Urban stream: Level of disturbance and water quality

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ABSTRACT
The growth of urban centers has been causing interference in water quality. Because of this, it is necessary to monitor the environment of water bodies, either by quality parameters or by the application of the Rapid Assessment Protocol (PAR). In this context, this study aimed to evaluate the level of disturbance and water quality of the Água Fresca Stream, a microbasin of the Cambé stream in the municipality of Londrina, in the north of Paraná, by means of a PAR and physicochemical analyses of turbidity, electrical conductivity and pH, and microbiological analyses of heterotrophic bacteria, total coliforms and Escherechia coli (E.coli). For this, five sampling points were established and water collection campaigns were carried out in two months with different rainfall rates, being March (215.1 mm) and April (83.6 mm) of 2022. From the analysis of the PAR it is concluded that the Água Fresca Stream can be considered as an impacted stretch, also observed by the values of electrical conductivity, from 161 to 173 µS/cm. The highest concentrations of total coliforms, heterotrophic bacteria and E.coli occurred in the month with the highest rainfall, reaching concentrations of 62,600, 163,900 and 3,000 CFU/100 mL, respectively, influenced by the greater surface runoff caused by rainwater.

Keywords: Rapid assessment protocol, Physicochemical indicators, Microbiological indicators, Quality parameters, Precipitation.

1 INTRODUCTION

The growth of urban centers has been causing interferences in water quality, especially of rivers and streams present in cities, caused both by soil sealing and engineering works (TUCCI, 2008; ESTEVES, 2011).

In the monitoring of an aquatic matrix, the water body should be considered as an integral part of a complete environment, forming its hydrographic basin (ARAUJO, 2004), in which the water has physical, chemical and biological characteristics that can alter its degree of purity, characterized as quality parameters (VON SPERLING, 2007).

The condition of the water quality of a water body is determined by a set of conditions and standards necessary to meet the preponderant uses, established by CONAMA Resolution No. 357/2005, indicating the classification, along with the environmental guidelines for its framing from physico-chemical and microbiological parameters (BRASIL, 2005).

The physicochemical parameters demonstrate the relationships existing in the aquatic environment and their conditions to maintain a balanced and living ecosystem. As for the microbiological parameters, these are composed of microorganisms that indicate fecal contamination, *and Escherichia coli (E.coli)* is the only species whose exclusive habitat is the human intestine and homothermic animals in which its presence guarantees exclusively fecal contamination (BRASIL, 2005).

In addition to these parameters, another way to monitor the quality of water bodies is by applying the Rapid Assessment Protocol - PAR, an environmental analysis tool that establishes the levels of impacts on stretches of watersheds through the visual analysis of the structure and functioning of the water body (CALLISTO et al., 2002).

