FIRST STUDY ON AMMONIA (NH3) CONTAINED IN THE PARAGOMINAS STREAM IN THE MUNICIPALITY OF THE SAME NAME, SOUTHEASTERN PARÁ

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ABSTRACT

Non-ionized or free ammonia is the most toxic nitrogenous substance in the aquatic environment, and the absence of information about it causes a deficiency in the assessment of water quality. This was the gap that guided this research since the generation and disposal of these data can help in the integrated or non-integrated management of the water quality of the Igarapé Paragominas. The objective is to identify the presence or absence in the urban section, characterize the anthropic origin and verify whether or not three parameters associated with water quality act on non-ionized or free ammonia. The method used was hypothetical-deductive with quantitative and qualitative coverage of an observational nature. The data obtained and analyzed indicated that in the five areas analyzed, the occurrence of non-ionized or free ammonia indicated. They also indicated that in areas where the population agglomeration is smaller, the concentration of this gas, in mg/L, is also lower (A1, 0.13 ± 0.04) and, proportionally, to the smaller amount

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of effluents that enter the sampling area; as this cluster grows, so does the concentration (A2, 0.26 ± 0.04; A3, 0.37 ± 0.17; A4, 0.81 ± 0.44), depending on the inverse occurrence; the water temperature showed an increasing trend (A4, 26.75 ± 0.92); the DO concentration in mg/L was more effective in A2 (2.27 ± 0.81), as opposed to that identified in E5 (1.50 ± 0.36). Finally, it was observed that the growth of the population agglomeration occurred in A2, A3 and A4, associated with the deficiency of basic sanitation, the three component parameters of water quality, act directly and indirectly, in the concentration of non-ionized or free ammonia, which causes problems to the Paragominas stream and the lack of information about this, determines an inefficient management regarding the quality of water in this tributary, on the right bank, of the Uraim River.

Keywords: Wastewater. Population growth. Water quality management.

INTRODUCTION

The lack of data on water quality in many Brazilian municipalities makes it difficult for municipalities to manage water resources in the city. The 5,540 Brazilian municipalities have serious problems regarding this quality, due to the economy (UNESCO, 2025) and social (TUNDISI, 2008) disordered development. Another problem is the deficient basic sanitation infrastructure (ANA, 2025) associated with wastewater discharged into surface water (BRAZIL, 2005) that causes a decrease in what is conventionally called conserve today so as not to lack tomorrow. However, this has not yet occurred, and this causes a gap in the context of the basic needs of communities: the right to quality water (ALMEIDA; KLUSKA; ALMEIDA, 2014).

Water quality, in terms of wastewater discharge, in Brazil has guidelines defined by its own legislation (BRAZIL, 2011). Municipalities also do so (PARAGOMINAS, 2014). However, the growth of populations that occurs in them and their concentration in the urban area (IBGE, 2016), has caused a severe water management problem, as in the case of the so-called integrated management (SILVA; PORTO, 2003). This type of management is one of the tools that meets goal six of the Sustainable Development Goals and ensures the right to the natural resource for future generations, in addition to increasing water security (SILVA *et al.,* 2019).

Undoubtedly, water quality is analyzed under component parameters of physical (e.g., temperature) and chemical properties such as: pH, dissolved oxygen – DO; nitrogenous compounds such as non-ionized or free ammonia NH_3 (BRAZIL, 2005; 2011) To identify and measure them, there are several mechanisms such as kits for analysis. With all this, the gap of ignorance is still high (MOEIZADEH; YONG; WITHANA, 2024). Another problem for water quality is the absence of studies that indicate the characteristics of the areas of influence and the places where surface water is collected (PASSOS *et al.,* 2019).

The biggest problem of NH_3, in the aquatic environment, is its toxicity since it is dependent on the biogeochemical nitrogen cycle (EDWARDS *et al.,* 2024; WANG *et al.,* 2020). Another fact that is still unclear is the real value of non-oxidized ammonia, as an indicative factor and not the sum with ionized ammonia, since its toxicity is lower in surface watersNH_3 (IP; CHEW; RANDALL, 2001). In addition, there is a decrease in the levels of OD, in relation to the presence NH_3 (SERAFIN; ZABINONI FILHO, 2009). Another variable that, in Brazil, acts as an indicator of water quality, the water temperature and that acts on the levels of NH_3 (IVAN *et al.,* 2024).

All knowledge about its genesis from two main sources: natural and anthropic must be the object of constant observations, with special attention to the second (DANTAS *et al.,* 2022). Especially in municipalities where economic and population development increases density and urban agglomerations, and where recreation areas are located on the periphery (LIOYD *et al.,* 2024; SANDU *et al.,* 2022; WANG *et al.,* 2020). A major problem lies in the lack of attention that the surface waters of urban tributaries pay in relation to what it discharges into the main river of NH_3 (ANH *et al.,* 2023; LIANG *et al.,* 2025).

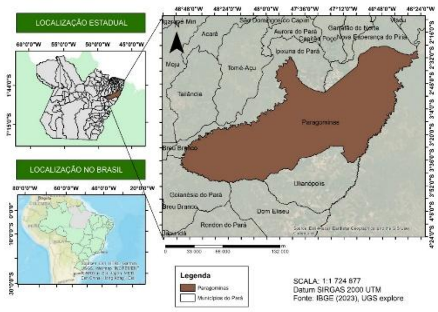
All these approaches are associated with the Paragominas stream, in the municipality of the same name, Pará, Brazil. The most serious is the absence of hydrological information regarding the quality of the water due to the presence of it, which generates insufficient management of this water resource. This justified and increased the relevance of this research, whose objectives were: 1) to identify the presence or absence of , from the beginning of the urban perimeter to the flow into the main river; 2) to characterize the anthropogenic influences of urbanized areas on the water quality of this stream in the areas of water sampling; 3) Check the actions of pH, dissolved oxygen (DO) and water temperature on this gas.

MATERIAL AND METHODS

PHYSIOGRAPHY OF THE AREA

The municipality of Paragominas (Figure 1), located in the southeast of Pará (2º59'S; 47º21'W), at an altitude of 89 m (ALVES; OAK; SILVA, 2014), occupies 31.1% (19,343 km2) of the Capim River integration region (PARÁ, 2023). Of this area, 29.7 km2 are urbanized, and 21.34% of the households are connected to sanitary sewage. The population was equivalent to 105,550 inhabitants in 2022, of which 96. 150 inhabitants in the urban area, and 9,400 in the rural area (IBGE, 2023).

