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DETECTION OF POSSIBLE POLLUTING MICROPLASTICS IN THE PARAGOMINAS STREAM, MUNICIPALITY OF THE SAME NAME, PARÁ, BRAZIL

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Antônio Pereira Júnior[1], Gundisalvo Piratoba Morales[2], Norma Ely Santos Beltrão[3], Gysele Maria Morais Costa[4], Maik Cauan Silva Recoliano[5], Maria Eduarda Moreira Martins[6], Ana Carolina Sampaio Moreira[7] and Paula Freitas de Almeida[8]

ABSTRACT

Emerging pollutants such as microplastics – MPs (particles < 5mm), have currently raised the concern of water resource managers, especially in urban areas. The problem becomes more serious when there is no information and data about the possible presence or absence of them in urban waters. This gap was fundamental for the execution of this research in the Paragominas stream, in the homonymous municipality, in addition to determining the four objectives: To identify: 1) the possible origins of the MPs in the two environmental matrices; 2) the presence or absence in the two environmental matrices: water and sediments in five areas of the urban stretch; 3) the shapes and colors, and 4) the possible environmental changes that their presence can cause in surface waters. The method used was investigative with quantitative and qualitative scope and observational nature. The data obtained and analyzed in the five areas (24.255 items) of the urban section indicated that there is the presence of MPs. The greatest magnitude occurred in surface waters (23500 items/m3); the lowest, in sediments (755 items/kg); Regarding the shape, the fibers had a greater magnitude (96.60%), with a predominance of the color blue

[1] PhD student in Environmental Sciences
University of the State of Pará
E-mail: antonio.junior@uepa.br
[2] PhD in Environmental Geochemistry and Petrography
University of Pará State
Travessa Eneas Pinheiro, 2626, Bairro Marco, Belém, Pará
E-mail: gundymorales@gmail.com
[3] PhD in Agriculture Economics and Rural Development
University of Pará State
E-mail: normaelybeltrao@gmail.com
[4] PhD student in Environmental Sciences
Federal University of Pará
E-mail: gyselemorais@hotmail.com
[5] Undergraduate in Chemistry
University of the State of Pará
E-mail: maik.csrecoliano@aluno.uepa.br
[6] Undergraduate in Environmental and Sanitary Engineering
University of the State of Pará
E-mail: maria.em.martrins@aluno.uepa.br
[7] Undergraduate in Chemistry
University of the State of Pará
E-mail: ana.csmoreira@aluno.uepa.br
[8] Specialist in Linguistic Studies and Literary Analysis
University of the State of Pará.
E-mail: paula.freitas@uepa.br

(44.13%). In the distribution by areas, A4 – Green Lake, presented, in water, the highest magnitude (8050 items/m3), and the lowest, in A2 – Avenida Selecta (2300 items/m3). As for sediments, the fibers highest magnitude occurred in A1 - Constantino Pereira do Sacramento Highway (320 items/Kg), and the lowest, in A5 – Padre Carvalho Street (25 items/Kg). This is the first study on this topic, in this stream, and can be used by municipal managers and develop actions that allow and control the abundance of MPs and avoid additional costs both in health and in the treatment of water for public supply.

Keywords: Emerging pollutants. Biofouling. Population density. Urban impacts.

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INTRODUCTION

Emerging pollutants such as microplastics – MPs[9] (< 5mm), at an international level, have an identified presence in the media of three components of the environment: soil, water, and air. The proliferation of MPs in the environment occurred shortly after the end of World War II (HARTMANN, 2019), and intensified with the growth of both population and consumption of products whose packaging is plastic and inappropriately disposable (CAIXETA *et al.,* 2022). This proliferation and detection, in surface waters and sediments, needs to be detected, it is already in evidence in North America, the Asian Continent, Europe, and South America.

In North America, in the state of North Carolina, the presence of MPs in the Neuse River has already been identified, based on the relationship between land use and occupation and the concentrations of this emerging pollutant (ALLEN, 2021; KURKI-FOX *et al.,* 2023). In Texas, the surface waters of lakes receive domestic effluents in urban areas, and one of the pollutants identified are MPs. In the San Marcos River, and this associates the deficiency, reception, conduction, and adequate treatment of these domestic and industrial effluents (STOVALL; BRATTON, 2022).

On the Asian continent (AZEVEDO, 2024), studies conducted in Indonesia (NURIKA *et al.,* 2023), Malaysia (ZAHID *et al.,* 2022), Vietnam (THANH *et al.,* 2022), the evidence of the MPs, the problem lies in the contamination of aquatic fauna of vertebrates (e.g., fish), or filter feeders (e.g., mussels). In China, the problem is regarding the form of intervention that can, in fact, mitigate the pollution caused by MPs (SADIA *et al.,* 2024). In Europe, in Portugal, this concern is already a fact (PRATA *et al.,* 2020).

In South America, MPs have already been identified in Colombian coastal waters (GARCÉS-ORDÓÑES *et al*. 2024; SÁEZ-ARIAS *et al.,* 2023). In Brazilian territory, they were detected in 1995 (MONTAGNER; VIDAL; ACAYABA, 2021). In the North region, the Amazon area, studies (SANTANA *et al.,* 2024; SOUZA; SILVA; OLIVEIRA, 2023) already show the presence of these MPs. Research conducted in the state of Amazonas (GEROLIN *et al.,* 2020). In this state, the MPs have already been detected in the Javari River, municipality of Benjamim Constant (SILVA *et al*., 2024) and in Itacoatiara (GUIMARÂES *et al.,* 2023).

In Pará, the MPs were identified and studied in the municipality of Santarém, in a water reservoir, the Samuel Hydroelectric Power Plant (OLIVEIRA, 2022). In the northeast

[9] National Ocean and Atmospheric Administration – NOOA. 2024. Available at: What are microplastics?

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region, more specifically the state of Ceará, in the Metropolitan Region of Cariri (LIMA, *et al.,* 2024), the pollution of the Salgado River caused by PM was investigated. In the southeast region, in Guanabara Bay, the presence of PM has already been evidenced (ALVES; FIGUEIREDO, 2019).