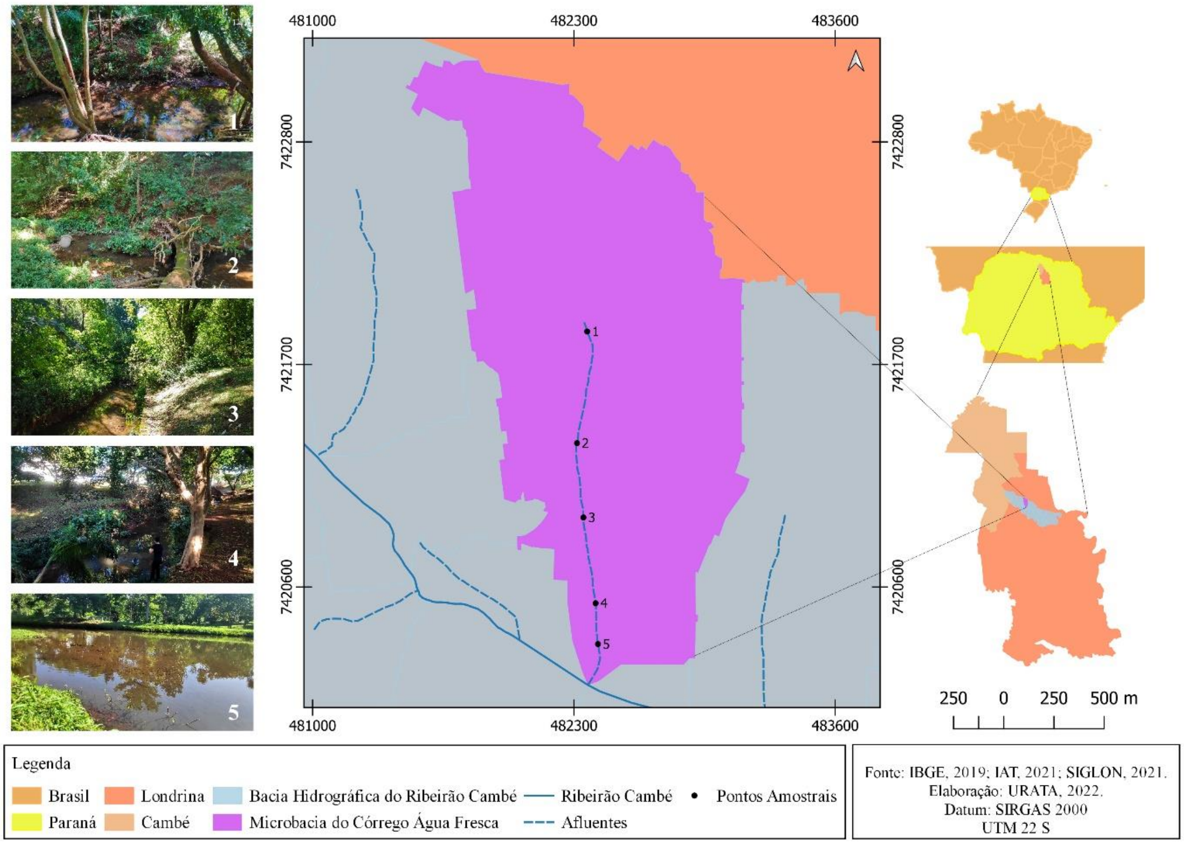
In this context, this study aimed to evaluate the level of disturbance of the Água Fresca Stream, microbasin of the Cambé stream, in Londrina, in the north of Paraná, by the application of a PAR and to determine the quality of its water by means of physicochemical and microbiological analyses in two collection campaigns with different rainfall indices and to compare the results with CONAMA Resolution No. 357/2005.

2 METHODOLOGY

2.1 CHARACTERIZATION OF THE STUDY AREA

The Água Fresca stream, located in the urban area of Londrina, is a first-order tributary of the Cambé river basin, being one of the most important tributaries, since it was the first source of supply of the municipality of Londrina (BARROS, 2012). To evaluate the level of disturbance and water quality of the stream, five sampling points were determined along its course, as shown in Figure 01.

Figure 01: Location of the Ribeirão Cambé watershed and the Água Fresca Stream watershed, with emphasis on sampling points 1, 2, 3, 4 and 5.



Source: Own elaboration.

The first point is located near the Water Treatment Plant - ETA of the Paraná Sanitation Company - SANEPAR and the source of the stream, which suffered a burial in the 1970s (FRANCE et al., 2013), the second and third point are close to the *campuses* of the University Center Philadelphia (UniFil), the fourth point is near the Municipal Cemetery John XXII, and, finally, the fifth point is the mouth of the Água Fresca Stream, flowing into Lake Igapó II.

2.2 RAPID ASSESSMENT PROTOCOL (PAR) OF THE ÁGUA FRESCA STREAM

To determine the level of disturbance of the water body, the PAR proposed by Callisto et al. (2002) with modifications was applied (Chart 01). Such modifications are characterized by the exclusion of some parameters, due to the impossibility of evaluation on the day of the field visit.

Table 01: Rapid Assessment Protocol (PAR) in stretches of river basins

Parameters	Punctuation		
	4 points	**2 points**	**0 point**
1.Type of occupation of the banks of the water body (main activity)	Natural vegetation	Pasture field/Agriculture/Monoculture/ Reforestation	Residential/Commercial/Industrial
2. Erosion near and/or on the banks of the river and siltation in its bed	Absent	Moderate	Sharp
3.Anthropic changes	Absent	Change of domestic origin	Changes of industrial/urban origin
4. Water transparency	Transparent	Blurred	Opaque/Colorful
5.Vegetation cover in the bed	Partial	Total	Absent
6. Type of background	Stone/Gravel/Sand	Mud/Sand	Cement/Plumbing

Source: Modified from Callisto et al. (2002).