Figure 1 - Location map of the municipality of Paragominas, Pará State, Brazil.



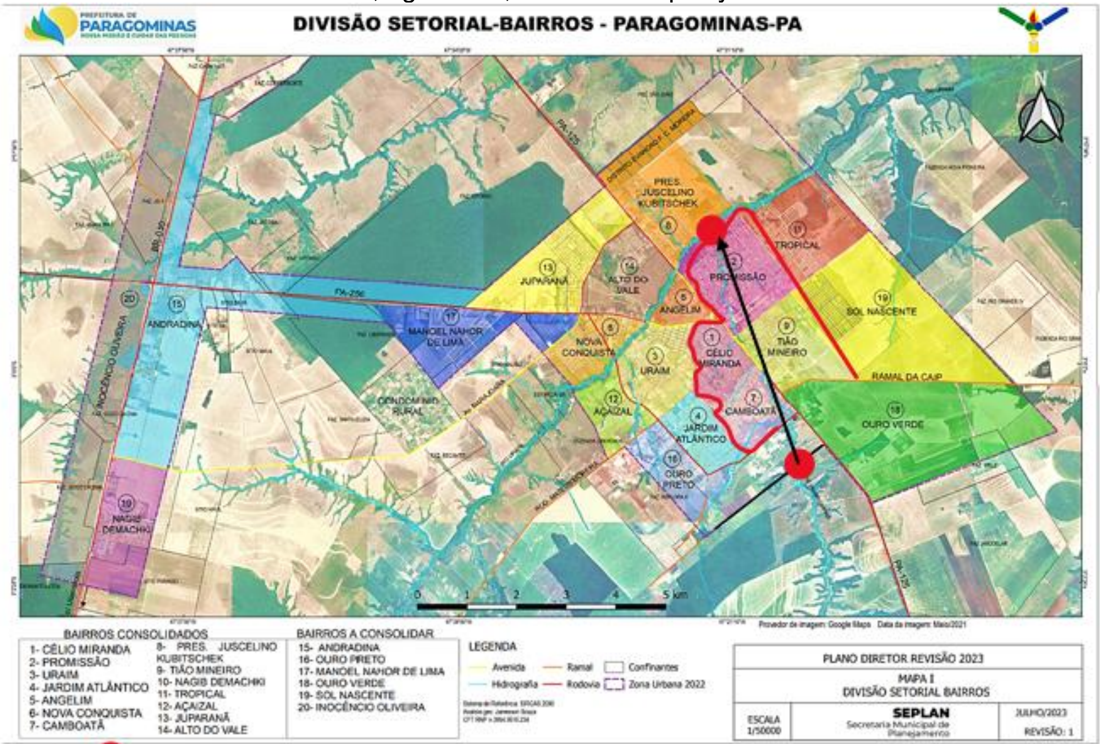
Elaborated by: Silva, G. R. (2025)

The climate in the Köppen classification is equatorial *Ah* Expressive, rainy tropical and dry logo. According to Thornthwaite's classification, the climate will be humid tropical, with significant droughts (RODRIGUES *et al.,* 2020), and the current vegetation corresponds to secondary forests in stages of development such as capoeira. This is a result of the use and occupation of the soil, in the face of deforestation to support growing cattle ranching. Municipal Law No. 870 (PARAGOMINAS, 2014) governs municipal sanitation

Research area

The watershed of the Paragominas stream (Figure 2) has an area equivalent to 66 km^2, and a perimeter equal to 51 km (PARAGOMINAS, 2014) and is a tributary of the right bank of the Uraim River, and has, in the rural course, 11 dams (RODRIGUES *et al.,* 2020). In this context, the chosen area begins at the Constantino Pereira do Sacramento Highway, former Pioneers Highway and extends to Padre Carvalho Street (≈ 4.4 km, in the direction M → J). The flow of this stream into the Uraim watershed is 500 m from this street, at the following geographical coordinates: 046º49'48.0" W; 02º48'14.9"S.

Figure 2 – Area of the urban stretch of the Paragominas stream, from the Constantino Pereira do Sacramento Highway to the flow into the Uraim River, right bank, in the municipality of the same name. Pará State. Brazil.



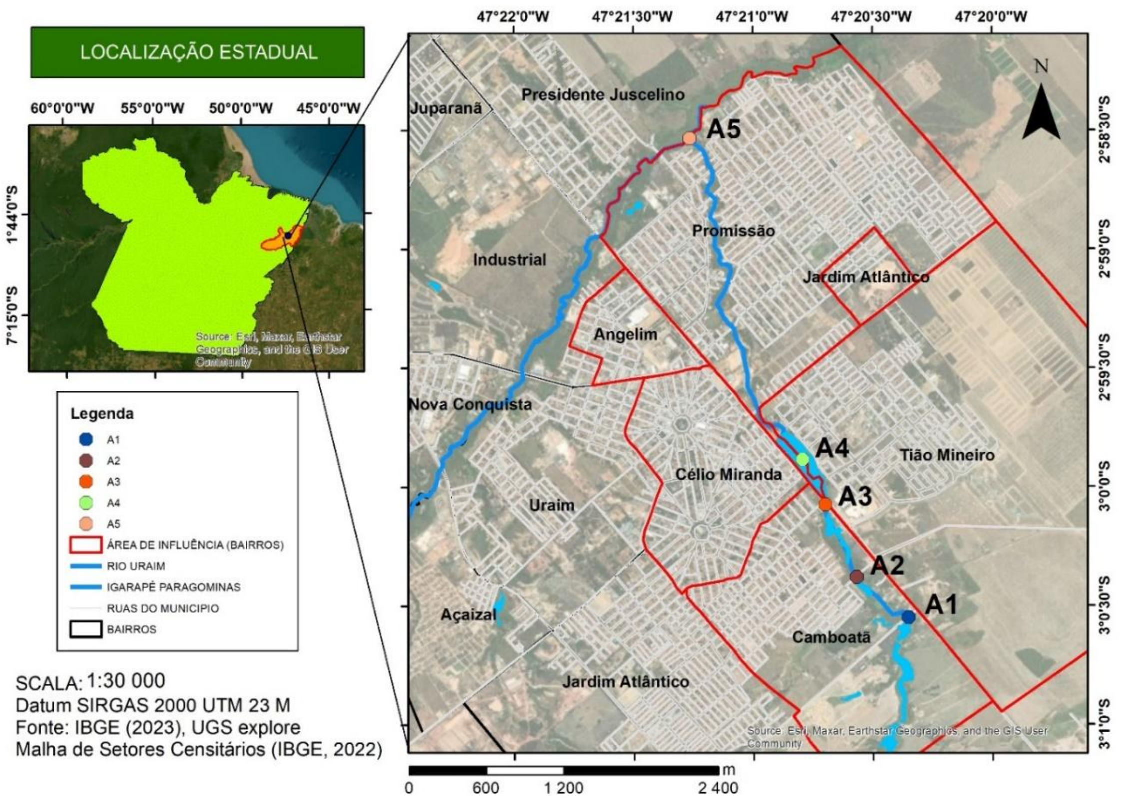
Subtitles: Paragominas stream, urban section; , extension of the area. **Source:** adapted from the original contained in Paragominas (2023).

