



## **Urban Environmental Indicators: Case Study of Passo Fundo-RS**

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## RESUMO

Rapid urbanization results in several challenges related to urban infrastructure, and it is difficult to draw up new solutions for improvements, adaptations, and plans for better urban development. In this context, this study aims to analyze the urban environmental indicators of the city of Passo Fundo, in the north of Rio Grande do Sul, according to the Connected Smart Cities Ranking (RCSC) to identify positive and negative points in the indicators analyzed in relation to the object of study. For this, the research methodology was divided into the following stages: bibliographical review, diagnosis of the city, survey of the indicators of the analyzed Environment axis, and comparison of the indicators of Passo Fundo/RS with the indicators of medium-sized cities in the South Region of Brazil best classified in the Ranking in the years 2019, 2020 and 2021. From the comparison of the results, it was possible to verify the development of Passo Fundo during the three years of analysis, ascertaining that there was a concern with investments to improve infrastructure and services aimed at to the Environment. With the study, it was possible to see that Passo Fundo seeks to improve its services but lacks attention in terms of water loss rates during its distribution and the city's sewage collection and treatment. Furthermore, the importance of measuring and monitoring urban indicators was noted so that they can contribute to the planning of new municipal guidelines, and to the development of initiatives to combat and prevent urban health-related problems.

**PALAVRAS-CHAVE:** Smart cities; Environment; Urban Indicators

## 1 INTRODUCTION

Cities are developing at an intense pace, generating several consequences for the environment and the population, making it a great challenge for governments to find quick and efficient solutions to help with the scenario found in urban centers. In this context, policies and strategies aimed at the organization and legislation of urban and environmental dynamics become necessary (TORRES et al., 2013).

The emergence of cities occurs through decisions, which result in their transformations. Therefore, it is understood that urbanization occurs due to changes in technologies, economics, and social issues, such as culture and habits (ZHENG; KHAN; ABBAS, 2022). However, as urban transformations and expansions occur, city planning becomes complex, due to the range of infrastructures and sectors to be managed, that is, having obstacles that often go unnoticed or are left to be resolved in the future.

Among these obstacles, the need for debates involving environmental issues and the health of the population stands out. In view of this, for Caiaffa (2008, p. 1789), the guarantee of urban health comes from the following factors: “the role of the physical and social environment in shaping people’s health; the need to assess phenomena having as their object unfair and avoidable inequalities in the physical, social and health environment and governance and governability, as proposals for solutions to inequities.” Just like environmental problems, urbanization influences inequality, and consequently causing problems of violence and economic imbalance in relation to income, demonstrating the emerging reality of large cities (SHAN; ANN; WU, 2017; FURTADO et al., 2020).

For Lima (2022), valued urban areas have complete infrastructure and services, which are occupied according to purchasing power, while the low-income population lives in cheaper areas with precarious conditions. In this way, the spatial distribution of health services becomes heterogeneous, with the city center having a greater concentration of these services, unlike

peripheral areas (RAYNAUT; FERREIRA, 2018). In other words, the services offered are based on your location and socioeconomic conditions.

Furthermore, Latin American urbanization is characterized by industrialization, lack of care for the environment, cities with a high level of population and surrounded by peripheral areas (FAJERSZTAJN; VERAS; SALDIVA, 2016). At a national level, disorderly urbanization has led to problems with water supply, sewage, and irregular occupations, increasing the levels of water-borne infections or the proliferation of diseases in risk areas (CAIAFFA, 2008). As a reference, there is the case of *Aedes aegypti*, in which the conditions of urban planning, sanitation, waste collection and hygiene play a fundamental role in the contamination of the population (ALMEIDA; COTA; RODRIGUES, 2020).

It is understood that health care has transformed according to scientific-technological evolution, which occurred efficiently in urban centers, making life in the city more advantageous in terms of health (FAJERSZTAJN; VERAS; SALDIVA, 2016). However, considering the following perspectives, it is essential to implement adequate urban infrastructures, which seek efficient strategies, having as a reference the problems caused by the lack of planning for the population.

With this, it is understood that proper urban administration can minimize the current problems of cities, such as environmental degradation and housing growth (LOFHAGEN, 2020). Furthermore, through technological advances and the use of ICTs (information and communication technologies), it is possible to have greater control over urban needs, allowing the population to no longer solely depend on governments and authorities to solve problems.

In this way, the concepts of Smart Cities began to become more conspicuous, as a utopia, aiming to help public managers, urban planners, and companies to outline strategies that bring improvements to cities and the population. To this end, smart cities are concerned with the development of the population, the environment, and the city as a whole (GUIMARÃES; JÚNIOR; LIMA, 2021).

