https://doi.org/10.1590/S1413-415220230084

Scientific Paper

Evaluation of indicators for the management of urban solid waste generated by national databases

Avaliação de indicadores para a gestão de resíduos sólidos urbanos gerados por bases de dados nacionais

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ABSTRACT

Databases, whether public or private, provide information and data on performance indicators related to urban solid waste that can contribute to the development and improvement of public policies in this sector. In view of the above, this work aimed to analyze and compare the performance indicators adopted by the Brazilian Association of Urban Cleaning and Special Waste Companies, the Brazilian Institute of Geography and Statistics and the National Sanitation Information System – Solid Waste on the mass of urban solid waste collected, selective collection and final disposal, in order to explain their differences and outline an overview of the provision of this service in the country. To obtain the data, a bibliographic survey was carried out using books and academic works on the topic; and the websites of the aforementioned databases were accessed to verify the indicators used in the assessment of basic sanitation throughout the Brazilian territory. From the analysis, divergences were evident in the published information, mainly in relation to the amount of urban solid waste collected and the municipal initiatives for selective collection. The study highlighted the need to adopt auditing and information certification procedures to improve the quality of regulation and management in the sector, in order to promote data reliability; in addition to improving the structuring of questionnaires and statistical techniques, aiming to make the diagnosis of the studied scenario as realistic as possible to define the most appropriate management model.

Keywords: urban solid waste management; database; performance indicators.

RESUMO

As bases de dados, públicas ou privadas, fornecem informações e dados sobre indicadores de desempenho relacionados aos resíduos sólidos urbanos que podem contribuir para o desenvolvimento e aprimoramento de políticas públicas nesse setor. Diante do exposto, o presente trabalho teve como objetivos analisar e comparar os indicadores de desempenho adotados pela Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais, pelo Instituto Brasileiro de Geografia e Estatística e pelo Sistema Nacional de Informações sobre Saneamento – Resíduos Sólidos sobre a massa de resíduos sólidos urbanos (RSU) coletada, coleta seletiva e destinação final, a fim de explicar suas diferenças e traçar um panorama da prestação desse serviço no país. Para a obtenção dos dados, foi realizado levantamento bibliográfico por meio de livros e trabalhos acadêmicos sobre o tema; e foram acessados os *sites* das bases de dados citadas para verificar os indicadores utilizados na avaliação do saneamento básico em todo o território brasileiro. Mediante a análise, evidenciaram-se divergências nas informações publicadas, principalmente em relação à quantidade de RSU coletada e às iniciativas municipais de coleta seletiva. O estudo destacou a necessidade de adotar procedimentos de auditoria e certificação de informações para melhorar a qualidade da regulação e da gestão no setor, a fim de promover a confiabilidade dos dados, além de aprimorar a estruturação de questionários e técnicas estatísticas, visando tornar o diagnóstico do cenário estudado o mais realista possível para definir o modelo de gestão mais adequado.

Palavras-chave: gestão de resíduos sólidos urbanos; banco de dados; indicadores de desempenho.

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Conflicts of interest: the authors declare no conflicts of interest.
Funding: none.
Received on: 06/19/2023 – **Accepted on:** 05/03/2024

INTRODUCTION

The industrialization process was a milestone in economic and social development, being characterized by a change in the pattern of production and consumption, thus contributing to a significant increase in the generation of products and, consequently, solid waste (SILVA; CAPANEMA, 2019). Associated with this is the advance of urbanization in Brazilian cities and the growth of metropolitan regions, generating several consequences, such as an increase in the complexity of the management system and in the costs of urban cleaning and solid waste management services (LOURENÇO, 2019). These factors lead to an increase in the generation of solid waste, whose inadequate management and disposal cause socio-environmental impacts, for instance by compromising water bodies, intensifying floods, contributing to atmospheric pollution and the proliferation of vectors of health and health relevance, in addition to collection in unsanitary conditions on the streets (SOARES, 2017), damaging quality of life in urban systems (BARROS *et al*., 2019).

According to Santos (2023), inadequate management of urban solid waste (USW) represents one of the biggest contemporary concerns in the environmental, social and economic areas. In Brazil, this change of scenario has led to greater attention being focused on the sector, with an emphasis on new legislation that establishes principles, objectives, instruments, guidelines, goals and actions adopted by the Union, alone or in cooperation with the states, the Federal District, the municipalities or the private sector (JUCÁ *et al*., 2014; SILVA FILHO; SOLER, 2019).

Thus, in recent years the solid waste component has gained notability on the agenda of Brazilian municipalities with the approval of new legislation, such as the National Basic Sanitation Policy — Law nº 11,445/2007 (updated by Law nº 14,026/2020) and the National Policy of Solid Waste (NPSW) — Law nº 12,305/2010 (CAMARGO, 2014). Both the National Basic Sanitation Policy and the NPSW determine that, for municipalities to have access to the Union's budgetary resources, it is necessary to prepare the Municipal Plan for Integrated Solid Waste Management and the Municipal Basic Sanitation Plan (CORBELLINI, 2015). With the implementation of the NPSW, some Brazilian municipalities added other steps to their technological route for solid waste management, such as selective collection, recycling and composting (NORBERTO *et al*., 2021).

