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Research paper

Water quality of an urban stream and the perception of the surrounding population

Qualidade da água de um córrego urbano e a percepção da população de entorno

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ABSTRACT: Accelerated urban growth in Brazil, without adequate planning, combined with the precariousness of sanitation, are the main causes of environmental degradation, resulting in deforestation, siltation of water bodies, suppression of riparian forests, and pollution of water resources, among others. This model of occupation and transformation of Brazilian cities is also present in the urban watershed in Várzea Grande (MT). The main objective of this study was to characterize the water quality of the Manga stream, located in this city, and to correlate it with the legal standards and the perception of the residents near the stream. The studies presented were conducted in two stages, in two periods: drought (August/2022) and rain (February/2023), with water collection at five points. Interviews were conducted with the residents, indicating in the results that the local community of the watershed is low-income and has little schooling, and they are aware of the problems and the lack of execution of public policies in the neighborhood. The changes in water quality, mainly indicated by the high results of *Escherichia Coli bacteria*, nitrogen, and phosphorus in the water, reflect the failures of inspection, public policies, and the precariousness of sanitation, which affects the population living near the stream and violates their rights to a healthy environment.

Keywords: Urban Pollution, Eutrophication, Sanitation

RESUMO: *O acelerado crescimento urbano no Brasil, sem adequado planejamento, aliado à precariedade do saneamento são as principais causas da degradação ambiental, resultando em desmatamento, assoreamento dos corpos d'água, supressão das matas ciliares, poluição dos recursos hídricos, entre outros. Esse modelo de ocupação e transformação das cidades brasileiras também estão presentes em Várzea Grande (MT), nas microbacias urbanas. O principal objetivo deste trabalho foi caracterizar a qualidade da água do córrego da Manga, localizado nessa cidade, e correlacionar com os padrões legais e com a percepção dos moradores próximos ao córrego. Os estudos apresentados foram realizados em duas etapas, em dois períodos do ano: estiagem (agosto/2022) e chuvoso (fevereiro/2023), com coleta de água em cinco pontos. Com os moradores foram realizadas entrevistas, indicando nos resultados que a comunidade local da microbacia é de baixa renda e pouca escolaridade e que eles sabem dos problemas e da carência da execução das políticas públicas no bairro. Constatou-se que as alterações na qualidade da água, indicadas principalmente pelos elevados resultados de bactérias Escherichia coli, de nitrogênio e de fósforo na água, refletem as falhas de fiscalização, das políticas públicas e a precariedade do saneamento, que afeta a população que vive próxima ao córrego e viola seus direitos a um ambiente saudável.*

Palavras-chave: *Poluição Urbana, Eutrofização, Saneamento.*

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INTRODUCTION

The 17 Sustainable Development Goals were proposed to outline guidelines to end poverty, protect the environment and climate, and ensure peace (ODS; ONU, 2015). Among these, SDG 6 - Clean Water and Sanitation stands out, which aims to guarantee clean water and equitable access to sanitation for all, considered human rights, in addition to improving water quality and reducing pollution (ONU, 2015). In Brazil, these rights, also guaranteed by the Federal Constitution, are continually violated in most cities. Sanitation data indicate some progress in recent years, as the proportion of municipalities with a sewage network increased from 47.3% in 1989 to 60.3% in 2017 but fell to 55.8% in 2021, demonstrating that not everyone has access to this right, especially the low-income population (SNIS, 2021).

The precariousness of sanitation is part of the management, occupation, and territorial transformation model of cities, resulting in negative socio-environmental impacts, mainly on aquatic environments used as a place for dilution and disposal of domestic sewage and solid waste. Among the most common impacts on urban water bodies are silting, deterioration of water quality, and the burial of wetlands and springs. For the population that lives near these bodies of water, usually low-income, the impacts are related to the increase in waterborne diseases, the proliferation of mosquitoes, unpleasant odors, and flooding.

This model predominates in Brazilian cities, such as Várzea Grande, located in the metropolitan region of the capital of Mato Grosso, Cuiabá. In terms of sanitation, the city is among the ten worst in the country, with only 28% of collected sewage and 18% of treated sewage (PBRH UPG 4, 2024).

In this sense, the present study aimed to evaluate the water quality of a degraded stream in the urban area of Várzea Grande and how the population living in its surroundings perceives and lives with this environmental degradation.