Along with the concept, it is possible to work with urban indicators, allowing the evaluation of urban indices, understanding the obstacles in each city, and encouraging the improvement of urban planning. As a way of helping municipalities work with smart city indicators, there are currently ranking programs, such as Connected Smart Cities. This program annually evaluates, through the Connected Smart Cities Ranking (RCSC), all Brazilian cities with more than 50 thousand inhabitants using smart city indicators.

The RCSC indicators are based on NBR ISO 37120 on Sustainable Cities and Communities (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 2021), which presents standards that point out and establish definitions and methodologies for smart city indicators, and NBR ISO 37122 is also used (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 2020), which presents a set of indicators to measure progress towards a smarter and more sustainable city. NBR ISO 37122 is the first standard to address issues about Smart Cities, being published in Brazil only in 2020, requiring adjustments to portray the country's reality (MULLER, 2020). In relation to Connected Smart Cities, the preparation of NBR ISO 37122 allowed new discussions in relation to the program's indicators, due to its analyses, which make it possible to draw comparisons and seek new solutions (RIGON, 2019).

Therefore, municipalities can monitor urban indicators in their planning, as a way of improving their development, as the indicators allow for a large base of information that aims to be shared, seeking to make cities more intelligent, sustainable, and efficient.

Given these perspectives presented, the objective of this research is to analyze environmental indicators in the municipality of Passo Fundo, located in the north of Rio Grande do Sul, using as a reference the Ranking Connected Smart Cities (RCSC) for the years 2019, 2020 and 2021, as well as the best-ranked medium-sized cities in the south of the country in this same ranking. Based on the results obtained, we seek to present a data analysis to identify positive and negative points of the Environmental indicators of the city of Passo Fundo/RS.

## 2 METHODOLOGY

This work took place through qualitative, exploratory research, based on a case study analyzing environmental indicators in the city of Passo Fundo/RS. Therefore, this research has an applied nature, which aims to seek knowledge that can be used to mitigate real problems. For this, the research was delimited according to the following steps (Figure 1):

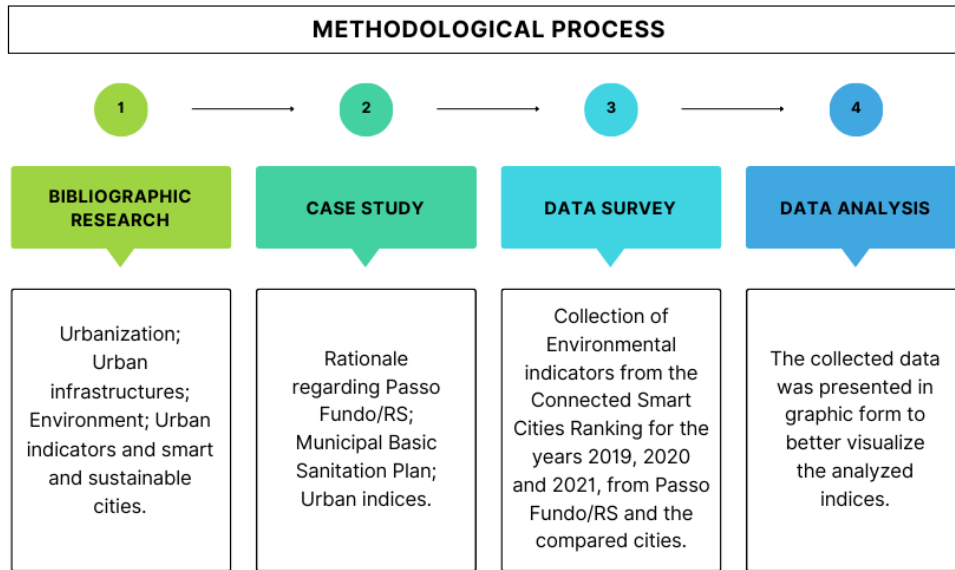
Stage 01: Carrying out bibliographical research, aiming to understand the concepts of Passo Fundo's urban infrastructure and its planning, as well as the concept of Smart Cities, Environment and Urban Indicators, based on previous studies, through books, theses, dissertations, as well as publications from the Scopus Science and Google Scholar databases.

-Stage 02: Case study regarding the city of Passo Fundo, as well as analysis of the provided mobility plan guidelines through the Municipal Basic Sanitation Plan, as well as the analysis of the urban environmental indicators of the municipality and the compared cities.

-Step 03: Collection of data from the Urban Indicators of the Environment axis of the Connected Smart Cities Ranking for the years 2019, 2020 and 2021, allowing us to understand the evolution of these indices during the three years.