In view of this, solid waste management and urban cleaning began to have greater visibility among the growing demands of local communities and Brazilian society (MONTEIRO, 2001), encouraging municipal public administrations to pay greater attention to the management of this waste, from the process that involves collection, transportation and treatment until final destination (CONKE; NASCIMENTO, 2018).

In this context, the management of USW reaches a notable proportion, thus requiring the development of methodologies that aim to improve decision-making in the processes inherent to the management of USW (CORREIA; AQUINO; CORREIA, 2019). To this end, diagnosing the scenario in which the municipality finds itself is essential to understand its characteristics and, subsequently, define the most appropriate management model (BONATO *et al*., 2021).

The development of a Solid Waste Plan — municipal, intermunicipal, state or national — requires mapping and elaboration of diagnoses that offer instruments to identify challenges and realistic future projections, in addition to promoting improved management of the solid waste sector. The solution to this problem would be to build or obtain reliable indicators to identify flaws in the system and real possibilities to overcome them (ROMANI; SEGALA, 2014).

The creation of indicators linked to sustainability and specific to the management of USW is relevant, as it provides managers with technical data for decision-making in the solid waste sector and analyzes aspects of society's relationship with the environment (UGALDE, 2010; PINTO *et al*., 2020). Therefore, it is necessary to apply a tool that allows an easy and quick evaluation of data to assist in the management of USW (ARRUDA *et al*., 2020).

According to Besen and Dias (2011), "the use of information contained in databases, as well as the use of sustainability indicators, can contribute to a greater qualification of public solid waste policies in the country".

Consolidation in providing services related to public cleaning and USW management depends on the quality of the information generated and aggregated in a database and the critical assessment of how such information is made available by the municipal public sector and by management organizations in the sector. Data, both quantitative and qualitative, made available in a database by public and private entites serve to evaluate and measure activities, identifying existing deficiencies in municipalities and/or regions that require greater use of resources, as well as self-assessment of management and investments, contributing to the adoption of methods, techniques and processes for the improvement of the waste sector and the quality of life of society according to local and regional peculiarities (CONKE; NASCIMENTO, 2018).

In the scenario of solid waste management, national surveys provide conflicting data. Therefore, the existence of these discrepant technical indices, depending on the source, can cause a distorted perception of reality, influencing and reducing the quality of decisions on the implementation of new programs and/or reinforcement of existing programs, compromising improvements in services solid waste management and urban cleaning (PERUCHIN; SCHNEIDER, 2019). Thus, it can make performance indicators fundamental for the formulation of public policies of an economic, social and environmental nature (PEREIRA; CURI; CURI, 2018).

Given the above, the objective of the article is to analyze and compare performance indicators such as: USW generation, mass collected, quantity per capita, selective collection programs, and final destination of USW nationwide, as adopted by the Brazilian Association of Urban Cleaning and Special Waste Companies (ABRELPE), Brazilian Institute of Geography and Statistics (IBGE) and the National Sanitation Information System — Solid Waste (SNIS-RS). This is to identify the existence of contrasting information; clarify the origins of this contrasting information; and identify gaps and opportunities for improvements in the systematization of information about these services of greatest social interest.

METHOD

The study uses quantitative variables to collect data, with the reference period of the databases being between 2000 and 2021, in a non-sequential manner. This time frame was established because it was considered sufficient for analysis, taking into account the transformations that have occurred in the sector over the years and seeking to fill gaps found in the research.

The research was organized in phases: in phase 1, studies were carried out to select intuitions whose potential was favorable to the choice of the reference scenario.

In phase 2, the process of obtaining data took place through bibliographical surveys in books, periodicals and academic works available electronically on journal websites, in addition to specific federal legislation related to solid

waste management, capable of offering technical support in the preparation of the project. The SNIS-RS, IBGE and ABRELPE websites were also used to provide data on the indicators applied in the assessment of USW management throughout the Brazilian territory.

In the third phase, an Excel spreadsheet was created to organize the performance indicators available in the reports by year of publication.

The indicators worked on were evaluated and selected, thus composing the fourth stage of the research. This information was organized in a table, taking into account the indicators and periodicity. Subsequently, a comparative analysis of the data generated was carried out, identifying the strengths and limitations of the databases studied.

RESULTS AND DISCUSSION

Analysis of indices generated by the Brazilian Association of Urban Cleaning and Special Waste Companies ABRELPE, IBGE and SNIS-RS in 2000, 2004 and 2008

The National Basic Sanitation Survey (NBSS), carried out by IBGE in the 2000 edition, covered 5,475 of the municipalities existing in the base year of the survey, and in the same period 32 municipalities did not provide data to compose the report (IBGE, 2000). In 2008, there were 5,562 participating municipalities, and only two did not collaborate for data collection (IBGE, 2008).

According to literature data, comparing the results obtained in NBSS 2008 with those collected by NBSS 2000, it was possible to verify an improvement in basic sanitation services provided throughout the country, which shows that almost 100% of Brazilian municipalities had solid waste management, with the exception of two.