However, the challenge regarding the cause-effect relationship in the environment, especially in the national territory, due to its extension, in terms of the aquatic environment, this new type of pollutant is a challenge from two perspectives: 1) operational management system; 2) water quality monitoring (ABREU, 2023). These MPs, in aquatic environments, raise concerns about the abundance and degree of risk they pose to aquatic fauna (KHAN *et al.,* 2024), due to their non-detection with the naked eye (KRAUSE, 2021; KURKI-FOX *et al.,* 2023), in addition to the high permanence time in water bodies. All this associated with the absence of legal guidelines These three challenges allowed the PM to be named emerging environmental pollutants (MONTAGNER *et al.,* 2021).

These global concerns lie in the fact that polymers, or simply plastics, undergo chemical changes in order to be adapted to the purposes for which they are intended post-manufacturing (RANI-BORGES, 2022). It becomes even more intense when, after use, they are discarded in inappropriate places. Such action causes changes in the environment and increases the risks of changes in public health (MONTAGNER, *et al.,* 2021). Such modifications cause a high resistance to decomposition by bacteria, in addition to the high adsorption capacity with other contaminating agents such as pesticides (BATISTA; AMADO, 2023).

Within this framework, the analysis, study, and research on the problems caused to urban water bodies, human health, and the environment by the presence of these microplastics in surface urban waters such as in the urban stretch of the Paragominas stream, in the state of Pará, becomes imminent. All these facts, plus the generation of data that facilitate and contribute to municipal management, for better effectiveness and efficiency in the management of water resources, justified and contributed to the relevance of this research. In addition, these arguments also contributed to the establishment of four objectives: 1) the possible origins of the MPs in the two environmental matrices; 2) the presence or absence in the two environmental matrices: water and sediments in five areas of the urban stretch; 3) the shapes and colors, and 4) the possible environmental changes that their presence can cause in surface waters.

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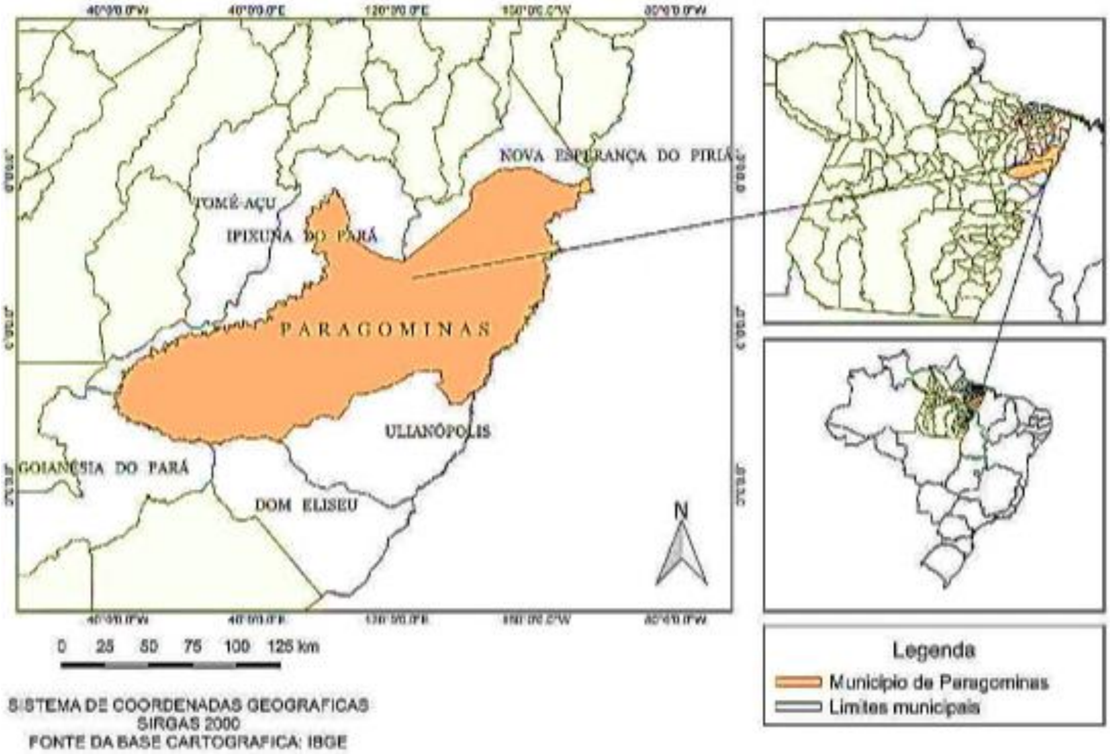
MATERIAL AND METHODS

PHYSIOGRAPHY OF THE MUNICIPALITY

The municipality of Paragominas (Figure 1) is located 316 km from the Metropolitan Region of Belém, in the southeastern region of the state of Pará, under the following geographic coordinates, in *Universal Transverse Mercartor* (UTM), 23M, 223948 E; 9671781 N. The current vegetation classified as primary, is characterized by capoeira, whose stages are varied (PARAGOMINAS, 2019). The climate is hot and humid, which is why it is classified as Awi, in the Köppen classification parameter, and as B1WA', in the climatic type established by Thornthwaite. The average annual temperature is 26.3ºC (February and June = 25.6ºC; October and November = 27.0 ºC), with annual relative humidity around 81% (76% to 85%), and annual rainfall reaches 1800 mm, with oscillations between 800 mm and 2800 mm (BASTOS; PACHECO; FIGUEIREDO, 2005).

Figure 1 – Location of the municipality of Paragominas, southeast of Pará. Brazil.



Source: Souza et al., 2019.

