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CHARGES TO GENERATORS FOR SOLID WASTE MANAGEMENT SERVICES: AN ANALYSIS OF THE FINANCIAL SUSTAINABILITY OF BRAZILIAN MUNICIPALITIES

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ABSTRACT

Purpose: To analyze the generator charging models established in Brazilian cities, evaluating the effect on financial self-sufficiency in urban solid waste management (USWM) services.

Theoretical framework: Brazilian municipalities have faced difficulties in implementing charging for USWM services, which is based on the polluter-pay principle. Although national legislation makes charging possible, the lack of updated data, trained human resources, and planning, among others, results in unsuccessful charging strategies as well as low charging.

Method: A documentary research was carried out with 1,851 Brazilian municipalities that reported charging for USWM services in 2021, which represents around 47% of the Brazilian population.

Results and conclusion: The results indicate that the implementation of collection increased by 17% in Brazil, but only 8% of municipalities achieved financial self-sufficiency. The 151 self-sufficient municipalities implemented systems using the area of the property in the collection calculation methodology. In the end, good practices for the implementation of the charging were listed.

Research implications: The results obtained enable municipal managers to learn about the challenges of implementing collection and about which models are practiced in Brazil, helping in the decision-making process.

Originality/value: The evaluation of the collection models established in Brazilian cities and the variables used to calculate the collection contribute to the design of public policies that provide a fair and balanced charging for the provision of USWM services.

Keywords: Financial sustainability, Urban solid waste management, Cost recovery, Charging Strategy.

COBRANÇA AO GERADOR PELOS SERVIÇOS DE MANEJO DE RESÍDUOS SÓLIDOS: UMA ANÁLISE DA SUSTENTABILIDADE FINANCEIRA DOS MUNICÍPIOS BRASILEIROS

RESUMO

Objetivo: Analisar os modelos de cobrança ao gerador instituídos nas cidades brasileiras avaliando o efeito na autossuficiência financeira nos serviços de manejo de resíduos sólidos urbanos (MRSU).

Referencial teórico: Os municípios brasileiros têm encontrado dificuldades para implantação da cobrança pelos serviços MRSU, que se baseia no princípio do poluidor-pagador. Embora a legislação nacional possibilite a cobrança, a falta de dados atualizados, de recursos humanos capacitados, de planejamento, dentre outros, resulta em estratégias de cobrança malsucedidas e baixas arrecadações.

Método: Foi realizada uma pesquisa documental com 1.851 municípios brasileiros que declararam a existência de cobrança pelos serviços de MRSU em 2021, que juntos representavam cerca de 47% da população brasileira.

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Resultados e conclusão: Os resultados indicam que a implantação da cobrança aumentou 17% no Brasil, entretanto apenas 8% dos municípios alcançaram a autossuficiência financeira. Os 151 municípios autossuficientes implantaram sistemas usando a área do imóvel na metodologia de cálculo da cobrança. Ao final, foram elencadas boas práticas para a implantação da cobrança.

Implicações da pesquisa: Os resultados encontrados possibilitam que os gestores municipais conheçam os desafios para a implantação da cobrança e quais os modelos praticados no Brasil auxiliando no processo de tomada de decisão.

Originalidade/valor: A avaliação dos modelos de arrecadação instituídos nas cidades brasileiras e as variáveis utilizadas para cálculo da cobrança contribuem para o desenho de políticas públicas que propiciem uma cobrança justa e equilibrada para fazer jus à prestação dos serviços de MRSU.

Palavras-chave: Sustentabilidade financeira, Manejo de resíduos sólidos urbanos, Recuperação de custos, Estratégias de cobrança.

CARGOS A LOS GENERADORES POR SERVICIOS DE GESTIÓN DE RESIDUOS SÓLIDOS: UN ANÁLISIS DE LA SOSTENIBILIDAD FINANCIERA DE LOS MUNICIPIOS BRASILEÑOS

RESUMEN

Propósito: Analizar los modelos de carga de generadores establecidos en las ciudades brasileñas, evaluando el efecto sobre la autosuficiencia financiera en los servicios de gestión de residuos sólidos urbanos (USWM).