The water body under analysis does not present a classification. However, the resolution of the National Council for the Environment - CONAMA (BRASIL, 2005), Chapter II – Classification of Water Bodies, Section I – Fresh Waters, article 4, item III, class 2, waters may be destined: b) for the protection of aquatic communities; c) primary contact recreation (swimming); d) irrigation of... parks and gardens; e) fishing activity. The anthropogenic activities contained in items c, d, and e, are linked to both A_1 and A_2.

Selected areas for sampling

In this extension, five areas were selected, based on the criterion of population clusters, from the smallest to the largest, identified as A_1 - Constantino Pereira do Sacramento Highway, 850 m from the PA 125 Highway, towards W → E, from the Fazendinha area; A_2 - Selecta Avenue, residential complex (Camboatã neighborhood), which previously housed numerous sawmills; A_3 - confluence of Gregório Santos Araújo Street (Camboatã neighborhood); A_4 – Green Lake (Tião Mineiro neighborhood); A_5 – Bridge over Padre Carvalho Street, in the Promissão neighborhood (Figure 3).

Figure 3 – The five selected areas in the urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.



Prepared by: Silva G. R. (2025).

The emergence of this area comes from an urbanization of this area where an open-air dump prevailed, which was subjected to dredging services, enlargement of the original bed. It currently has an extension equal to 1000 m (PARAGOMINAS, 2014), without the maintenance of the original or secondary riparian forest. In the Master Plan for the Development of the Municipality – PDDM (PARAGOMINAS, 2020).

The conservation of the riparian forest, in article 25, was cited in the PDDM, obedience to the conservation of the Permanent Protection Area (APP), the ranges established by the Forest Code, Law No. 12,651 (BRASIL, 2012). The protection of water resources, on the other hand, is cited in Municipal Law No. 1123 (PARAGOMINAS, 2023) which establishes the Municipal Development Master Plan of Paragominas. In Law No. 765 (PARAGOMINAS, 2015), in chapter III, of the principles, article, 5, item VIII, it mentions that there will be protection, preservation and recovery of ecosystems.

Include here the aquatic ecosystems, especially the Paragominas stream, a tributary of the right bank of the Uraim River Microbasin. In chapter III, of Environmental Control, section III, of water pollution, the guidelines for the discharge of effluents into surface waters, it states that this can only occur if there is obedience to the standards established by law, in the three legislative spheres: federal, state, and municipal.

METHODS

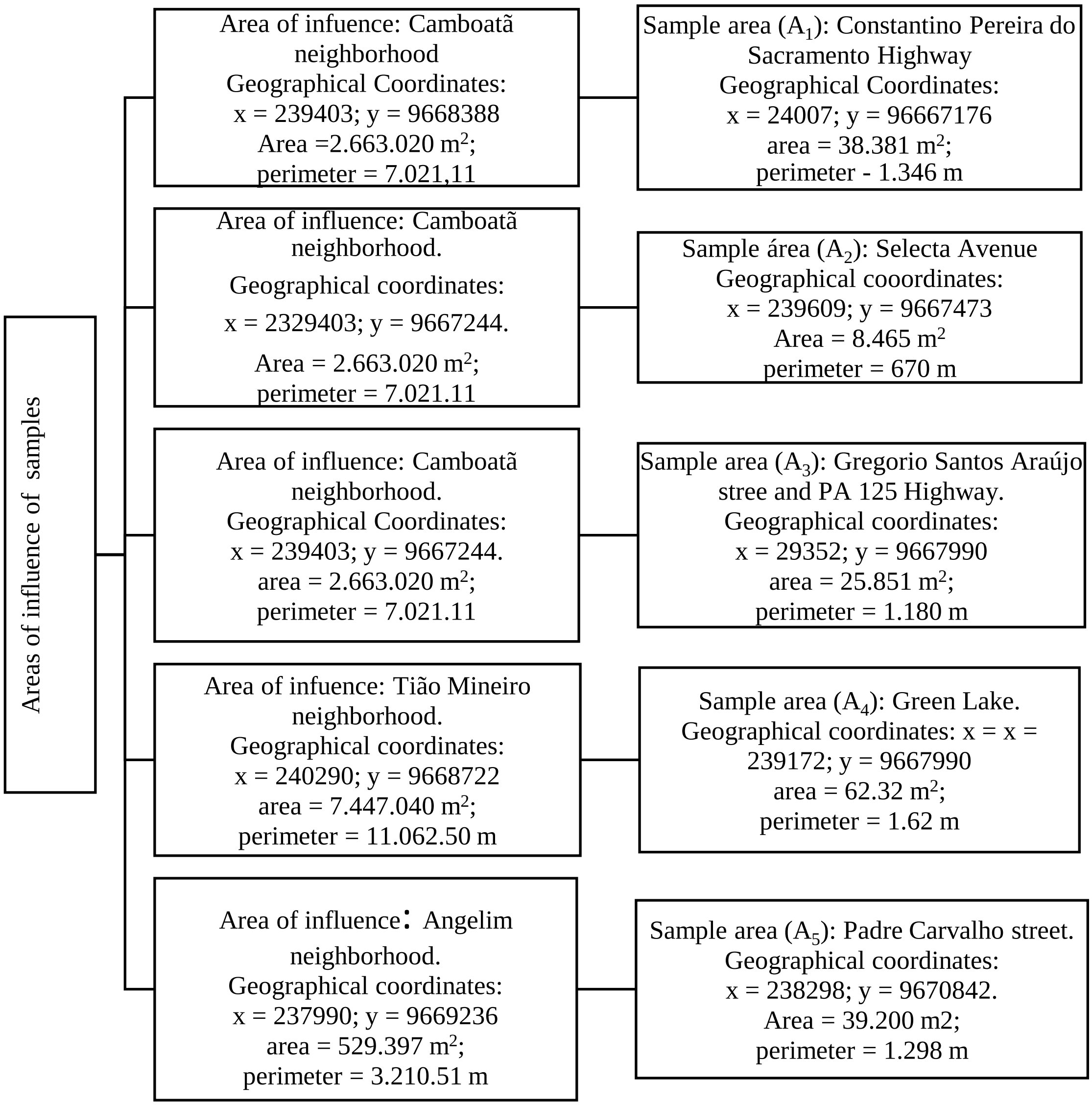
The method used was hypothetical-deductive in view of the information gap (PRODANOV; FREITAS, 2013) about the water quality of this stream with the water management bodies of the municipality of Paragominas. This method was associated with quantitative and qualitative comprehensiveness with an observational nature (PEREIRA *et al.,* 2018). In this case, it was to identify the concentration of non-ionized or free ammonia (NH_3) in the surface waters of the urban stretch of the Paragominas stream, due to the high toxicity it presents in surface waters.