The demographic census conducted in 2020 found that there are 105,550 inhabitants in this area equivalent to 19,342,565 km^2 (IBGE, 2023). The microbasin of the Uraim River, the main water source of the municipality, has an extension equivalent to 505,437 ha (area) and 414 km^2 of perimeter (FERREIRA *et al.,* 2024). In 2022, 38,284

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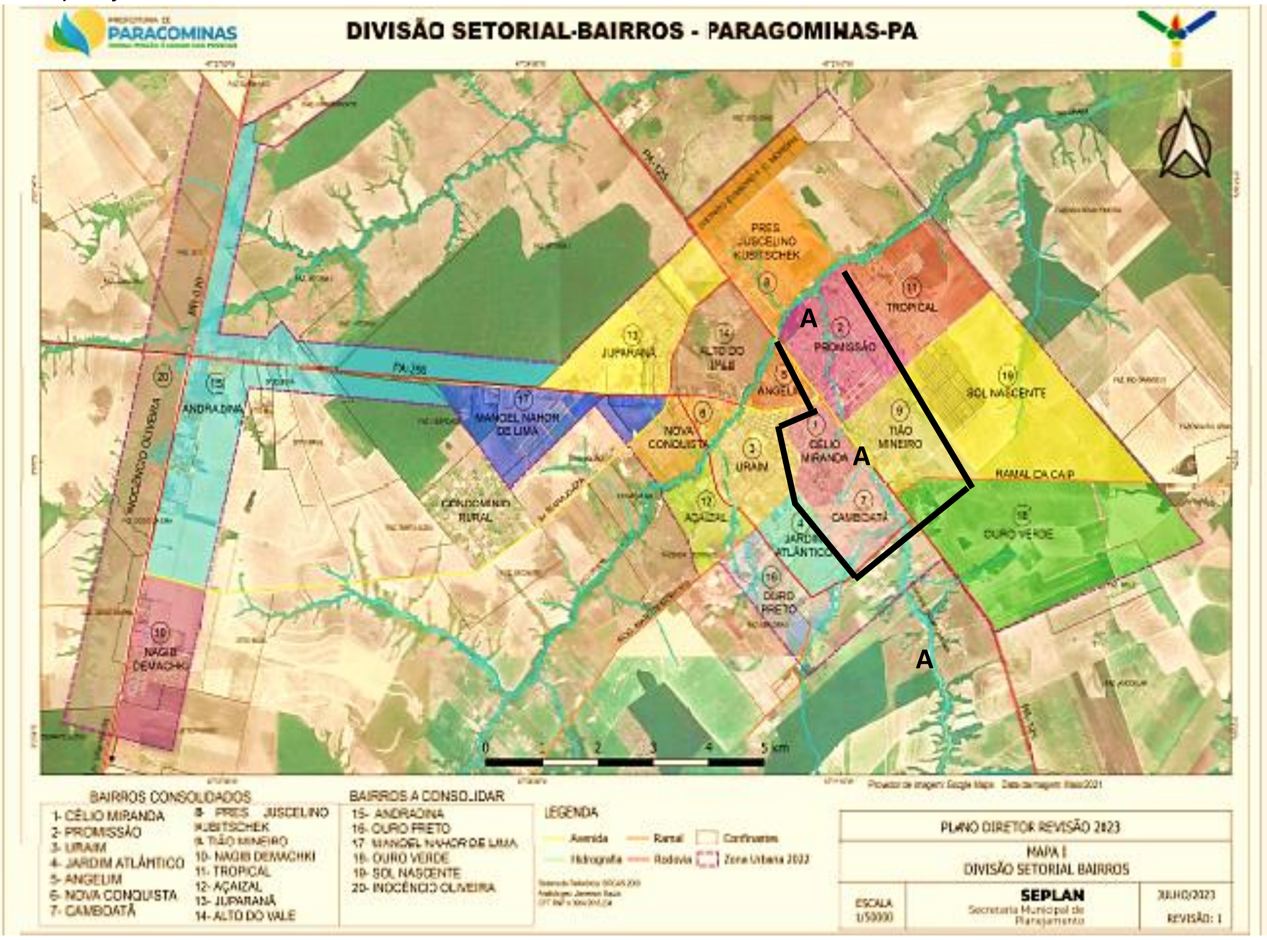
residences were rebuilt, of which 33,006 (86.3%) were occupied (IBGE, 2023). The Municipal Master Plan (PARAGOMINAS, 2023) indicated that Paragominas has 16 neighborhoods already consolidated and six to be consolidated. Of this total, four of them, Célio Miranda[1] and Camboatã[7], are on the left bank, upstream (M) → downstream (J), of the Paragominas[A] stream; the Tião Miranda[9] Promissão[2] neighborhoods are on the right bank, in he same direction (Figure 2).

Figure 2 – Identification of the four marginal neighborhoods of the Paragominas stream, in the homonymous municipality. Pará. Brazil.



Source: Paragominas, 2023.

METHOD

For a more adequate development of this research, the so-called "exploratory research" was adopted, with quantitative and qualitative coverage, of an observational nature (PEREIRA *et al.,* 2018). The best justification for this type of research with qualitative scope lies in the fact that it deepens the way of knowing the object studied and how it occurs in the analyzed environment (LÖSCH; RAMBO; FERREIRA, 2023): origin, shapes,

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colors, and changes in the environmental matrices analyzed, especially in aquatic communities.

As for quantitative coverage, it was adopted because it allows a numerical translation of information about the object studied (MINEIRO; SILVA; FERREIRA, 2022). In this case, the MPs, in terms of shape (fiber, films, and fragments), and color found in the Paragominas stream (GÜNTHER, 2006).

RESEARCH AREA

The Paragominas stream is positioned under the following geographic coordinates: 239920.6 E; 9667047.7 N, at an altitude of 79 m, whose sinuous length (≈ 4.4 km), flows into the right bank of the Uraim River, in the so-called zone V, in the Urban Territorial Zoning. The five areas are located in the urban section: A1 – Constantino Pereira do Sacramento Highway (Figure 3a), A_2 – Selecta Avenue (Figure 3b); A_3 - Camboatã (Figure 3c); A_4 – Green Lake (Figure 3d), and A_5 – Padre Carvalho Street (Figure 3e) were defined according to the population density of these neighborhoods, and the collections always occurred in the M → J direction.

Figure 3 – The five water collection points, in the urban stretch of the Paragominas stream, homonymous municipality. Pará. Brazil.

Source: authors (2025).

