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Débora Pereira da Silva*, Douglas Pereira da Silva Pitaluga, Paulo Sérgio Scalize, and Hebert Oliveira Santos

Seasonal evaluation of surface water quality at the Tamanduá stream watershed (Aparecida de Goiânia, Goiás, Brazil) using the Water Quality Index

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Abstract: Freshwater is an essential natural resource for humanity, however, its quality has been compromised as a result of natural and anthropogenic interference. The objective of the present study was to determine the Bascarán Water Quality Index (WQI_B) for the Tamanduá stream in the municipality of Aparecida de Goiânia, Goiás, Brazil, and relate it to the limits established by CONAMA resolutions n^{o} 357 [1] and n^{o} 274 [2], for Class 2 freshwater bodies. The study was carried out at three sampling points proximate to urban parks, with samples collected in both the dry and the rainy seasons with the measurement of flow. The physical, chemical and biological parameters were analyzed as recommended in *Standard Methods* [3]. Parametric descriptive statistics were used for data analysis. The WQI_B results classified the water as acceptable (24%), normal (48%), improper (20%) and unpleasant (8%), with turbidity, DO and total coliforms responsible for decreased WQI_B in the rainy season. The parameters pH, apparent color and DO do not conform with CONAMA resolution n^{o} 357 [1] while water resources for bathing were classified as excellent according to CONAMA resolution n^{o} 274 [2].

Keywords: Bathing, water resources, Water Quality Index

1 Introduction

Impairment of the quality of water resources is related to natural and anthropogenic phenomena [4]. Anthropic interferences are associated with the release of domestic effluents, industrial effluents and diffuse urban and agricultural load [4, 5], while marked natural interferences include relief, fauna, flora and precipitation events that transport particles and impurities to watercourses [6].

The impacts caused by these phenomena can be evaluated using Water Quality Indexes (WQIs), which express, in a simple and objective way, the quality of water to the general public, and are a useful tool for the management of hydrographic basins [7].

Among the existing methods for calculating WQIs, such as WQI-NSF (National Sanitation Foundation) and WQI-CETESB (Companhia Ambiental do Estado de São Paulo; Environmental Company of the State of São Paulo), the Bascarán Water Quality Index (WQI_B) allows flexibility in the inclusion or exclusion of variables [8], thereby facilitating its use.

Studies have been undertaken to evaluate the water quality of some water bodies in Brasil [4, 9, 10], especially in the São Caetano stream in the municipality of Balsas in the state of Maranhão, where Oliveira *et al.* (2017) [11] adopted the WQI_B for the analysis of surface water quality, and found regular water quality and the presence of thermotolerant coliforms do not conform with CONAMA resolution n^{o} 357 [1].

Globally, Ewaid & Abed (2017) [12] analyzed water quality in the Al-Gharraf River, which is the main source of water in southern Iraq, and classified it as unsuitable for human consumption without prior treatment due to

***Corresponding Author: Débora Pereira da Silva:** Department of Academic Areas III, Instituto Federal de Goiás (IFG) and Master student in the PPGEAS, Universidade Federal de Goiás (UFG), Goiânia, Brazil, E-mail: debora_pdsilva@hotmail.com
Douglas Pereira da Silva Pitaluga: Department of Academic Areas III, Instituto Federal de Goiás (IFG), Goiânia, Brazil, E-mail: pitaluga.ifg@gmail.com
Paulo Sérgio Scalize: Postgraduate Program in Environmental and Sanitary Engineering (PPGEAS) and Environmental Sciences (CIAMB), Universidade Federal de Goiás (UFG), Goiânia, Brazil, E-mail: pscalize.ufg@gmail.com
Hebert Oliveira Santos: Postgraduate Program in Geotechnics, Structures and Civil Construction (GECON), Universidade Federal de Goiás (UFG), Goiânia, Brazil, E-mail: hebert_oliveiras@hotmail.com

high turbidity values and Mena-Riviera *et al.* (2017) [13] assessed the surface water quality of the sub-basin of the Burío River in Costa Rica, which is characterized by urban and rural tropical areas. The water quality level was predominantly average based on of WQI-NSF and the parameters that determined the water quality were Biochemical Oxygen Demand, Dissolved Oxygen, Total Phosphate and Nitrate.