OBTAINING DATA

Primary

The primary data were obtained from water sampling in the five areas of the urban stretch of the Paragominas stream. It involved five areas of influence: Constantino Pereira do Sacramento Highway, Camboatã neighborhood, Tião Mineiro neighborhood, Célio Miranda neighborhood, and Promissão, all of which have domestic effluent flow to the areas where the collections were conducted. In the selected urban section, the five selected areas were enumerated (Figura 4), according to the sectorization of the neighborhoods (PARAGOMINAS, 2023).

Figure 4 – Area of Influence and collection with the respective numbers and denominations of the neighborhoods that border the Paragominas stream, in the municipality of the same name. Pará State. Brazil.



Source: authors (2025).

The water sampling followed the parameters established by the Standard Methods for the Examination of Water and Wastewater (APHA, 1985). For sampling, 10 glass borosilicate flasks (V = 500 mL) were used, with a screw-on cap and coated with aluminum foil. The collection was conducted in the morning, starting at 07:00, in the dry-rainy transition period, due to the upward trend and possible gaseous atmospheric loss. Then, they were stored in a cooler to be transported to the Environmental Quality Laboratory (LQA), where they were stored in refrigerators at 4ºC, for analysis that took place the day after collection.

Laboratory tests

Laboratory analyses took place on February 18, 2025. To conduct this action, the Amônia Tester, AKSO brand, was used, which uses the Nessler method to identify the quantity of ammonia in the five areas of the urban stretch of the Paragominas stream. The temperature of the sampled water at 25 ºC, with a measurement range between 0.00 and 5.00 ppm with accuracy (± 0.10 ppm + 5%) with a sample volume equal to 10 mL. The wavelength equivalent to 455 nm. The basis for these analyses was supported by the established guidelines National Health Foundation (FUNASA, 2013).

SECONDARY DATA

To obtain secondary data, the following were accessed: *Links* electronic products that store publications on the subject of this research, especially ammonia in surface waters: Environment & Water; Brazilian Agricultural Research Corporation (EMBRAPA), Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES) via CAFe, Google Scholar, PLOS ONE, ResearchGate, Science Direct; Virtual Journal of Chemistry, *Web of Science*, among others.

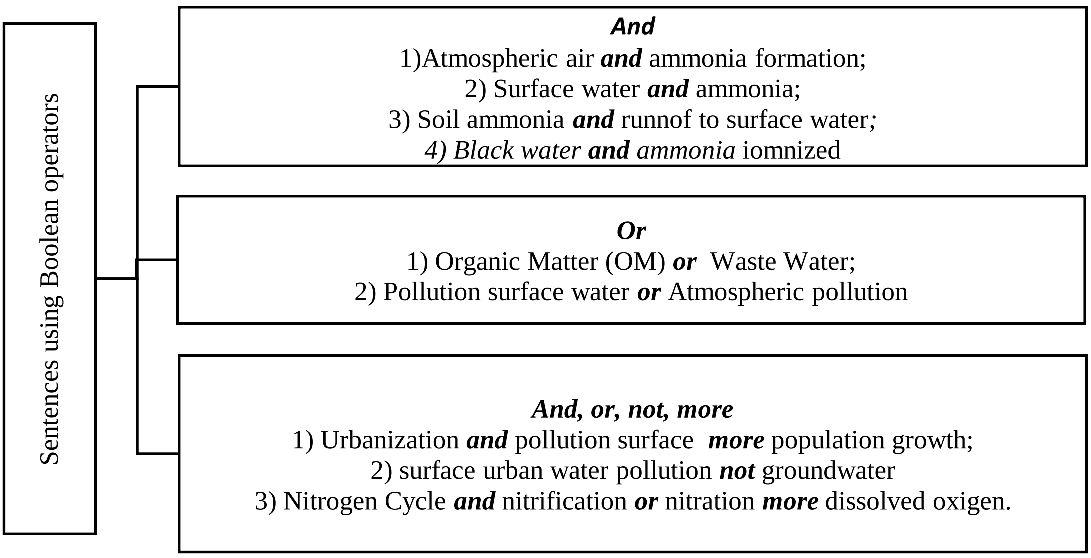
The time limit comprised the last 54 years, which were divided into five decades and four years, to expand the number of publications with the objective of better supporting the discussions, based on research and publications inherent to the theme of this research. These periods allowed an effective interpretation and evolution of studies and national legislation about this gas in the aquatic environment and its implications for water quality and its inhabitants (Figure 5).