-Step 04: From the analyses, the data were tabulated and presented using graphs to allow better comparison and visualization of the results.

Figure 1- Stages of the methodological process used in the research.



Source: Elaborated by the authors, 2023.

Figure 1 presents the study development stages mentioned above, aiming to better understand the stages of the methodological process adopted in the research.

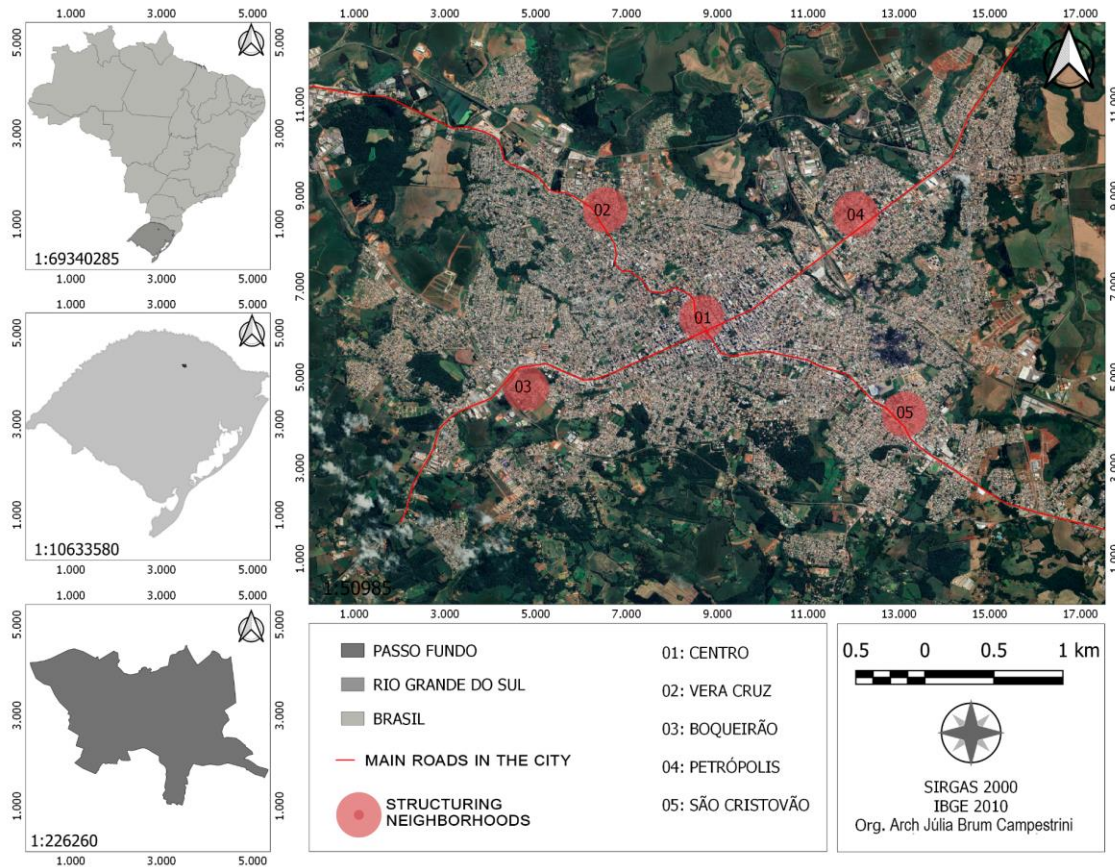
### 2.1 Study Object: Passo Fundo/RS

Located in the north of the state of Rio Grande do Sul, the city of Passo Fundo/RS becomes an object of study with the aim of investigating the city's development in the environmental area, revealing its infrastructures in comparison with medium-sized cities best classified in the southern region of the country in the last three years of the Connected Smart Cities Ranking.

Furthermore, Passo Fundo is characterized by being an educational, medical, and economic hub in the north of Rio Grande do Sul. The city holds the title of National Capital of Literature and hosts the International Folklore Festival, welcoming groups from various countries for cultural performances. In this way, Passo Fundo becomes a reference for those seeking tourism, health, work and education, fostering its constant development.

Its location (Figure 2) has an urban network of small municipalities, also becoming a reference in the socioeconomic and population dynamics of nearby cities (MULLER, 2021). There are six municipalities that surround the object of study: Pontão, Coqueiros do Sul, Carazinho, Santo Antônio do Planalto, Ernestina, Marau and Coxilha, interconnected by the RS-135 and RS-324, and the BR 153 and BR 285.

Figure 2 – Location map of the city of Passo Fundo/RS.



Source: Elaborated by the authors, 2022.