In the context of the present study, the hydrographic basin of the Tamanduá stream is considered highly relevant to the region due to the presence of urban public parks within its extension. Among these, Parque Ecológico Municipal Tamanduá (Tamanduá Municipal Ecological Park) and Parque da Criança (Children's Park) stand out due to the use of water for irrigation of vegetables [14]. There are environmental impacts in the region, with the main ones being contamination by domestic and industrial effluents, erosion and silting of the watercourse, deforestation and high concentrations of dust and atmospheric gasses [15].

Thus, the objective of the study was to determine the WQI_B of the Tamanduá stream, and to compare the results of the studied parameters with the limits established in CONAMA resolutions nº 357 [1], quality regulation of surface water bodies and effluent discharge requirements, and nº 274 [2], defining the conditions for users who have direct contact with the Brazilian surface waters sanctioned by the Conselho Nacional do Meio Ambiente - CONAMA (National Environmental Council).

2 Methods

The hydrographic basin of the Tamanduá stream is located in the metropolitan region of the municipality of Aparecida de Goiânia in the state of Goiás, Brazil. The stream has an extension of 11.3 km, with its main source located in Parque Ecológico Municipal Tamanduá and its mouth in the Santo Antônio stream. Three sampling points were defined with different dynamics of land use and occupation along their lengths, as described in Tab. 1 and spatially distributed as shown in Fig. 1.

According to the classification of Koppen (1948) [16], the region possesses a humid tropical climate (Aw), in which the dry season occurs from May to September and the rainy season between October and April. However, a month is only considered to belong to the rainy season when monthly rainfall exceeds 60 mm. Six sampling campaigns were carried out in the dry season (two in July, two in August and two in October, 2017) and four in the rainy season (two in November 2018, one in January and one in February, 2018). The month of October was considered as part of the dry season because only 51 mm of rainfall occurred, according to rainfall data obtained from the conventional station nº 83423 of the Instituto Nacional de Meteorologia (National Institute of Meteorology) [17].

During sample collection, the flow rate of the Tamanduá stream was measured using the method recommended by the *U.S. Environmental Protection Agency - (EPA)* [18] that conforms to the characteristics of the watercourse.

Water samples were collected, preserved and transported as indicated by the Guia da Cetesb [19]. Analyses were performed according to the methods recommended in *Standard Methods* [3]. The parameters used to calculate the WQI_B were: turbidity (T), apparent color (AC), electrical conductivity (EC), total dissolved solids (TDS), pH, free carbon dioxide (CO_2), dissolved oxygen (DO), alkalinity (A), chloride (CL) and total coliforms (TC). Water temperature (WT), thermotolerant coliforms (THC) and heterotrophic bacteria (HB) were also analyzed.

From the sample data, the concentrations of the parameters were related to the limits established in CONAMA resolution nº 357 [1] as shown in Tab. 3, due to the allocation of water to the irrigation of vegetables [14], and in CONAMA resolution nº 274 [2], since there is potential recreation involving primary contact in regions of public parks. It establishes the limit for thermotolerant coliforms for the excellent category of 250 NMP/(100 mL) in at least 80% of the studied samples.

The WQI_B was developed by Martines Gamaliel Bascarán [20] and is determined using Equation 1:

$$WQI_B = K * \frac{\Sigma(C_i * P_i)}{\Sigma P_i} \quad (1)$$

Where:
C_i = percentage value corresponding to the parameter, defined in Tab. 2;
P_i = weight corresponding to the parameter, defined in Tab. 2;
K = adjustment constant as a function of the visual appearance of the water, being able to adopt 1.00 for clear waters without apparent contamination, 0.75 for waters with slight color, foam and unnatural turbidity of the water, 0.50 for waters with appearance of being contaminated and with strong odor and 0.25 for black waters that have fermentations and odors. In this study, K = 0.75 was adopted.

The WQI_B values range from zero to one hundred corresponding to terrible for $0 \leq WQI_B < 10$, very bad for $10 \leq WQI_B < 20$, bad for $20 \leq WQI_B < 30$, unpleasant for $30 \leq$

Table 1: Coordinates and description of the sampling points along the Tamanduá stream.

Point	Coordinates	Elevation (m)	Characteristics
P1	16°45'34.9"S 49°20'19.8"W	850	Source of the Tamanduá stream located in Parque Ecológico Municipal Tamanduá.
P2	16°45'35.9"S 49°20'17.7"W	849	Stretch with stone retaining wall (channelized) located 71 m downstream from P1, within the Parque Ecológico Municipal Tamanduá.
P3	16°46'23.8"S 49°16'57.0"W	770	Located 6789 m downstream from P2, in the proximity of Parque da Criança.

