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Urban stream syndrome at the hydrographic network in Recife city, Brazil

Síndrome dos riachos urbanos na rede hidrográfica da cidade do Recife, Brasil

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Abstract

This paper describes the urban stream syndrome at Recife, a coastal city in northeast Brazil. The term "urban stream syndrome" describe ecological degradation of streams in urban environments. Recife city comprises a low flat plain surrounded by small hills, with a hydrographic network formed by three main rivers and almost a hundred streams, some of them severely degraded. The accelerated population growth has generated disorderly urbanization and has negatively affected the water courses that suffer from problems of water quantity and quality. To carry out a diagnosis and check if the stream is sick, the integrity of the banks, color and smell of the water in the streams, the chemical quality of the water, the presence of organic matter and problems with the fauna were analyzed. Around 25% of the city sewage is not collected, which leads to the pollution of the entire hydrographic network. Most of the streams are eutrophic, with very low levels of dissolved oxygen and only more tolerant species can survive. This condition requires integrated public policies, including selective collection, efficient treatment, and regular monitoring. The situation in the study area underscores the urgency of coordinated action among governments, civil society, and watershed committees.

***Keywords*:** urbanization; water pollution; river degradation.

Resumo

Este artigo descreve a síndrome do riacho urbano em Recife, cidade costeira no nordeste do Brasil. O termo "síndrome do riacho urbano" descreve a degradação ecológica dos riachos em ambientes urbanos. Recife compreende uma planície baixa e plana cercada por pequenas colinas, com uma rede de cursos d'água formada por três rios principais e quase cem riachos, alguns deles gravemente degradados. O crescimento populacional acelerado gerou urbanização desordenada e afetou negativamente os cursos d'água, que sofrem com problemas de quantidade e qualidade da água. Para fazer um diagnóstico e verificar se o córrego está doente, foram analisadas a integridade das margens, a cor e o cheiro da água dos córregos, a qualidade química da água, a presença de matéria orgânica e problemas com a fauna. Cerca de 25% do esgoto da cidade não é coletado, o que leva à poluição de toda a rede hídrica. A maioria dos riachos é eutrofizado, com níveis muito baixos de oxigênio dissolvido e apenas espécies mais tolerantes conseguem sobreviver. Essa condição requer políticas públicas integradas, incluindo coleta seletiva, tratamento eficiente e monitoramento regular. A situação na área de estudo ressalta a urgência de ações coordenadas entre governos, sociedade civil e comitês de bacias hidrográficas.

***Palavras-chave*:** *urbanização; poluição das águas; degradação de rios.*

Introduction

In the XX century, cities all over the world went through a rapid increase of population and an excessive rate of imperviousness that dramatically altered the hydrological processes. Most urban streams have been engineered to cope with high flow in the rainy period but after the rainy days the flow decreases abruptly because there is no base flow. Water quality also deteriorates due to diffuse pollution in urbanized basins and stream ecology becomes severely degraded. This consistent suite of effects was termed the "urban stream syndrome" by Meyer et al. (2005).

Urban stream syndrome presents variations in different countries due to a variety of environmental and social factors influencing urban streams. Variations in urban stream syndrome could depend on differences in climate (Hale et al., 2015), urban infrastructure (Parr et al., 2016), resources available in less-developed countries (Capps et al., 2016), hydraulic efficiency of storm water drainage (Walsh et al., 2005), terrain morphology, imperviousness rate, soil use, soil occupation and presence of industrial plants.

The urban stream syndrome is prevalent worldwide, as evidenced by studies conducted by Driscoll et al. (2003), Halstead et al. (2014), and Booth et al. (2015). Urban streams present physical, chemical and biological differences from natural streams. The main differences are elevated concentrations of contaminants and nutrients, modified channel morphology and stability, reduced biotic diversity accompanied by dominance of tolerant species and a showier hydrograph (Paul & Meyer, 2001; Meyer et al., 2005). All over the world symptoms of streams that drain urbanized areas are similar with only small specific differences. Meyer et al. (2005) describes a consistent suite of effects characterizing a complex problem that demands a multidisciplinary approach including stream hydrology, stream ecology, social, economic, and political dimensions. The main symptoms of the urban stream syndrome refer to changes in the hydrology of water courses, chemical quality of the water, morphology of streams, organic matter, problems in ichthyofauna, eutrophication and problems with algae growth. Hydrological changes in watercourses are very evident in the urbanization process. Increased imperviousness reduces infiltration and increases surface runoff. The drainage system with gutters and galleries accelerates the flow so that peak flows in streams are greatly expanded and occur more quickly.