In this protocol, the evaluation is performed with a score of 0 to 4 points according to the conditions of each parameter analyzed, in which the classification is obtained by the sum of the values attributed, as shown in Chart 2.

Table 02: Score to determine the level of disturbance of the section under study

Punctuation	Level of Disturbance
>16	Natural
11-16	Changed
0-10	Impacted

Source: Modified from Callisto et al. (2002).

2.3 PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSES

To perform the physicochemical and microbiological analyses, two water collection campaigns were carried out: in March and April 2022. At each point, water samples were collected in triplicate (distance of 2 to 5 m from each other) using a previously sanitized aluminum bucket and transferred to sterile plastic vials of 100 mL, where at each point one vial was destined for physicochemical analysis and another for microbiological analysis, totaling 30 samples.

After collection, the vials were packed in Styrofoam boxes with dry ice and transported to the Sanitation and Microbiology laboratories of the Federal Technological University of Paraná (UTFPR), Londrina campus, for analysis.

The physicochemical parameters analyzed were turbidity, electrical conductivity and pH with benchtop equipment: turbidimeter (PoliControl/AP2000), conductivity meter (TECNOPON/MCA-150) and pHmeter (IonLab/PH-500B-I), respectively, up to reading stability.

For the microbiological analyses, 3M Petrifilm plates were used for *counting E.coli* and total coliforms, and 3M *Petrifilm Aqua Heterotrophic Count* plates were used for counting heterotrophic bacteria. For this, 1 mL of the homogenized water samples were inoculated in the center of the plates, lowering the plastic film and distributing the inoculum with a diffuser before the gel was formed. After solidification of the gel, the plates were incubated in a bacteriological oven at 35°C, for a period of 24 hours for the total coliform plates *and E.coli,* and for 48 hours for the plates of heterotrophic bacteria The confirmation of the presence of the microbiological indicators followed the manufacturer's instructions (3M, 2021).

The rainfall data for each collection campaign were obtained by the Hydrological Information System (SIH) through the portal of the Water and Land Institute - IAT, of the Porto Londrina station (IAT, 2022), and the monthly accumulation and precipitation were analyzed ten days before the collection campaigns.

3 RESULTS AND DISCUSSION

3.1 PROTOCOL FOR RAPID ASSESSMENT OF THE LEVEL OF DISTURBANCE (PAR) OF THE ÁGUA FRESCA STREAM

The results of the PAR and the level of disturbance of the Água Fresca Stream are presented in Table 01.

Table 01: Score of the Rapid Assessment Protocol (PAR) of the five sampling points of the Água Fresca Stream, together with its classification of the level of disturbance

Parameters	**Sampling Points**				
	Point 1	**Point 2**	**Point 3**	**Point 4**	**Point 5**
1.Type of occupation	Reforestation (2)	Reforestation (2)	Reforestation (2)	Reforestation (2)	Reforestation (2)
2.Erosion and/or siltation	Moderate (2)	Moderate (2)	Moderate (2)	Sharp (0)	Absent (4)
3.Anthropic changes	Urban changes (0)	Urban changes (0)	Urban changes (0)	Urban changes (0)	Urban changes (0)
4.Water transparency	Transparent (4)	Transparent (4)	Transparent (4)	Protection (2)	Transparent (4)
5.Vegetation cover in the bed	Absent (0)	Absent (0)	Absent (0)	Absent (0)	Absent (0)
6.Type of background	Old (2)	Old (2)	Channeled (0)	Old (2)	Old (2)
Summation	**10**	**10**	**8**	**10**	**12**
Disturbance level	**Impacted**	**Impacted**	**Impacted**	**Impacted**	**Changed**

Source: Own elaboration

Thus, it is verified that the Água Fresca Stream can be considered an impacted water body, with the exception of point 5 which is altered.