Marco teórico: Los municipios brasileños han enfrentado dificultades para implementar el cobro por los servicios de la USWM, que se basa en el principio de que quien contamina paga. Aunque la legislación nacional hace posible la tarificación, la falta de datos actualizados, recursos humanos capacitados y planificación, entre otros, da lugar a estrategias de tarificación infructuosas y a una tarificación baja.

Método: Se llevó a cabo una investigación documental con 1.851 municipios brasileños que informaron haber cobrado por los servicios de la USWM en 2021, lo que representa alrededor del 47% de la población brasileña.

Resultados y conclusión: Los resultados indican que la implementación de la recolección aumentó un 17% en Brasil, pero solo el 8% de los municipios lograron la autosuficiencia financiera. Los 151 municipios autosuficientes implementaron sistemas utilizando el área de la propiedad en la metodología de cálculo de recolección. Al final, se enumeraron las buenas prácticas para la aplicación de la tarificación.

Implicaciones de la investigación: Los resultados obtenidos permiten a los gestores municipales conocer los retos de la implementación de la recolección y sobre qué modelos se practican en Brasil, ayudando en el proceso de toma de decisiones.

Originalidad/valor: La evaluación de los modelos de recaudación establecidos en las ciudades brasileñas y las variables utilizadas para calcular la recaudación contribuyen al diseño de políticas públicas que proporcionen una tarificación justa y equilibrada para la prestación de los servicios de la USWM.

Palabras clave: Sostenibilidad financiera, Gestión de residuos sólidos urbanos, Recuperación de costos, Estrategia de carga.

1 INTRODUCTION

The data reported to the National Sanitation Information System (SNIS), by Brazilian municipalities in 2021, regarding the provision of services for the management of solid urban waste (MRSU) presented the following values: expenditure 26,63 billion reais, revenues 8,51 billion reais (SNIS, 2022). While the provision of the services represents one of the largest investments made by Brazilian municipalities, on the other, problems such as low revenues leave Brazilian municipalities with difficulties to comply with the responsibility to offer these services in full (L. Dutra et al., 2020; Kaza et al., 2018).

In turn, Law 11,445/2007, which established guidelines from the National Basic Sanitation Policy (PNSB) provided for the possibility of charging for these services, and it could be established fees, tariffs or other public prices (BRAZIL, 2007). This became imperative with Law 14.026/2007, of the New Sanitation Framework, which provides that municipalities that do not initiate collection by the MRSU service, may face legal consequences, such as loss of tax benefits from the federal government and administratively penalized for carrying out revenue waiver in breach of the Tax Liability Law (BRAZIL, 2007, 2020a).

However, it is very difficult for municipalities to measure the value of expenses because they are often unaware of the elements that make up the costs of the services provided (Mannarino et al., 2016).

Added to this, it is noteworthy that unlike countries like Japan and the United States where the MRSU collection has been taking place since the 70s (L. Dutra et al., 2020)However, in Brazil the National Policy on Solid Waste (PNRS) has only 13 years of implementation. The first official document establishing criteria for the collection was published in 2021 by the National Agency for Water and Sanitation (ANA, 2021; BRAZIL, 2010), which from 2020 started to exercise regulatory action also for public services urban cleaning and solid waste management (SLUMRS).

Thus, the present study aims to analyze the collection models instituted in Brazilian cities, evaluating their financial self-sufficiency in the MRSU and the variables used for calculating the collection. Thus, this study has high potential for designing public policies related to fair and balanced collection to live up to the provision of MRSU services.

2 THEORETICAL FRAME

2.1 SOLID URBAN WASTE MANAGEMENT IN BRAZIL

Municipal solid waste (MSW) is composed of household waste originating from household activities in urban dwellings and urban cleaning waste originating from sweeping, cleaning of public places and roads and other urban cleaning services BRAZIL, 2010. Its management is considered a public service, which of being performed with regularity, continuity, efficiency, in a safe manner, with tariff modicity, with rational use of water resources, integrated with other public services and aiming at universalization (Alzamora & Barros, 2020; Dutra et al., 2020; Kaza et al., 2018).

In Brazil, the municipalities are the owners of urban cleaning services that seek to keep the cities clean through sweeping services, pruning, weeding and scraping and by services of urban solid waste management (MRSU), which include the stages of collection, transportation, transshipment, treatment, environmentally adequate final disposal of solid waste and environmentally adequate final disposal of the waste (de Souza et al., 2021; International Finance Corporation, 2014; Kaza et al., 2018; Rodi'c & Wilson, 2017; Soltani et al., 2016; Wright et al., 2019).