MATERIAL AND METHODS

STUDY AREA

This study was developed in the urban area of Várzea Grande (MT), in the micro basin of the Manga stream, a tributary of the right bank of the Cuiabá River, which is part of the Paraguay Hydrographic Region, one of the 12 Brazilian hydrographic regions. The Cuiabá River crosses the metropolitan area of the state capital, with Cuiabá on the left bank and Várzea Grande on the right bank (**Figure 1**). The municipality of Várzea Grande has an estimated population of approximately 299,472 inhabitants (IBGE, 2022). The region's climate is Tropical Continental Wet and Dry, with an average annual rainfall of 1,400 mm and an average annual temperature between 24.5 and 25.1°C (Tarifa, 2011).

According to Seba (2024), the history of the occupation of the Manga stream micro-basin is linked to the Cristo Rei neighborhood, previously known as Capão de Negro, colonized by refugee slaves. Later, at the end of the 19th century and beginning of the 20th century, the region was a place for managing cattle that came from Poconé and Nossa Senhora do Livramento, which, before being taken to be sold in Cuiabá, was separated

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using a large wooden corridor, called “mangueirão,” hence the name Manga stream (SEBA, 2024).

From the 1970s onwards, with incentives from federal public policies, there was intense occupation of the State of Mato Grosso, in general, and Várzea Grande, in particular, by immigrants coming mainly from the South and Southeast regions of Brazil. This migratory phenomenon occurred disorderly and without due socio-environmental care or land regularization (Silva; Sato, 2012). As in most of Brazil, the occupation of the city of Várzea Grande adopted the hygienist concept, in which the channeling and rectification of urban streams, together with the construction of stormwater galleries, was the only solution adopted to urban problems, specifically flooding, and inundation (Menezes Filho; Amaral, 2014). The city's riverside regions and wetlands, including the once-valued Manga stream, have been increasingly devalued, transforming them into sewage retention zones, urban waste, and housing for the underprivileged population, which lives with high rates of waterborne diseases (Zeilhofer; Miranda, 2012).

The sources of the Manga stream are located in the green area of Marechal Rondon International Airport, running for approximately 6 km through the neighborhoods of Cristo Rei, Manga, Construmat, and Alameda (currently a junction of neighborhoods, it has been renamed Ponte Nova neighborhood) and flowing into the Cuiabá River still in the urban area (**Figure 2**). The disorderly occupation of the micro-basin resulted in the suppression of vegetation, leaving only a patch of vegetation of approximately 75,646 m², which includes three springs located within the Marechal Rondon International Airport, with native vegetation mixed with invasive species such as Leucaena and castor oil plant (**Figure 2**).

Currently, the occupation of the micro basin is well consolidated, with many residential and commercial buildings close to the stream, which discharge untreated sewage directly into the water or into septic tanks. Around 76% of Várzea Grande's sewage is discharged into rudimentary septic tanks, but infiltration into the urban area is low due to the shallow water table and low soil porosity (PBH UPG P4, 2023). There is also disposal of dead animals and solid waste (on-site observations).

Figure 1. Location map of Mato Grosso, the municipality of Várzea Grande, located at coordinates 15° 38' 52" South and 56° 7' 60" West, and the Manga stream micro-basin (without scales)

