALITY (WQI)

The WQI was calculated, as established by Brown et al. (1970), adapted from the NSF index, on a scale from 0 to 100, being divided into five categories. The calculation refers to the weighted predatory of the water qualities corresponding to the parameters that integrate the index, according to the equation (1). The weights of all parameters considered in the calculation of the WQI are presented in Table 3.

$$IQA = \Pi q_i^{\,w_i} \qquad (1)$$

Where:
IQA : Water Quality Index (0 and 100);
qi: quality of the i-th parameter (0 and 100);
wi: weight corresponding to the i-th parameter (0 to 1);
n: number of variables that enter the calculation of the WQI.

Table 3: Weight of parameters in iqa calculation

Parameter	Weight
Thermotolerant Coliforms	0,15
ph	0,12
Turbidity	0,8
Total Nitrogen	0,10
Total phosphorus	0,10
Temperature	0,10
Dissolved Oxygen	0,17
DBO 5.20	0,10
Total Solids	0,8

From the calculation performed, it was possible to classify the spring water according to the quality andwater indices described in Table 4.

Table 4: Categories of water quality classification according to IQA values.

Category	Classification
$79 < IQA \leq 100$	Great
$51 < IQA \leq 79$	Good
$36 < IQA \leq 51$	Regular
$19 < IQA \leq 36$	Bad
$IQA \leq 19$	Bad

Source: Cetesb (2013).

2.4 DATA ANALYSIS

To evaluate the temporal and dispersion trend, the data of each collection (dry and rainy months) were submitted to descriptive statistics using the software Sisvar version 5.0 (Ferreira, 1998). For the WQI, the mean values obtidin the dry and rainy months were compared to the indices established for classification of "class 2" waters.

3 RESULTS AND DISCUSSION

3.1 PARAMETERS USED TO CALCULATE THE IQA

The dispersion measures for the variables used in the dry months (DM) and rainy months (CM) are presented in Table 5.

All parameters analyzed, except pt, are in the appropriate range for "class 2" waters, according to Conama Resolution 357/2005. However, in the dry months, turbidity, ST and PT showed great variation between the data, with a high coefficient of variation (Table 5), these results can be explained by the fact that the first collections were performed in the transition period between the rainy months and the dry months. In a similar study, Ferreira et al. (2015) also observed a high variation among these data, corroborating the results found here.

Table 5: Descriptive statistics for the WQI parameters of the Sussuapara Stream in the municipality of Palmas-TO in 2021.

Parameter		Average	Median	Maximum	Minimum	Standard deviation	CV (%)
ph	MS	7,35	7,34	7,2	7,5	0,12	1,75
	MC	7,7	7,56	7,9	7,5	0,16	2,12
NT (mg $^{L-1}$)	MS	0,138	0,139	0,148	0,130	0,008	6,21
	MC	0,117	0,115	0,120	0,115	0,006	1,846
EN (mg $^{L-1}$)	MS	0,03	0,03	0,04	0,02	0,008	27,21
	MC	0,06	0,06	0,07	0,05	0,008	13,6
OD (mg $^{L-1}$) O2	MS	5,52	5,40	5,90	5,30	0,26	4,73
	MC	7,2	7,25	7,5	7,0	0,22	3,04
DBO5.20 (mg $^{L-1}$) O2	MS	1,57	1,60	1,80	1,40	0,17	10,84
	MC	2,55	2,55	2,70	2,40	0,12	5,06
Turbidity (NTU)	MS	0,96	0,45	2,00	0,14	0,77	80,74
	MC	19,78	39,90	41,00	38,80	1,05	2,66
CTR (NMP/100 mL)	MS	898,60	905,05	980,40	829,70	64,46	7,17
	MC	1073.5	1081.95	1203.30	960.60	89,93	10,13
ST (mg $^{L-1}$)	MS	0,39	0,32	0,70	0,25	0,20	52,88
	MC	1,10	1,15	1,2	0,9	0,14	12,85
Temperature $^{(}$the C)	MS	26,35	26,4	26,8	26,00	0,34	1,29
	MC	25,02	25,00	25,4	24,6	0,38	1,54