Thus, municipal management needs to develop actions that promote compliance with environmental legislation, acceptability by users of services and financial sustainability in MRSU services (Marshall & Farahbakhsh, 2013; Rodi'c & Wilson, 2017; Soós et al., 2017; Wilson et al., 2017). How to also act to reduce environmental impacts and promote the circular economy of materials and energy to preserve resources for future generations (Dutra et al. 2018; Liu et al. 2017; Soltani et al. 2016).

To this end, municipalities may provide the service directly through their secretariats and departments or through municipal authorities; and indirectly through concessions or permissions to outsourced companies, authorizations to social organizations or public consortia.

Data from SNIS (2022) they show that the direct service provided by the city hall occurs in 94.63% of the municipalities, followed by the service provided by public companies in 2.71%, local authorities in 1.96% and, finally, in indirect service provided by means of mixed economy companies with public administration in 0.69%. In 5.49% of municipalities there is a partial or total concession of the service, denoting a practice little adopted in the solid waste sector, in which the stage of collection of household waste is granted in 73.6% of the municipalities with concession (SNIS, 2022).

For the planning of urban cleaning activities and MRSU is mandatory the elaboration and implementation by the holders of Integrated Solid Waste Management Municipal Plans (PMGIRS). These plans should contain a broad diagnosis of the situation of the solid waste generated, its characterization and forms of disposal and final disposition adopted, as well as strategies for meeting the present and future demands aiming at the universalization of services BRAZIL, 2010.

In addition, state and federal governments must draw up their own plans to identify major waste streams and their socio-economic and environmental impacts and propose guidelines for planning and other solid waste management activities, including international and macroeconomic trends BRAZIL, 2010.

The budgetary planning for the activities of SLUMRS. is dealt with in the Multiannual Plan (MAP) of each municipality, which contains the description of the set of public policies for the management of solid waste over a period of four years (period of the mandate), and will provide input for the elaboration of the Law on Budgetary Guidelines (LDO) and the Annual Budget Law (LOA).

Accordingly, the correct management of solid waste is tied up with the availability of financial resources, which jeopardize on average 4% of the local budgets in high income countries, 11% in medium income countries and can reach 19% in low income countries (Kaza et al., 2018), with charging the generator for the MRSU service being one of the ways of recovering costs while raising awareness among generators and boosting the circular economy (Alzamora & Barros, 2020; Chung & Yeung, 2019; Slavik & Rybova, 2017).

2.2 THE CHARGE TO THE GENERATOR FOR THE MRSU SERVICE

With regard to the collection by urban cleaning services and MRSU, Brazilian legislation brings a legal difference in the way of raising revenues. According to the Supreme Federal Court (STF) Binding Summary 19, public services for the collection, removal and treatment or disposal of waste from real estate are specific and divisible services (as long as these are dissociated from urban cleaning services), being constitutional their collection by means of a fee or tariff. On the other hand, urban cleaning services, carried out for the benefit of the general population, are indivisible and it is unconstitutional to charge them by means of a fee BRAZIL, 2009.

Thus, while urban cleaning services are financed by the municipal public purse, MRSU services, because of their divisible nature, can be financed by fees or tariffs proportional to the

use of the services (Dutra & Siman, 2024). This vision has as its fundamental principle the "polluter pays" in which it is understood that those responsible for the generation of solid waste should bear the costs for mitigating the impacts of its management, as is already done with services such as water supply, sanitary drainage and residential electricity (Alzamora & Barros, 2020; Chung & Yeung, 2019; L. Dutra et al., 2020; Kurniawan et al., 2021; Meng et al., 2018; Rodi'c & Wilson, 2017; Soós et al., 2017; Wright et al., 2019).

In this sense, the MRSU charge aims to raise awareness among generators to understand that it is not a free service, encourage reduction in generation, boost the circular economy of waste and show that responsibility for management should be shared with all (Alzamora & Barros, 2020; Slavik & Rybova, 2017). The existence of a specific charge (fee or tariff) is directly correlated to the proper destination of the waste as well as to a greater coverage of collection and recycling services (L. Dutra et al., 2020; Gradus et al., 2019). Finally, it is up to the municipal managers to propose public policies that expand the systems for the prevention, recycling and energy recovery of solid waste, to the detriment of those less onerous systems, like the landfill of waste (Slavik & Pavel, 2013).