The city has a demographic density of 235.92 inhabitants/km<sup>2</sup> (IBGE, 2010), and an estimated population of 206,103 people (IBGE, 2021). Furthermore, according to the latest IBGE 2010 census, around 180,120 people live in urban areas, while 4,706 people live in rural areas.

Currently, the city has 22 sectors divided between neighborhoods, subdivisions, and villages. Among these sectors, four neighborhoods formed subcenters according to the structure of the city, those being the Boqueirão, Vera Cruz, São Cristóvão and Petrópolis neighborhoods, as seen in Figure 2, where the city center is also highlighted. From this central area, the city developed and followed other forms. Therefore, as the city grows, urban planning must be reviewed, with the aim of improving the quality of life of its citizens.

## 2.2 Urban Environmental Indicators

As a way of deepening the understanding of the Environmental indices of the cities analyzed, the data collection of this study included the analysis of the indicators from the 2019, 2020 and 2021 Rankings, seeking significant changes in the analyzed indices in this comparison.

Thus, concerning the Environment axis, it was carried out the analysis of eight indicators relating to the service and distribution of water and sewage, recyclable materials, waste collection and recovery, in addition to monitoring areas at risk. The 2021 Ranking removed the indicator of outages in the Water Supply System, due to a lack of information from some

municipalities. Each indicator has the source and unit of measurement of this data, so that it is possible to control and update this information annually, as shown below in Table 1.

Table 1- Urban indicators of the Environment Axis of the Connected Smart Cities Ranking (RCSC).

INDICATOR	UNIT	SOURCE 2019	SOURCE 2020	SOURCE 2021
Urban Water Attendance Index	%	SNIS	SNIS	SNIS
Loss Index in Water Distribution	Average hours	SNIS	SNIS	SNIS
Urban Sewage Service Index	%	SNIS	SNIS	SNIS
Sewage Treatment Index	%	SNIS	SNIS	SNIS
Recyclable Materials Recovery Index	%	SNIS	SNIS	SNIS
Waste Collection service coverage	%	SNIS	SNIS	SNIS
Risk Area Monitoring	YES/NO	Cemaden	Cemaden	Cemaden
Percentage of the Total Amount of Plastic Waste Recovered in the City	%	SNIS	SNIS	SNIS- Urban Systems

Source: Prepared by the authors based on RCSC (2019), RCSC (2020) and RCSC (2021).

Furthermore, compared to the city of Passo Fundo, the medium-sized cities in the southern region of Brazil that were best classified in the RCSC 2021 were chosen within the scope of the Environment axis as a way of understanding their weaknesses and potentialities, and compare them with the Passo Fundo indices. The cities compared to Passo Fundo are shown in Table 2, namely: Balneário Camboriú (SC), Blumenau (SC), Jaraguá do Sul (SC) and Maringá (PR).

Table 2- Classification of medium-sized cities in the South region in the 2019, 2020 and 2021 Rankings

CITY	RANKING POSITION 2019	RANKING POSITION 2020	RANKING POSITION 2021
Balneário Camboriú (SC)	17 <sup>o</sup>	16 <sup>o</sup>	12 <sup>o</sup>
Blumenau (SC)	9 <sup>o</sup>	19 <sup>o</sup>	16 <sup>o</sup>
Jaraguá do Sul (SC)	41 <sup>o</sup>	62 <sup>o</sup>	17 <sup>o</sup>
Maringá (PR)	26 <sup>o</sup>	24 <sup>o</sup>	25 <sup>o</sup>
Passo Fundo (RS)	-	-	-

Source: Prepared by the authors from the RCSC (2019), RCSC (2020) and RCSC (2021).