Figure 5 - The four and a half decades used to compose the *corpus* of this research.

Source: authors (2025).

To compose the *corpus* of this research, it was necessary to apply Boolean operators. Their use is justified because they allow and facilitate the combination of words of interest (FREITAS *et al.,* 2023). In this study, they were used, both in isolation and in association (Figure 6).

Figure 6 – Use of Boolean operators for the selection of the literature that composed the *corpus* of this research.



Source: authors (2025).

STATISTICAL ANALYSIS OF THE DATA

Due to the condition of non-parametric data, Analysis of Variance (ANOVA) was used as a criterion, followed by the Kruskal-Walli's test, with the BioEstat 5.0 software (IDM, 2023), to verify the difference between the means with the use of the *Paleontological Statistics software* (PAST, 2024). For the Principal Component Analysis, the Kaiser criterion (eigenvalues < 1) was applied.

RESULTS

The analysis of the data obtained indicated that, in the five areas analyzed, the concentrations of non-ionized or free ammonia are affected by pH, temperature and DO (Table 1).

Table 1 – Values for the ammonia averages, Hydrogen potential (pH), Temperature and Dissolved Oxygen (DO), measured in the five areas of the urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.

	Ammonia-Free.	**Water T**	**pH**	**DO**
Areas Analyzed	**(mg/L)**	**(ºC)**	**--**	**(mg/L)**
Constantino Pereira do Sacramento Highway.	0.13	23.65	5.42	2.04
Selecta Avenue	0.26	26.20	6.19	2.27
Confluence of Gregório Santos Araújo Street	0.37	23.95	5.58	1.70
Green Lake	0.81	26.75	5.37	2.07
Padre Carvalho Street	1.21	25.30	6.53	1.50
	$p < 0.05$			

Source: authors (2025).

It is observed that the *p value*, is significant to the action of the three variables on the concentration of ammonia in the five areas analyzed ($p < 0.00193$). The eigenvalues found explain 82.2% of the variations in the data obtained and their action on the concentration of non-ionized ammonia (Table 2).

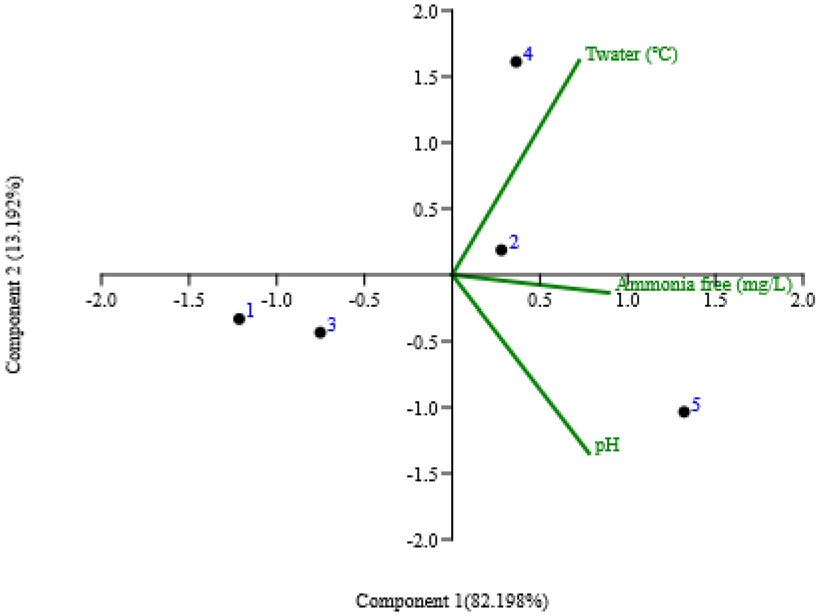
Table 2 – Eigenvalues and percentages of variations of the principal components between non-ionized or free ammonia, temperature, and pH in the five areas analyzed in the urban stretch of the Paragominas stream, in the municipality of the same name. Pará State. Brazil.

Main Components	Eigenvalue	(%) Variation
1	1.86589	82.198
2	0.299467	13.192
3	0.104646	4.61

Source: authors (2025).

It can be seen that non-ionized or free ammonia showed tendencies for increases or decreases, under the action of temperature and pH, especially at A_5 (Figure 7).

Figure 7 – Effect of pH temperature on ammonia concentration, in the five areas analyzed in the urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.



Legend: 1 - RCPS, Constantino Pereira do Sacramento Highway (A_1); 2 - Selecta Avenue (A_2); 3 - Camboatã neighborhood (A_3); 4 - Green Lake (A_4); 5 - Padre Carvalho street (A_5). Source: authors (2025).

It was also verified that the concentration of ammonia tends to variations, as a function of temperature and DO supply. In this case, the variability between them is 85.09%, and are explained by these three components (Table 3).

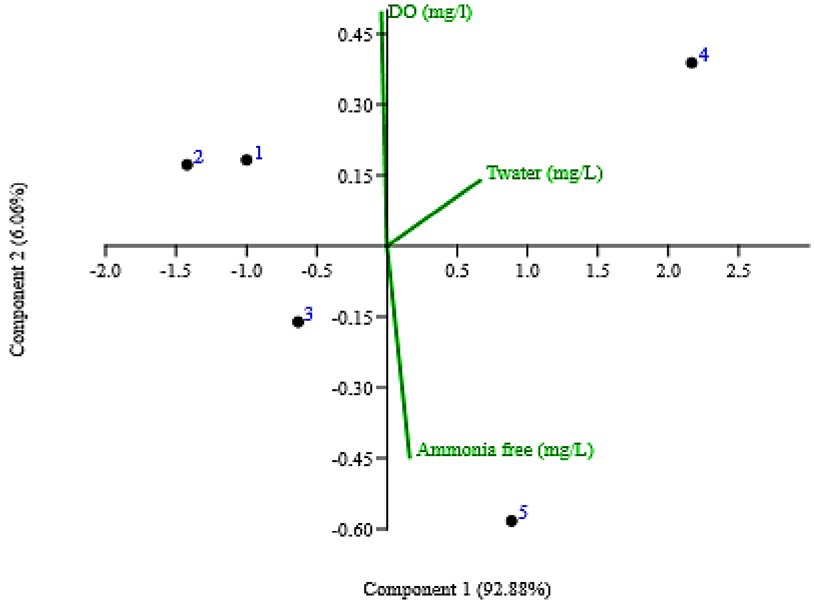
Table 3 - Eigenvalues and percentages of variations of the principal components between non-ionized or free ammonia, temperature and DO supply, in the five areas analyzed in the urban stretch of the Paragominas Stream, in the municipality of the same name. Pará State. Brazil.