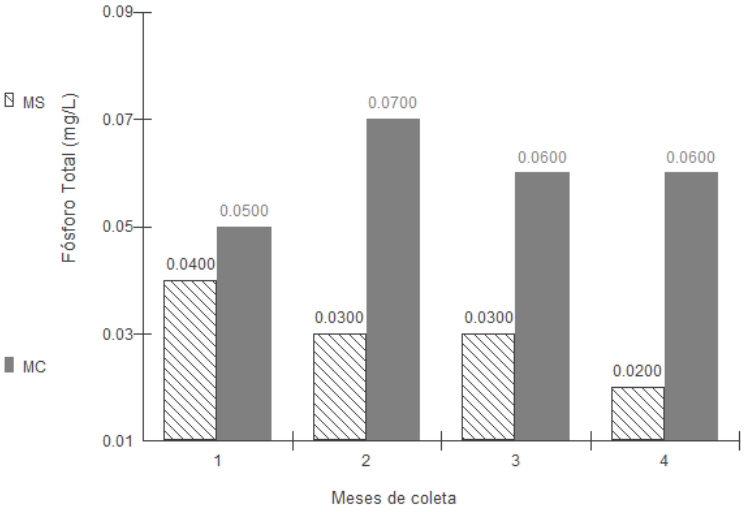
NT: total nitrogen; PT: total phosphorus; BOD 5.20: biochemical oxygen demand; OD: dissolved oxygen; CTR: thermotolerant coliforms; ST: total solids; MS: dry months; MC: rainy months.

For OD, a low coefficient of variation was observed, indicating that there was no major change between the data (Table 5). However, in the dry months, the mean values were below 6 mg/L, which can be explained by the high temperatures, making it less soluble in these conditions (Ayroza, 2012). The values of pH, BOD5.20 and CTR also did not present a high coefficient of variation between seasons, with a more homogeneous behavior. In the case of NT, the values observed for the standard deviation were close to zero, indicating that the data, in addition to having low dispersion along the two collection stations, were concentrated around the mean.

Thermotolerant coliforms (CTR) had greater variation in the rainy months, with a high standard deviation (Table 5). This variation may have occurred due to the greater transport of organic matter by precipitation, especially in November, after a prolonged dry period (Figure 2).

In the case of total phosphorus (PT), the study showed differences between the months of collection (Figure 3). In the rainy months, an average value above the permitedido by the legislation (0.05 mg/L) was observed. Considering the study area as urban, this may indicate the release of untreated domestic sewage, which has a high load of this nutrient (Ferreira et al., 2015). Moreover, in the months of higher precipitation (Figure 2) there may be greater pumping of residues of an organic nature, which contributed to increase the concentration of phosphorus in the environment.

Figure 3: Mean Total Phosphorus for the dry and rainy months collected in the Sussuapara Stream, Palmas-TO (2021).



*MS: Dry months; MC: Rainy months

Phosphorus has many implications in water quality, when the concentration of this nutrient is high, there may be an increase in cyanophilias in the environment, producing toxins harmful to human health (Cottingham et al., 2015).

3.2 WATER QUALITY INDEX (WQI)

The values observed for the WQI of the sussuapara stream source in the rainy months ranged from 42.8 to 49.2, falling under the "regular" quality range (Table 6). Collares et al. (2021) also observed a reduction in the WQI in a monitoring station within the urban area in the municipality of Cândido Sales, which presupposes the release of domestic sewage, influencingthe characteristics of the water body.

Table 6: Average Of The QualidAde Water Index (WQI) at the source of the Sussuapara Stream, Palmas-TO (2021).

IQA

Months of collection	Average	Maximum	Minimum	Classification (CETESB)
MS	74,52	78,80	72,60	Good
MC	47,22	49,2	42,8	Regular

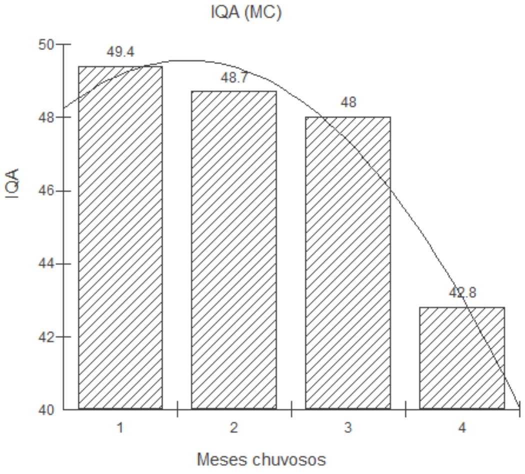
*MS: dry months; MC: rainy months.