As can be seen in Table 1, there is an increase in the amount of USW collected in the municipalities, from 59,066,892 tons/year in 2000 to 66,973,120 tons/year in 2008. The collection coverage index reaches almost its entirety, but the percentage of waste disposed of in sanitary landfills in 2008 was reduced by 6.7% in relation to NBSS 2000. This is favorable when analyzed from the perspective of the final destination of the solid waste collected: 47.1% went to sanitary landfills, 22.3% to controlled landfills and only 30.5% to dumps, that is, more than 69% of all waste collected in Brazil was disposed of in sanitary and/or controlled landfills. However, when the evaluation is carried out on numbers of municipalities, the result was not favorable: 63.6% sent them to dumps, 18.4% to controlled landfills and 3.8% to landfills, and 5% did not inform where they send their waste.

In Table 1, it can be seen that the 2008 NBSS revealed advances in the selective collection service, although it appears to be incipient.

ABRELPE, in 2004, collected information regarding collection and urban cleaning services in Brazilian municipalities with more than 100 thousand inhabitants. Of the total of 120 municipalities invited to participate in the sample, responses were obtained and data from only 49 municipalities were compiled, 19 from the Southeast region, ten from the South region, ten from the Northeast region, six from the North region and four from the Central-West region. This represents 22%, around 40 million inhabitants, of the Brazilian population estimated by IBGE for 2004 (181.6 million inhabitants).

Table 1 also presents the results of the amount of domestic solid waste collected, according to this ABRELPE sampling. These municipalities collected 59,214,680 tons/year, with a per capita mass of 0.67 kg/inhabitant/day. Of these municipalities, only 16 (17.2%) had selective collection coverage.

In the 2008 edition of the Panorama of Solid Waste in Brazil, data are presented on the evolution of USW obtained in direct research by ABRELPE in all regions of Brazil, reaching 352 municipalities, expanding the information available in the sample. Of this amount, 205 municipalities were used to project the quantities of solid waste collected in each Brazilian macroregion, as well as the national total. The sample considered for projections at the national level was the sum of samples from the five macroregions of the country.

The data shows that Brazil has made positive progress in the collection of USW over the years. In general, the amount of domestic solid waste collected grew 5.9% compared to the previous year, which indicates a substantial increase

Table 1 - Comparative survey of urban solid waste reports for the years 2000, 2004 and 2008 by the Brazilian Association of Urban Cleaning and Special Waste Companies (ABRELPE), the Brazilian Institute of Geography and Statistics (IBGE) and the National Sanitation Information System — Solid Waste (SNIS-RS).

YEAR	DATA BASE	INDICATORS						
		[1]Total USW generation (million/tons/year)*	[2]USW per capita generation (kg/person/year)*	[3]USW collected (million/tons/ year)	Mass collected per capita of DW + PW* (kg/person/day)	Percentage discarded in landfills (%)	Waste collection coverage index (population) (%)	Coverage of selective collection (%)
2000	IBGE Census	-	-	59.066,892	0.74	47.1	99.4	8.24 (451 municipalities)
2004	ABRELPE Sampling	59,214,680	-	59,214,680	0.67	-	-	17.2 (16 cidades)
	SNIS-RS Sampling	-	-	36,747,896	0.76	40.2	94.4	61.3
2008	IBGE Census	-	-	66,973,120	1.20	40.4	99.9	17.87 (994 municipalities)
	ABRELPE Sampling	61,925,535	394.2	54,457,635	0.95	45.1	87.9	55.9
	SNIS-RS Sampling	-	-	35,700,000	0.98	41.8	100	54.4

USW: urban solid waste; DW: domestic waste; PW: public waste; 1, 2, 3: The data provided by ABRELPE and IBGE were in ton/day and kg/inhabitant/day. To standardize the information contained in the table, the calculations were made based on ton/year and kg/inhabitant/year.
Source: IBGE (2000; 2008); ABRELPE (2004; 2008) and SNIS-RS (2004; 2008).

in the scope and performance of these services. In the year 2008, 87.9% collection coverage was achieved, and 45.1% of USW had an adequate destination (landfill) and 55.9% of the collected material was segregated.

As for SNIS-RS, data were obtained in 2004 for 161 municipalities, which represent 2.9% of the country's municipalities, with a total population of 69,076,804 inhabitants, corresponding to 38% of the total Brazilian population.

For the 2004 sample, regular collection services had a reasonable coverage, with an average of 94.4%, reaching a mass quantity received in USW processing units through land disposal (dumps, controlled and sanitary landfills) of 36,747,896 tons in the year. Selective collection is practiced in 61.3% of the municipalities participating in the sample.

In the base year 2008, of the 527 municipalities invited, valid responses were obtained from 372, resulting in a compliance rate of 70.5% and, on the other hand, an increase of 66 municipalities (21.5%) in the database when compared to the previous year.

The average of the waste collection coverage index indicator is practically 100% for the urban population. It was found that, for the 2008 sample, the amount of household and public waste collected was in the order of 35,700,000 tons, corresponding to a per capita value of 0.98 kg/inhabitant/day.