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ENVIRONMENTAL MATRICES - SAMPLING

Water and sediment

The collections were conducted during the dry-rainy transition period in the months of October and November, in the morning. The sampling protocol for both water and sediment was adapted from that described by the *National Oceanic and Atmospheric Administration* (MASURA, 2015). The instruments were provided by the Environmental Quality Laboratory (LQA), of Biology and Chemistry, of the *Campus* VI, Paragominas (Board 1).

Board 1. Instruments used for water and substrate collection. Paragominas stream, a municipality of the same name. Pará. Brazil.

Collection of...	Instruments used	Brand	Volume
Water	Aluminum bucket collector w/handle	--	10 L
	Granulometric control sieve	TPL	75 µm. 150 µm.
	Borosilicate bottle with screw cap	Vidrex	500 mL
Bottom sediments	Bottom collector with 4m extension.	--	1800 mL
	Storage in aluminum containers.	Thermal	CP 1360

Source: authors (2025).

Primary data

Water

For water sampling to obtain primary data, we used an aluminum bucket with a capacity equal to 10 L was used. It was dipped four times in the Paragominas stream, for a total of 40 L; then, they were screened in meshes of 75 and 150 µm, respectively. Soon after, the sieves were washed with distilled water and this water was filled in borosilicate bottles (Total V = 500 mL; $V_{Occupied}$ = 250 mL), which were sealed with aluminum foil, to avoid the insertion of other types of plastics such as the one contained in the original lid of these bottles. After these actions, the samples were stored in a *cooler* containing ice gel, with a temperature set to 10 ºC, and taken to the Biology and Environmental Engineering Laboratories of *Campus* VI, Paragominas, and were stored at 18º C for further analysis.

Sediments

Sampling was conducted using a manual collector (Figure 4a), on a 4-m stick, at the end of which there is a circular cup with a volume equal to 1,800 mg (Figure 4b). This collector was immersed in the water body until it reached the substrate. Then it was raised to the edge of the boat, where excess water was removed and then the substrate was

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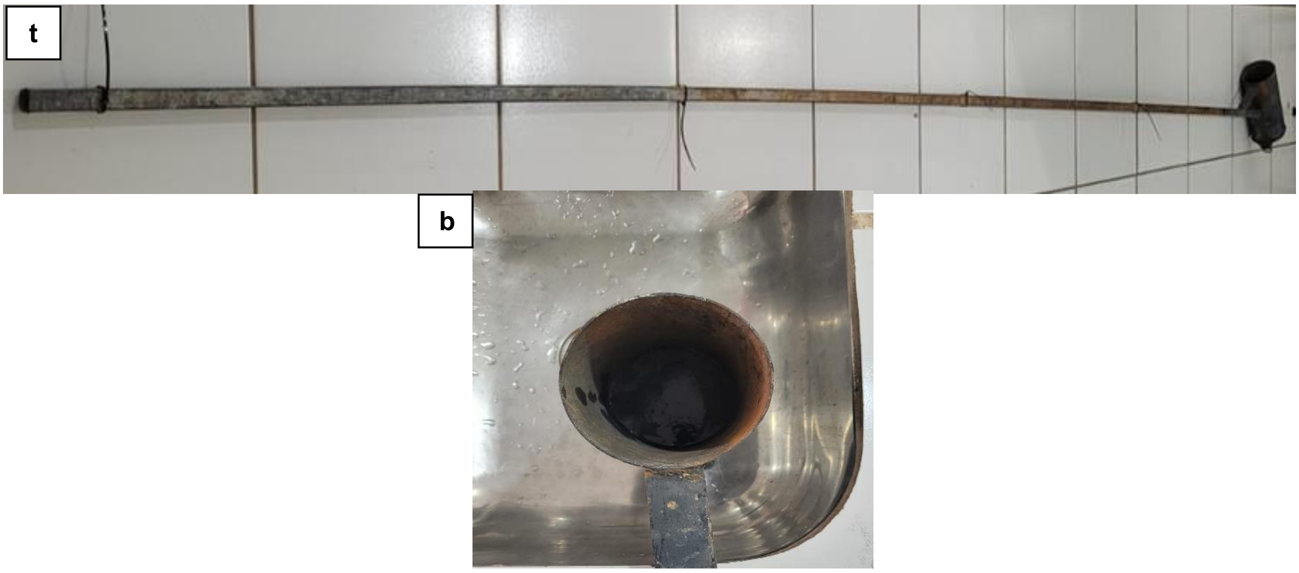
deposited in the aluminum containers that was filled to the edge. Finally, the samples were packed in a *Cooler* capacity for 32 L, and taken to the Forest Engineering laboratory, where they were stored in a refrigerator, on the *campus* VI, Paragominas, for further laboratory analysis.

Figure 4 – Instruments used for field collections: a) sediment collector; b) Aluminum container for collection for substrate.