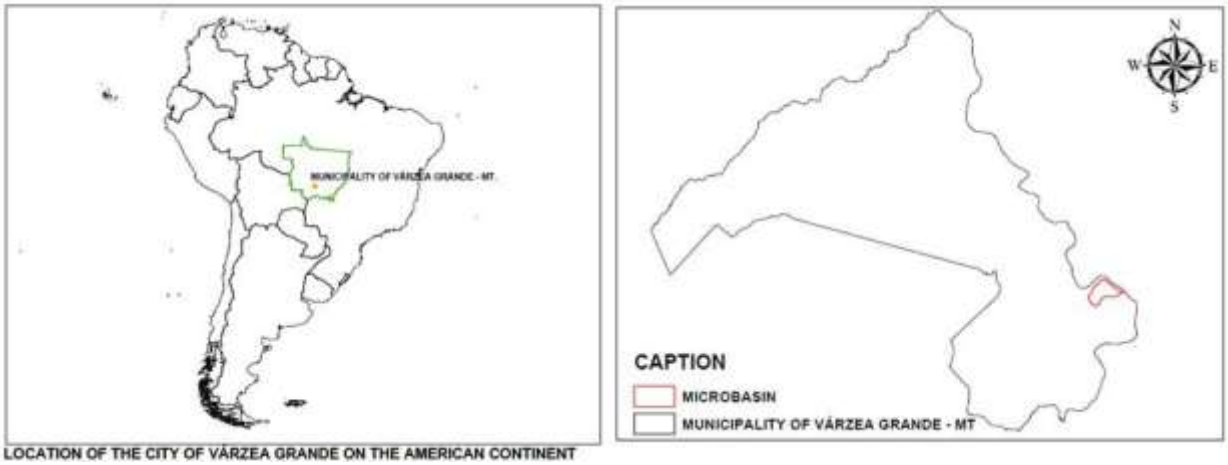

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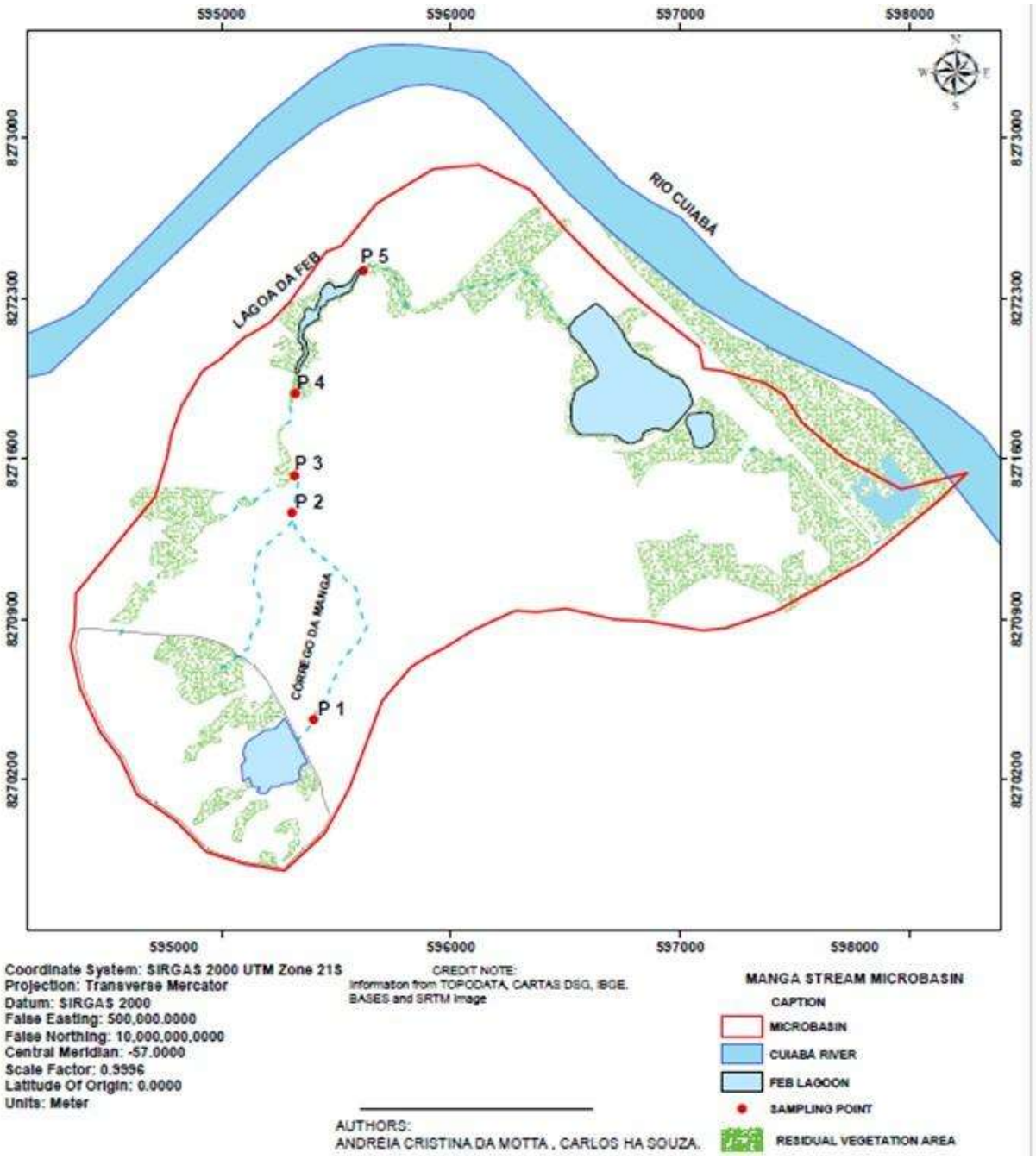
Figure 2. Map of the location of the Manga stream micro basin with water collection points, land use, and presence of remaining vegetation



