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Um Panorama Das Outorgas Para Lançamento De Esgoto Da Cidade De Belém, Amazônia, Brasil

An Overview Of The Sewage Discharge Permits Of Belém City, Amazon, Brazil

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Resumo

O trabalho identificou as bacias urbanas da cidade de Belém que possuem vazões indisponíveis para serviços ambientais, a partir das outorgas de lançamento de esgoto emitidas pela Secretaria de Meio Ambiente e Sustentabilidade (SEMAS) de 2013 a 2016. A metodologia foi dividida nas seguintes etapas: 1 - coleta de informações da SEMAS; 2 - classificação de usuários; 3 - identificação e organização dos dados; 4 - cálculo do fluxo indisponível; 5 - quantificação por área de captação urbana; e 6 - visualização dos pontos de descarga das licenças existentes. Os resultados mostraram que a maior parte das autorizações é proveniente de condomínios residenciais (62,5%), seguidos de indústrias (25%) e outros, aeroportos e hospitais (12,5%). Todas as bacias analisadas apresentaram vazões indisponíveis. Essas bacias foram saturadas pela quantidade de esgoto (com outorga) lançado. Além disso, havia diferentes níveis de esgoto não tratado proveniente das populações que vivem nessas bacias. Assim, é necessário alterar o nível de tratamento de esgoto exigido para os pedidos de outorgar e implantar uma rede coletora de esgoto e estações de tratamento na região de Belém. Essas medidas também ajudarão a reduzir a poluição da água no entorno de Belém e na região, incluindo suas praias.

Palavras-chave: Quantidade de água; qualidade da água; vazão indisponível; bacias urbanas.

Abstract

The work identified the urban catchments of Belém city that possess unavailable flows for environmental services, starting from permits of the discharge of sewage issued by the Bureau of Environment and Sustainability (SEMAS) from 2013 to 2016. The methodology was divided into the following stages: 1 - collection of information from SEMAS; 2 - classification of users; 3 - identification and organization of the data; 4 - calculation of the unavailable flow; 5 - quantification

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by urban catchment; and 6 - visualization of the discharge points of the existing permits. The results showed that most of the permits come from residential condominiums (62.5%), followed by industries (25%) and others, airport and hospital (12.5%). All the analyzed catchments presented unavailable flows. These catchments were saturated by the amount of sewage (with permit) discharged. In addition, there were different levels of untreated sewage coming from the populations that live at these catchments. Thus, it is necessary to change the level of sewage treatment required for permit requests and to implement a sewage collection network and treatment plant in the Belém area. These measures will also help reduce water pollution around Belém and the region, including its beaches.
Keywords: Water quantity; water quality; unavailable flow; urban catchments.

Introduction

The role of governments in achieving the correct management of water resources is increasingly challenging due to the increasing demand for water quantity and quality for the proper development of human activities, both for human and industrial purposes. The reduction of the quality of water can reduce the diversity of fauna and flora, restrict water availability for basin users, and also impact future water conflicts (Pinheiro *et al*., 2013). According to recent studies conducted by the National Water Agency of Brazil (ANA), 57% of the population resides in municipalities that do not have sufficient flow rate to dilute the released organic load.

The granting of the right to use water resources is an administrative act issued by the public authority (Federal, State or District), where powers are transferred to the user so that he can carry out interventions that can change the quality and quantity of water. However, to use water resources for the dilution of sewage, it is necessary to submit a permit request to the environmental agency. When authorized, the volume of water approved is considered "unavailable", in total or in part, for other uses in the river basin (Chagas *et al*., 2015). Many states already issue this approving modality in Brazil, but there is no consensus regarding the methodology, analysis nor technique to be used in the requests made by users (Zandonadi *et al*., 2015).