The first parameter as to the type of occupation of the banks, are characterized by areas of plant reforestation (Figure 02), since for having been a source of the city of Londrina, suffered loss of its native vegetation (COSTA, 2009).

Figure 02: Riparian forest in some points of the Água Fresca Stream.

Source: Own elaboration.

Erosion near and/or on the margins and siltation in the bed (parameter 2) is interconnected with the stability of the margins and the protective capacity of the water body. This parameter was present in all the analyzed points, either caused by the flow of water that wears the margin, called as fluvial erosion, by the influence of rainfall erosion, that is, erosion caused by rainwater or by anthropogenic erosions, as shown in Figure 03.

Figure 03: Signs of erosion at some points of the Água Fresca Stream.

Source: Own elaboration.

The third parameter is related to the construction of dikes or dams, rectification of the water body, plumbing or waterproofing by engineering works, which reduce the dredging area (BIZZO; MARK; ANDRADE, 2015) or by the dumping of household sewage. At the sampling points, the anthropic alterations were characterized mainly by the channeling of the stream, as shown in Figure 04.

Figure 04: Engineering works in some points of the Água Fresca Stream.

Source: Own elaboration.

The Environmental Company of the State of São Paulo – CETESB characterizes the transparency of water, indicated by parameter 4, by the presence of suspended solids or organic debris, being directly related to the physical parameter of turbidity (CETESB, 2019). The sampling points were classified with transparent water, with the exception of point 4. Still in point 4, this was the only one to present aquatic plants, representing parameter 5, as shown in Figure 05. These plants participate in the cycling and storage of nutrients and the formation of organic debris (HEGEL; MELO, 2016).

Figure 05: Presence of macrophytes at sample point 5 of the Água Fresca Stream.

Source: Own elaboration.

The sixth parameter, referring to the type of bottom, is related to the physical properties of the soil, which when integrated to the slope, composes the erosive potential parameter of the soil (BELTRAME, 1994). At the sampling points, points 1, 2, 4 and 5 had mud bottoms and points 3 were channeled (Figure 06). In channeled stretches, there is the loss of native species, since the proper conditions of survival are often not maintained.

Figure 06 Type of bottom of the Água Fresca Stream: (a) mud and (b) channeled.

(a) (b)

Source: Own elaboration.

It is worth mentioning that at all points, solid waste was found, such as bags, plastic packaging, fabrics, Styrofoam and construction waste in the vicinity of the stream, potentially being carried by the surface runoff of the rain.

3.2 PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSES

The first campaign, in March, accumulated a monthly rainfall of 215.1 mm, and the second, in April, with 83.6 mm. Analyzing 10 days prior to collection, the month of March accumulated 112.1 mm and that of April 9.5 mm.

The results of the physicochemical parameters are presented in Table 02.

Table 02: Means and standard deviations of the physicochemical parameters at the sampling points

Sampling Point	**Turbidity (NTU)**		**Electrical Conductivity (µS/cm)**		**ph**	
	1st Campaign	2nd Campaign	1st Campaign	2nd Campaign	1st Campaign	2nd Campaign
1	1,80±0,67	0,89±0,53	173,30±6,43	173,00±4,95	6,50±0,03	6,10±0,12
2	1,65±0,07	1,47±5,11	171,20±1,02	166,50±1,61	7,16±0,12	6,28±0,16
3	0,91±0,14	0,99±0,13	165,85±0,85	163,20±0,10	7,19±0,15	6,54±0,06
4	6,52±3,33	2,50±0,25	161,80±0,77	161,70±0,68	7,37±0,09	6,53±0,07
5	1,76±0,66	2,44±0,05	162,30±0,57	162,60±0,06	7,32±0,07	6,44±0,10

Source: Own elaboration.

In the first campaign, with the highest rainfall index (March), the pH was close to 7.0. In the second campaign, the pH presented lower values, with a higher value at point 3 (6.54). Carvalho, Schlittler and Tornisielo (2000) explain that the pH tends to rise and approach neutrality with increased rainfall, due to the greater runoff and dilution of dissolved compounds, which corroborates the results.