FIELD COLLECTIONS AND LABORATORY ANALYSIS

Water collections for quality analysis were conducted at five points (**Figure 2; Table 1**) during the dry season in August 2022 and the rainy season in February 2023.

In the field, electrical conductivity, dissolved oxygen, pH, and water temperature were measured using a multiparameter probe. The collected water samples were preserved and

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sent for laboratory analysis of the following parameters: dissolved solids, total phosphorus, *Escherichia coli*, and total nitrogen. All water collection and analysis procedures followed AWWA/APHA (2017) standards. The results were compared to the standards of Conama Resolution No. 357/2005 for Class 2 water bodies, such as the Manga stream, where there is no formal classification, and related to the interviews conducted with residents in the surrounding area.

Table 1. Description and location of water collection points in the Manga Stream micro basin

SAMPLES POINTS	ADRESS	GEOGRAPHIC COORDINATES	DESCRIPTION OF POINTS
P1	Deputado Emanuel Pinheiro Street	15º 38' 1,821" S 56º 6' 39,047" W	There are houses and workshops on the bank, a riverbed with canalized sides, without any natural vegetation, with a predominance of secondary vegetation and the sporadic presence of wild animals
P2	Gonçalo Botelho de Campos Street	15º 38' 31,198" S 56º 6' 35,699" W	There is no riparian forest and no APP housing, and there are invasive species (leukemias, castor oil plant), aquatic vegetation, and sand sediments in the bed. Sewage discharge occurs, and there is erosion in the bank's soil. Overflow occurs during the rainy season, causing flooding in nearby homes and daycare centers.
P3	Coronel Manoel Gomes Street	15º 37' 44,794" S 56º 6' 38,548" W	Concreted and sedimented bed, with exposed soil and erosion processes, domestic animals; location of disposal of solid waste from homes and waste from the upstream water treatment plant (observed on-site by the very strong smell of chlorine and sudden increase in turbidity).
P4	Antônio Jacobe Street	15º 37' 27,482" S 56º 6' 28,738" W	There are exposed soil and erosion processes, small remnants of riparian forest on the bank, sandbanks on the bed, and a lot of domestic, industrial, and construction waste. industriais e de construção civis.
P5	Vereador Abelardo Street	15º 37' 56,606" S 56º 6' 38,604" W	Irregular housing in risk areas, as in other points, there is riparian forest and vegetation such as Leucaena, castor oil plant, and some fruit trees on the banks, with erosion and silted bed, altered color of water with a lot of foam and the bad smell caused by the effluents; location of garbage dumps.

INTERVIEWS WITH RESIDENTS

The interviews with residents were based on Gil (2017), with a structured and semi-structured script applied to those who have lived near the stream for more than 10 years. Conducted between August and November 2022, the questions addressed aspects regarding age, type of housing, education, family income, length of residence in the location, disposal and recycling of solid waste, destination of domestic sewage, water supply services, occurrence of waterborne diseases and perception of the quality of the stream water. Authorization for the interviews was granted by the Ethics Committee (CAAE No. 58288122.3.0000.5690), following CONEP regulations (CNS Resolution 466/2012 and Resolution 510/2016).

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RESULTS

WATER QUALITY

Table 2 shows the results of the water quality of the Manga stream during the dry and rainy seasons.