In the state of Pará, the Environment and Sustainability Bureau (SEMAS) is responsible for conceding rights to users, and establishing criteria for analysis, such as water availability and dilution flow (SEMAS, 2017). The major obstacle in the state of Pará is the lack of classification of water bodies, requiring water bodies to be treated as class II, according to Art. 42 of CONAMA

Resolution 357/2005 (Pizella & Souza, 2007). This requirement results in incompatible levels of quality and treatment, not reflecting reality, as the vast majority of water bodies are seriously compromised in their quality. Most water bodies are in close proximity to urban centers, which do not have enough structure to collect and treat the domestic sewage, including solid waste that is thrown near or directly into the channels.

In this context, the type of treatment used is also important, since it directly reflects the quality and quantity of water for the dilution of sewage, since the higher efficiency reflects in lower values of the BOD (biochemical oxygen demand) released. Improve pollutant removal means that less effort will be made by the water body to self-purify the organic load present in the liquid mass. According to Jordão & Pessoa (2009), the treatment of effluents per tank and anaerobic filtering has an efficiency of the removal of organic matter between 25 and 50%, while the secondary treatment has an efficiency of removal of suspended and dissolved organic matter between 80 and 95%, as it is able to remove part of the nutrients and pathogens. With tertiary treatment, up to 99% of organic matter can be removed, and nutrients, pathogens and heavy metals are also effectively removed, as well as some nonbiodegradable compounds. However, the variable "efficiency" depends on several factors, such as the type of treatment, the physical and biological characteristics of the effluent, the correct maintenance/operation of the equipment, etc.

Currently, the municipality of Belém ranks 87th in the "Ranking of Sanitation 2016" carried out by Instituto Trata Brasil, which ranked the 100 best municipalities according to information obtained by the Sanitation Information System (SNIS). The study identified that there were no major investments in sanitation in Belém, since no new connections were observed and the volume of treated sewage increased (Instituto Trata Brasil, 2016).

Pinheiro *et al*. (2013) identified the existence of some stretches of the Capibaribe River in the state of Pernambuco where anthropogenic action has already profoundly compromised the quality of the water, rendering the permitting of new projects impractical. Felix *et al.* (2013) showed that due to increased river degradation, the number of surface allowances decreased in the municipality of São Luís-MA between 2008 and 2012. If there is no correct management of water resources in the municipality of Belém, there may be no more superficial water catchment in the municipality, since all of its river basins may suffer pollution in a few years, becoming expensive or even impractical to use posterior.

In this context, and according to the works of Batista *et al.* (2015) and Deus *et al.* (2019), where the first showed the advance of the sewages discharged in Belém on the beaches of the region and the second showed the contamination of these beaches by norovirus genogroups I and II. Thus, the objective of the study is to evaluate sewage discharge permits in the city of Belém, identifying the water bodies that are already compromised and are no longer able to dilute the discharged sewages and quantifying the unavailable flow for each urban catchment in the region.