In the PAR, with the exception of point 4, the points had transparent water, a characteristic confirmed by the low turbidity values found. The highest turbidity of the stream occurred exactly at point 4, in the first campaign, with 6.52 NTU. This value is related to the water being turbid, possibly influenced by the characteristics of the margins analyzed in the PAR, where it has a more accentuated erosion and consequently greater sediment intake.

The Cambé stream is classified as class III, and comparing the results of the stream for turbidity and pH with the values allowed by CONAMA Resolution No. 357 of 2005 for this class (100 NTU for turbidity and pH from 6.0 to 9.0), in both campaigns, these parameters at all points are in force with the legislation.

The electrical conductivity is not legislated, but "indicates the amount of salts existing in the water column and, therefore, represents an indirect measure of the concentration of pollutants", with values higher than 100 µS/cm being an indication of impacted environments (CETESB, 2019). In this study, all points in both campaigns exceed this reference value, where point 1 obtained the highest value in the first and second campaigns (173.30 and 173.00 µS/cm respectively). This parameter corroborates the result of the level of disturbance obtained by the PAR.

The results of the microbiological concentrations are shown in Table 03.

Table 03: Mean concentration of colony-forming units (CFU) of heterotrophic bacteria (BH), total coliforms (TC) and *E.coli* (EC) in the two data collection campaigns

Sampling Point	BH (CFU/100mL)		CT (CFU/100mL)		EC (CFU/100mL)	
	1st Campaign	2nd Campaign	1st Campaign	2nd Campaign	1st Campaign	2nd Campaign
1	101.800	87.500	28.700	19.000	1.500	3.000
2	126.200	66.000	51.700	18.000	2.900	2.700
3	114.900	67.400	48.000	13.200	2.800	1.700
4	163.900	81.200	61.800	22.100	2.900	1.700
5	151.200	95.600	62.600	20.900	2.700	1.500

Source: Own elaboration.

The heterotrophic bacteria were influenced by precipitation, which with a higher flow of water flow there was a higher concentration of colonies, reaching 163,900 CFU/100 mL at point 4. This behavior is expected, since with greater runoff there may be a greater contribution of organic matter to water bodies. This microbiological group are usually in greater quantity in relation to the bacteria of the coliform group, due to the possibility of natural presence in the waters (BARTRAM, 2003). There is no current legislation for the monitoring of heterotrophic bacteria, and it is, therefore, a parameter that indirectly relates the organic load present in the water.

Total coliforms also followed the same behavior as heterotrophic bacteria, finding an average of 50,560 CFU/100 mL and 18,640 CFU/100 mL in the first and second campaigns, respectively. Similar results were found by Pontuschka et al. (2021), who also linked the increase in coliforms with increased rainfall, where the highest concentrations occurred in densely urbanized areas.

As for *E.coli bacteria, the point with* the highest concentration was point 1, in the second campaign, with 3,000 CFU/100 mL. This result may have been influenced by the presence of wild animals present at the site due to the vegetation cover and the decrease in water volume. In addition, point 1 in the second campaign obtained values close to those verified in the first campaign for points 2, 3, 4 and 5, and in the first campaign obtained the lowest concentration with 1,500 CFU/100 mL. At the other points, it reached an average of 2,825 and 1,900 CFU/100 mL in the first and second campaigns, respectively.

Comparing the concentration of *E.coli* with CONAMA Resolution No. 357/2005, with a maximum permissible value of 2,500 CFU/100 mL for class III water with primary contact, it is observed that only point 1, in March, and points 3, 4 and 5, in April, have values lower than allowed. For the other uses, the established limit is 4,000 CFU/100 mL, in which all points are within the required standard.

4 CONCLUSIONS

Through this study, the Água Fresca Stream can be considered to have an impacted level of disturbance in most of its watercourse. This impact can also be analyzed in the values obtained for the electrical conductivity, which along the stream ranged from 161 to 173 µS/cm.

All physicochemical and microbiological parameters are within the values established by CONAMA Resolution No. 357 for water body classified as class III, with the exception of *E.coli* for primary uses of water.

In addition, these parameters were influenced by rainy events, with the highest values resulting from the month of highest rainfall, due to the greater surface runoff caused by rainwater.

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