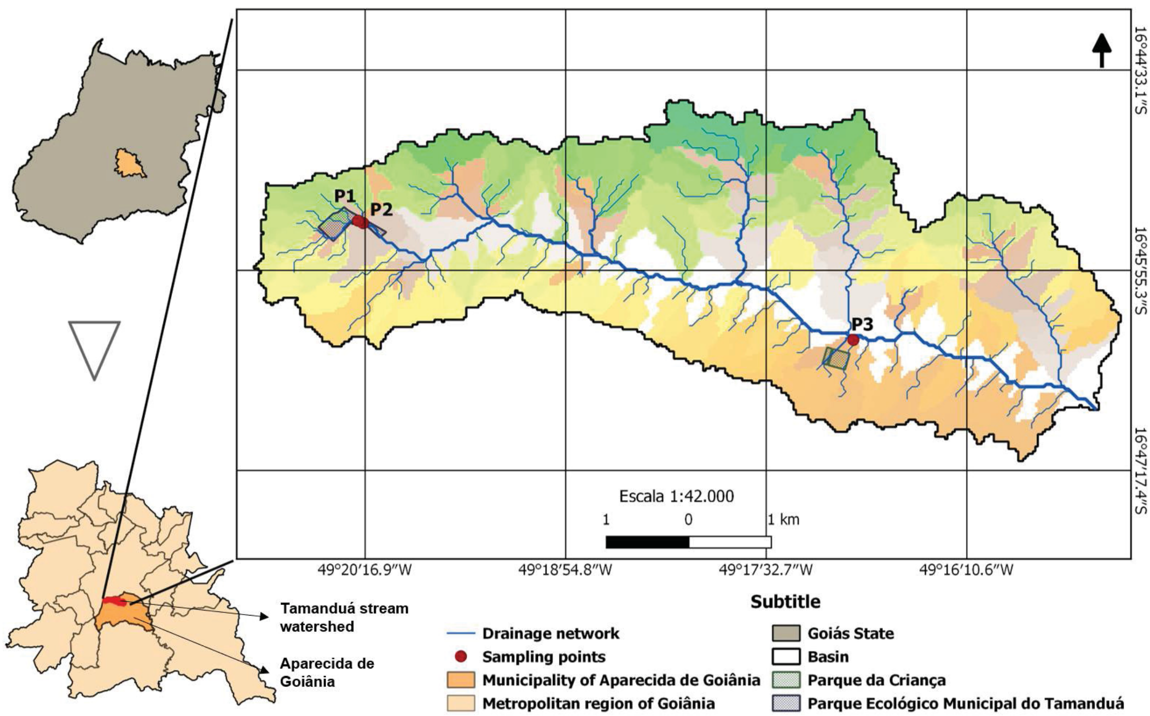

Figure 1: Regional location of the hydrographic basin of the Tamanduá stream in the municipality of Aparecida de Goiânia, with the expansion of the area of the basin showing the delimitation of the parks and the location of the sampling points.

WQI_B <40, inappropriate for 40 ≤ WQI_B <50, normal for 50 ≤ WQI_B <60, acceptable for 60 ≤ WQI_B <70, pleasant for 70 ≤ WQI_B <80, good for 80 ≤ WQI_B <90, very good 90 ≤ WQI_B <100 and great for WQI_B = 100, as shown in Fig. 2 [7, 8].

The results were statistically analyzed using parametric descriptive statistical tests [21], by means of which the harmonic mean of quantitative variation, standard deviation (σ) and the coefficient of variation were obtained.

3 Results and Discussion

Fig. 2 provides the WQI_B values obtained during the study period, with all samples being found to be within four ranges: unpleasant, inappropriate, normal and acceptable. The WQI_B values for P1 (source), which were obtained on only five occasions, were within the range of normal and superior to the WQI_B of the other sampling points. At P2, 40% of the results were acceptable, 20% were normal, 30% were inappropriate and 10% were unpleasant. At P3, 20% of the samples were acceptable, 50% were normal, 20% were inappropriate and 10% were unpleasant.

Table 2: Weight attributed (P_i) and percentage values (C_i) to the water quality parameters for calculation of the WQI_B.