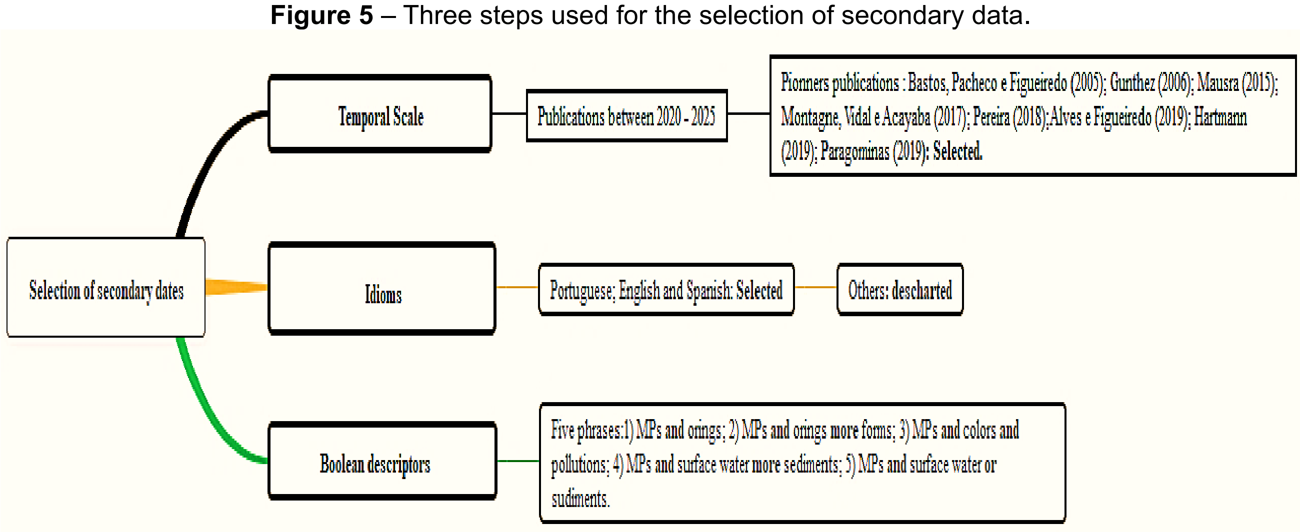


Source: authors (2025).

SECONDARY DATA

To obtain the secondary data, the following steps were performed (Figure 5).

Figure 5 – Three steps used for the selection of secondary data.



Source: authors (2025).

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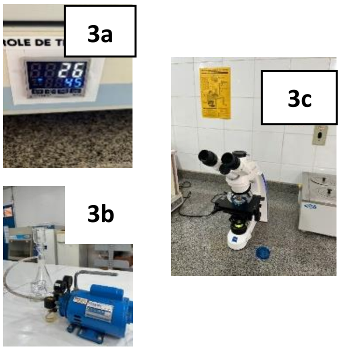
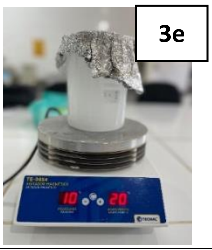
LABORATORY ANALYSIS

Water and sediment

The separation of the possible items of PM, contained in the water and sediments, was conducted in different stages (Board 2).

Board 2. Laboratory procedures for detecting PM in water and sediment. Igarapé Paragominas, a municipality of the same name Stop. Brazil.

Analysis:	Actions		Goals
From the water	**1)** Collected water was measured; **2)** A similar volume of Hydrogen Peroxide (H2O2) was added at 15%; **3)** 72 h in the greenhouse at 45º (Figure **3a);** **4)** It was filtered with the use of a vacuum pump[2] (Figure **3b);** **5)** Physical characterization of the MPs using a binocular microscope with 4 objectives[3] (Figure **3c).**		Digestion of organic matter
Sediments	**1)** Sodium chloride (NaCl = 360 g/L) was weighed on a four-digit precision analytical scale (Figure **3d)**		Promotion of microplastic flotation.
	2) It was dried in the greenhouse for 4 to 5 days at 50ºC; **3)** An aliquot of 100g of sediment was weighed in duplicate per point collected; **4**) After drying, for 72 h, at 45ºC, 500 mL of Sodium Chloride (NaCl) was added; **5)** Removed supernatant; **6)** Hydrogen Peroxide (H_2O_2) was added; **7**) It was filtered, with the use of a vacuum pump, without circulating air.		
	8) The sample was homogenized using a heating plate with a magnetic stirrer[3] (Figure **3e)**		Dilution of NaCl.

Legends: [1]Temperature = 20º C; RPM = 10; [2]Prismatec brand, model 131/132; [3]Zeiss brand, Primo Star model. Source: Authors (2025).

The possible MPs were quantified and typified in terms of (1) shape (sphere, fiber, film, fragment, sphere, and pellets, and (2) colors, with the use of a Zeiss electron microscope, with a magnification of 10x. The textural classification of the sediment was conducted by the Laboratory of Soils & Plants, under the technical responsibility of Mr. Geordano I. Sobrinho (CREA/CRQ 1216270929).

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STATISTICAL ANALYSIS OF THE DATA

After obtaining the abundance with the number of particles obtained, descriptive statistics (absolute and relative frequency; mean, standard deviation, median, maximum, minimum) were applied. Next, the Man-Whitney Test (Dunn's method) and the Q-Square Test were performed.

RESULTS

DISTRIBUTION, SHAPE, AND COLORS OF MPS IN THE FIVE AREAS ANALYZED

The analysis of the data obtained and analyzed indicated the presence and MPs in the two environmental matrices collected (24255 items), with higher for water (23500 items.m^3) and lower for sediments = 755 items/ kg (Table 1).

Table 1. Distribution of the items identified in the two environmental matrices analyzed in five areas of the urban stretch of the Paragominas Stream, in the municipality of the same name. Pará. Brazil.

Areas analyzed	**ENVIRONMENTAL MATRICES**						
	Waters			**Sediments**			***p value***
	(item. m3)		(%)	(item.kg)	(%)		
A_1-RCPS	5925		24.43	320	1.32		< 0.0001
A2 – AS	2425		10.00	210	0.87		
A_3 – CBT	1200		4.95	120	0.49		
A_4 – **LV**	**8225**		**33.91**	**80**	**0.33**		
A_5 - PRC	5725		23.60	25	0.10		
Total	23500		96.89	755	3.11		
	FORMS						
Areas analyzed	**WATER (Items/m^3)**						
	Fibers		**Movies**		**Fragments**		***p value***
	n	(%)	*n*	(%)	*n*	(%)	
A $_1$- **RCPS**	5675	23.40	0	0	250	1.03	< 0.001
A_2 – **AS**	2300	9.48	0	0	125	0.52	
A_3 – **CBT**	1150	4.74	0	0	50	0.21	
A_4 – **LV**	**8050**	**33.19**	**0**	**0**	**175**	0.72	
A_5 - **PRC**	5700	23.50	0	0	25	0.10	
Total	22875	94.31	0	0	625	2.58	
Areas analyzed	**SEDIMENT (Items/Kg)**						
	Fibers		**Movies**		**Fragments**		***p value***
	n	(%)	*n*	(%)	*n*	(%)	
A_1 - **RCPS**	**270**	**1.11**	**0**	**0**	**50**	**0.21**	< 0.001
A_2 - **AS**	100	0.41	00	0	110	0.45	
A_3 - **CBT**	120	0.49	00	0	0	0.00	
A_4 - **LV**	40	0.16	0	0	40	0.16	
A_5 - **PRC**	25	0.10	0	0	0	0	
Total	555	2.29	0	0	200	0.82	
	AREAS ANALYZED						
Colors	A_1 - **RCPS**	A_2 - **AS**	A_3 - **CBT**	A_4 - **LV**	A_5 - **PRC**	∑ (%)	
	-- --------------------------------------Items (%) --------------------------------						
Yellow	0.00	0.1	0.10	0.14	0.00	0.2	
Blue	**14.14**	**2.59**	**1.64**	**12.90**	**12.86**	**44.13**	