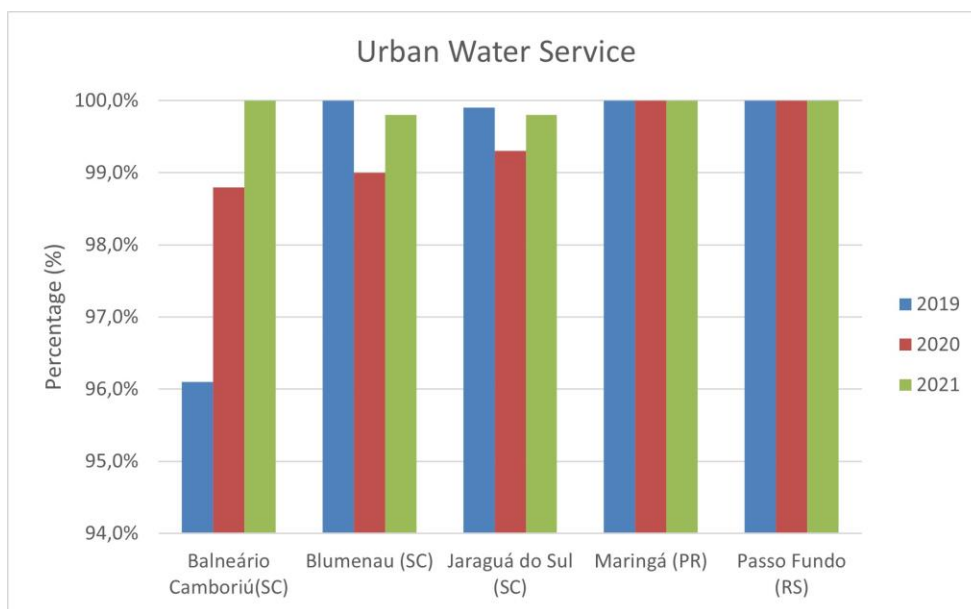
According to Table 2, the four cities in the south of the country best classified in the RCSC were analyzed and compared with the municipality of Passo Fundo, three of them are in the state of Santa Catarina and one in Paraná. Table 2 also shows the positions of these cities in the Ranking in the last three years. It is noted that Passo Fundo did not enter the general ranking in the three years of analysis. Furthermore, it should be noted that according to IBGE (2010), medium-sized cities are those with a population of 100,000 to 500,000 inhabitants.

### 3 ANALYSIS AND RESULTS

The analysis of the Environmental indicators was carried out based on the graphs generated with the collected data, which were grouped according to subject and unit, for better research development. Therefore, the first verification (Graph 1) accounts for the urban water service indicator, in which Passo Fundo has 100% service in the three years analyzed. The same occurs in the city of Maringá. The other analyzed cities demonstrate similar growth, where it is

apparent that all municipalities are seeking to improve the services provided to boost the quality of life of their communities.

Graph 1: Urban Water Service Indicator in the 2019, 2020 and 2021 Rankings.

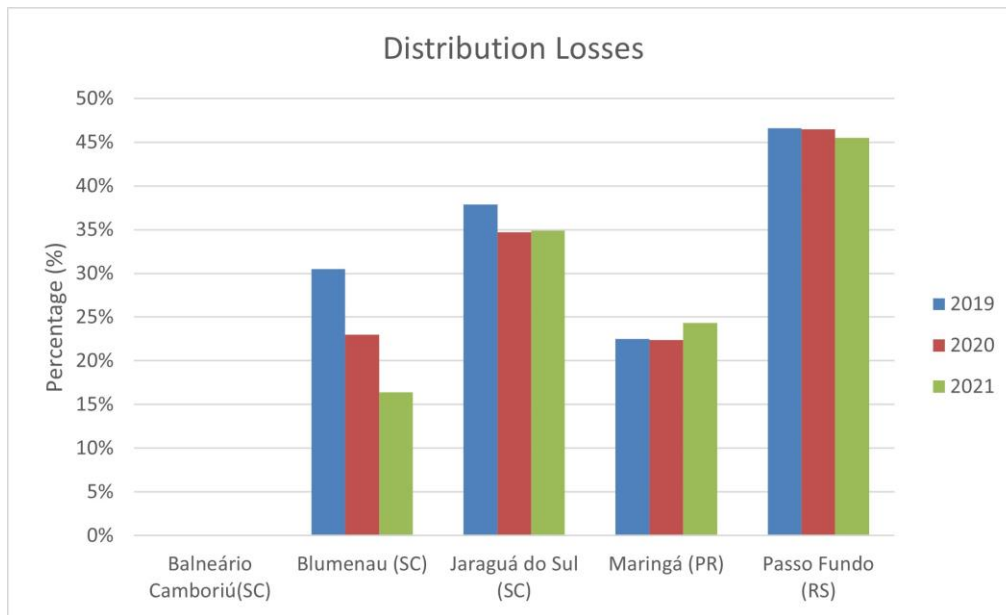


Source: Prepared by the authors.

The second indicator on the Environment axis (Graph 2) concerns losses in water distribution. Passo Fundo presented high rates of water distribution losses, indicating that despite the municipality offering good service to the population, greater investments are needed in its distribution, so that there are no losses and consequences for the environment. However, according to the Passo Fundo Municipal Basic Sanitation Plan – PMSB (2014), the municipality already has a goal of carrying out an inspection and maintenance of water distribution points by 2034, with the aim of minimizing these losses, and if necessary, replace networks in precarious condition. Unlike other cities, the city of Balneário Camboriú presented an excellent percentage in the three years, attesting to an efficient service in this regard, demonstrating that the municipality has been investing in strategies that minimize water losses.