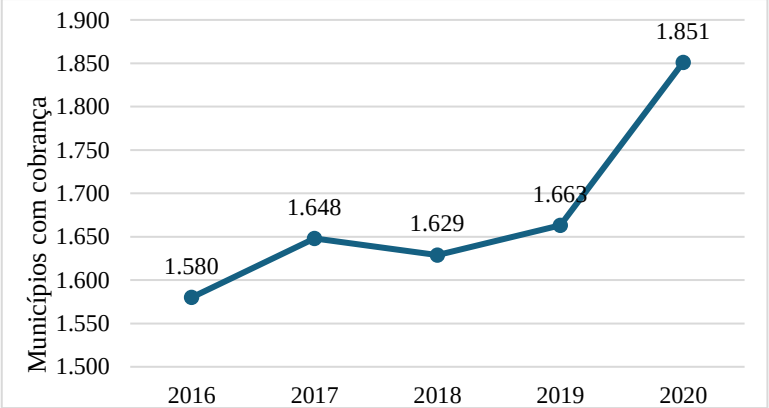
To PWC and SELURB (2022) individualized collection for MRSU services is still strongly correlated to the environmentally appropriate treatment and final disposal of solid waste, and current Brazilian legislation assigns MRSU a treatment of household economic utility (*utility*) in order to attract investments for its universalization.

Corroborating, the analysis of the data from 2017 to 2020 shows that Brazilian municipalities have evolved in charging for MRSU services, showing an increase of 17% in the number of municipalities that reported the existence of charging to the generator, as shown by

Figure 1.

Figure 1

Evolution in collection for solid waste management in total number of municipalities from 2016 to 2020.



Source: Self-authored with data from: (SNIS, 2017, 2018, 2019, 2020, 2021).

In Brazil, there is a need to define whether the charge will be made by means of a fee, tariff or other public prices for the provision of the services. According to the Ministry of the Environment, the fee is a form of tax, and can be charged to the user for the simple fact that the service is being offered, even if not used, while the fee is non-tax, being charged only to the users who use the service, being still subject to termination (BRAZIL, 2016).

In this sense, Brazil (2016) recommends that small generators (households and small retail establishments) should be charged in the form of a fee, while large generators using public services (other retail establishments and generators of other types of waste that are not similar to household ones) should be charged in the form of a fee.

Finally, there is the need to choose the collection document in which the collection will be carried out, for collection methods in which there is the need for invoicing, being common the existence of 3 ways, which can coexist within the same territory:

- In specific billet: where the amount charged to the user is made by means of billet that has as its sole purpose the collection for MRSU services;
- In municipal tax ticket: where the value for MRSU services is charged in already existing billet as the Urban Property and Territorial Tax (IPTU); and
- In a bill for other services: where the value for MRSU services is charged in an existing billet for water supply and/or sanitary drainage or electricity supply.

It should be noted that if the service is billed in already existing billet, the presence of different barcodes for each service is required, which will ensure the individualization of accounting flows (L. Dutra et al., 2020).

Due to the debate on strategies to achieve the financial sustainability of the MRSU system, Reference Standard No. 1 was published by the National Agency for Water and Sanitation (ANA), which provides on the regime, structure and parameters of the collection for the provision of the public MRSU service, as well as the procedures and deadlines for setting, readjustment and tariff reviews (ANA, 2021). That rule states that the charging model to be adopted must ensure the economic and financial sustainability of the provision of the services, taking into account tariff variations and the adoption, preferably, of the charging scheme by means of a tariff (ANA, 2021).

To Alzamora and Barros (2020) it is virtually impossible to determine the best arrangement for implementing a charging model due to the variety of local conditions, with the improvement of the system dependent on the application of adequate technology, advances in environmental education and the participation of users. Appropriate analysis tools are needed to enable decision-making by municipal decision-makers (Di Nola et al., 2018; Hornsby et al., 2017).

In this way, there is no ideal charge, but rather the one that is most suitable for the municipality, which must consider its social, economic and territorial particularities (Hornsby et al., 2017).