Walsh et al. (2005) summarizes the hydrological changes as increase of frequency of overland flow, increased frequency of erosive flow, increase of magnitude of high flow, decrease of lag time to peak flow, increase of rise and fall of storm hydrograph. These effects can cause a high level of stress in the river ecosystem in addition to causing flooding problems. With regard to the chemical quality of water in urban watercourses, there is an increase in nutrients and chemical compounds due to diffuse pollution and domestic effluents. This happens even in cities with a sewage collection network due to leaks in the network. The characteristics of the shape of the river channel are the result of the dynamic balance of flows and erosion and/or sedimentation over centuries. In the process of urbanization, this balance is altered, giving rise to erosion on the banks or incision of the river bed. Walsh et al. (2005) found that main morphology problems are modification on channel width, changes on depth and reduction on channel complexity.

In efforts to combat erosion, engineering interventions often involve channel straightening or the use of impermeable surfaces, resulting in a reduction in both channel complexity and instream

habitat—common symptoms of urban stream syndrome. Moreover, erosion, channel incision, and simplification may lead to a decline in hyporheic flow (Grimm et al., 2015) and hydrologic isolation from riparian vegetation (Groffman et al., 2003). Other symptoms include changes in the organic matter content. However, the causal relationship is not very clear. Studies carried out in urban streams in Australian cities report that environments with abundant trees experience a significant accumulation of fallen leaves, contributing to higher concentrations of coarse particulate organic matter compared to rural reference streams (Miller & Boulton, 2005).

Concerning fish populations, a majority of investigations indicate a decline or reduced abundance of sensitive fish species, resulting in a less diverse assemblage and dominated by disturbance-tolerant species (Roth et al., 1996; Wang &Lyons, 2003; Roy et al., 2005; Roy et al., 2014). Several studies have been carried out regarding benthic macroinvertebrates (Wang & Lyons 2003; Miltner et al., 2004; Walsh 2004). On a global scale, urban streams tend to display species-poor assemblages, predominantly composed of disturbance-tolerant taxa. In instances of high degradation within urban basins, a limited number of species, such as oligochaetes (typically tubificids, lumbriculids, and naidids) and chironomids, often exert numerical dominance (Walsh et al., 2005).

As urban hydrosystems of the Global South have different characteristics from those of the Global North, Wantzen et al. (2019) have used the name Southern Urban Hydrosystem Syndrome. The situation in the global south is more complex, the riparian zones are often inhabited by the poorest part of the population, which has neither political power nor technical skills and is rarely involved in problem analysis, or in decision-making (Wantzen et al., 2019). Although Recife belongs to global south, hereinafter the expression urban stream syndrome will be used.

This paper aims to describe, through a bibliographical review and documentary analysis, the urban stream syndrome in the city of Recife, a coastal city in the Northeast of Brazil composed of a low plain and surrounded by small hills, with a network of water courses formed by three main rivers. and almost a hundred streams ranging from 120 m to 8.2 km, most of which are quite degraded.

Materials and methods

Study area

Recife is a commercial and tourist city, in northeastern Brazil (8°04′03″ S, 34°55′00″ W), and has been built with large areas of land reclamation from river banks, stream reaches, wetland and mangroves (Figure 1). The urban population in Brazil has increased extremely since the second half of the 20th century and currently the country is predominantly urban. Recife is densely populated, with terrain surface occupied by buildings, streets, pavements and urbanization that has led to high rates of imperviousness.