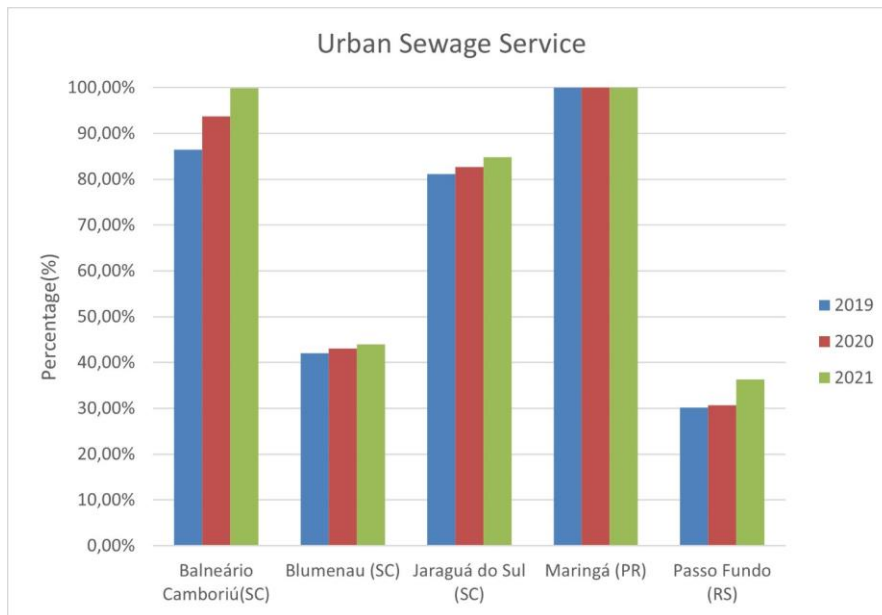
Graph 2: Water Distribution Loss Indicator in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors.

The next analysis is regarding the Urban Sewage Service indicator (Graph 3). The cities of Balneário Camboriú and Maringá presented high rates, demonstrating concern in the provision of this infrastructure. In relation to Passo Fundo, the city has low rates compared to the other cities analyzed, presenting a greater challenge for the municipality. However, the Municipal Basic Sanitation Plan of Passo Fundo – PMSB (2014) has as a guideline to increase the scope of the sewage service in the urban area of Passo Fundo, and most of the actions to put this guideline into practice require investment. Their goal is to conclude these activities by 2034, aiming to improve the services offered to the population.

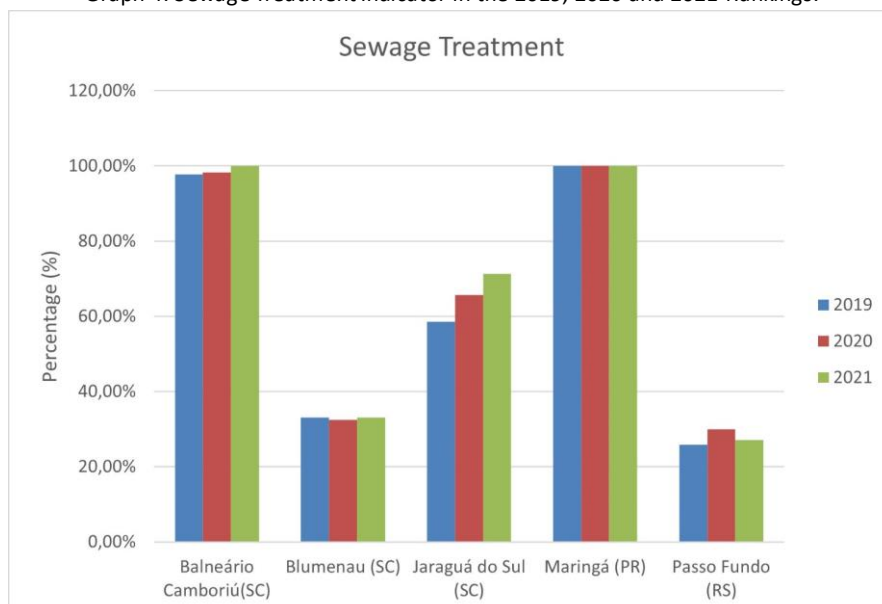
Graph 3: Urban Sewage Service Indicator in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors.

The same situation is seen in the Sewage Treatment indicator (Graph 4), in which Passo Fundo is also insufficient, a fact that was already expected, as this index is directly related to collection, and as the city does not collect sewage nor would it provide the necessary treatment. Thus, once again the municipalities that performed best in this index were Balneário Camboriú and Maringá, during the three years of analysis. However, it is evident that the five municipalities are seeking improvements in their rates each year, as they show growth in relation to treatment during the three years analyzed, demonstrating that there is a concern with these infrastructures.