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White	0.08	0.18	0.00	0.00	0.00	0.26	
Grey	0.28	0.00	0.04	0.41	0.00	0.73	
Orange	0.00	0.00	0.00	0.10	0.00	0.1	
Lilac	0.10	0.00	0.00	0.00	0.00	0.1	
Silver	0.00	2.06	0.00	0.51	0.00	2.57	
Black	4.46	2.22	1.31	5.70	0.00	13.69	
Rose	0.55	1.13	0.00	0.82	0.44	2.94	
Purple	0.00	0.00	0.31	0.51	0.00	0.82	
Transparen t	3.21	2.37	0.98	5.4	4.61	16.57	
green	0.31	0.59	0.45	1.95	0.13	3.43	
red	2.50	0.82	0.51	5.45	5.18	14.46	
Total						100.00	

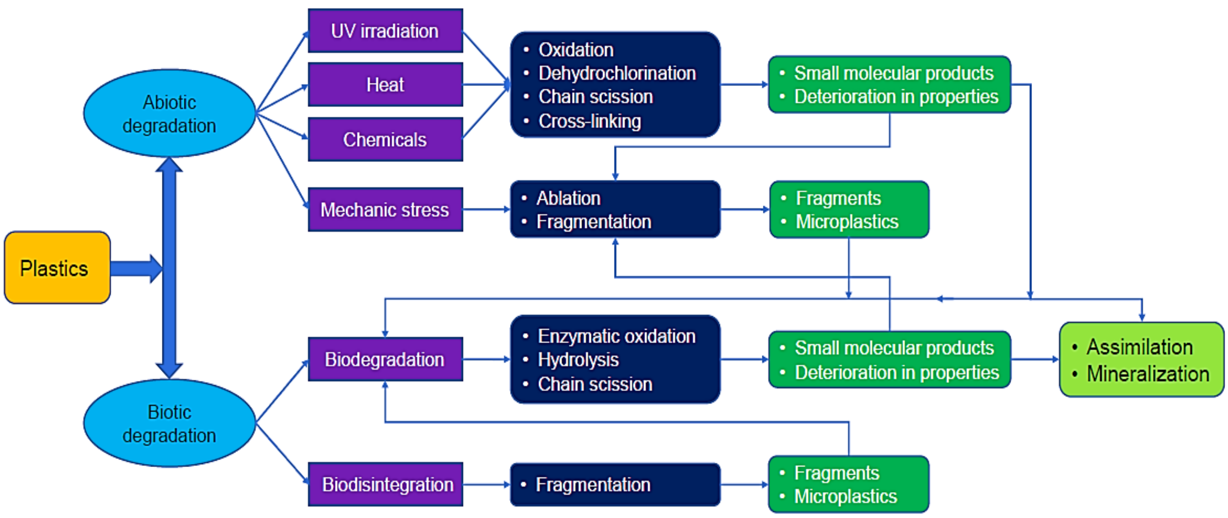
Subtitles: RCPS, Constantino Pereira do Sacramento Highway; **AS,** Avenida Selecta; **CBT**, Camboatã; **LV,** Lago Verde; **RPC**, Padre Carvalho Street.

DISCUSSIONS

ORIGINS

For better accuracy about the MPs, the factor originates from entering surface waters. Regarding this origin, Vargas *et al.* (2022), state that their formation involves wave movements, wind over surface waters, and UV radiation emitted by the sun. Therefore, the MPs in surface waters urgently need actions that contribute to mitigating their formation in these waters. In addition, Zhang *et al.* (2021), warn of the lack of knowledge about the process of degradation of plastics in the aquatic environment from the interaction between biotic and abiotic factors, to the formation of MPs (Figure 6).

Figure 6 – Degradation of primary plastics to produce secondary plastics or MPs.



Source: Zhang *et al.* 2021.

However, degradation, regardless of the type, will only occur if there is plastic, of industrial origin, for the purpose of packaging products for human consumption, then called primary. About this origin, Osman *et al.* (2023), showed that these packages can contain cosmetics, personal hygiene products, pharmaceutical products, among others. On the other hand, the secondary part is indicated for fishing artifacts such as nets or lines, plastic bottles, and plastic food packaging that, in general, after use, are disposed of inappropriately and that contribute to the formation of MPs in a direct way, as they will suffer both biotic and abiotic degradation.

On plastic bottles, Egun and Evbaytro (2020), conducted research in Nigeria, on the use, disposal, non-reuse, reuse, and proliferation of improper disposal of plastic bottles and the inefficiency of "environmental sanitation" and the formulation of a national plastic waste policy to mitigate such origins. In the study conducted by Hoeke *et al.* (2024), it indicated that one of the most relevant contributions to the formation of MPs comes from tires in different percentages: 85% originates from their wear; 15% when they are subjected to the calibration process. Regarding the destination/year, these authors indicated that, in the environment, 80% goes to the soil and 20% goes to surface waters.

All these origins described here may be involved in the presence of plastics in the five areas of the urban stretch of the Paragominas creek because a municipality with 60 years of existence still has failures in terms of basic sanitation, solid waste collection (PARAGOMINAS, 2019), marginal vegetation suppression of urban water bodies, population growth that determines the extension of the urban area and the periphery with greater production of daily solid waste whose destinations can be the streams and rivers that constitute the urban microbasin of the Paragominas stream.