Study Area

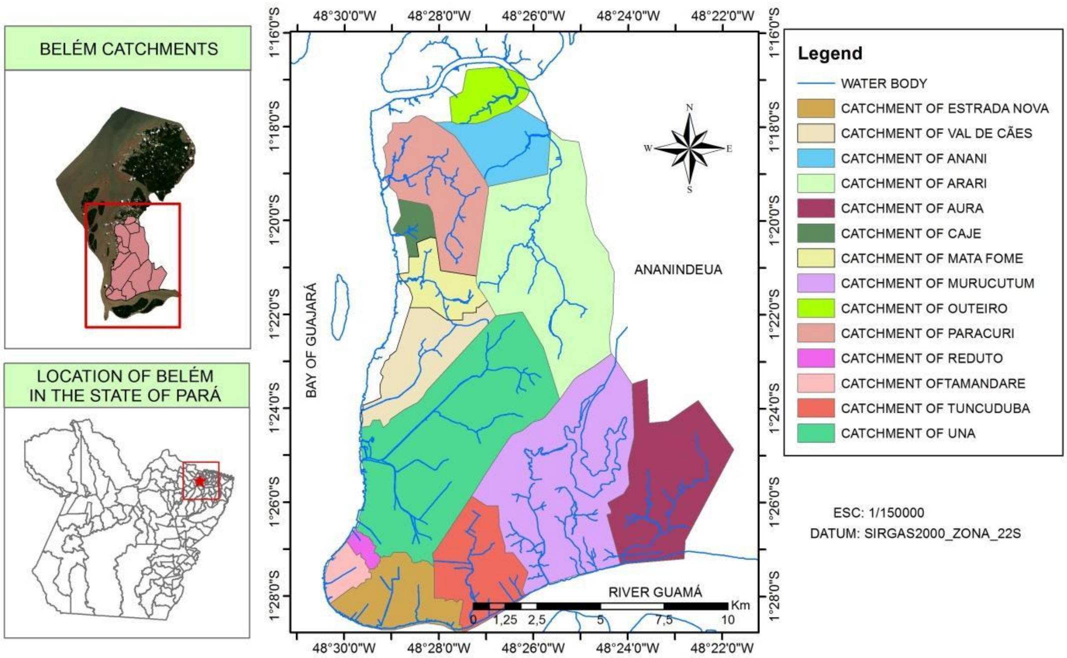
The analyzed area includes the municipality of Belém, capital of the state of Pará. The capital is bordered by the Guamá and Baia do Guajará rivers, located at the geographic coordinates 01 ° 27'20 "S and 48 ° 30'15" W. Belém has a population and a territorial area equal to 1,446,042 inhabitants and 1,059,458 km² (IBGE, 2017), respectively. The municipality has 14 small catchments (Figure 1). It was verified that sewage discharge points with valid permits are present in 6 of the 14 catchments (Table 1). The catchments shown in Figure 1 and presented in Table 1 drain their waters to rivers and streams that flow into Guajará Bay, feeding it and being fed due to the tidal cycle. These catchments are largely degraded along their entire course, and as such, contribute to the pollution of Guajará Bay, according to a study by Batista et al. (2015). The main characteristics of these basins include the disorderly occupation of houses on stilts at the banks of the canals, the absence of basic sanitation, and the silting of the canal motivated by the removal of ciliary wood (Figure 2).

Table 1 - Drainage area of the six analyzed small catchments.

Small catchments	Arari	Mata Fome	Outeiro	Paracuri	Una	Val de Cães
Drainage area (km^2)	31.68	14.00	5.10	14.60	37.72	2.48

Source: Elaborated by the authors (2021).

Figure 1 - Study area and small catchments in the municipality of Belém.



Source: Elaborated by the authors (2021).

Figure 2 - Sedimentation in the São Joaquim canal in the Una catchment.

Source: Elaborated by the authors (2021).

Methodology

Information of sewage discharge permits for dilution in the small catchments of Belém was requested to SEMAS from 2013 to 2016. The data include geographic location; name of the water body receiving the sewage; sewage discharge; dilution flow; population served; authorized BOD load for discharge; type of treatment applied to sewages; and efficiency of BOD reduction in the treated sewage. The data were organized to better identify the location of the launch points in the catchments. Thus, each user was classified by name: Hospital (H), Airport (A), Industry (IN) and Residential (R). To represent the various users classified as residential condominiums, the identification "R" was followed by the Arabic number in ascending order from the source to the mouth (e.g., R1 was the most upstream in the water body). When there was a user who launched at three distinct points, his Arabic number was followed by the point of identification of the launch point (e.g., R6.1, R6.2 and R6.3).