Parameter	pH	AC	T	EC	TDS	DO	A	CO_2	CL	TC	Percentage value (C_i)
Weight (P_i)	1	2	2	4	2	4	1	2	1	3	%
	1	>250	>400	>16000	>20000	0	>1500	>60	>1500	>14000	0
	2	100	250	12000	10000	1	1000	50	1000	10000	10
	3	60	180	8000	5000	2	800	40	700	7000	20
	4	40	100	5000	3000	3	600	30	500	5000	30
Analytical	5	30	50	3000	2000	3.5	500	20	300	4000	40
value of the	6	20	20	2500	1500	4	400	10	200	3000	50
parameter	6.5	15	18	2000	1000	5	300	9	150	2000	60
	9	10	15	1500	750	6	200	8	100	1500	70
	8.5	5	10	1250	500	6.5	100	7	50	1000	80
	8	4	8	1000	250	7	50	5	25	500	90
	7	<3	<5	<750	<100	7.5	<25	<3	0	<50	100

[1]AC – Apparent Color (mg Pt L^{-1}); T – Turbidity (NTU); EC – Electrical Conductivity (μS cm^{-1}); TDS – Total Dissolved Solids (mg L^{-1}); DO – Dissolved Oxygen (mg L^{-1}); A – Alkalinity (mg L^{-1} $CaCO_3$); CO_2 – Free Carbon dioxide (mg L^{-1}); CL – Chlorides (mg L^{-1}); TC – Total Coliforms (NMP/100 mL).

Analysis revealed that, in general, collections during the rainy season had lower WQI_B values than the dry season. This finding can be explained by seasonality and the resultant increase in flow, since rainfall events carry pollutants associated with particles to the watercourse [6]. The deterioration of WQI_B in 100% of the samples at P2 and P3, and 50% at P1, during the rainy season can be attributed to the concentrations of the measured parameters as presented in Tab. 3.

Among the parameters used to obtain the WQI_B, turbidity, DO and total coliforms were determinant in decreasing water quality. The relationship between turbidity, which may be natural (rock, silt and clay particles) and/or anthropic (domestic and industrial sewage, microorganisms and erosion), and total coliforms, indicating fecal contamination by warm-blooded animals and which are also found naturally in soil and vegetation, suggests that high concentrations for turbidity may be associated with effluent discharge [22].

According to the results of the laboratory analysis presented in Tab. 3, some parameters had values above the thresholds established by CONAMA resolution nº 357 [1] for Class 2 freshwater bodies. The variable pH represents the concentration of H^+ ions in the water [22]. For 100% of the samples at P1 during the dry and rainy seasons, and 16.7% of the samples at P2 during the dry season, had values lower than the range between 6.0 and 9.0 established by the resolution. The values measured at sampling point P1 (source) were suggested to represent the normal conditions of the site and is the origin of the processes of rock dissolution and photosynthesis [22]. A reduction in pH similar to that observed at points P2 and P3 during the rainy season of the present study, was also observed by Vasco *et al.* (2011)[4] in the Poxim river sub-basin in the state of Sergipe. An increase in pH along the course of the basin was also documented and may be related to natural factors such as algae photosynthesis or the quality of the environment such as deforestation in urban areas.

The parameter of apparent color was lower than the upper limit of 75 mg Pt L^{-1} for Class 2 freshwater bodies in all samples collected during the dry season. However, during the rainy season this limit was exceeded in 50% of samples collected at P2 and P3. This increase can be associated with anthropic activities in the areas adjacent to the stream such as the release of clandestine domestic effluents, since the sewage collection and treatment index is only 42%, according to BRK Ambiental (2018)[23], and the contribution of rainwater with high solids density. An increase in apparent color in the rainy season was also observed by Piratoba *et al.* (2017)[10] in the port area of Barcarena, state of Pará, due to seasonality and the location of the sampling points, which were influenced by anthropic activities such as dumping of domestic and industrial effluents.