Main Components	Eigenvalue	(%)Variation
1	2.22282	92.878
2	0.144998	6.0586
3	0.0254413	1.063

Source: authors (2025).

The significance index ($p < 0.00193$) indicates that there is a difference between the means of the values obtained, and that the actions on non-ionized or free ammonia are effective both by temperature and by DO (Figure 8).

Figure 8 – Action of temperature and DO on ammonia, in the five areas of the analyzed urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.



Legend: 1 = A_1 – Constantino Pereira do Sacramento Highway; 2 = A_2 – Selecta Avenue; 3 = A_3 – Confluence of Gregório Santos Araújo Street with PA 125 Highway; 4 = A_4 – Lago Verde; 5 = A_5 – Padre Carvalho Street.
Source: authors (2025).

Figure 8 shows that low temperature is one of the environmental factors that act positively on the concentration of DO in A_1 and A_2. The concentration of DO was higher at A_4. On the other hand, the concentration of non-ionized or free ammonia tends to decrease in A_3. The temperature acted on the A_4 and A_5, in a slightly more effective way.

The action of pH and DO on the concentration of the NH_3. The variance index of 68.73% better explains the relationship between these three variables (Table 4).

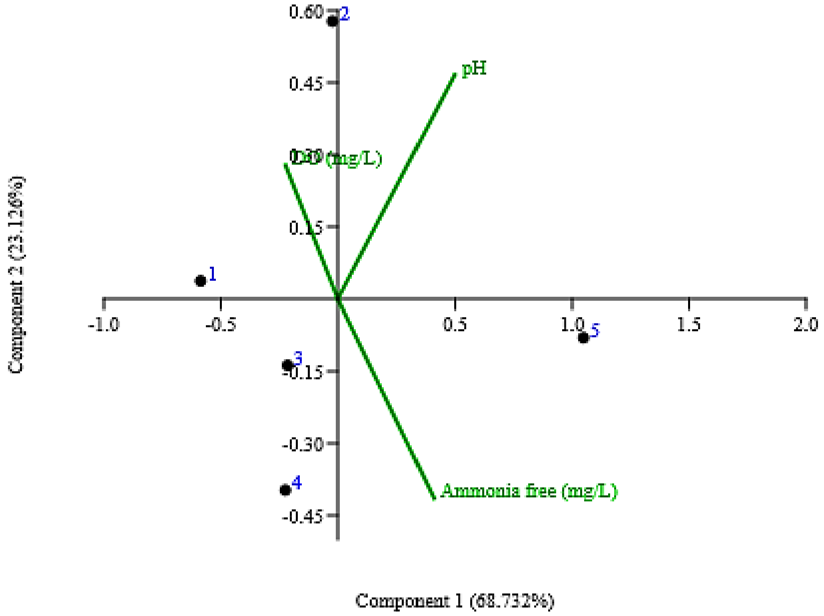
Table 4 - Eigenvalues and percentages of variations of the principal components between non-ionized or free ammonia, pH and DO supply, in the five areas analyzed in the urban stretch of the Paragominas Stream, in the municipality of the same name. Pará State. Brazil.

Main Components	Eigenvalue	(%)Variation
1	0.385093	68.732
2	0.12957	23.126
3	0.0456166	**8.1418**

Source: authors (2025).

The significance index ($p < 0.00193$) indicates that there is a difference between the means of the values obtained, and that the actions on non-ionized or free ammonia, as a function of pH, caused a rapid growth of this gas, were more effective in A_2. DO, on the other hand, reduces the concentration of NH_3 in A_5 (Figure 9).

Figure 9 – Role of the variables that make up the parameters of water quality analysis on the concentration of NH_3. Paragominas stream. Pará State. Brazil.



Legend: 1 - Constantino Pereira do Sacramento Highway (A1); 2 - Selecta Avenue (A2); 3 - Camboatã neighborhood (A3); 4 - Green Lake (A4); 5 - Padre Carvalho street (A5). Source: authors (2025).

DISCUSSIONS

ORIGIN

In the Paragominas stream, they tend to present numerous origins: physiological aspects of aquatic fauna and flora, soil, atmosphere, solid waste, population growth, among others. Study (QUEIROZ; BOEIRA, 2007) about the genesis in aquatic ecosystems, begins in the catabolic process of the aquatic inhabitants who excrete them. They can also come from soil, especially those where there is frequent use of fertilizers (agriculture and livestock) containing NH_3 (WISKICH; RAPSON, 2023) that release around 20% of this gas into the water. The burning of petroleum-based fuels, human excrement (SILVA, J.; SILVA, T.; BECKER, 2016) and vehicle catalytic converters, by 80% (GUIMARÃES; de MELLO, 2006).

In these ecosystems, the , has a bacteriological origin, as long as these microorganisms have been responsible for the residual degradation process of the OM that entered it NH_3 (MEDHI, 2021). Another source is wastewater, in which, in general, there is 55 to 60% ammonia nitrogen, a stage composed of NH_3 (HUANG; SHANG, 2006). In addition to wastewater, dumps that are established, whether temporary or permanent, in inappropriate locations (SILVA *et al.,* 2018) generate OM input, and this becomes a limiting factor for , which depends on the process of mineralization and immobilization of this OM, in addition to the nitrogen cycle and consequent nitrification NH_3(FRENEY; SIMPSON, 1981).