3 METHOD

The methodology employed aimed to identify the variables of the collection models existing in Brazil so that it is possible to identify the variables used and to assess their effectiveness in terms of financial sustainability in order to contribute to the formulation of guidelines that favor a fair and balanced collection, according to the methodological steps presented in

Figure 2.

Figure 2

Methodological steps

Source: Self-authored (2024).

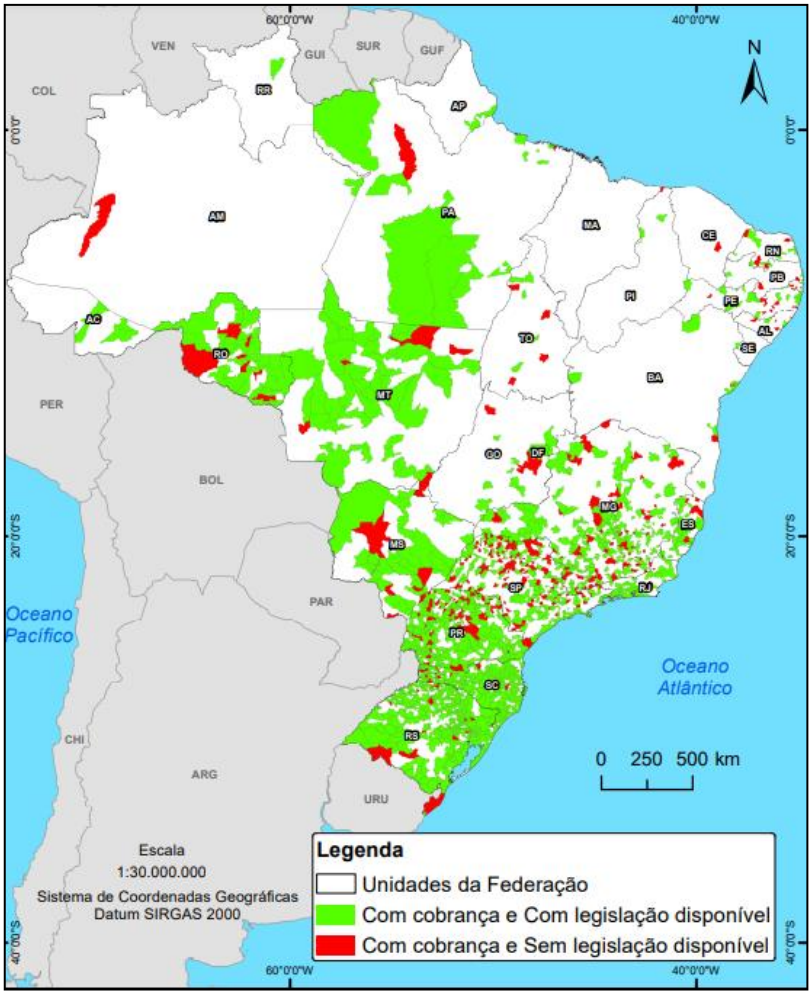
To do so, a documentary survey was conducted with the 1,851 Brazilian municipalities that declared the existence of collection by MRSU services (Code FN201) in the Thematic Diagnosis Urban Solid Waste Management published in 2021, with data collected in 2020, by the National Sanitation Information System (SNIS, 2021), administered by the National Sanitation Bureau of the Ministry of Regional Development (SNS/MDR.).

Of the total of municipalities that declare that they have some form of collection, legislation was found in 1,511 municipalities. Thus, out of the total of 5,570 existing municipalities in Brazil (IBGE, 2024)However, documentary research was carried out in 27% of the total of municipalities and 82% of those that declare that they have some form of collection, which together represented about 47% of the Brazilian population in 2020. A

Figure 3 it presents the map with the location of the 1,851 municipalities that participated in the documentary research, with a highlight (in green) to the 1,511 municipalities from which it was possible to obtain the legislation that implemented the collection in its territory.

Figure 3

Map of the municipalities that participated in the documentary research



Source: Self-authored (2024).

3.1 DATA COLLECTION

The data collection was carried out by a team of 8 researchers participating in the Research Project "Development of a tool for decision making in integrated management of solid waste", registered at the Pro-Rector of Research and Post Graduation of the Federal University of Espírito Santo (PRPPG/Ufes) under the number 10131/2020, in the months of March to December 2022.