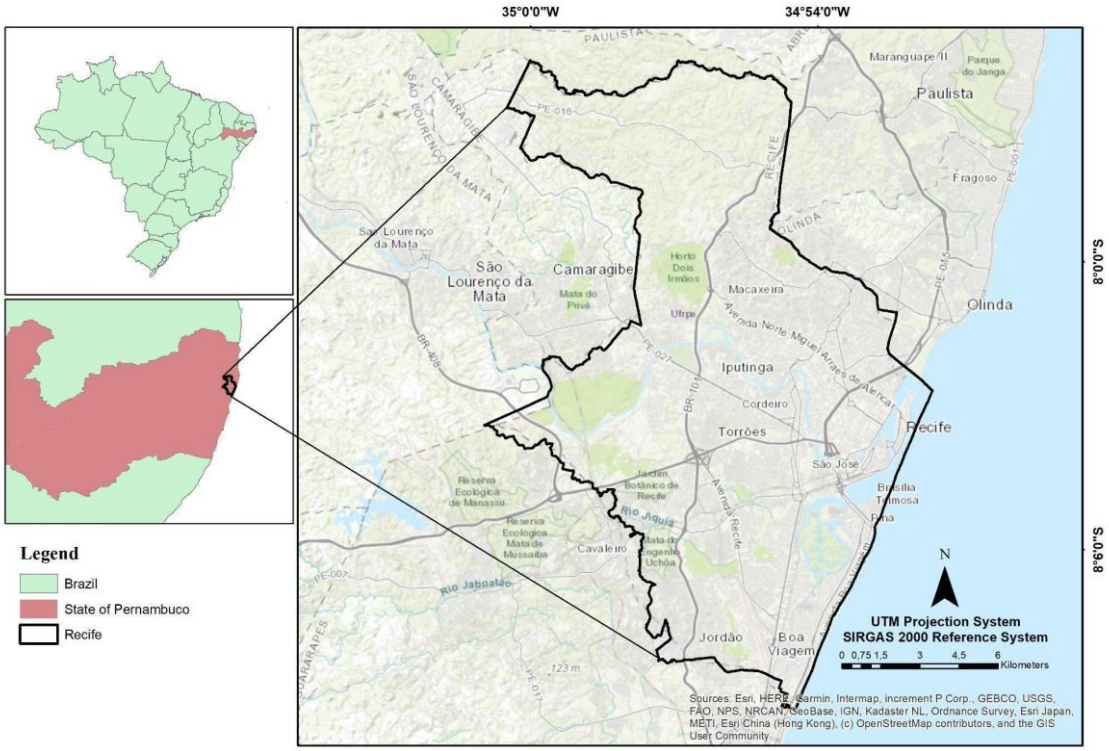

Figure 1 - Recife, a coastal city in Pernambuco state at northeast Brazil.

Recife has an area of 218 km², 67.43% of which is occupied by low-altitude hills (around 100.0m), 23.26% is occupied by plains, 9.31% is occupied by water surfaces and the rest is occupied by special zones of environmental preservation. Table 1 shows the population of Recife and the population of its Metropolitan Region (RMR) including 13 neighboring Municipalities.

Table 1 - Population increase in Recife and its metropolitan region since the last decades of the twentieth century

Ano	Recife	Metropolitan Region
1970	1.060.701	1.755.083
1980	1.203.887	2.386.453
1990	1.298.229	2.867.548
2000	1.422.905	3.337.565
2010	1.537.704	3.690.547
2022	1.488.920	3.726.974

Note: Data of IBGE (2025).

One of the phenomena that can be observed in the last decades is the periurbanization (DeMatteis, 1996) in which it is observed that the city of Recife as the core of the metropolitan region did not have a very high growth rate, but the peripheral cities grew a lot, also increasing the imperviousness and the social problems. A symptom of the social aspects of the syndrome, mainly in countries in the southern hemisphere, refers to the occupation of the banks of watercourses by the

poor population who build their houses in the riparian zone and often land part of the cross section of the stream to make the base of their homes (Figure 2). Recife faces historical challenges in basic sanitation, exacerbated by deficient infrastructure and low sewage coverage. In 2017, the Recife Municipal Basic Sanitation Plan (Recife, 2017) was developed in accordance with Federal Law Nº 11.445/2007. Subsequently, this legislation was updated by Federal Law Nº 14.026/2020, which established service universalization targets, including 90% sewage collection and treatment by 2033 (Brasil, 2020). It is a social problem that is difficult to solve and that causes additional problems with sewage and garbage in the streams.

Figure 2 - Slums occupying the stream banks causing additional problems with sewage and garbage in the water course.

The climate in Recife is hot and humid, the average temperature is 26ºC and being a coastal city, most of the rain comes from the Atlantic ocean. Silva et al. (2016) present a simplified description mechanism that operate to produce rain in Recife region: Intertropical Convergence Zone, the Upper-Tropospheric Cyclonic Vortex, the Easterly waves disturbance and disorders associated with frontal

systems, and also land and sea breezes. The mean annual precipitation can exceed 2.400 mm Notably, in May 2022, an extreme rainfall event resulted in 551 mm of precipitation over a five-day period, surpassing the monthly average. (Morengo et. al., 2023). Recife experiences recurrent flooding due to its low elevation and gentle slope, which hinder the natural drainage of rainwater. The inefficiency of the drainage infrastructure, combined with the region's intense rainfall and the influence of tides at the drainage system outlet, exacerbates the situation. This issue becomes particularly severe when peak precipitation coincides with high tides, making flood control even more challenging (Fonseca Neto et al., 2022).

Three main rivers cross the city of Recife (Figure 3) from west to east and have a shared estuary with a single outlet to the sea in the region of the port of Recife: the Beberibe river in the north, the Capibaribe river, the most important in the center and the Tejipió River in the south.