PRESENCE IN WATER AND SEDIMENTS

Water

In this matrix, the magnitude (23500 items/m^3) identified in the surface waters of the Paragominas creek can be explained from what was exposed by Chaves *et al.* (2023): 1) on the surface of MPs, biofilms are formed – biofouling; 2) when the biofilm is detached, there is descale; 3) from this, there is decantation when the colony of microorganisms is very dense and, then, the MPs attach themselves to the sediments. This may have occurred in the analyzed stretches of the Paragominas stream.

This fact corroborates the study conducted by Caixeta *et al.* (2022) that identified the sources and effects on environments, including the aquatic environment. This is an indicator that the water of the stream has been under the action of anthropic activities during the 60 years of existence of the municipality. This statement is in line with evidence found in the research consulted by Lin, Chiu and Kuo (2022) state that PMs can threaten the plankton and even the benthos, and indicate that anthropogenic activities, when they lose buoyancy, can sink and harm the benthic fauna.

One of these activities was evidenced in the study conducted by Montagner *et al.* (2021), which identified the inadequate disposal of solid waste (79%), including plastics. For Oluwoye *et al.* (2023), the civil construction industries that use plastics as a protection mechanism for structures produced from environmental stimuli contribute massively to the presence of MPs in surface and groundwater.

The greatest magnitude of the presence of MPs was evidenced in A_4 (8050 items/m^3). In this place, the flow of water is not so intense ($\overline{v}$ = 5.1 m/s), so this may have concentrated this amount of items. On this hydrodynamic fact, Bernardo, Stefani, and Smith (2022), concluded that aquatic plants allow the retention of MPs, either in suspension or in the substrate, is described in the research conducted by when they observed such action in the case study conducted on the Sorocaba River, in São Paulo.

Still from the perspective of riparian vegetation, in the study conducted by Souza, Silva, and Oliveira (2023), in the Mindu stream, Manaus, Amazonas, it was conclusive regarding the performance of riparian vegetation. Another factor of increase in the magnitude of MPs that can explain what happened on the A_4 is associated with flooding. For D'Avignon *et al.*(2022), floods can resuspend MPs previously stored in the beds of water bodies. So, it is necessary to continue the studies in order to prove this fact, since this is the first study on MPs in this area.

Another explanation is listed with the ineffectiveness of preventive control from the source, which shows the inefficiency of the precautionary principle, contained in chapter II, article 6, item I, of the National Solid Waste Policy (BRASIL, 2010). The municipal law on Integrated Solid Waste Management (PARAGOMINAS, 2019), on p. 35, second paragraph: …or preferably also in **plastic bags**... However, the most efficient solution to plastic bags and sacks is recycling, together with plastic bottles, as described by Santos *et al.* (2012).

This can be observed in the study conducted by Ferreira *et al.* (2022), who reported such evidence regarding public policies in the area of water resources management, in

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relation to emerging pollutants such as MPs. In this line of thought, Abreu (2023), increases the National Water Resources Management System (SNRIH), acts with the principle of integrated and non-dissociative management regarding the quantity and quality of water.

Plastics have been active since the end of World War II (1943), and to this day there is still no regulation or legislation, although Bill n.º. 2542 (BRASIL, 2022) about the circular economy involving plastic packaging is already in progress in the Brazilian National Congress. What draws attention is the statement made by Moraes *et al.* (2024), regarding the presence and increase in the production of industrialized plastics that has occurred since 1950. Therefore, integrated, and non-dissociative management is still flawed.

Sediments

The sediments of the five areas surveyed contained the presence of MPs. The highest magnitude in terms of the presence of MPs, in number of items (320 items/kg), occurred in A_1 – Rodovia Constantino Pereira do Sacramento Highway – RCPS. In A_5 – Padre Carvalho Street, presented the lowest magnitude (25 items/kg), both with granulometric texture classified as medium and low water flow velocity ($\overline{v}$ = 0.8 m/s). As for the aspect of the magnitude found, the greater or the smaller, Soler et al. (2025), present hydrodynamic justifications for this fact.

By conducting ex *situ* research, that is, in the Laboratory from gutters prepared by them, with sediments collected in the Negro, Solimões and Amazon rivers, downstream and upstream of the Metropolitan Region of Manaus – RMM. They found that the highest concentrations in areas with two aspects: shallow depth and low water velocity. The latter was measured in the five areas, and in A_5, the lowest average occurred. Regarding depth, the geodetic studies indicated only a slope equal to - 0.14º, from A_1 to A_5.

Such justifications are similar to those presented in the study conducted by Gerolin *et al.* (2020), *in situ,* in the Amazon River. In this study, the authors characterized the highest concentration of PM particles at low depths (5-7m) and lower concentrations at high depths (34m). In Paragominas, A1- Constantino Pereira do Sacramento Highway, it has an average depth equal to 2.5 m;. $\vec{v}_{água} = 0.8\ \mathrm{m}/s;$ A_5 – Padre Carvalho Street: depth = 2.1 m; $\vec{v}_{água} =$ 8,9 m/s, there was a prevalence of water velocity, since in terms of depth, the difference was not significant: 0.4 m.

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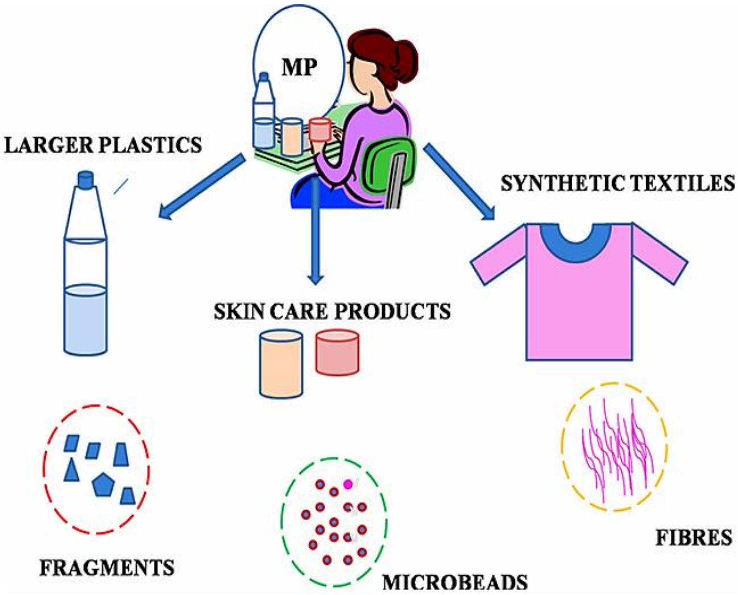
Shapes and colors

About these two pieces of evidence, academic studies conducted by Issac and Kandasurbramanian (2021), confirm the existence of various shapes and colors. These authors state that fibers (Figure 7) are formed from synthetic clothes when subjected to washing ($\overline{x}$ = 700,000/6kg).