The total mass collected is destined for dumps, controlled or sanitary landfills. However, in terms of the mass received by these units, the distribution is not the same. There is a more favorable environmental situation, as 65.1% of the total is destined for the unit classified by the municipal management body as a landfill; 21.4% goes to controlled landfills; and 13.5% goes to dumps.

Selective collection is practiced in 54.4% of the municipalities in the sample. It is worth noting that there is no information on the scope of this selective collection in each municipality, and it may only occur in a small part, as well as in a significant part of it.

The SNIS-RS informs, in the reports for these two periods, that the coverage data must be viewed with caution, as the estimates of the population served provided by the municipalities are often very imprecise. It also points out information and indicators related to the mass of waste collected, which considers both the municipalities that declared to weigh the collected waste (62.5%) and those that reported not using scales (37.5%). Therefore, the estimated value of the mass collected may have been subject to some inaccuracies.

ABRELPE and IBGE

Within this comparative analysis, the year 2003, relating to the ABRELPE Solid Waste Panorama, was not selected, as the information presented in this edition was secondary data extracted from the NBSS conducted by IBGE in 2000 and the Integrated Management Manual of Urban Waste developed by the Business Commitment for Recycling (CEMPRE) in 2000.

In the 2004 edition published by ABRELPE the year 2003 was analyzed. The institution reported that, during the preparation of the first edition of the Panorama of Solid Waste in Brazil 2003, some inconsistencies were identified in the NBSS 2000 database in relation to the divergences presented in the published text and in the disclosure tables, which increased the amount of waste generated in the country's municipalities and made it difficult to analyze the amount per capita.

When consulting the management of IBGE, ABRELPE obtained the following information: "In fact, divergences were detected in the data on the topic of waste, referring to the daily amount of garbage collected and the destination given to solid waste in Brazilian municipalities". Although ABRELPE has made available a new table containing data on the amount of solid waste collected (from homes, commerce and public roads) for all municipalities in the country, it was decided in the preparation of this article not to use the report published based on sources of secondary sources of information, as it would present the same limitations as such sources.

Analysis of indices generated by the ABRELPE and SNIS-RS between 2011 and 2021

When analyzing the data presented in Table 2, it can be noted that significant changes occurred in the USW sector over these ten years, resulting from the implementation of the NPSW principles and guidelines. However, according to van Elk and Boscov (2016), to implement and achieve sustainable NPSW practices there is an extensive journey to be undertaken.

The data presented in Table 2 refer to the years between 2011 and 2020 and point to differences in the information published by ABRELPE and SNIS-RS. It was not possible to compare NPSW-IBGE data as there was no study focusing on that period, the last publication being of 2008.

When checking the data published by these databases, it becomes clear that the regular collection of solid waste has been the main focus of solid waste management in recent years. However, for Santos and van Elk (2021), although Brazil follows the path of universalizing the collection service, this service needs to be improved in areas of subnormal agglomerations and rural areas.

The data released shows that the waste collection coverage index indicator has been increasing continuously, reaching almost 92% of the total number of households across the Brazilian territory in 2020; while, in urban areas, the rate exceeds 98%. Since 2017, the SNIS-RS has published the average collection coverage rate in two ways: serving the total population (rural and urban) and only the urban population. Thus, the average indicators vary between 90.5 and 98.8%.

The Southeast region is responsible for the largest amount of mass collected, with just over 40 million tons per year, followed by the Northeast region, with just over 16.5 million tons, the South region with around 8.5 million tons, the Midwest with 5.8 million tons and the North region, 4.9 million tons/year according to a survey carried out by ABRELPE in 2021. SNIS-RS, in the same period, published different percentages for each region: Southeast, 28.9 million tons/year; Northeast, 18.9 million; South, 7.7 million; North, 5.15 million; and Midwest, 4.94 million. According to Santos and van Elk (2021), when a comparative analysis is carried out between the Brazilian macroregions, the Southeast stands out in terms of USW generation as it has a greater number of inhabitants and greater purchasing power compared to the others, producing basically twice as much as the Northeast, which comes second in terms of quantity of mass collected per day.

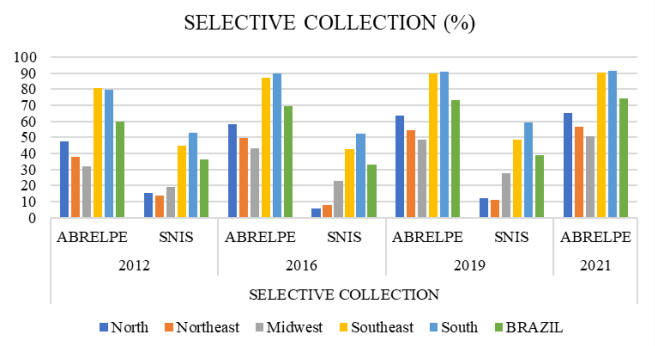
Regarding the selective collection of recyclable materials, despite an increase of 12 to 15% in this parameter over the years reported, it is clear that there is a large discrepancy in the values indicated by the two institutions. While the Thematic Diagnosis of USW Management by the SNIS-RS indicated the presence of the service in 1,161 Brazilian municipalities or 20.8% in 2013, 1,256 or 22.5% in 2017, and 1,664 or 36.3% in 2020, ABRELPE published the following numbers: 3,459 or 62.1% in 2013; 3,923 or 70.4% in 2017; 4,145 or 74.4% in 2020.