Data segregated by municipality of the Thematic Diagnosis Management of Urban Solid Residues were sought at the National Sanitation Information System website (SNIS, 2021), which reflect the level of financial sustainability of municipalities as well as the quality and universality of the provision of MRSU services. A Table 1 summarizes the data collected in SNIS.

Table 1

Variables identified in the National Sanitation Information System (SNIS).

Parameter (Code in SNIS)	**Variables**
Financial self-sufficiency (IN005)	%
Average expenditure per capita on MSW (IN006)	R$/inhabitant
Existence collection with container lifting (Co131)	Yes; No
Existence of night collection (Co008)	Yes; No
Existence of any service granted (GE202)	Yes; No
Existence of balance collection (Co021)	Yes; No
Existence of selective collection (Cs001)	Yes; No
Form of provision of the services	Direct public administration; Municipality; Public enterprise; Mixed economy company
Form of collection (FN202)	Rate; Rate
Average incidence of collection cost in total management cost (IN024)	%
Average incidence of the cost of the variation in the total cost of handling (IN046)	%
RPU collection occurrence along with RDO (Co154)	Yes; No
Population served (Co164)	Inhabitants
Total population	Inhabitants
Quantity collected in selective collection (except organic matter) (Cs026)	Tons
Total amount of waste collected (Co119)	Tons
Average revenue collected per capita with management services (IN011)	R$/inhabitant
Recyclable Recovery Rate (IN031)	%

Source: Self-authored (2024).

The documentary research was carried out on the Internet in sites of city halls and municipal legislative chambers in search of the legislation in force in each municipality studied. Tax and/or urban cleansing codes, decrees, laws, resolutions of municipal councils and regulatory agencies, among other municipal laws governing the collection by MRSU in municipalities, were consulted.

It should be noted that in Brazil there is no central repository with the laws of all municipalities, which made the search be carried out municipality by municipality. Moreover, sometimes the legislation available is not the most recent because there is sometimes a delay in publicizing the legislation adopted.

For each of the 1,511 municipalities, the legislation establishing the collection, the collection model, the collection institution tool, the collection document used, the MRSU services covered in the collection, the parameters used for the calculation of the collection, the method of calculating the collection and the types of taxpayers covered in the collection, as presented in the Table 2.

For the cataloging of the consulted legislation, a cloud database was created on the *Microsoft SharePoint* platform, which functioned as a unified collaboration repository for

storing the discovered documents. For the monitoring of the data *collection process, an application was developed in Microsoft Power Bi*, which allowed the evaluation and visualization of collected data in real time.

Table 2

Variables identified in the documentary research.

Parameter	**Variables**
Legislation establishing recovery	Law; Supplementary Law
Billing Template	Fixed; By use; Combined
Instrument of collection	Rate; Rate; Other public prices
Collection document	Specific billet; In billet of water and/or sewer; In billet of IPTU
Services covered	Collection; Transport; Final arrangement; Sweeping; Road conservation; Stream cleaning; Galleries cleaning; Other
Parameters used for the calculation of the charge	Area units; Area bands; Built-up area; Tested; Location zone; Service frequency; Construction pattern; Water consumption; Waste production coefficient; Other
Method of calculating recovery	Tabulated values; Formula
Types of contributors	Commercial; Industrial; Service Delivery; Residential; Land

Source: Self-authored (2024).

The data collected was systematized in Microsoft Excel software and, due to the population difference in the municipalities surveyed, were grouped by population range according to SNIS (2021), as shown in Table 3.

Table 3

Distribution of participating municipalities by population.

Range	**Municipal population**
1.	≤ 30 thousand inhabitants
2.	between > 30 thousand and ≤ 100 thousand
3.	between > 100 thousand and ≤ 250 thousand
4.	between > 250 000 and ≤ 1 million
5	between > 1 million and ≤ 4 million
6	> 4 million

Source: Self-authored (2024).

In addition, due to the long time lag between the publication dates of the consulted legislations, they were classified in bands by publication time (5, 10, 20, 30 and more than 30 years).