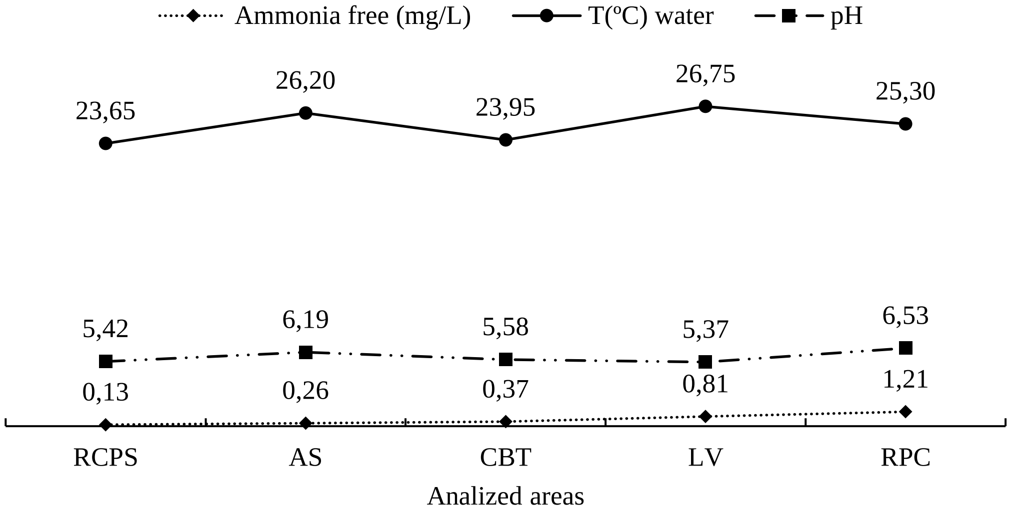
Sediments also contribute to the genesis of NH_3. However, this will only occur if the micro bacterial concentration, responsible for the decomposition of the OM that, in this place, has accumulated. In this case, the form of degradation is from the mineralization of N_2 (EPA, 2025). Among the anthropogenic sources that are consistent with the economy of Paragominas, there is the use of synthetic fertilizers and livestock, the latter, via nitrogenous excreta (urea, uric acid). Such sources have already been identified from the study of the biogeochemical cycle (EDWARDS, *et al.,* 2024).

Maintenance of non-ionized or free ammonia in water

In the five areas analyzed, this chemical compound was identified. Its permanence in these places is linked to two variables, one physical and one chemical, which identify, in resolution 357 (BRASIL, 2005), the quality of the water: temperature and pH. The free form occurs when the second parameter has an alkaline character (dos REIS; MENDONÇA, 2009; SILVA *et al.,* 2014), this stage intensifies the toxicity of this gas in the aquatic environment, which compromises the aquatic fauna, and the water has two altered characteristics: odor and taste (MAZARI-HIRIART *et al.,* 2008; SAALIDONG *et al*. 2025), since, in the normal state, as for ammonia concentrations, the water is odorless and tasteless.

In the case of temperature and pH, at A_5, 25.30 ºC and 6.53 were identified, respectively, for a concentration of 1.50 mg/L (Figure 10a). This indicates that the concentration of non-ionized or free ammonia (NH_3), was increased. Studies conducted on this relationship (BOYD; TUCKER, 1992; FELIX; CARDOSO, 2004) concluded that this creates a certain range of free ammonia equivalent to 0.60 mg/L. The range identified for ammonia non-ionized or free, in Paragominas, under these conditions of measured temperature and pH, was twice as high (1.21).

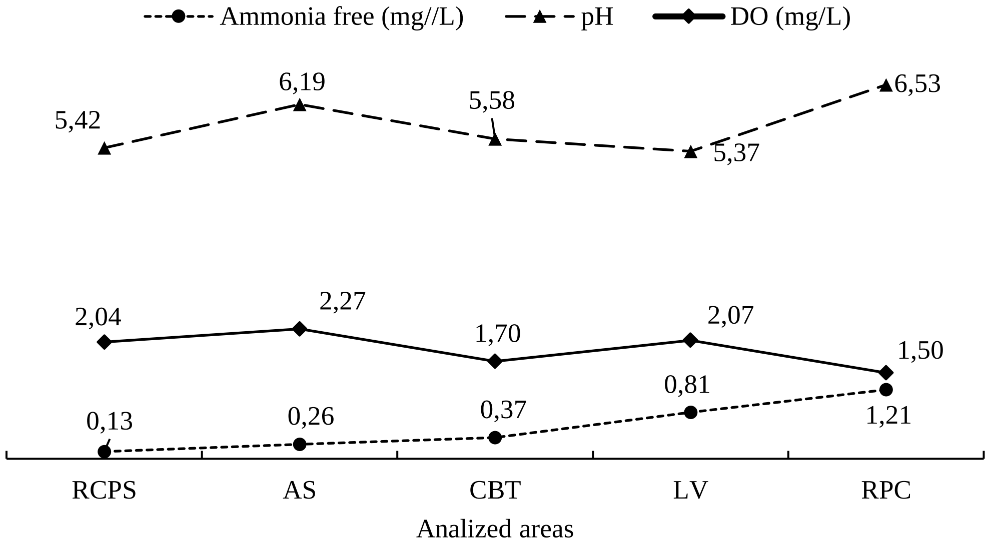
Figure 10a – Comparative data on the concentration of the non-ionized ammonia, and pH oscillations and trends of temperature variations in the five areas analyzed in the urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.



Legend: RCPS, Constantino Pereira do Sacramento Highway (A_1); Selecta Avenue (A_2); Camboatã neighborhood (A_3); Green Lake (A_4); Padre Carvalho street (A_5). Source: authors (2025).

As for the action of DO and pH in relation to the concentration of non-ionized ammonia in the five areas analyzed, the variation in the concentration of the first water quality parameter acts directly on the concentration of non-ionized ammonia (Figure 10b).

Figure 10b – Comparative data on the concentration of the non-ionized ammonia, pH oscillations and trends of DO concentrations in the five areas analyzed in the urban stretch of the Paragominas stream, in the homonymous municipality. Pará State. Brazil.



Legend: RCPS, Constantino Pereira do Sacramento Highway (A_1); Selecta Avenue (A_2); Camboatã neighborhood (A_3); Green Lake (A_4); Padre Carvalho street (A_5). Source: authors (2025).

This direct action of DO on non-ionized ammonia (WANG *et al.,* 2023) is a preponderant factor for nitrification to occur: (oxidation and formation of nitrite, nitrate, and organic nitrogen), i.e., there is a direct contribution to the continuity of the organic nitrogen cycle that returns to the environment. This importance of DO for nitrification is due to the availability of bacterial actions (*Nitrosomonas, Nitrobacteria*, aerobic reaction), as well as mitigating the toxic effect of ammonia (HOSSAIN; FAKHRUDDIN; KHAN, 2007).