The reduction in the value of WQI in the rainy months occurred, possibly, due to the large increase in turbidity, total solids and thermotolerant coliforms (Table 5), especially in the months of higher precipitation. In addition, the total phosphorus recorded a value above that indicated by the legislation for waters "class 2" (Figure 3). Considering that the spring is located in urban area, the rafter of organic matter, as well as other residues, certainly and s so relatedto the fall in the value of WQI.

This deterioration of water quality in the rainy months, due to the higher surface runoff, was also observed by Bilich & Lacerda (2005) in the surface waters of the Federal District, with a reduction in the WQI in these periods. Lima et al. (2020) also observed a reduction in the WQI in the urban area of a hydrographic basin located in the municipality of Una, in Belém. In addition, the increase in water volume in periods of precipitation allows the revolving of the bottom and resuspension of particles, andleading to turbidity, solids and biochemical oxygen demand (Borges, 2009).

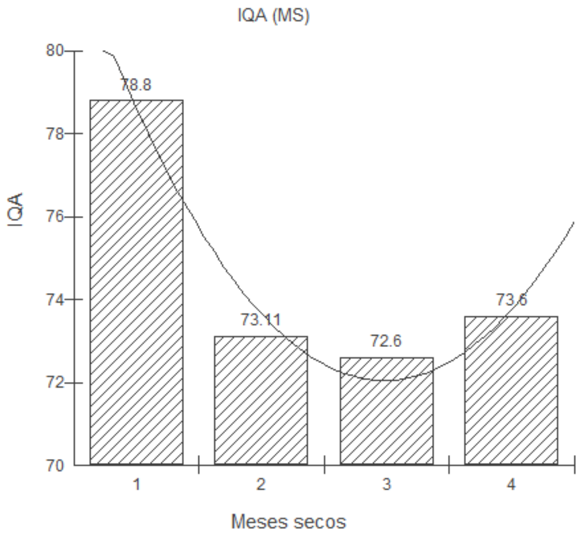
It is possible to observe that in December there was a sharp decrease in the value of WQI (Figure 4), probably the large volume of rainfall observed in November (Figure 2) contributed to increase the volume of organic matter and solids, causing the month of December to register an WQI with lower quality, even though it is within thefa ixa established as "regular"

Figure 4: IqA for rainy months.* 1: February; 2: April; 3: November; 4: December.



For the dry months, the values observed for the WQI ranged from 75.80 to 72.60, falling under the "good" quality range (Table 6). The improvement of the WQI observed in these months can be attributed to the end of the rainy season with less volume of organic matter and solids, in addition to less revolving of dispersed material. It is noted that all parameters used to calculate the WQI were better evaluated in the dry months (Table 5).

Figure 5: IQA for dry months.* 1: June; 2: July; 3: August; 4: September.



However, in July, August and September there was a significant decrease in the WQI in relation to june (Figure 5). This dynamic can be explained by the higher concentration of nutrients and total solids in the dry months, but that did not affect the change in the water quality index as "good".

Thus, it was verified in this study that precipitation played a fundamental role in the dynamics of the parameters of the water ofthe spring of the Corrego Sussuapara, reducing the quality of the water.

4 CONCLUSION

All parameters analyzed for the calculation of the WQI presented higher means in the rainy months and the total phosphorusconcentration f icou above that recommended by Legislation. The water quality at the source of the Sussuapara Stream was classified as "good" and "regular", in the dry and rainy months, respectively.

In view of the results presented, it is recommended the continuity of monitoring, with the adoption of programs for the recovery of permanent preservation areas and the implementation of urban drainage networks that minimize the transport of waste from organictureza to the spring.

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