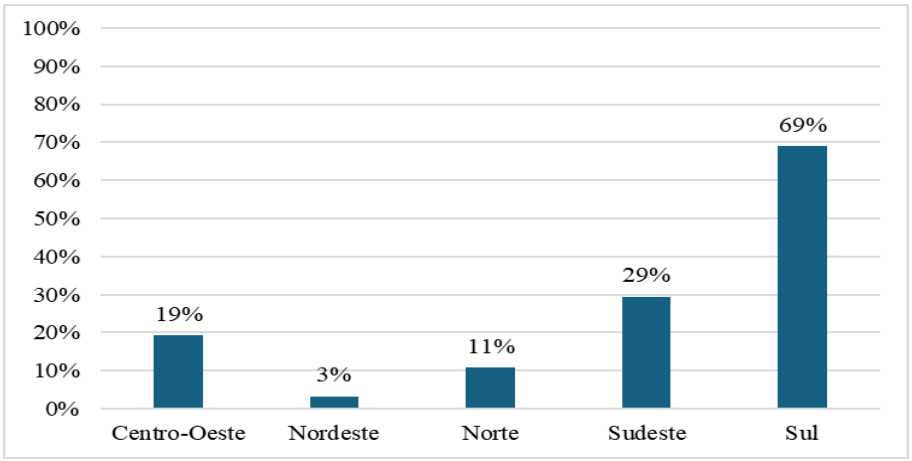
4 RESULTS AND DISCUSSION

4.1 FINANCIAL SUSTAINABILITY ANALYSIS OF MUNICIPALITIES CHARGED FOR MRSU SERVICES

The analysis of the data of the 1,851 municipalities that declared the existence of collection by MRSU services in the (SNIS, 2021) has made it possible to verify that there are regional differences in the adoption of the levy. As we can verify in Figure 4 in the southern region 69% of the municipalities have a collection system, while in the northeastern region only 3% of the municipalities have adopted the collection system. In this sense, Mannarino et al. (2016) they show that although the requirements defined by the PNRS are the same for the whole country, the reality about the capacity to invest in the management of solid waste is very different between the Brazilian regions and municipalities.

Figure 4

Existence of collection for MRSU services in municipalities of Brazilian regions



Source: Self-authored with data from: (SNIS, 2021).

Cetrulo et al., (2018) they highlight that the technical and management capacity available in the country is not sufficient to face the challenges of implementing legislation, as municipalities face a lack of human resources for planning, implementing, managing and supervising legal requirements.

The data collected enabled the classification of municipalities, by population range, of financial self-sufficiency, the amounts collected, the expenses per capita, average costs of the collection service and the collection and variation incidences in the total cost of the MRSU service, as shown by the Table 4.

Table 4

Financial self-sufficiency by population group of municipalities that declared the existence of collection by MRSU services in the (SNIS, 2021).

Range	Total municipalities	Total population	Average financial self-sufficiency	Average expenditure per capita on MRSU (R$/inhab.)	Average revenue collected per capita (R$/inhab.)	Average incidence of collection cost in total management cost	Average impact of the cost of the variation on the total cost of the MRSU
1.	1,340	13 550 359	34.84%	R$145.16	R$38.35	62.01%	23.40%
2.	320	17 415 779	50.24%	R$111.57	R$48.19	60.67%	20.14%
3.	113	17 607 786	57.74%	R$117.67	R$63.50	56.06%	19.75%
4.	67	31 335 974	44.70%	R$145.07	R$64.84	47.26%	14.55%
5	10	18 384 280	59.52%	R$138.01	R$83.23	43.36%	12.77%
6	1.	6 747 815	100.00%	R$322.21	R$322.21	35.09%	12.39%

Source: Self-authored with data from: (SNIS, 2021).

An important fact is that the methodology used by the Ministry of Cities to investigate the financial self-sufficiency of municipalities used with the formula of calculation the "Revenue collected with fees and tariffs related to the management and management of MSW" divided by the sum of the "Expenditure of public agents implementing MRSU services" with the "Expenditure with private agents performing MRSU services". Expenditure amounts, with public and private agents, account for expenses with urban cleaning services that should not generally be included in the account, since they cannot be financed by collection due to legal impossibility. In this respect, the SNIS does not allow the real financial self-sufficiency of the municipalities with the MRSU services to be calculated, since there is no official data that allows the separation of MRS. spending from urban cleaning spending.