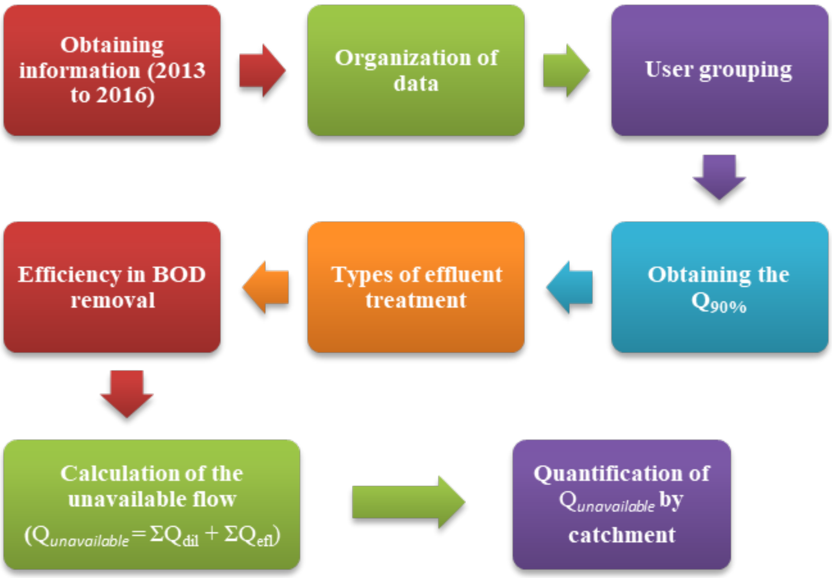
For the analysis of the process, it was necessary to calculate the water availability of the catchment in which the launching point is inserted, and water flow and drainage area were necessary information. In relation to the flow rate, the user can give this information with real on-site measurement data. If this flow rate was not measured, SEMAS itself applied the methodology of reference flow regionalization, in this case Q90%. Further details on Q90% regionalization can be found in the work of Barros *et al*. 2019.

The unavailable flow for each small catchment was obtained through Equation 1 (Teodoro *et al*., 2013).

$$Q_{unavailable} = \sum Q_{dil} + \sum Q_{efl} \qquad (1)$$

Where $Q_{unavailable}$ (m³/h) is a portion of the total flow of the river (catchment), which cannot be used; ΣQ_{dil} (m³/h) is the sum of the flows to dilute the sewage discharge; and ΣQ_{efl} (m³/h) is the sum of the users' outflows. The cartographic information of the ANA (National Water Agency) (ANA, 2017) available at http://www3.ana.gov.br/ and the permits data were geoprocessed and spatialized on a map, allowing for the quantification of permit points in each catchment. Figure 3 illustrates the methodology developed.

Figure 3 - Illustration of the developed methodology.



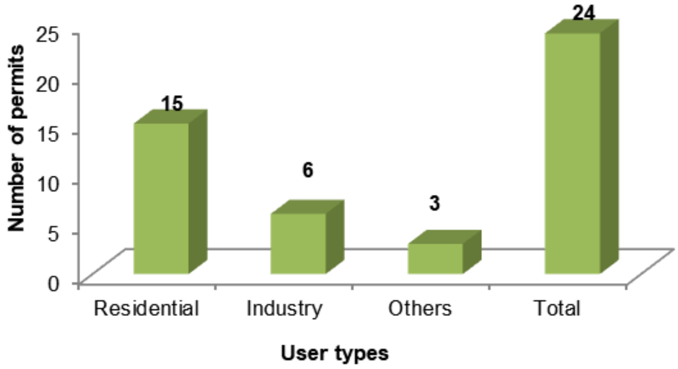
Source: Elaborated by the authors (2021).