Table *2*. Spatial and temporal variation of water quality in the Manga stream during the dry season (August/2022) and rainy season (February/2023). Legend: VMP = Maximum Permitted Value for class 2 water bodies, according to Conama Resolution 357/2005

Month	Sample Points	Electrical conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH	Total Dissolved Solids (mg/L)	Water Temperature (ºC)	Total Phosphorus (mg/L)	*Escherichia coli* (NMP/100 mL)	Total Nitrogen (mg/L)
ago/22	P1	210,5	1,17	7,36	137,5	28,5	3,65	$8,3x10^{+4}$	8,03
	P2	397,3	1,64	7,98	258,5	30,1	3,60	$2,0x10^{+4}$	9,74
	P3	411,0	0,70	7,92	261,15	29,4	5,49	$1,4x10^{+5}$	10,48
	P4	393,3	1,6	7,63	255,45	28,5	4,25	$7,9x10^{+4}$	13,32
	P5	377,2	4,08	7,69	245,05	25,6	3,62	$2,4x10^{+4}$	9,35
fev/23	P1	595	2,63	7,23	383,5	28,4	4,89	$2,0x10^{+5}$	16,11
	P2	385,8	3,45	7,47	250,9	29,4	2,54	$4,8x10^{+4}$	8,32
	P3	397,5	3,54	7,44	258,7	29,3	2,43	$4,0x10^{+4}$	7,92
	P4	417,1	2,09	7,38	271,05	29,4	5,15	$4,8x10^{+4}$	10,05
	P5	321,3	3,98	7,23	208,65	28,3	3,33	$4,8x10^{+4}$	6,84
VMP			≥ 5,0	6,0-9,0	500		0,05	$1,0x10^{+3}$	

The electrical conductivity in the Manga stream, which reflects the number of dissolved ions, salts, and compounds, showed high results, especially at point 1, where the values were 210.5 µS/cm in August 2022 and 595 µS/cm in February 2023. All results largely corroborate Araújo *et al*. (2018), who found 68.3 to 377.6 µS/cm variation in the same stream. However, different from the present study, close to P1 in the rainy season, a lower result was obtained. The variation was smaller at points 2, 3, and 4, but the values can still be considered high. Despite the absence of water quality data from the stream prior to environmental degradation, it can be inferred, based on the hydrogeochemical conditions of the region, that the conductivity should be naturally high, considering the values measured by Lima *et al*. (2023) in groundwater in the region, which ranged from 639 and 762 µS/cm.

At all sampling points, the dissolved oxygen concentration was lower than the minimum legal limit (5 mg/l) due to the discharge of domestic sewage, except at point 5 during the dry season, which presented a higher dissolved oxygen concentration. When there is an excess of organic matter present in domestic sewage, the water's oxygen demand for the decomposition process increases above the dilution and self-purification capacity of the water body, reducing the oxygenation of the water (Esteves, 2011), as found in the Manga stream.

The pH of the water at the five points analyzed varied between 7.26 and 7.98, remaining within legal standards and with low temporal and spatial oscillation, which indicates that the use of the stream for the dilution of urban waste did not alter this variable.

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In the Jacaré stream, neighboring the Manga stream, and degraded, Lima *et al*. (2023) observed that the pH varied from 7.35 to 7.84, similar to the present study.

Dissolved solids increased at all points during the rainy season, except at point 5, with all values within the standards permitted by law (<500 mg/l) but point 1 had a significant increase at this time of year. Applying the Pearson correlation index, a percentage of 99% was obtained with electrical conductivity, demonstrating that both variables had the same space-time oscillation pattern and that most of the dissolved solids are in ionic form. Both variables may be related to the hydrogeochemical conditions of the basin and to the domestic sewage discharged into the stream. Lima *et al*. (2023) observed high concentrations of total solids (> 380 mg/l) and electrical conductivity (> 639 µS/cm) in groundwater in the region, as well as high concentrations of iron ions, up to 0.57 mg/l, associated with the predominant Latosol in the region, rich in clay and silt, and the presence of calcium carbonate, considering the moderate values of total hardness (up to 240 mg$CaCO_3$/l). Therefore, it can be inferred that, in part, the dissolved solids and conductivity of the Manga stream may be associated with both domestic sewage and the hydrogeochemical conditions of the drainage basin, such as the presence of iron ions and carbonates.

The temperature did not show clear spatial and temporal variation, except for the lowest result at point 5, due to the shading of the stream bed.