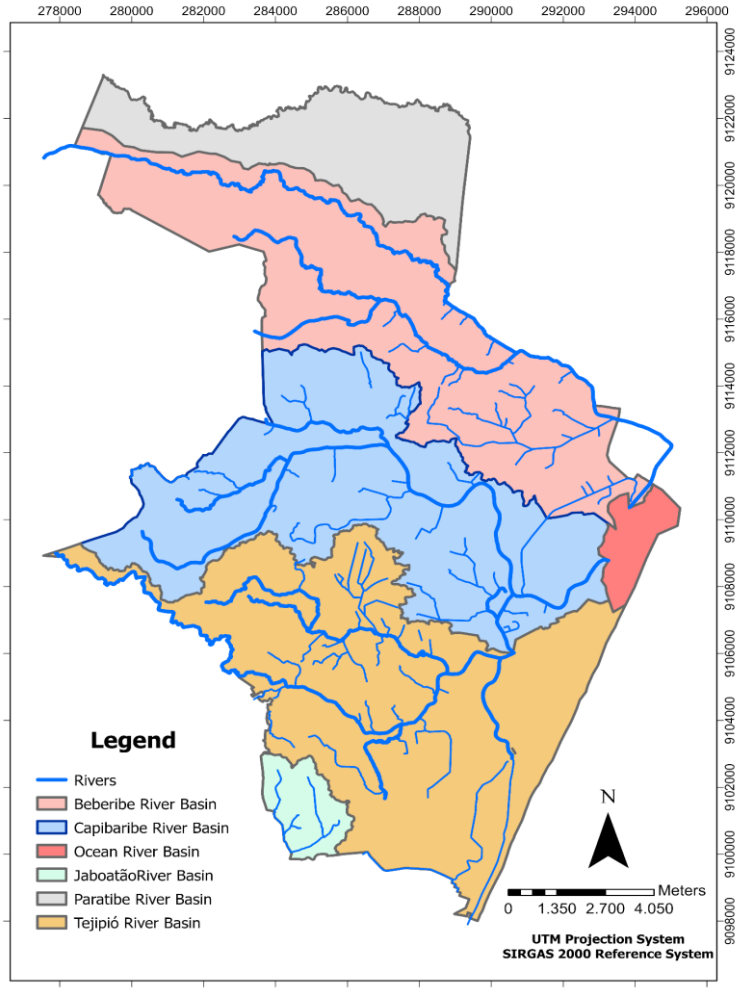

Figure 3 – River basins in the city of Recife.

The Beberibe River basin, with a total area of 79.0 km², of which 55.4 km² is within Recife, has 25 affluent streams in the city of Recife, the largest of which is the stream of Macacos with 8.2 km. The Capibaribe river basin has a total area of 7400.0 km², with 59.90 km² within Recife, and its hydrographic

basin in Recife has 34 streams, one of which the Camaragibe stream is the longest. The Tejipió River basin, with a total area of 93.2 km², with 61.88 km² within Recife, has 39 tributary streams with a total length of more than 23 km in Recife.

Out of the 99 streams within the urban fabric of the city of Recife, seven of them stand out for their length: Vasco da Gama/Arruda stream, Macacos stream, Derby-Tacaruna stream, Cavouco stream, Setúbal stream, Jordão stream, and Curado stream, all of which are over 5 km long. The Tacaruna-Derby, Setúbal, and Jordão streams deserve even more attention, as they have 100% of their beds covered, indicating the unplanned urbanization that the city has experienced, resulting in environmental problems in these watercourses. In general, most of the streams in Recife have a significant portion of their course covered or even concreted. Table 2 presents the percentage of bed covering and concrete lining in the streams and tributaries of the main rivers in Recife.

Table 2 - Covering and lining of streams in the main rivers of Recife

Basin	River	Total number of stream	Lined (%)	Not lined (%)	Covered (%)
Beberibe	Beberibe	19	78.20%	17.38%	4.41%
	Morno	6	22.34%	77.66%	0.00%
Capibaribe	Capibaribe	28	73.56%	23.34%	3.10%
	Camaragibe	5	54.15%	45.85%	0.00%
Jaboatão	Jaboatão	6	37.98%	75.58%	0.00%
Tejipió	Jordão	3	96.69%	3.31%	0.00%
	Jiquiá	19	35.29%	56.72%	5.62%
	Curado	1	7.92%	92.08%	0.00%
	Tejipió	10	30.80%	68.67%	0.53%
	Moxotó Ibura	2	29.99%	66.17%	3.84%

Note: Data of EMLURB (2016).