Results and Discussion

Analysis of permits

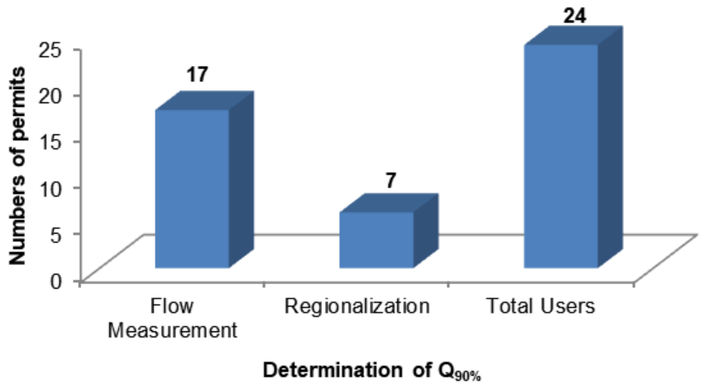
Of the 24 permits analyzed between 2013 and 2016, the vast majority (62.5%), had the purpose of human use (residential/condominiums), with 15 permits, followed by industrial use with 6 (25%), and other uses (hospitals and airport) with 3 permits (12.5%) (Figure 4). In the mentioned period, there was a growth of residences with condominium expansion occurring mainly in the basins of Paracuri, Ariri and Una, which contributed to the increase in the requests of permits for human use. In this context, Silva et al. (2017) observed that in the Paraguaçu catchment, in Bahia state, Brazil, 10% of the permits had the purpose of human supply, and only 4% were destined for industrial use. It was also observed that, of all the permits, 17 were obtained through flow rate measurement, and 7 permits used the Q90% regionalization method (Figure 5).

Figure 4 - Permits used in the period from 2013 to 2016 by different user types.



Source: Elaborated by the authors (2021).

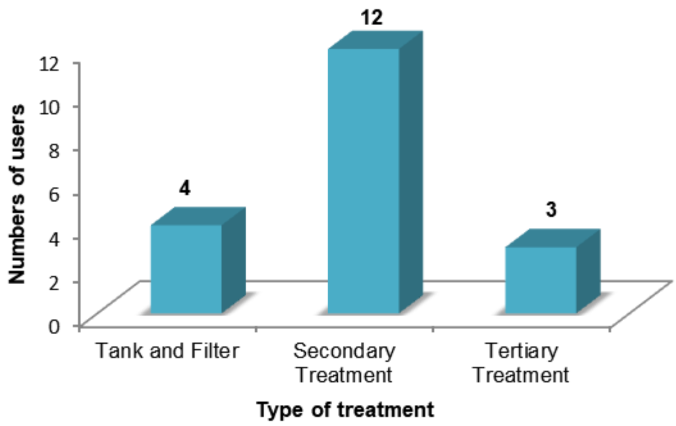
Figure 5 - Methods of $Q_{90\%}$ determination used in the period from 2013 to 2016.



Source: Elaborated by the authors (2021).

According to Figure 6, it is possible to observe that 4 users treated their sewage with an anaerobic tank and filter, 12 with sewage treatment stations (STS) at a secondary removal level, and 6 with STS a tertiary level. It is important to note that there is always some type of treatment, even if there is a discrepancy regarding the efficiency in the applied systems.

Figure 6 – Types of treatments performed from 2013 to 2016.

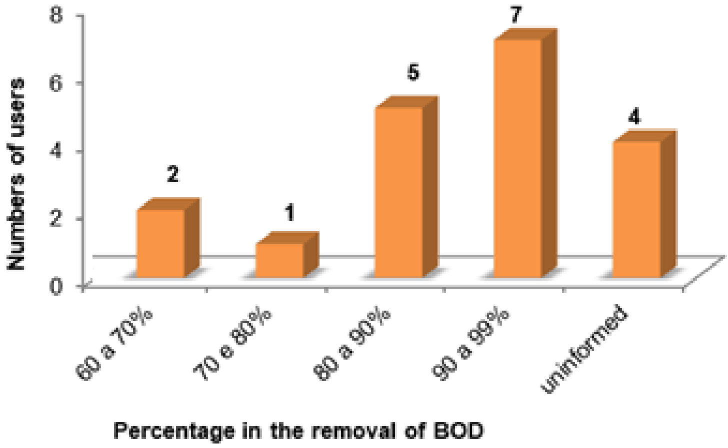


Source: Elaborated by the authors (2021).

Popular housing developments, most of which depend on bank financing and are often promoted by government incentives such as “Minha casa, Minha vida”, need to carry out simpler projects, so that the costs are not onerous for their residents. “Minha casa, minha vida” is a federal government program managed by the Ministry of Cities, consisting of the construction of housing units intended for low-income families (Brasil, 2011). However, in the case of high-quality condominiums, SEMAS requests STS, which have proven to be more efficient in the removal of organic matter (from 70% to 95%) but with higher costs, and this higher cost is reflected in the final price of the property.