Regarding turbidity, the CONAMA resolution nº 357 [1] establishes the upper limit of 100 NTU, so all values studied are in compliance with the resolution. The harmonic mean of this parameter ranged from 3.9 to 10.9 NTU in the dry season and from 7.0 to 45.9 NTU in the rainy season. The high levels of turbidity in the rainy season, especially

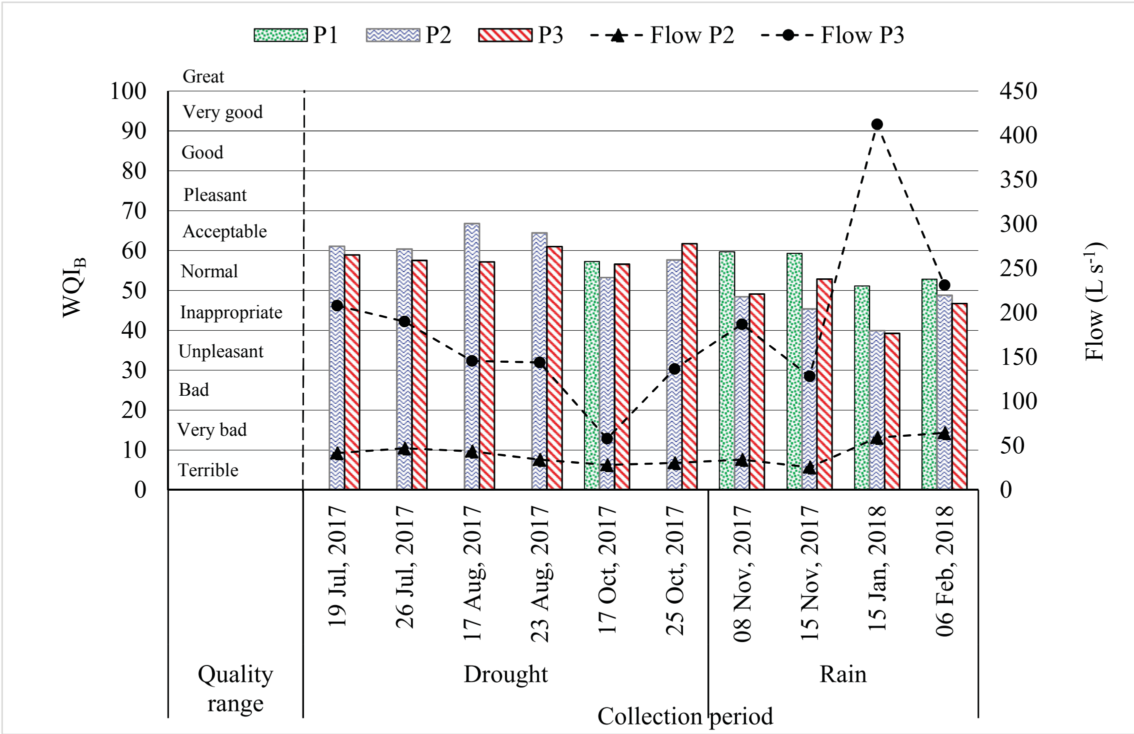

Figure 2: Values of the WQI_B for the sampling points (P1, P2 and P3), as well as the flow for the Tamanduá stream at the time of sample collection.

at P3, can be linked to the increase of flow in that season, which promotes the dissolution and transport of particles, and the influence of anthropic activities in the watercourse. The influence of flow on turbidity was also documented by Vasco *et al.* (2011)[4] in the Poxim river in the state of Sergipe.

Electrical conductivity (EC) is a parameter that conveys the ionic concentration of water [22], for which the legislation does not establish a limit. The harmonic mean of this parameter ranged from 189.7 to 208.3 µS cm^{-1} in the dry season and from 192.9 to 216.2 µS cm^{-1} in the rainy season. In general, the rainy season had higher EC than the dry season. This result was also observed by Alvarenga *et al.* (2012) [6] in the tributary microbasin of the Paraíba do Sul river in the state of São Paulo, where one of the dry periods studied had low levels of EC (26.0 to 27.1 µS cm^{-1}) in relation to the rainy season and the other dry period (34.0 to 50.1 µS cm^{-1}). Low ED was found at P3, which, according to Estever (2011)[24], can be explained by the dilution of ions caused by the high flow rate in relation to the other collection points.

Water temperature had a harmonic mean ranging from 23.7 to 27.7°C in the dry season and from 24.1 to 24.4°C in the rainy season, thus the low standard deviation (σ) characteristic of the humid tropical climate (Aw). The CONAMA resolutions do not establish limits for this parameter.