The total phosphorus concentration was well above the maximum limit of 0.1 mg/L at all points and periods, indicating a hypereutrophic environment, according to the classification of Lamparelli (2004). This is due to the use of stream water to dilute domestic sewage with detergents (rich in phosphorus).

The *Escherichia coli* bacteria, indicative of the presence of feces from warm-blooded animals, mainly humans, presented densities well above the legal limit of 1,000 NMP/100ml at all points and periods, with the highest concentration at point 1 during the rainy season.

Even without a standard in legislation, total nitrogen presented very high concentrations at all collection points, also indicative of a hypereutrophic environment (Esteves, 2011), with higher results in P1 in the rainy season and P4 in the dry season.

INTERVIEWS WITH RESIDENTS

The results of the interviews conducted with 17 residents living near the Manga stream, the majority of whom were female (82.4%), are shown in **Figures 3**, **4,** and **5**, divided into three main categories: personal data, questions about waste and opinion and satisfaction regarding the place of residence. The age range of the interviewees varied from 31 to 90 years, with the majority between 30 and 70 years (64.7%), with time living in the location varying from 11 to 60 years (Figure 3). Regarding family income, 47.1% earn between 1 and 3 minimum wages, 35.3% receive between 2 and 5 wages, 5.9% between 4 and 7, and 11.8% receive eight or more wages. In terms of education, 35.3% of respondents have completed secondary education, 17.6% have completed higher education, 11.8% have incomplete higher education, 17.6% have incomplete first year, 5.9% have completed second year, 5.9% have incomplete primary education and 5.9% are illiterate (**Figure 3**).

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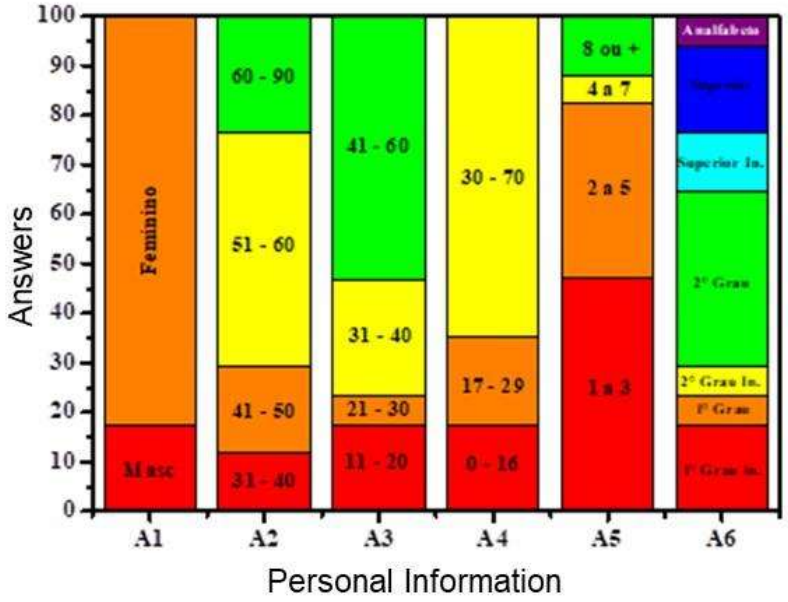
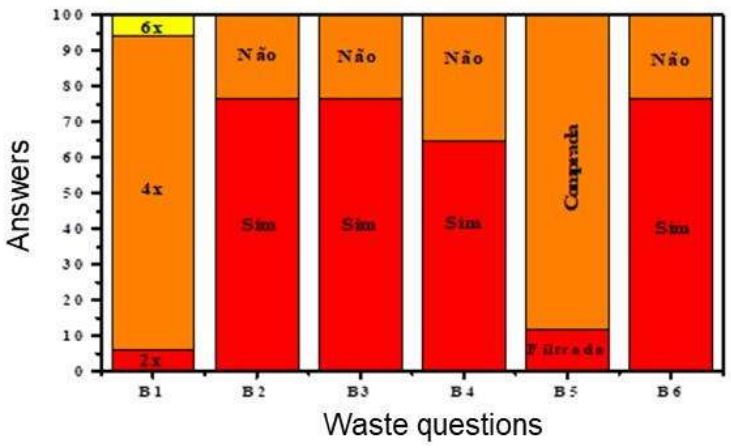
Figure 3- Results of personal information obtained in interviews with residents living in the surroundings of the Manga stream



LEGEND:
A1=Gender
A2=Age
A3=Length of residence
A4=Age of residents in the household
A5=Family income
A6=Education level

Residents highlighted solid waste as one of the main causes of environmental impact in the Manga stream, even considering that, of the 17 interviewees, 88.2% confirmed that there is public garbage collection three times a week; 76.47% reported that they burn garbage in their backyards; 76.47% recycle PET bottles and aluminum cans. Regarding the origin of the water supplied by the public supply network, 76.47% know the origin of the water in their homes; 64.7% have already had illnesses related to stream water, and 88.24% buy drinking water (**Figure 4**).