Research methodology

The methodology included a bibliographical review of manuscripts and documentary analysis of reports from water supply and sewage collection companies, reports from environmental agencies, reports from other public agencies, as well as maps and photographic records.

A qualitative characterization of the water in eight distinct urban streams along the three main basins of the city was conducted, considering the water bodies of greater relevance and contribution to the drainage network. The water quality classification for urban streams was based on the guidelines proposed by Resolution No. 357/2005 of the National Environmental Council *"Conselho Nacional do Meio Ambiente - CONAMA"* (Brasil, 2005), which classifies water bodies into five categories (special class, class 1, class 2, class 3, and class 4) based on the necessary quality levels to meet the population's needs. The higher the class number, the less demanding the intended uses for the water. Physical-chemical and biological parameters from the Master Plan for Drainage and Management of Urban Waters of Recife (EMLURB, 2016) were considered, including Temperature, Electrical Conductivity, Turbidity, Total Dissolved Solids, Dissolved Oxygen, Salinity, pH, Nitrogen Compounds, Phosphorus, Carlson Trophic State Index Variation, Ammoniacal Nitrogen, Total Hardness, Chloride,

Nitrite, Nitrate, Total Nitrogen, and Heavy Metals (Aluminum, Lead, Lithium, Mercury, and Zinc), Total and Thermotolerant Coliforms, and Planktonic Community.

A visual analysis was also conducted for each watercourse in this study, as irregular discharge points of untreated effluents are commonly identified directly into the city's watercourses.

Results and discussion

To carry out a diagnosis and check if the stream is sick, the integrity of the banks, color and smell of the water in the streams, the chemical quality of the water, the presence of organic matter and problems with the fauna were analyzed. In case there were problems with one or more of the analyzed items, the stream was considered sick, that is, it is suffering from urban stream syndrome.

One of the first symptoms of urban stream syndrome is erosion produced by increased flow due to urbanization leading to widening or deepening of the stream cross section. Generally, the stabilized cross-section is the result of a secular process in which nature reaches a balance according to the flow rates of the stream and the physical and geometric characteristics of the river channel.

Urbanization modifies soil impermeability and amplifies flows, breaking the balance, causing erosion on the banks and bottom of the stream. An increase in sealing of 10% to 20% can cause channel instability in addition to damaging the ecosystem (Booth, 1991; Booth & Reinelt, 1993; Schueler, 1994). Bledsoe & Watson, (2001) have shown the links between imperviousness, increases in discharge and stream power, and the risk of channel instability in urbanizing basins.

To face the consequences of increased flows and the occurrence of erosion, river channels are lined with engineering works such as stone masonry or concrete, which protect locally but accelerate flow, causing more problems downstream. Figure 4 shows an example in which urbanization has increased flows, causing erosion, which led to the need for lining.

Figure 4 - Jiquiá stream as an example of the urban stream syndrome in Recife, where urbanization has increased flows, causing flood and erosion.

With regard to water quality, in Recife almost all streams are subjected to the stresses of urbanization. Only some stretches of streams located in parks or protected areas are in good ecological condition.

As an example, the initial section of the Sítio dos Pintos stream (a tributary of the Camaragibe River) is located in an Environmental Protection Area. In this stretch, at least eight species of fish were found, including tilapia, traíra and poraquê, which is also known as electric fish (Recife, 2020). The electric fish (Electrophorus electricus) has an advantage because it is considered resistant to disturbed environments, being able to survive in murky, shallow, muddy and oxygen-poor environments (Froese & Pauly, 2023). However, after this initial stretch, the stream passes through an urbanized area, receives a large load of domestic sewage and becomes heavily polluted. Two other streams that were studied in detail were Cavouco and Parnamirim, whose basins are highly urbanized. The Cavouco stream basin has its coverage classified predominantly by urban infrastructure (95.7%) followed by agriculture and pasture (4.2%) and with a small percentage of forest formation (0.1%). The Parnamirim stream basin also has its coverage predominantly classified as urban infrastructure, representing 98.8% of all land use and occupation in the basin (MAPBIOMAS, 2022).

In addition, both basins also have limited sanitary sewage collection. This context of the low rate of correct disposal of sewage in the stream basins is a reflection of the low rate of sewage collection in the city of Recife, where only 44% of its sewage is collected, making Recife one of the 20 worst cities in service base in Brazil (SNIS, 2022).

The current situation of rivers and streams in the city of Recife is worrying, as they are characterized by significant eutrophication rates (Table 3). The degree of trophy will assess the enrichment of water by nutrients and its possible effects related to the excessive growth of algae, aquatic macrophytes and cyanobacteria (CETESB, 2021).