Regarding the efficiency of BOD removal, it is observed that no user has an efficiency less than 60%, which is considered good, since CONAMA 430/2011 established this percentage as the minimum (Brasil, 2011). Four users did not report their percentages, two users exhibited efficiency between 60 and 70%, one user exhibited efficiency between 70 and 80%, five users exhibited efficiency between 80 and 90%, and seven users exhibited efficiency between 90 and 99% (Figure 7).

Figure 7 - Percentage of BOD removal in user sewage in the period from 2013 to 2016.



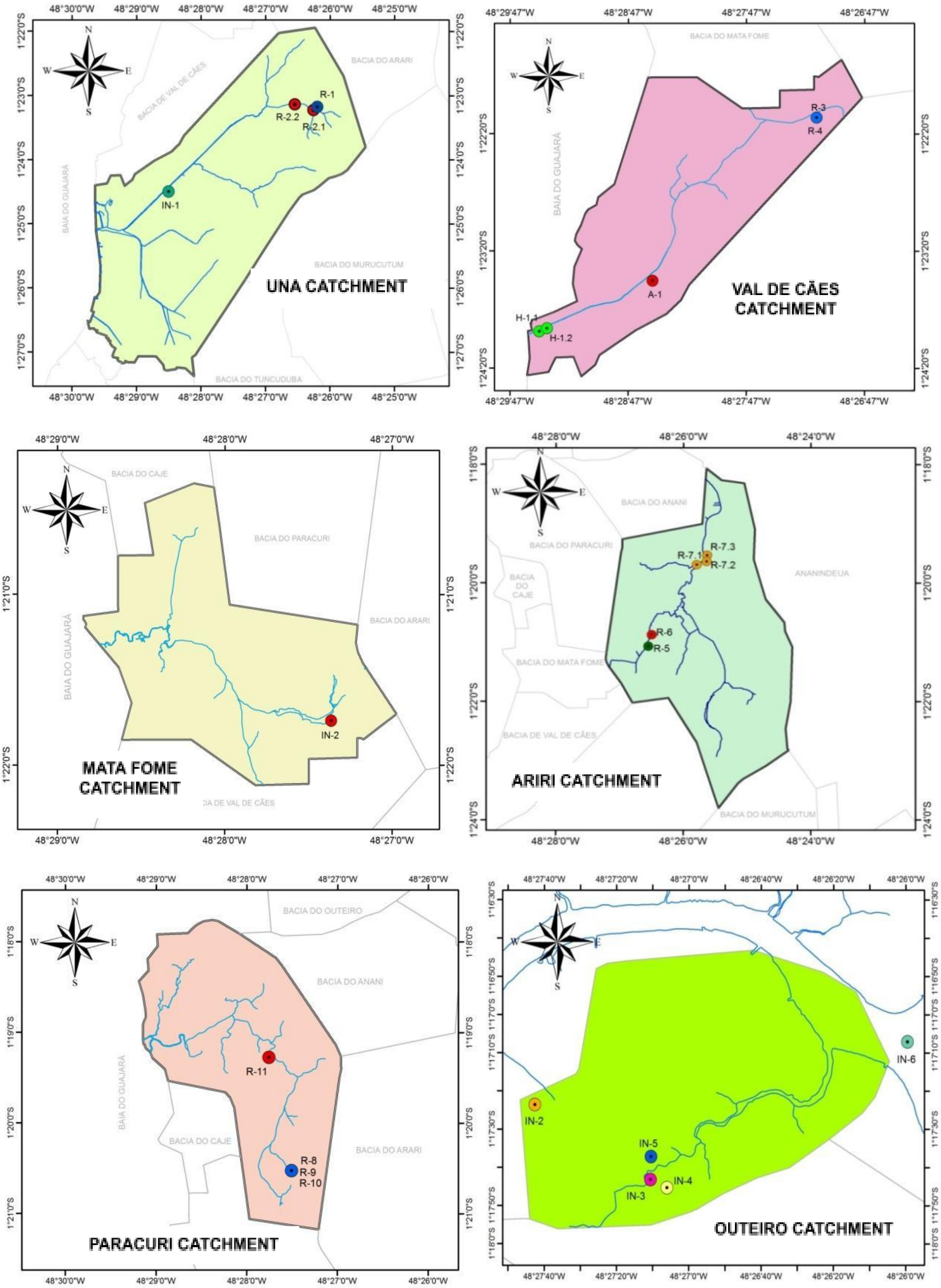
Source: Elaborated by the authors (2021).