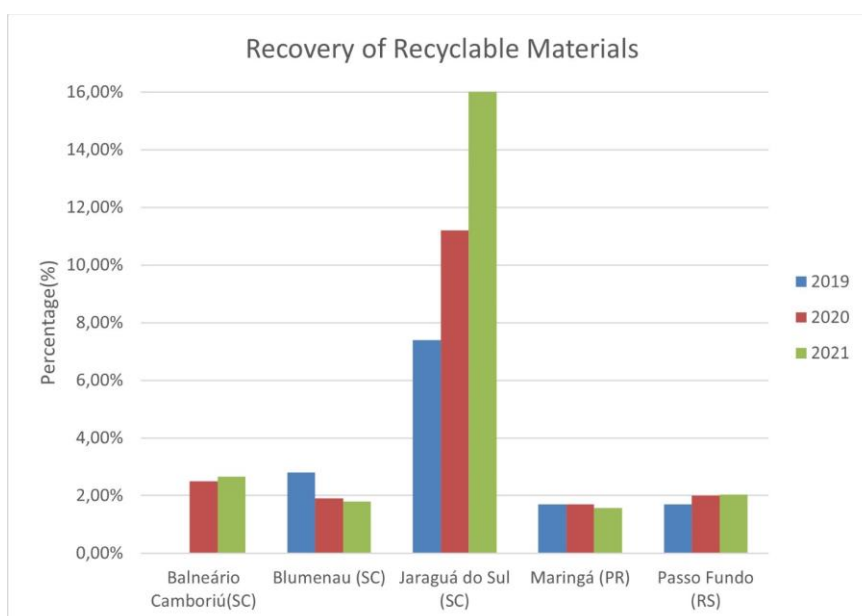
Graph 4: Sewage Treatment Indicator in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors.

Next, the “percentage of recovery of recyclable materials” indicator of the municipalities was analyzed in relation to the waste collected (Graph 5). Passo Fundo, Balneário Camboriú, Blumenau and Maringá, have recovery rates below 10%, while Jaraguá do Sul surprises with increasing rates over the three years, reaching 16.22% in 2021. In general, the rates analyzed have great potential of growth, an important aspect so that it is possible to increasingly mitigate environmental impacts. In relation to waste from Passo Fundo, it is necessary to highlight that within the Municipal Target Plan 2021/2024 (2023), the municipality managed to increase the coverage of selective waste collection by 10%, highlighting the concerns regarding the destination of materials for recycling.

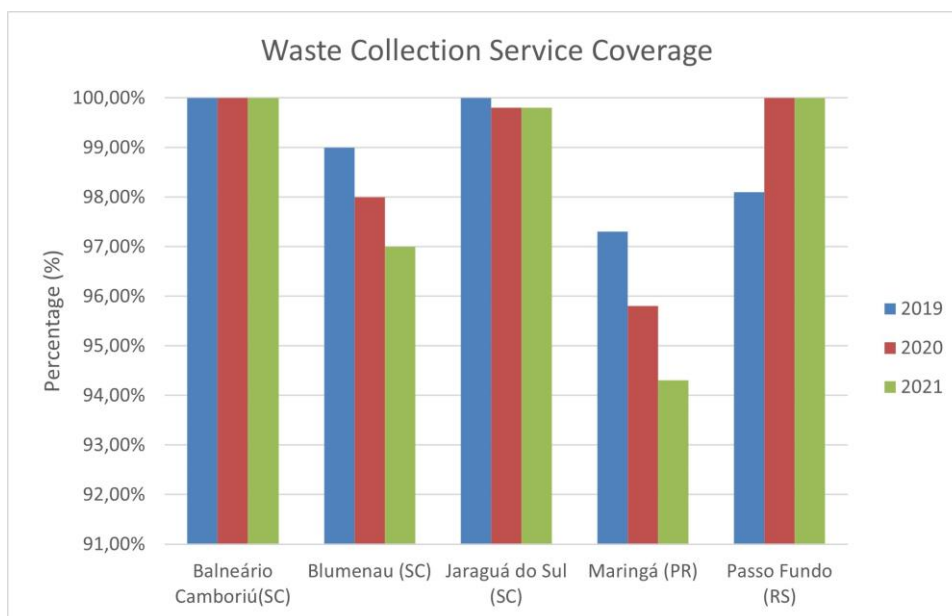
Chart 5: Recyclable Materials Recovery Indicator in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors.