Table 3 - Classification of the trophic state of streams in the city of Recife (EMLURB, 2016)

Stream/Channel	Basin	Trophic state
Prado	Capibaribe	Hypereutrophic
Derby/Tacaruna	Capibaribe	Hypereutrophic
Cavouco	Capibaribe	Hypereutrophic
Vasco da Gama/Arruda	Tejipió	Hypereutrophic
Canal do Ibura Moxotó	Tejipió	Hypereutrophic
Malária	Tejipió	Hypereutrophic

Note: Data of EMLURB (2016).

Dissolved oxygen (DO) is considered one of the most important parameters in water resource management planning (Ji et al., 2017). This parameter provides information on the assessment of water body ecosystems and may be affected by anthropogenic processes (Zhang et al., 2019). Wastewater discharged into aquatic matrices has large amounts of pollutants and organic compounds. Thus, the greater the amount of organic matter, the greater the number of decomposing microorganisms, increasing the consumption of oxygen available in the environment to carry out the decomposition of

all organic matter (Liu et al., 2016), consequently the DO indices of the water body fall, reaching almost zero, leading to deaths of more sensitive organisms (Wang et al., 2012). Table 4 shows dissolved oxygen results of some streams from Recife.

Table 4 - Dissolved oxygen concentrations in some Recife streams

Stream / Channel	Basin	DO ($mg.L^{-1}$)	Reference
Prado	Capibaribe	0.10	Emlurb (2016)
Derby/Tacaruna	Capibaribe	0.12	Emlurb (2016)
Cavouco	Capibaribe	0.15	Emlurb (2016)
Parnamirim	Capibaribe	<0.5	Cometti et al. (2018)
Vasco da Gama/Arruda	Tejipió	0.14	Emlurb (2016)
Canal do Ibura / Moxotó	Tejipió	0.10	Emlurb (2016)
Malária	Tejipió	0.10	Emlurb (2016)

The quality and good ecological functioning of the aquatic ecosystem of an urban stream is influenced by the poor water quality and its low OD rates, leading to the loss of sensitive organisms and the excessive increase of tolerant species, modifying the diversity of the biota and its functionalities (Sterling et al., 2016).

Rodrigues et al. (2017), in a study carried out on the analysis of the benthic macrofauna of the Cavouco stream as bioindicators of water quality, found taxa representing Hirudinea, Gastropoda, Ostracoda and Insecta. The study points out that the low number of taxonomic groups presents a high level of pollution where the water from Cavouco was classified as very polluted and heavily polluted. Assis et al. (2017), also in the Cavouco stream, collected juvenile species of Nile tilapia (O. niloticus), highlighting that the ecosystem of the Cavouco stream is impacted, bringing consequences for the species that inhabit it. Hyporheic meiofauna compositions are important in trophic and ecological relationships for the aquatic environment. In hyporheic zone of Parnamirim stream, Cabral et al. (2019) found individuals of Oligochaete and Amphipod taxa, Carvalho Filho et al. (2020) found most representative taxa: Nematoda, Annelida, Acari and Rotifera, in addition to Insecta, Amphipoda and Nauplii. It was also possible to observe the presence of tortoises (Phrynops geoffroanus) in the Parnamirim stream (Cabral et al., 2022). These animals, despite being carnivores, are very resistant and adapted and can also feed on fruits and seeds. In anthropized environments, they also feed on organic matter from domestic sewage (Souza, 2004).

An analysis was carried out to diagnose which tributaries had the symptoms of diseased streams in the Beberibe river basin, in the Capibaribe river basin and in the Tejipió river basin. Streams considered to be diseased are marked in red, those in good condition are marked in green and those with an undefined situation are marked in yellow (Figure 5).