The TDS values of all samples collected were in accordance with the limit established by the CONAMA resolution nº 357 [1] of up to 500 mg L^{-1}. The harmonic mean in the dry season ranged from 126.3 to 142.3 mg L^{-1} and in the rainy season from 128.7 to 144 mg L^{-1}; thus, this variable did not exhibit a large change between the evaluated periods. The results showed that the samples collected at P3 had the lowest concentrations in the dry and rainy seasons in relation to the other points, demonstrating the direct relationship of this parameter with electrical conductivity, which also had low concentrations at P3 [24]. Higher values of TDS were observed at P2 and P3 in the rainy season due to increased flow. This finding differs from that found by Fonseca & Salvador (2005)[9] in a study carried out in the Rio Bonito basin in Descalvado, state of São Paulo, who obtained higher values in the dry season.

With regard to DO, the legislation establishes a minimum limit of 5 mg L^{-1}. Thus, only one sample collected during the rainy season at P3 had values in nonconformance, suggesting the presence of pollution in the stream. The harmonic mean of this variable ranged from 5.9 to 8.5 mg L^{-1} in the dry season and from 7.0 to 8.6 mg L^{-1} in the rainy season. The samples collected in P2 and P3 had lower concentrations in the rainy season. This may be associated with the process of organic matter transport due to rainfall events, which is indirectly related to DO concentration. Similar results were obtained by Fonseca & Salvador (2005)[9] in their study conducted in the Rio Bonito basin in Descalvado, state of São Paulo.

The alkalinity of surface water is responsible for the neutralization of acid, and occurs as hydroxide (OH^-), carbonate (CO_3^{-2}) or bicarbonate (HCO_3^-) [22], with no limits established by the legislation. The harmonic mean in the dry season ranged from 15.0 to 38.4 mg L^{-1} of $CaCO_3$ and in the rainy season from 17.0 to 66.4 mg L^{-1} of $CaCO_3$, and thus higher values were documented for the rainy season.

Free carbon dioxide is a parameter that is related to the decomposition of organic matter and the respiration of organisms, and for which legislation has not established limits. The harmonic mean in the dry season ranged from 6.0 to 21.0 mg L^{-1}, while in the rainy season it ranged from 22.4 to 39.2 mg L^{-1}. Thus, the highest concentrations were in the rainy season due to the high organic matter load carried by rain events. Furthermore, considering the entire sampling period, the samples collected at P1 and P2 had higher concentrations than P3, as a result of respiration of the roots of the plants that released CO_2 in the environment according to Atarashi-Andon *et al.* (2012)[26] in permanent preservation area near to P1 and P2 demonstrating the indirect relationship of this parameter with pH, which also had high concentrations at P3.

The CONAMA resolution nº 357 [1] establishes the limit of up to 250 mg L^{-1} for chloride; thus, all values of the present study were in compliance. The harmonic mean in the dry season ranged from 19.5 to 33.5 mg L^{-1} and in the rainy season from 21.4 to 28.0 mg L^{-1}, with no variation between the two periods. Sampling point P1 (source) had higher values than the other sampling points, with the level being associated with the dissolution of minerals [22] as mica, quartz and garnet due to the presence of metamorphic rock type micaschists as the region according to Rodrigues *et al.* (2005)[25]. This result was also found by [10] in their study in the port area of Barcarena, state of Pará, who attributed the small amount of variation to the location of the sampling points and the release of effluents. They also found no significant influence of seasonality.

With respect to heterotrophic bacteria, the legislation does not determine limits. The harmonic mean for the dry season ranged from 26 to 318 UFC mL^{-1} and in the rainy season from 83.4 to 200.9 UFC mL^{-1}. There was no variation between the periods analyzed and in general, P2 and P3 had higher values than P1 in the dry and rainy seasons. The lower level of heterotrophic bacteria in P1 may be related to the natural flora of the water because the sampling point is at the source of the Tamanduá stream.

CONAMA resolution nº 357 [1] has no established limits for total coliforms. The harmonic mean in the dry season ranged from 35 to 87 NMP/(100 mL) and in the rainy season from 17.7 to 75.9 NMP/(100 mL). Sections of the river that were not polluted did not exhibit great variation between the studied periods, similar to what was observed by Fonseca & Salvador (2005)[9] in the Rio Bonito basin in Descalvado, state of São Paulo.