Figure 4. Result of questions related to solid waste and water quality answered by residents near the Manga stream



LEGEND:
B1 = Is there garbage collection: how many times/week?
B2 = Do you usually burn your garbage?
B3 = Do you usually recycle your garbage?
B4 = Has anyone in your family contracted water-related diseases?
(B5) = The water you drink is...
(B6) = Do you know where the water in your home comes from?

In Figure 5, the results indicate that 41.18% of respondents are satisfied with where they live, 29.41% are somewhat satisfied, 23.53% are very satisfied, and 5.88% are

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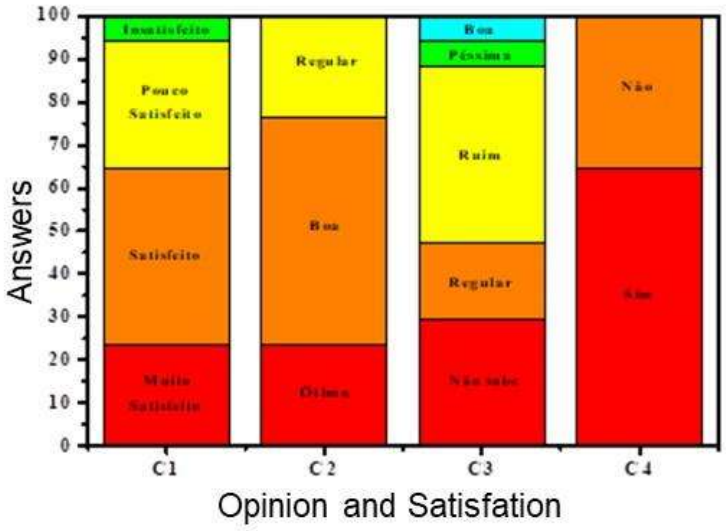
dissatisfied. Regarding the water quality in the public supply network, 52.94% consider it good, 23.53% excellent, and 23.53% adequate. Regarding the Manga stream, 41.18% consider it poor, 29.41% do not know, 17.65% consider it fair/good, and 5.88% consider it terrible. Approximately 64.7% of residents believe in the possibility of improving the stream with the help of the community and the city hall, while 35.29% do not believe this is possible (**Figure 5**).

Figure 5. Results of questions related to satisfaction with the place where they live and with water, answered by residents close to the Manga stream



LEGEND:
C1=Degree of satisfaction with the place where you live
C2=Opinion on the water quality in your home
C3=Opinion on the quality of the river water
C4=Do you believe it is possible to restore the stream?

DISCUSSION

The water quality results of the Manga stream did not meet the standards established by Conama Resolution No. 357/05 for class 2 water bodies for the parameters dissolved oxygen, total phosphorus, and *Escherichia coli*. Other parameters, such as temperature, electrical conductivity, pH, total nitrogen, and dissolved solids, do not have references established by legislation or are within legal standards. These results indicate a violation of legislation and the use of water predominantly for diluting domestic sewage and waste disposal, as observed in the field and by residents. The degradation of water quality is aggravated by erosion of the stream banks, silting of the bed, dumping of solid waste, and disorderly construction in the surrounding area.