Unavailable flow

Figure 8 shows the discharge points of the users in each catchment. The points were identified according to the user grouping (Figure 3). After the application of Equation 1, we obtained the value of the unavailable flow for each catchment. For the Una catchment, which includes one industry and two residential users, the unavailable flow was equal to 44,680 m^3/day. In the case of one of the residential users, it has two different discharge points.

In the Val de Cães catchment, which includes three different users in terms of activity (i.e., hospital, airport and two residential areas) and has 5 discharge points (and one user that has 2 points), the unavailable flow was equal to 4,256 m^3/day. In the Mata Fome catchment, the unavailable flow was equal to 5,142 m^3/day. The unavailable flow of the previous basin (Val de Cães), which has 3 permits, is less than unavailable flow of the Mata Fome catchment that has only one industry (user). This observation occurred because in Val de Cães catchment there is an STS at the tertiary level that includes chlorination, which reduces organic matter values. In contrast, the industry belonging to Mata Fome only had treatment at the secondary level.

Figure 8 - Catchments with sewage discharge points in the period from 2013 to 2016.



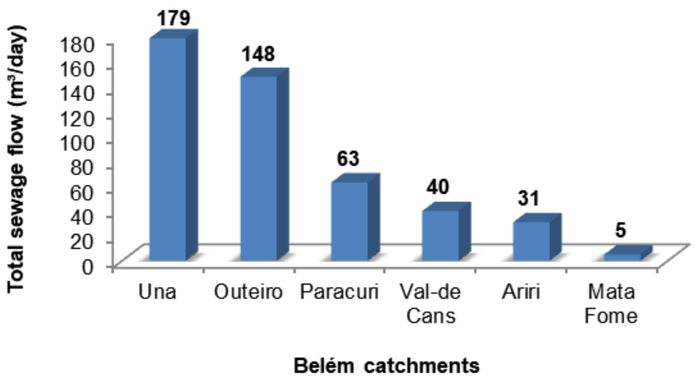
Source: Elaborated by the authors (2021).

In the Ariri catchment, the unavailable flow was equal to 15,749 m³/day for three users, all residential, one of which discharged in 3 different points. A relevant fact to be observed was that the population served by the 3 residential users was 3,364 people. All these people had their sewage treated by an STS before it enters bodies of water. In the Paracuri catchment, the unavailable flow was equal to 4,782 m³/day, with four users total and three of them discharging their sewage at the same point. All users had activity associated with residential use. In the Outeiro catchment, the unavailable flow was equal to 28,567 m³/day, resulting in 5 permits for the industries.

Overview of the catchments with unavailable flow

It is observed in Figure 9 that the Una catchment with 179 m³/day had the highest sewage discharge, followed by the Outeiro catchment with 148 m³/day and the Paracuri catchment with 63 m³/day. These values represented only those users that required permits (industries, condominiums, hospitals and airports).