With regard to the Brazilian macroregions, Graph 1 shows the evolution of the initiative to provide selective collection of household waste throughout the years 2012, 2016, 2019 and 2021.

Table 2 – Comparison of reports between 2011 and 2020.

YEAR	DATA BASE	INDICATORS						
		Total USW generation (tons/year)	USW generation per capita (kg/person/year)	USW collected (million tons/year)	Mass collected per capita of DW + PW (kg/person/day)	Percentage discarded in landfills (%)	Waste collection coverage index (population) (%)	Coverage of selective collection (%)*
2011	ABRELPE	61,936,368	381.6	55,534,440	1.097	58.06	89.66	58.6
	SNIS-RS	-	-	55,300,000	0.960	60	98.4	38.0
2012	ABRELPE	62,730,096	383.2	56,561,856	1.107	57.98	90.17	59.8
	SNIS-RS	-	-	57,900,000	1.000	51.9	98.5	20.0
2013	ABRELPE	76,387,200	379.9	69,064,935	0.941	58.26	90.41	62.1
	SNIS-RS	-	-	61,100,000	1.010	59.0	98.4	20.8
2014	ABRELPE	78,583,405	387.63	71,260,045	0.963	58.4	90.68	64.8
	SNIS-RS	-	-	64,400,000	1.050	58.5	98.6	23.7
2015	ABRELPE	79,889,010	390.9	72,543,750	0.972	58.7	90.8	69.3
	SNIS-RS	-	-	62,500,000	1.000	66.8	98.6	22.5
2016	ABRELPE	78,257,825	379.6	71,300,000	0.948	58.4	91.0	69.6
	SNIS-RS	-	-	58,900,000	0.940	59.0	98.6	21.8
2017	ABRELPE	78,426,820	377.7	71,558,250	0.944	59.1	91.24	70.4
	SNIS-RS	-	-	60,600,000	0.950	64.2	91.7 - 98.8	22.5
2018	ABRELPE	79,069,585	379.2	72,748,515	0.956	59.5	92.01	73.1
	SNIS-RS	-	-	62,780,000	0.960	75.6	92.1 - 98.8	23.7
2019	ABRELPE	79,069,585	379.2	72,748,515	0.955	59.5	92	73.1
	SNIS-RS	-	-	65,110,000	0.990	75.1	92.1 - 98.8	25.8
2020	ABRELPE	82,477,300	390.0	76,079,836	0.980	60.2	92.2	74.4
	SNIS-RS	-	-	66,600,000	0.970	73.8	90.5 - 98.7	29.9

DW: Domestic Waste; PW: Public Waste; *The selective collection coverage index refers to municipalities that have some selective collection initiative; **Percentage of Brazilian municipalities that have a selective collection service, with the calculation estimated in relation to 5,568 Brazilian municipalities, plus two districts (Fernando de Noronha and Distrito Federal), totaling 5,570 locations.
Source: ABRELPE (2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018; 2019; 2020) and SNIS-RS (2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018; 2019; 2020).



Source: ABRELPE (2012; 2016; 2019; 2021) and SNIS-RS (2012; 2016; 2019; 2021).

Graph 1 – Evolution of the selective collection service index by microregion.

Regarding the selective collection indicator, the USW Management Thematic Diagnosis carried out by the SNIS-RS indicated the presence of the service in 1,111 or 36.5% of the municipalities participating in the sample in 2012, 1,215 or 33.1% in 2016, 1,438 or 38.7% in 2019, and 1,567 or 32.0% in 2021. As for the percentage of municipalities in Brazil that have a selective collection service, they are 20.0% in 2012, 21.8% in 2016, 25.8% in 2019 and 29.9% in 2021. ABRELPE published the following numbers: 3,326 or 59.8% in 2012, 3,878 or 69.6% in 2016, 4,070 or 73.1% in 2019 and 4,145 or 74.4% in 2021.

When analyzing the evolution of selective collection for the Brazilian population in the years 2012, 2016, 2019 and 2021, it is possible to note that, according to data generated by the SNIS-RS, the percentage of Northern and Northeastern municipalities that are served does not exceed 15%, less than half those that are served in the Midwest. Although the Midwest macroregion is in an intermediate position, with selective collection being practiced in between 19.3 and 27.7% of municipalities, there is a lag in relation to the rates for the South and Southeast.