The next indicator concerns Waste Collection Service Coverage (Graph 6). The study observed that all the cities analyzed presented satisfactory rates over the three years. In relation to Passo Fundo, according to the Passo Fundo Municipal Basic Sanitation Plan – PMSB (2014), it is planned to expand waste collection by 2034 to more areas of the city, in order to increasingly improve collection and care for the environment. Although all cities present rates above 90% in this regard, the survey indicates that there are still areas that are not served in terms of both water supply and solid waste collection.

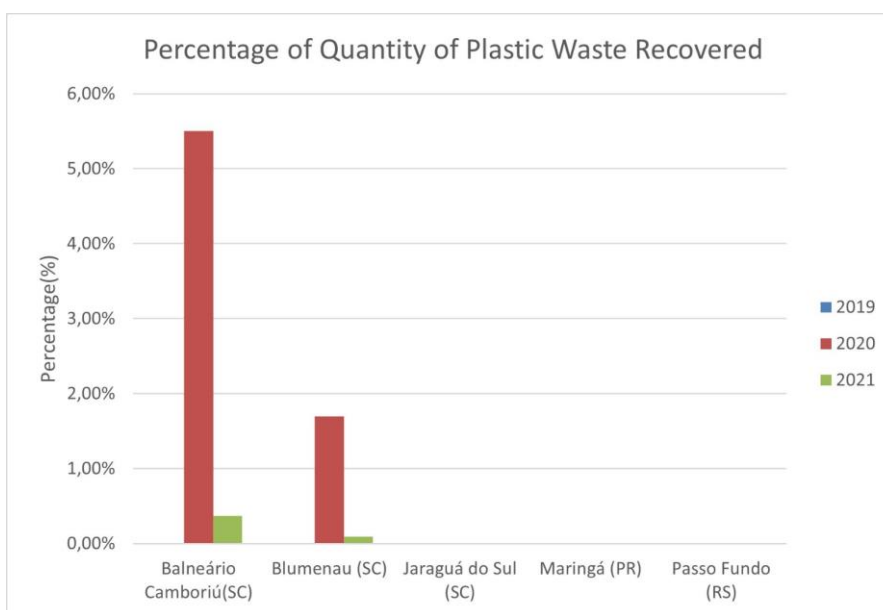
Graph 6: Waste Collection Service Coverage Indicator in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors

Regarding the indicator Percentage of Quantity of Plastic Waste Recovered (Graph 7), an indicator that seeks to reduce polluting materials that do not decompose in nature, Passo Fundo, Maringá and Jaraguá do Sul have low or no recovery rates in three years of analysis, requiring more sustainable initiatives in recycling and waste recovery programs. However, Balneário Camboriú and Blumenau stand out in the indicator, presenting an increase in waste recovery in the years 2020 and 2021, demonstrating that the cities have strategies regarding this indicator and that they are giving positive results.

Chart 7: Percentage Indicator of the Amount of Plastic Waste Recovered in the 2019, 2020 and 2021 Rankings.



Source: Prepared by the authors.

Finally, we sought to evaluate the monitoring of risk areas indicator, an indicator that is extremely important to know which cities monitor places where there may be movements, such as landslides, undermining, falls or rockslides; banks and rocks, as well as floods, torrents and other factors that can be caused by natural damage. Based on this control, municipal managers can prepare and devise strategies to face these health risks. Thus, according to the study, the four cities in Santa Catarina have monitoring of risk areas, while Passo Fundo does not, lacking this important service on assisting the management of the city and the safety of its citizens.

#### **4 FINAL CONSIDERATIONS**

The analysis of urban environmental indicators in the city of Passo Fundo, as well as the best classified medium-sized cities in the south of the country by the Connected Smart Cities Ranking of 2019, 2020 and 2021, is significant for the knowledge of the cities investigated and their urban infrastructures of these municipalities.

According to the study, Passo Fundo, compared to the other municipalities analyzed, has regular rates, standing out positively in the indicators of water supply and coverage of waste collection service. However, it is essential that the city seeks new alternatives, especially regarding water losses during its distribution and the collection and treatment of the city's sewage. With the aim of being able to offer at least more adequate basic sanitation for its citizens, so that they have health, well-being, and a better quality of life, and so that the environmental impacts on watercourses with the disposal of sewage are mitigated.

Thus, this study highlighted the importance of measuring and analyzing the urban indicators of cities, with a view to more targeted and assertive urban planning, demonstrating greater transparency to public managers, urban planners, and companies about the current scenario of their cities, understanding the obstacles they face and the potential they present, in order to outline short and long-term strategies to enable a healthier, more sustainable and safer urban environment.

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