Figure 7 – Shapes and colors of the MPs from their origins.



Source: Issac and Kandasurbramanian (2021).

In the research conducted in Paragominas, on the Paragominas stream, the fibers obtained a higher magnitude (94.64%), to the detriment of the fragments (2.77%). In the state of Amazonas, Manaus, Silva *et al.* (2024). in a study conducted in the Javari River, municipality of Benjamin Constant, Manaus, Amazonas, there was a greater magnitude for the fragments in opaque white color (61.83%). which was similar to the study conducted in the Cagayan de Oro River, in the Philippines by Gabriel *et al.* (2023), and in the Amazon basin by Morais *et al* (2024), fibers were the MPs of the highest magnitude: 63% and 96%, respectively. The blue color was the one with the highest magnitude (59%).

Changes in environmental matrices

The ecotoxicological problems caused by the presence of MPs are diverse, In this context, Haque and Fan (2023), state that this class of pollutant, currently considered emerging, causes changes in both water and soil. This occurs due to the phobia of water and the external origin of the MPs. These two factors make them prepared to serve as an ecological niche and allow the proliferation of microorganisms. In this line of research, Sun *et al*. (2023), applied the name plastisphere.

Among the problems generated in surface waters by the presence of MPs, the process of adsorption of substances is the most worrisome for water management. In the study conducted by Souza, Silva, and Oliveira (2023), in the Mindu stream, Manaus, Amazonas, one of the factors that contribute to this is the presence of natural organic matter, whose interaction has three links: the hydrological cycle, the biosphere, and the geosphere. Concern is shared by Martins *et al.*(2024) was conclusive as to the existence of cross-pollution of MPs, given their high adsorption capacity.

In the study conducted by Rani-Borges, Vicente and Pompêo (2022), these researchers also found that drugs and organochlorine compounds can be transported by MPs. which is confirmed in the research conducted by Rochman (2014). This author reports that toxic substances transported by MPs in two ways: by absorption, when they enter and attach to the polymer chain, or by adsorption, when they attach only to the surface of MPs, in addition to organochlorine pesticides, confirming the research of Martins et al. (2024).

Among the numerous damages caused by MPs to plankton, studies carried out by Moraes *et al.* (2023), Guimarães *et al.* (2023), Thanh *et al.* (2022) and Zimmermann *et al* (2020), state that there are recurrent losses due to the presence of MPs in surface freshwater for plankton, such as the increase in ecotoxicity such as the transport of Persistent Organic Pollutants (POPs). Other losses were identified in the literature review conducted by Aranda and Rivas (2023). These authors explained that MPs can serve as heavy metal carriers due to mineral affinities.

On the Amazon River, research conducted by Rico *et al.* (2023), on the problems caused to plankton, on the cause-effect of the presence of MPs, and aquatic organisms, the authors concluded that MPs, when ingested, act on the digestive tract, and consequently, compromise food digestion, while in the epidermis, they tend to increase epidermal sorption. In the study conducted by Chaves *et al.*(2023), three phenomena that occur in MPs interfere with their distribution in water: 1) biofouling, which is the formation of biofilms on the surface of MPs; 2) descale, i.e., the release of biofilm. In this case, the MPs decant and adhere to the sediment, which they call bio-Turbidity.

In the Paragominas stream, all these impacts, due to the presence of MPs, may be occurring, and represent a danger in the medium and short term for the aquatic community and visitors to the areas used as a bathhouse, in this municipality, and need more in-depth studies to identify and prevent the Paragominas community.

CONCLUSION

As the first research of its kind in the surface waters of the Paragominas stream, in the urban section, the data on MPs in the five areas analyzed indicated that there is a presence of MPs in all of them. This is an indication that both the destination and the final disposal of plastic materials in these areas are occurring, that is, inadequately. From the perspective of population growth and urbanization, areas A_1 and A_5 presented the lowest abundances, this reflects in the population quantity, since in both, the population was not clustered.

On the A_3, confluence of Gregório Santos Araújo Street with PA 125 Highway, the removal of marginal and aquatic vegetation may have facilitated the accumulation of MPs in the sediments. In addition, the surface runoff that is evident on Gregório Santos Araújo Street (Camboatã) and the deficient sanitation associated with the meager (in terms of volume generated) treatment of domestic effluents may increase the carryover and deposition of MPs in this area. On the A_4, the deformity of the original meander, urbanization, the population concentration, and the culverts that flow into it, are sources that carried MPs, which increased their abundance in this area.

As for A_5, the presence of non-original riparian vegetation and aquatic vegetation was fundamental for the elaboration of Biofouling, which decreased the abundance of MPs in the sediments of this area. Thus, it is verified that the scenic landscape should not always be the primary objective, because in this area, the sediments do not reach the main river, the Uraim, which removes the pressure on the Gurupi River regarding the possible presence of MPs. All this data, in the cause-effect relationship, tend to worsen if there is no control or monitoring of the conditions described here.

Therefore, it is hoped that, with the information contained herein, the municipal managers of water resources in the municipality can prepare plans for monitoring and conservation of these resources, so that there is compliance with current water legislation and actions that can mitigate and prevent greater abundance of this emerging pollutant, and that this is related to one of the factors of the Sustainable Development Goals – SDGs, n. 6, and goal 6.1, and to avoid future excessive spending on health treatment for communities residing in this municipality.

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