Based on information published by ABRELPE, the panorama of selective collection in the Brazilian macroregions has made progress, gradually increasing over the years. The North and Northeast regions exceed 56%, with values above the rates generated for the Midwest, which are between 31.8 and 50.5% of the municipalities. The South and Southeast have over 90% coverage. Despite the numbers, ABRELPE considers selective collection in the Brazilian territory to be incipient and claims that the service does not cover all neighborhoods. Similar data were published by Conke and Nascimento (2018), who show that the scope of selective collection is incipient, covering only 41% of municipalities, and efficiency too, since only 10% of what are potentially recyclable materials go through the collection process. Santos and van Elk (2021) point out that selective collection initiatives in Brazilian municipalities are limited to providing a voluntary delivery point, and this action does not cover the entire urban territory, thus affecting the expansion of this service in the country.

Although outdated, the NBSS 2000 and 2008 publications cite 451 and 994 municipalities with selective collection, respectively, which at the time corresponded to 8.19 and 17.86% of the country's total municipalities for each base year of the study.

It is clear that the amount of material recovered through formal selective collection programs is still reduced when compared to the total mass of USW collected, indicating the need for further investigations. It is worth remembering that the average indicator of municipalities with collection services is based on information from door to door selective collection initiatives, voluntary delivery points or the like.

In terms of the final disposal of USW in processing units via land disposal, the following modalities are presented: dumps, controlled and sanitary landfills. Observing Table 2, it appears that between 60 and 70% of the USW collected is sent to sanitary landfills; between 30 and 40% are discarded in controlled landfills and dumps. The SNIS-RS data, referring to the percentage indicator discarded in landfills, indicates that there was an average increase of 10% over a decade, while the data made available by ABRELPE grew by around 2% in the same period (between 2011 and 2020).

The discrepancy in the data is quite alarming in terms of the rate of urban solid waste collected, as there is a difference of more than 10 million tons each year, as presented in the table. According to Peruchin and Schneider (2019), the inequality of the data generated by this indicator allows a margin of error in solid waste management, making it impossible to maintain the consistency of information in relation to the environmentally appropriate final disposal services for USW.

SNIS-RS does not calculate the per capita generation of domestic waste (DW) and public waste (PW), therefore it uses the term "mass collected per capita" to ensure greater accuracy of the indicator. In other words, the calculation is made based only on the waste collected and not on an estimate of total generation, although it assumes that generation should not reach a value above 10% in relation to collection for the urban population, since the coverage of the home collection service is almost complete for the population of Brazil, reaching a percentage of 91.8% (SNIS-RS, 2017) and 90.5% (SNIS-RS, 2020).

It should also be noted that ABRELPE informs in its summaries that generation per capita is calculated based on the total population estimated by IBGE each year. It is worth remembering that IBGE annually provides the estimated number of inhabitants per Brazilian municipality. ABRELPE does not clarify the number of municipalities participating in the research, as it did not disclose who and how many were interviewed. Conke and Nascimento (2018) reveal that ABRELPE guarantees the confidentiality of the data due to an agreement made with the municipalities, since the answers, for the most part, are confidential. The authors emphasize that this type of procedure must be reviewed, as it is public in nature and, therefore, must offer transparency and easier access to information.

In SNIS-RS, the calculation is based on the number of inhabitants of the municipalities that voluntarily participate in the research. Based on the percentages generated in each indicator for the municipalities in question, they are extrapolated to Brazil as a whole by due weighting.

It is worth mentioning that the information is made available by the municipalities, with a fluctuation in the number of declaring managers each year. This may cause changes in the percentages calculated by the indicators, explaining the divergences found in the reports issued by ABRELPE and SNIS-RS in these periods.

Divergences between the reports made available by the databases

For Castle (2006), the variety of formulas used by institutions to calculate the same indicators makes understanding and comparisons difficult and can lead to large discrepancies in results, justifying the importance of standardization. According to Conke and Nascimento (2018), the differences found in reports by ABRELPE, IBGE and SNIS-RS databases can be explained by three factors:

Sampling method adopted

IBGE carries out a census survey covering the national territory, thus reaching the total mass of the Brazilian population and municipalities so that the scenario studied is as realistic as possible. As for ABRELPE and SNIS-RS, until 2008 the survey was carried out by sampling, with the object of study being to define a number of Brazilian municipalities to represent the totality. Starting in 2009, the latter two have also adopted a national approach, reformulating the survey and inviting all Brazilian municipalities to participate by answering questions about solid waste. Therefore, ABRELPE does not disclose the primary data collected from municipalities and private entities that appear in the registry of service providers and also works with secondary data in some indicators, in addition to not specifying the number of entities participating in the sampling. The SNIS Thematic Diagnosis stands out for providing several files with primary data and presenting detailed explanations, allowing active data analysis with the reapplication of calculations (CONKE; NASCIMENTO, 2018).

The procedures selected for calculating the results

The USW indicator presents a disparity between the data published by ABRELPE and SNIS-RS. This may be due to the fact that SNIS-RS only works with municipalities that accept to participate in its diagnosis, not reaching all municipalities in the Brazilian territory; therefore, based on the available data, it carries out calculations and extrapolates the values to the entire country. ABRELPE does not provide the number of municipalities participating in the sample at the national and regional levels, implying that the research takes place in all Brazilian municipalities. Therefore, the index generated in relation to the mass collected per capita corresponds to the collected USW indicator. It is important to highlight that the calculation in which this indicator is adopted is related to the USW index collected and the urban population (based on IBGE data) and/or the population served (declared by the municipality).