The interview results revealed that the majority of residents are low-income, have little education, and have lived there for a long time, indicating a consolidated occupation. The general perception of residents points to the clear degradation of the stream due to the accumulation of garbage and sewage in its bed, in addition to the occupation of preservation areas by buildings built by residents or businesses. Residents highlighted the lack of effective public policies to address these problems. Water quality analyses corroborate the perception of 41% of those interviewed about the Manga stream, demonstrating that almost half of those interviewed do not perceive environmental degradation or consider it to be regular or good. This result corroborates the interviewees' opinions regarding their satisfaction with living in the location. On the other hand, some residents criticized the lack

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of action by local politicians, highlighting the lack of adequate sewage and the presence of waste around the stream as a serious problem, causing flooding and increasing the proliferation of mosquitoes, which contributes to diseases such as dengue, Zika, and Chikungunya, and the abandonment of places that have become deposits for domestic and construction waste. These concerns were reported by several residents interviewed, and they reflect the failures in environmental management and basic sanitation, combined with the model of occupation and urban transformation of Várzea Grande.

One resident interviewed proposed that the city establishes a specific day for rubble collection, suggesting that this could reduce irregular dumping near the stream and educate residents on proper waste management.

Other studies have also shown that precarious sanitation is the principal cause of the deterioration of water quality in water bodies in Várzea Grande, such as the research of Freitas (2023) in the Água Limpa stream, Migliorini and Dores (2023) in the Jacaré micro basin, Araújo (2018) in the Manga and Aeroporto streams and Nunes, Camargo, and Figueiredo (2018) in the Jacaré Lagoon. All these studies and the present study indicate that the degradation condition of urban water bodies in Várzea Grande is a systemic and continually neglected problem that mainly affects the low-income population.

This reality, common in many Brazilian cities, follows the logic of capital, in which the city is reproduced in a segregated way, with a significant portion of the urban population without essential conditions for dignified survival (Santos, 2021). The lack of actions by competent agencies to contain or at least mitigate the impacts resulting from how space is produced, where no thought was given to maintaining the quality of natural resources, directly affects the living conditions of the population, as observed by Santos (2021) in Vitória da Conquista (BA) and confirmed in the present study. It is also worth noting that the historical, political, cultural, and environmental processes of the construction and continuous transformation of the territory of the Manga stream micro-basin reflect the processes that occur on a macro scale (the entire city of Várzea Grande and the Cuiabá river basin, as observed by Figueiredo, Nunes, and Paes (2020), in the area of the Jacaré stream micro-basin).

The Várzea Grande Master Plan brought important regulatory advances, such as the principles of “environmental sustainability of the Municipality” and “universal right to housing, infrastructure, and public services and equipment” (Várzea Grande, 2021). Among the 16 objectives of the Plan, some are worth mentioning: i) promoting the quality of life and the urban and rural environment through the preservation, conservation, maintenance, and recovery of natural and built resources, ii) preventing occupation in areas subject to flooding or risks of environmental disasters, iii) promote and establish measures for the conservation of remaining native plants, iv) encourage the protection of the city water bodies, and v) strengthen the city environmental management, aiming at effective monitoring and control of the environment.

The City Hall has also been developing projects to improve sanitation conditions, applying resources to recover micro basins and collect network and sewage treatment plants. Investments were made through the PAC (Growth Acceleration Program) in water collection, construction of a Water Treatment Plant, reservoirs, distribution networks, and household connections (PBH UPG P4, 2023).

Public environmental and sanitation policies, as well as the Master Plan of the Municipality of Várzea Grande/MT (2021), demonstrate the importance of social

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participation in the process of managing and monitoring the implementation of these public policies, and in the role of public agencies, aiming to change the current reality to healthier environmental conditions combined with a fairer society with less socio-environmental exclusion and access to sanitation.

CONCLUSIONS

This research found that the water quality of the Manga stream does not meet the standards established by Conama Resolution 357/05 for class 2 water bodies due to the high content of dissolved oxygen, total phosphorus, and *Escherichia coli*, resulting from the predominant use for transporting and diluting domestic sewage and solid waste.

The residents of the Manga stream micro-basin interviewed in this study are directly affected by environmental degradation and the vast majority are aware of this. Therefore, there is a continuous violation of rights regarding access to sanitation and a healthy environment, which commonly affects populations with low income and education levels more seriously, as is the case of those living around the stream.

The interviewees demonstrated awareness of the pollution of the stream's water but highlighted the lack of awareness among public managers regarding the consequences of this situation. This study highlights the urgent need for effective implementation of public policies and promotion of ecological restoration of degraded micro-basins, such as the Manga stream, with the active participation of the local community, which has in-depth knowledge of the environmental reality and an interest in improving local conditions.

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