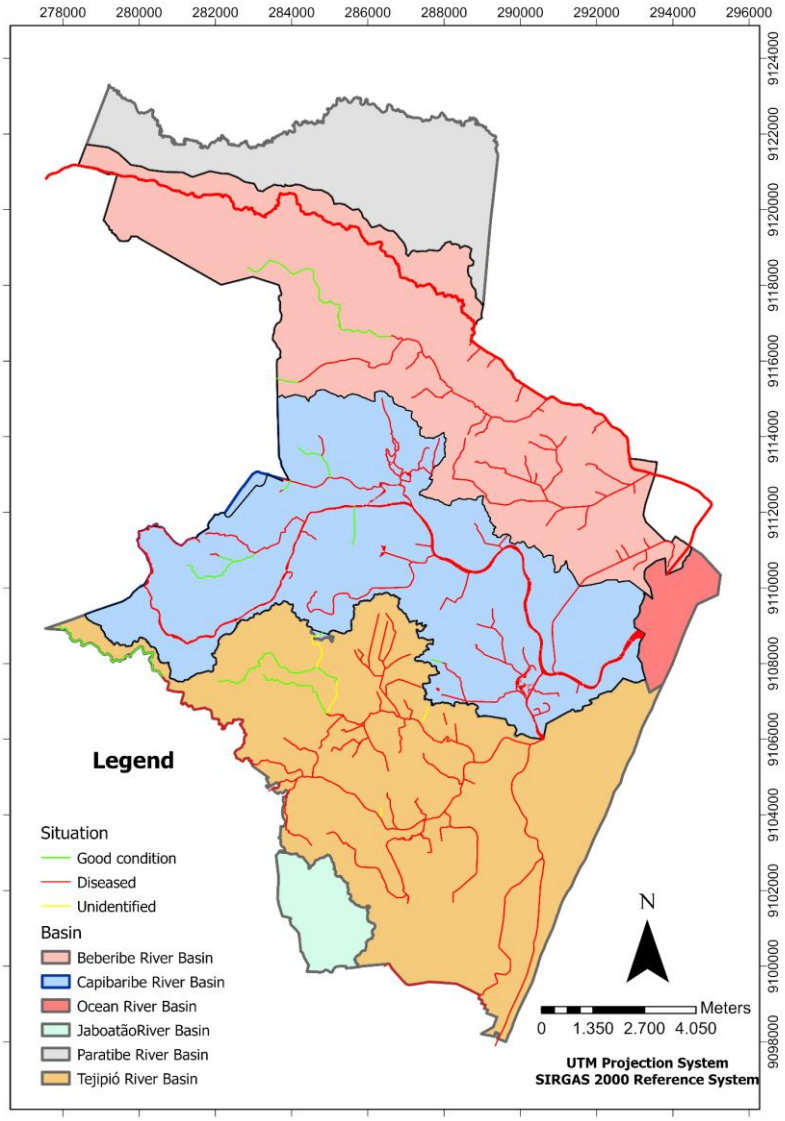

Figure 5 - River basins and the diagnose the quality in the rivers and tributaries in Recife city.

Awareness of the problem and first steps towards recovery

Gradually society and public managers are becoming aware of the problems of urban streams and some initiatives are being taken to face the problem. Actions were initiated in institutional matters, in the aspect of hydro-environmental education and with regard to sewage collection and treatment.

The watercourses located in Recife Metropolitan Region - RMR are the domain of the State of Pernambuco (Brasil, 1988). The fact that a watercourse crosses more than one municipality introduces a certain difficulty in the management of the basin. This is because it is up to the municipalities to take important actions, such as disciplining the use and occupation of the land and the collection of solid waste, which directly impact the quantity and quality of water in the watercourses. There is no legal provision for municipal ownership of watercourses in Brazilian legislation, nor is it believed that this

would be the solution to improve the situation of urban rivers. However, it is essential to manage water resources through the hydrographic basin, as provided for in the National Policy on Water Resources in Brazil, with the integration of actions by the State and municipalities that are part of the basin.

A public institution APAC (Pernambuco State Agency for Water and Clima) is the body responsible in Pernambuco state for implementation of water resources management instruments, as well as for advising the organizations of hydrographic basins. APAC is also responsible for "guiding and supporting municipalities towards an integrated management of water resources, as well as promoting the inclusion in municipal master plans of devices aimed at protecting water resources, essential to improving the quality of life" (Pernambuco, 2010).

The Hydro-Environmental Plan for the Capibaribe river basin was prepared, including actions such as the construction of urban parks, aimed at protecting the banks of the Capibaribe river and the development of socio-environmental actions with the aim of encouraging the population to live with and take care of the river. In the city of Recife, there are several stretches of the Capibaribe River that have areas that coexist with the river and there is a project for a Linear Park along the entire stretch of the Capibaribe River within the city of Recife (Monteiro et al., 2019).

With regard to hydro-environmental education, several initiatives have been taken by academia and non-governmental organizations. Researchers from the Universities of Pernambuco have been giving lectures and meetings with society to motivate citizens to engage in the revitalization process of urban streams (Preuss et al., 2020; Rodrigues et al., 2022; Cabral & Moura, 2021; Carvalho et al., 2020).