CONAMA resolution nº 274 [2] establishes the limit for thermotolerant coliforms in water intended for recreation with primary contact of up to 250 NMP/(100 mL) in at least 80% of the studied samples. Therefore, the concentrations of this parameter, as shown in Tab. 3, were lower than the upper limit, classifying the water as excellent for recreational activities. Since the water is also destined for the cultivation of vegetables [14], CONAMA resolution nº 357 [1] establishes the limit of up to 1000 NMP/(100 mL) in at least 80% of the samples, and so the analyzed stretches are in compliance with this legislation as well. The concentration of thermotolerant coliforms is indicative of fecal contamination by warm-blooded animals [22].

The US Environmental Protection Agency (1984) [27] also established the criteria for thermotolerant coliforms for recreation with primary contact of up to 200 Colony Forming Units (CFU) per 100 mL, therefore, considering the concentrations of this parameter in Tab. 3, surface waters in points P1, P2 and P3 can be used by users for direct contact.

4 Conclusions

The present work supports the conclusion that the WQI_B of Tamanduá stream exhibits seasonal variation because of the deterioration of water quality in the rainy season. During the analyzed period, 48% of the samples were of normal quality ($50 \leq WQI_B \leq 60$). Regarding CONAMA resolution nº 274 [2] and US Environmental Protection Agency (1984) [27], the water quality is classified as excellent and is compatible for primary contact recreational activities.

According to the results of the laboratory analysis, it can be concluded that the parameters pH, apparent color and dissolved oxygen do not meet the limits established by CONAMA resolution nº 357 [1] for Class 2 freshwater bodies, and characterize the water of the water body as inadequate

Table 3: Physical, chemical and biological parameters at the sampling points (P1, P2 and P3), as well as the maximum permitted values.

Date	pH	AC	T	EC	WT	TDS	DO	A	CO_2	CL	HB	TC	THD
P1 – Dry season													
17 Oct, 17	5.9	24.2	3.9	208	27.7	139	5.9	15	21.0	33.5	26	35	27
P2 - Dry season													
19 Jul, 2017	8.1	20.1	11.0	207	22.4	143	9.5	10	5	-	109	460	150
26 Jul, 2017	8.5	22.2	7.0	217	23.4	148	9.7	20	10	-	22	>1100	23
17 Aug, 2017	7.4	29.7	8.0	206	25.9	143	8.1	23	4	-	258	20	3.6
23 Aug, 2017	6.8	22.1	5.8	206	24.4	138	7.8	35	5	16.5	135	120	3.6
17 Oct, 2017	6.6	36.2	10.9	207	26.2	142	6.5	39	19	34.5	80	150	20
25 Oct, 2017	**5.9**	28.7	8.0	207	23.8	140	10.6	35	22	25.0	59	1100	35
Mean	-	25.4	8.0	208.3	24.3	142.3	8.5	21.7	7.1	23.1	62.9	87.0	8.8
Desv. pad.	0.9	5.6	1.9	3.9	1.3	3.1	1.4	10.2	7.2	7.3	75.0	450.6	50.8
Coef. var.%	-	22%	24%	2%	6%	2%	16%	47%	101%	32%	119%	518%	579%
P3 - Dry season													
19 Jul, 2017	9.0	34.1	17.0	184	21.1	122	9.1	15	4	-	189	21	15
26 Jul, 2017	8.7	31.2	14.0	182	22.1	119	10.7	42	4	-	225	>1100	43
17 Aug, 2017	7.5	31.3	15.0	177	25.8	121	7.9	53	10	-	816	75	75
23 Aug, 2017	7.3	27.0	11.3	188	23.9	125	8.0	55	4	13.0	855	210	20
17 Oct, 2017	7.0	30.4	8.0	216	27.0	144	5.6	70	12	31.5	848	28	21
25 Oct, 2017	6.7	29.2	7.2	196	23.6	130	12.7	69	15	22.0	180	36	35
Mean	-	30.4	10.9	189.7	23.7	126.3	8.4	38.4	6.0	19.5	318.0	46.1	26.1
Desv. pad.	0.9	2.2	3.6	12.8	2.0	8.4	2.2	18.6	4.4	7.6	321.4	70.5	20.4
Coef. var.%	-	7%	33%	7%	8%	7%	27%	49%	74%	39%	101%	153%	78%
P1 – Rainy season													
08 Nov, 2017	**5.6**	18.0	3.1	205	25.3	137	8.9	13	37.0	30.5	140	1100	35
15 Nov, 2017	**5.6**	14.4	9.6	203	25.4	135	8.1	21	31.0	33.0	108	20	<3
15 Jan, 2018	**5.7**	17.9	15.9	203	22.0	135	9.0	18	46.0	23.5	175	>1100	150
06 Feb, 2018	**5.8**	23.8	13.4	211	24.0	141	8.4	18	40.0	27.0	63	1100	43
Mean	-	17.9	7.0	205.4	24.1	137.0	8.6	17.0	37.7	28.0	105.3	75.9	10.2
Desv. pad.	0.1	3.4	4.8	3.3	1.4	2.4	0.4	2.9	5.4	3.6	41.3	467.7	55.3
Coef. var.%	-	19%	69%	2%	6%	2%	4%	17%	14%	13%	39%	616%	542%
P2 – Rainy season													
08 Nov, 2017	6.0	**77.5**	50.0	216	24.9	144	7.9	38	29	32.0	24	36	36
15 Nov, 2017	6.0	70.2	52.1	219	25.6	145	8.2	47	50	20.0	652	11	3.6
15 Jan, 2018	6.2	**82.9**	56.3	210	23.2	140	6.0	43	43	25.5	578	210	120
06 Feb, 2018	6.3	38.9	33.1	220	24.2	147	8.3	35	41	20.5	328	36	36
Mean	-	61.6	45.9	216.2	24.4	144.0	7.5	40.2	39.2	23.6	83.4	26.5	11.7
Desv. pad.	0.1	17.0	8.8	3.9	0.9	2.5	0.9	4.6	7.6	4.8	245.8	79.6	43.1
Coef. var.%	-	28%	19%	2%	4%	2%	13%	11%	19%	20%	295%	301%	368%
P3 – Rainy season													
08 Nov, 2017	6.7	49.3	26.8	194	24.9	129	8.5	70	20	24.0	932	150	150
15 Nov, 2017	6.6	20.2	18.2	195	25.3	130	8.3	73	23	23.5	68	27	20
15 Jan, 2018	6.7	**125.1**	97.2	185	22.5	124	**4.7**	63	24	20.0	540	11	11
06 Feb, 2018	6.8	**90.0**	70.9	198	24.1	132	8.3	61	23	19.0	438	11	11
Mean	-	45.0	34.3	192.9	24.2	128.7	7.0	66.4	22.4	21.4	200.9	17.7	16.8
Desv. pad.	0.07	39.81	32.29	4.85	1.07	2.95	1.59	4.92	1.50	2.16	307.64	58.25	59.00
Coef. var.%	-	88%	94%	3%	4%	2%	23%	7%	7%	10%	153%	328%	352%
CONAMA nº 357- Class 2	6.0 - 9.0	<75	<100	-	-	<500	>5	-	-	<250	-	-	<250