Regarding the scope of selective collection, Conke and Nascimento (2018) state that the way IBGE collects data for this indicator makes it possible to carry out the calculation in a simple way, simply dividing the number of municipalities that have the service by the total number of municipalities included in Brazil. The authors also report that, for this same item, without reaching the same number of municipalities participating in the IBGE to carry out the sample, the SNIS-RS also carried out this type of calculation, making its results underestimated. Therefore, when a response is not obtained from the entire desired sample, it may be more appropriate to perform calculations by projection, as is done by ABRELPE.

Conke and Nascimento (2018) suggest that the SNIS-RS carries out projective calculations for the selective collection indicator, as it is unable to reach all Brazilian municipalities in the sample and also because it has quality primary data to carry out such calculations.

Regarding the language used in the questionnaires

It is known that the questionnaire is a useful instrument in the data collection strategy, that its planning and construction are essential requirements for achieving the expected results, since there are no exact procedures that guarantee that its measurement objectives are achieved accurately and with good quality (AAKER; KUMAR; DAY, 2001).

With this in mind, when evaluating the questionnaires applied by the three reports, it was possible to notice the difference in the language applied in each one.

ABRELPE opted for a mixed questionnaire, which had: open-ended questions, where managers were free to respond in their own words, without being limited to choosing from a list of alternatives; questions in which the answers were dichotomous, with only two answer options, such as: yes/no; and multiple choice questions, in which respondents chose one of the alternatives, or a certain number of them.

IBGE worked with a multiple-choice and dichotomous questionnaire, but more comprehensive and with a sequential format of questions and answers to complement the subject covered in the topic. The questions that had two answer options were complemented with other questions, which allowed the topic covered to be evaluated in all aspects.

IBGE used response options such as: "Active program", "Pilot project", "Under development", "Interrupted program" or "No program".

The SNIS-RS form is similar to the one applied by IBGE. As it is an online form, it highlights inconsistencies in filling out, but does not help to reduce errors in the data declared by municipalities.

Strengths and weaknesses of the methodologies adopted by the ABRELPE, IBGE and SNIS-RS in the solid waste sector

The NBSS is a survey rich in information for the development of policies in Brazil related to urban solid waste management; however, the lack of standardization and periodicity of the research over the years does not allow it to be the only information base for the formulation of public policies in the sector. On the other hand, ABRELPE and SNIS-RS regularly monitor the expansion of solid waste management services and update metrics, which can be used as an effective mechanism to monitor the evolution of these policies.

Another limiting factor in access to the ABRELPE and NBSS information database refers to the lack of municipal data, which are only available at the state level and by macroregion, not allowing a detailed assessment of the Solid Waste Panorama in a municipal area. The SNIS-RS, in turn, presents information at the municipal level, but these data mostly refer to the urban sectors of the municipalities and do not reflect the situation in the rural sector.

Another difficulty to do with the databases is discontinued information, for example, the calculations carried out in dynamic groupings use the formulas presented in the ratios of the indicators used in each reference year, that is, there may be different formulas for the same indicator at the same time throughout the historical series. There are indicators that are calculated only for some reference years.

Furthermore, Brazilian databases referring to USW management do not include a step to verify the data provided in the collection process, since the information is made available by the service providers themselves and there is no mechanism for auditing and validating the data – unlike the SNIS with regard to water supply and sewage services, which relies on Ordinance 719, of December 12, 2018, to establish a methodology for auditing and certifying information related to this sector. The implementation is carried out through the Acertar Project, the result of a partnership between the Ministry of Cities and the Brazilian Association of Regulatory Agencies, whose objective is to improve the information management processes of sanitation service providers, acting in a preventive manner to identify possible errors and deviations (SNIS, 2022).

Although weaknesses are highlighted (Table 3), it is possible to note the potential of these data platforms for the growth of the sector. The main

Table 3 – Comparison of weaknesses and strengths identified in the databases studied.

DATABASE	WEAKNESSES	STRONG POINTS
SNIS-RS	- Lack of filling out information in certain segments - Possibility of error when filling out the form sent online - The indicators predominantly reflect the situation in the urban sectors of the municipalities - Discontinued information or change in indicators - Self-declaration of data - Lack of mandatory participation of municipalities - There is no proof of the data provided by technicians	- Regular monitoring of the expansion of sanitation services - Allows an evaluation of different types of providers - Assists in the formulation of municipal, state and/or national sanitation policies - Update of information and indicators
ABRELPE	- Results obtained from information provided by contracted companies and bibliographic research to carry out the management service - Data is not available at the municipal level - Primary data not available - Works with secondary data in some indicators - Discontinued information or changes in indicators - Lack of mandatory participation of municipalities - There is no proof of the data provided by the technicians - Does not specify the number of municipalities participating in the sample	- Frequency of publishing information - Can assist in the formulation of state and/or national sanitation policies - Update of information and indicators
IBGE	- Data is presented in total and municipalities by state - Waste generation data is not separated by municipality - Data is not updated annually - Does not present data on waste management costs - Does not present data on the methods or costs of selective collection systems	- Diagnosis of the installed infrastructure that covers the entire urban solid waste service chain - Assists in formulating the goals of the National Basic Sanitation Plan, through indicators based on information from research - Formulation of municipal and/or national sanitation policy