In the last decades of the 20th century, the city of Recife grew a lot and sanitation services did not keep up with the population increase. There is currently a large project in the metropolitan area of Recife to build sewage collection and treatment systems. A part of the system was expanded, but there are still many steps to go before universalizing the sewage system. Current data are that the municipality of Recife has a percentage of collected sewage of 74.69% and of what is collected, 99.7% is treated (SNIS, 2022). The Municipal Basic Sanitation Plan of Recife (Recife, 2017) follows national guidelines established by federal legislation, with responsibilities shared among different levels of government and regulatory agencies. The main legal framework is Federal Law Nº 14.026/2020, which updates Brazil's basic sanitation legal framework, establishing the goal of universal access to services by 2033, encouraging the regionalization of services, and setting national guidelines for access to federal funding (Brazil, 2020). Responsibility for basic sanitation in Recife primarily involves state and municipal public entities, with emphasis on the state concessionaire Compesa (Pernambuco State Basic Sanitation Company), which is mainly responsible for the operation of water supply and sewage services (Silva et al., 2021). Urban municipal management plays a role in regulating, monitoring, and implementing services, particularly in solid waste management and urban drainage (Jucá et al., 2020), which fall under the responsibility of EMLURB (Autarchy of Maintenance and Urban Cleaning of Recife). Among the 100 largest municipalities in the country, Recife currently ranks 76th in the national sanitation ranking (Instituto Trata Brasil, 2024), highlighting the significant challenges that the responsible authorities face in meeting the targets set by legislation. The basic sanitation policy in Recife faces significant obstacles and progress depends on the effective implementation of the new legal framework, the strengthening of local governance and integration between the competent bodies.

Conclusions

Urban stream syndrome has been reported in several countries and refer to changes in the hydrology of water courses, chemical quality of the water, morphology of streams, organic matter, problems in ichthyofauna, eutrophication and problems with algae growth. Such effects characterize a complex problem that demands a multidisciplinary approach including stream hydrology, stream ecology, social, economic, and political dimensions.

Recife is a highly urbanized coastal city. Urbanization rate in the Recife Metropolitan Region is much higher than the Brazilian average reaching the value of 96.6%. Three main rivers cross the city of Recife from west to east and have a shared estuary with a single outlet to the sea. Almost a hundred of streams (some of them have been channelized) drain the plain totalizing 9.31% of municipal area occupied by water surfaces.

The city of Recife grew a lot in the second half of the 20th century and the sewage system was not adequately expanded, so that about 25% of the city's sewage is not collected. This fact associated with diffuse pollution makes the city's streams very polluted, characterizing a situation of urban stream syndrome. Only a few stretches of streams that occupy an environmental preservation area are in health condition. The current situation of rivers and streams in the city of Recife is worrying, as they are characterized by significant eutrophication rates. The degree of trophy assess the enrichment of water by nutrients and its possible effects, and most of Recife watercourses are eutrophic and many of them are in a hypereutrophic condition.

Rivers and streams in Recife receive large amount of domestic sewage and dissolved oxygen is usually reduced or disappears when the water receives large amounts of biodegradable organic substances found, for example, in domestic sewage. Most streams in Recife have a low dissolved oxygen content, with many of them having dissolved oxygen below 0.15 mg/l. Despite the streams in Recife being very polluted, many living beings still resist, especially the more tolerant meiofauna and chelonians. The most representative taxa found in Recife's stream were: Nematoda, Annelida, Acari and Rotifera, in addition to Insecta, Amphipoda and Nauplii. It was also possible to observe the presence of tortoises. These animals are very resistant and adapted and in anthropized environments, they also feed on organic matter from domestic sewage.

The improper disposal of solid waste and the discharge of untreated domestic effluents exacerbate the degradation of urban rivers, intensifying pollution processes. In this context, the formulation and implementation of public policies that include selective waste collection, efficient treatment of waste and effluents, and systematic monitoring of pollution sources—both point and nonpoint—is essential. The inadequate management of domestic sewage, observed in the study area, highlights the urgent need for intervention, including the accountability of polluting agents. The urban stream syndrome poses a challenge that demands an integrated approach involving local governments, civil society, the private sector, and watershed management committees. Joint action among these stakeholders is crucial for basin conservation and the restoration of degraded water bodies. The adoption of sustainable strategies, tailored to the region's socio-environmental specificities, is indispensable to mitigate the impacts of urbanization on aquatic ecosystems.

Gradually society and public managers are becoming aware of the problems of urban streams and some initiatives are being taken to face the problem. Actions were initiated in institutional matters and with regard to sewage collection and treatment. Another line of action that was started a few years ago refers to hydro-environmental education for awareness of the problem, which has been done by academia and non-governmental organizations.

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The dataset that supports the results of this paper is available at SciELO Data and can be accessed via https://doi.org/10.48331/SCIELODATA.KZZDGA.

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