[1]AC – Apparent Color (mg Pt L^{-1}); T – Turbidity (NTU); EC – Electrical Conductivity (μS cm^{-1}); WT – Water Temperature (°C); TDS – Total Dissolved Solids (mg L^{-1}); DO – Dissolved Oxygen (mg L^{-1}); A – Alkalinity (mg L^{-1} $CaCO_3$); CO_2 – Free Carbon dioxide (mg L^{-1}); CL – Chlorides (mg L^{-1}); HB – Heterotrophic Bacteria (UFC mL^{-1}); TC – Total Coliforms (NMP/100 mL); THC – Thermotolerant Coliforms (NMP/100 mL); Mean – Harmonic mean; Desv. pad. – Standard deviation; Coef. Var.% – Coefficient of variation (%).

for the prevailing uses of irrigation of vegetables and, especially, human consumption without treatment.

In the period analyzed, total dissolved solids (TDS), electrical conductivity (EC) and chloride had higher harmonic mean values in P2 than in P3, with the former in greater proximity to discharge points for urban drainage networks and low flow. This, suggests clandestine releases of domestic effluents, due to the 42% collection and treatment of sewage in the city of Aparecida de Goiânia, according to BRK Environmental (2018) [23], since there are no effluents from sewage treatment plants at the points analyzed.

The Tamanduá stream has been experiencing major impacts, mainly from anthropogenic phenomena, and thus requires periodic monitoring. The results presented here indicate the need for intervention for the recovery and preservation of the water quality of this stream.

The water quality assessment provides strategic data that allow local governments to plan and manage water resources, formulate environmental policies to control pollution in the hydrographic basin, and act as an indicator of the efficiency of the protection policies implemented previously. This can also alert the local population to promote improved water quality.

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