In water resources management, monitoring the concentration of water is essential when it involves population growth due to the increase in water consumption and the generation of domestic effluents. In a study conducted as a literature review about NH_3(SILVA JÚNIOR, 2024), it was identified that population growth influences the volume of domestic effluents generated (CARVALHO; FERRAZ, 2007). As a result, the supply of OD tends to decrease due to the decomposition of OM. In Paragominas, in 2010, the population was equivalent to 97,819 inhabitants (IBGE, 2010), in the census conducted in 2022, the population was 105,508 inhabitants (IBGE, 2022).

Also in this municipality, in 2022, 7.044 inhabitants (6.67%) had their residential bathroom connected to the sanitation network. The others are discontinuous with this service, that is, their waste is destined for: holes, ditches, rivers, streams, among others (IBGE, 2022). Therefore, the waste and effluents generated during personal hygiene may be flowing into the two water bodies, especially the Paragominas stream that crosses the urban area of this municipality. How this waste originates free ammonia by decomposition of this OM, one of its origins, is explained.

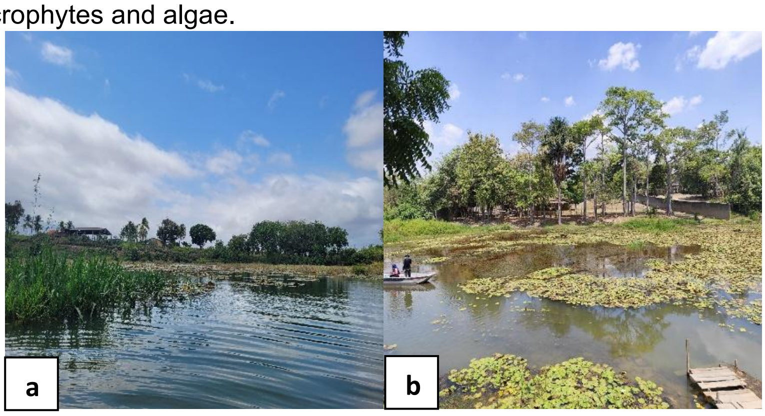
It was observed in the last two areas A_4 - Green Lake (Figure 11a), the vegetation cover is non-existent, so the solar radiation is more effective, and the temperature rises: from 23.95º C. In A_3, where there is the presence of marginal tree vegetation (Figure 11b), to 26.75ºC, which induces an increase in concentration of NH_3 (WERKNEH; GEBRU, 2023). Another fact: on the A_4, there are no aquatic plants because this type of vegetation is cleaned daily. In the cause-effect relationship, in A_5, there is an increase in the concentration of NH_3. This effect causes greater availability of nitrogen, which is consumed by the aquatic vegetation, which allows its dissemination. in this area (Figure 11c) because the absorption of **(**NH_3) as a source of nitrogen acts on the proliferation of this vegetation which, due to the marginal vegetation cover, does not dissipate since solar radiation does not enter the water column (Figure 11d).

Figure 11 – a) Green Lake without aquatic plants and marginal cover; b) Camboatã, with marginal cover (left bank) and aquatic plants; c) growth of aquatic vegetation; d) Shading caused by marginal tree vegetation. Igarapé Paragominas, in the homonymous municipality. Stop. Brazil.

Degradation of non-ionized or free ammonia in water

One of the ways of degradation of the , is the absorption via aquatic plants and algae. In the data obtained and analyzed, it is verified that in the first three areas, there was an increase in the concentration of this gas (A_1 = 0.13 mg/L; A_2 = 0.26 mg/L; A_3 = 0.37 mg/L). Study conducted on this topic (von SPERLING, 1996) in Lagos correlated land use and occupation with high concentration of algae, siltation, and presence of macrophytes. In A_1, agricultural sites are still found (Figure 12a), and leisure areas on the banks of the stream, as in A_2 (Figure 12b).

Figure 12 – a) site and macrophytes observed in A_1; b) Laser area on the margin (right) on A_2, also with the presence of macrophytes and algae.



Source: authors (2025).

The pH also causes solubility of this gas. However, in two areas (A_2; 6.19; A_3 = 5.58), the intermediate values are between low acid and almost neutral. The reference research for these arguments, based on the data found, was described by the Environmental Company of the State of São Paulo - CETESB (SÃO PAULO, undated).

In the last two areas ($\mathbf{A_4}$ = 0.81 mg/L; pH = 5.37; $\mathbf{A_5}$, 1.21 mg/L; pH = 6.53), focusing on the latter, the pH is alkaline. This chemical state of the water tends to increase non-ionized ammonia in the aquatic environment, and, with this, it is perceived that the concentration of DO tends to increase. Study based on the cause-effect relationship of these two variables for water quality (ADAMANTE, 2005; BRAZIL, 2005)It concluded that the DO acts indirectly on the , since its direct action in the aquatic environment occurs on catabolism and anabolism of the organisms of the water environment.

CONCLUSION

The data on free ammonia in the five areas of the urban stretch of the Paragominas stream indicate that there is a stage of pollution in growth, since the parameters DO, pH and temperature, in four of them (A_1, A_2, A_3 and A_4), and the increase in the concentration of free ammonia in A_5, may be flowing into the Uraim River, without any type of treatment. The expanding population growth and the lack of monitoring of basic sanitation in the municipality still do not present equity.

The physical alteration caused in the meander of the Paragominas stream, associated with the expansion of horizontal urbanization, the non-existence of public places as recreation areas and fishing activities, induce communities with economic hypo sufficiency to use the lakes formed in the urban peripheral area of Paragominas, especially children, as observed throughout this research. Fishing, in addition to being sport, is also used as a nutritional provider, since bonfires were observed during the recreational baths practiced there.

As there was previously no data that identified the current state of water quality, it is expected that municipal managers will take advantage of it to develop actions that may not intervene or even improve the areas that are now used for recreation, or even make a planned relocation of floating plants, keeping them under population control and letting them act in favor of water quality. In addition, a reforestation program with native species, on the banks of the Paragominas creek in the urban section will contribute to comply with the guidelines of the Municipal Water Resources Plan of the municipality.

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