Source: Freitas **et al**. (2018); Peruchin and Schneider (2019).

planning instruments at the national level in relation to sanitation, specifically the solid waste management and urban cleaning component, are the National Basic Sanitation Plan and the National Solid Waste Plan, as they present short, medium and long-term strategies to operationalize current legal provisions. To this end, information is obtained from various sources, with an emphasis on the most recent editions of SNIS-RS and ABRELPE, in addition to information from IBGE, with the indicators from these databases providing support for monitoring the goals stipulated by these two most important plans of the country.

The reports prepared by the three institutions have broad and accessible language, in addition to being available free of charge on their pages. Over the years, ABRELPE and SNIS-RS have presented reforms in the methodology applied and in the data publication format, which were designed to meet the needs of the time. The SNIS-RS, through the Historical Series Application, makes it possible to consult information and indicators related to USW year by year since data collection began, since consultation regarding this component was only available from the municipal database.

The information contained in the SNIS-RS reports provides primary data in a clear and transparent way, with explanations of the indicators generated and details of the calculations, allowing them to be recalculated by third parties.

CONCLUSIONS

The analysis of the evolution of information in national databases (ABRELPE, IBGE and SNIS-RS) in the area of USW management made it possible to evaluate and compare the following performance indicators: generation of USW, mass collected, quantity per capita, selective collection programs and final destination.

Initially, the analysis of the evolution of ABRELPE data in the period from 2011 to 2021 allows us to observe a progressive increase in the USW generation rate, going from 62 million to 83 million tons per year. In turn, per capita generation increased from 381.6 kg/inhabitant/year to 390.0 kg/inhabitant/year. The regular collection index indicator performed better, reaching an average of 92% coverage of this service, of which only 60%, on average, are discarded in landfills. Selective collection coverage reached 36.3% in 2020 in the municipalities participating in the SNIS-RS survey and 29.9% among all Brazilian municipalities. It is worth remembering that this number only reflects the initiatives of this service in the country.

When a comparative analysis of the indicators was carried out on a national scale, divergences in the information and inconsistencies in the methods applied by each base were evident. The discrepancy between the data is significant when evaluating the index of urban solid waste collected, released by ABRELPE and SNIS-RS, as there is a difference of more than 10 million tons in each year presented in the study. Another point that can be verified, and which deserves to be highlighted, is the gradual increase in municipal selective collection initiatives. The SNIS-RS indicated the presence of the service in 1,438 Brazilian municipalities in 2019 and 1,664 in 2020. ABRELPE released the following numbers: 4,070 in 2019 and 4,145 in 2020.

The data also revealed that the selective collection coverage indicator is not well distributed in the country, as it does not cover all neighborhoods of the municipalities, being concentrated in urban centers and showing itself in an incipient form, with better performances being seen in the South (56.9% — SNIS; 91.2% — ABRELPE) and Southeast (40.4% — SNIS-RS; 90.6% — ABRELPE) regions.

The research carried out in this study also highlights the different methodological procedures used in the databases, which justifies the discrepancy found in some indicators collected and treated by them. This is because they adopt different sampling methods and calculation procedures for the indicators, in addition to preparing a questionnaire with different language to obtain a response to the same research indicator within the USW sector.

When analyzing the characteristics of the databases separately, it becomes clear that the NBSS is one of the most complete surveys on the USW sector, but the lack of periodicity and standardization of the survey makes it difficult to use it as an effective mechanism for monitoring the evolution of the sector.

SNIS-RS has evolved over time, becoming the most consolidated public database in the country within the area of USW management, but its research does not reach all Brazilian municipalities and its data, for the most part, refer to the urban sectors of the municipalities and not the rural areas.

The data generated by ABRELPE, in the Panorama of Solid Waste in Brazil, in addition to being used in academic research, is also published on Brazilian government websites and international publications such as the World Bank Group's "What a waste 2.0". However, the research has limitations related to the exploratory nature of its method and the use of secondary data, and its results are not transparent since primary data is not made available, leaving a perception that the number of participating municipalities is similar in all editions, the sampling process not being described.

The brief analysis allows us to conclude that the data demonstrate a clear advancement of this service in the municipalities after the establishment of the NPSW, although the practice is still at a very low level. As for the indicators chosen to compose the research, they are effective in evaluating the performance of the USW management system in the country. Therefore, in order to improve the system, it is essential to adopt auditing and certification of information for the standardization of data, improving the quality of regulation and management in the solid waste sector and acting in a preventive manner to identify potential errors and deviations.

AUTHORS' CONTRIBUTIONS

Viana, A.J.: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft. Mannarino, C.: Supervision, Writing – review & editing. Ritter, E.: Writing – review & editing, Formal Analysis, Validation.

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