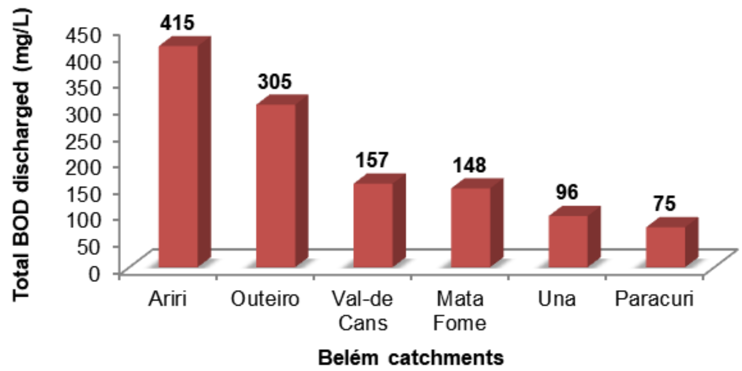
Figure 9 - Values of total sewage flow discharged by users in the period from 2013 to 2016 for the analyzed urbans catchments.



Source: Elaborated by the authors (2021).

It is also possible to observe (Figure 10) the total values of BOD discharged by each user allocated in each urban catchment after treatment. It is important to note that in the Mata Fome catchment where there is only one user (industry), the value of BOD discharged was equal to 148 mg/L. In the Paracurí catchment, there were 4 users that discharged sewage with BOD equal to 75 mg/L. This value, which was less than those observed in the Mata Fome catchment, was possibly due to the level of treatment applied by these users. In this case, 2 users treated the sewages at the tertiary level, which considerably reduced BOD values.

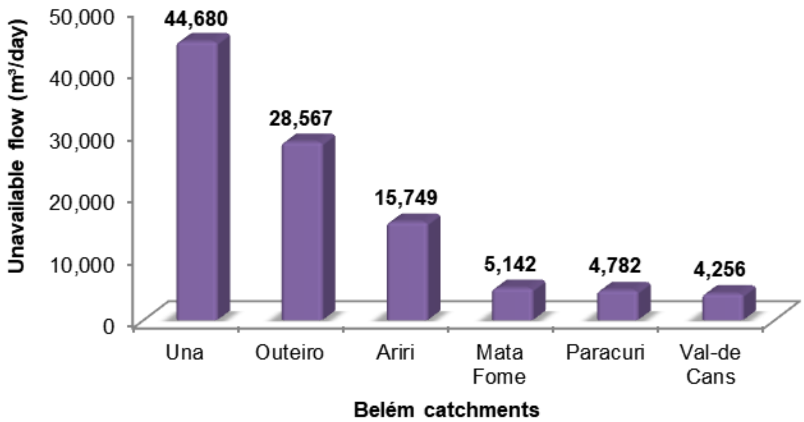
Figure 10 - Discharged BOD values in the period from 2013 to 2016 per urban catchment.



Source: Elaborated by the authors (2021).

Figure 11 shows the unavailable flow rates in each Belém catchment. The Una catchment had the highest value (44,680 m^3/day). An explanation for this high value in this catchment is the small river São Joaquim-São Raimundo. In this river, in addition to the permits for the discharge of treated sewage from the users registered by SEMAS, there was also untreated sewage coming from the population that grew and expanded close to this area. The other analyzed catchments also presented the same scenario of the Una catchment, highlighting the effects of the Outeiro catchment, which is considered an industrial pole of several segments.

Figure 11 – Unavailable flow in the period from 2013 to 2016 in the Belém catchments.



Source: Elaborated by the authors (2021).

Conclusion

Most of the permits for sewage discharge in the city of Belém come from residential condominiums (62.5%), followed by industries (25%) and other, such as the airport and hospital (12.5%). All analyzed catchments presented unavailable flow. These catchments are saturated by the amount of sewage (with permit) discharged. It is important to remember that the sewage treatment for the permit request is generally secondary level, that is, it removes only organic matter. In addition, there is untreated sewage coming from the other peoples that live in these catchments. Thus, for the environmental recovery of the catchments, among other measures, it is necessary to change the level of sewage treatment required for the permits demands and the implementation of a sewage collection network and treatment plants in the area of Belém. These measures will also help reduce water pollution around Belém and the region, including its beaches.

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