While current legislation makes it possible for collection to be able to recover 100% of the costs for MRSU services studies show the need to identify the provision to pay for these services (Chung & Yeung, 2019; Feitosa et al., 2018; He et al., 2021; Subhan et al., 2014). According to the authors, such consultation would indicate the monetary value that a population would be willing to pay in exchange for a particular product or service or to ensure the improvement of welfare.

A Table 4 shows that the average revenue collected per capita has been about 2 times less than the average expenditure per capita on the MRSU, with a greater deficit in the municipalities of Belt 1, where the average revenue per capita is about 4 times less than the average expenditure per capita. This can be explained in part by the higher incidence of sweep and collection costs in Track 1, which together represent 85% of the total costs with MSW.

The average per capita income of R$ 42.95 per inhabitant in Brazil is about 11 times less than the average per capita income of R$ 470.00 per inhabitant found in developed countries such as Australia, the United States of America, Japan and members of the European Union (Alzamora & Barros, 2020; R. M. de S. Dutra & Siman, 2024).

For a better analysis of financial self-sufficiency by population band the figures presented on average in the Table 4 are presented by self-sufficiency band in the Table 5.

Table 5

Number of municipalities per bands of financial self-sufficiency that declared collection by MRSU services in the (SNIS, 2021).

	Financial self-sufficiency					
Range	**< 20 %**	**≥ 20 % < 40 %**	**≥ 40 % < 60 %**	**≥ 60 % < 80 %**	**≥ 80 % < 100 %**	**≥ 100 %**
1.	607	310	165	110	62	86
2.	81	74	53	42	33	37
3.	29	19	14	16	13	22
4.	17	18	14	10	3.	5
5	1.	2.	2.	2.	3.	0
6	0	0	0	0	0	1.
Total	**735**	**423**	**248**	**180**	**114**	**151**

Source: Self-authored with data from: (SNIS, 2021).

In Table 5 it was found that only 151 of the Brazilian municipalities (8% of the municipalities surveyed) achieved self-sufficiency in the MRSU services. It is worth noting the existence of municipalities with values of financial self-sufficiency greater than 100% which may indicate an inconsistency in the data reported by municipalities or investments planned by municipalities for improvements of MRSU services. In addition, 40% of municipalities have figures lower than 20% pointing to insufficient revenue to recover MRSU services costs.

The figures presented in the Table 5 They also show that Brazilian municipalities are far from reaching Target 1 of the National Solid Waste Plan (PLANARES), which aims to reach 68% of municipalities with financial equilibrium in the cost of urban cleaning services and MRSU by 2040 (BRAZIL, 2020b).

A Table 6 presents the comparison of care to the population in municipalities with and without the charge for MRSU services. Where it is possible to verify that the municipalities with collection have the largest population attended with the services of MRSU in all population groups, with the exception of Band 5.

Table 6

Comparison of care to the population in municipalities without and with the charge for MRSU services (SNIS, 2021).

No charge for MRSU services								
Range	**Popup answered declared**	**Existence of service granted**	**Existence of selective collection**	**Average recycling rate**	**Nocturnal collection**	**Collection with container elevation**	**RPU collection along with RDO**	**Balance Usage**
1.	69.69%	4.86%	18.55%	2.80%	9.32%	5.82%	67.82%	20.27%
2.	78.99%	10.10%	29.81%	2.37%	45.91%	20.19%	66.59%	34.62%
3.	93.09%	20.24%	52.38%	1.67%	76.19%	40.48%	51.19%	72.62%
4.	97.86%	25.00%	68.75%	2.08%	90.63%	46.88%	53.13%	84.38%
5	99.81%	80.00%	100.00%	1.06%	100.00%	40.00%	20.00%	100.00%
6	99.10%	100.00%	100.00%	2.50%	100.00%	100.00%	0.00%	100.00%
Charged for MRSU services								
Range	**Popup answered declared**	**Existence of service granted**	**Existence of selective collection**	**Average recycling rate**	**Nocturnal collection**	**Collection with container elevation**	**RPU collection along with RDO**	**Balance Usage**
1.	86.10%	5.52%	51.42%	9.67%	9.93%	7.99%	57.76%	49.70%
2.	90.23%	6.88%	69.06%	7.35%	65.63%	30.31%	57.50%	71.25%
3.	95.00%	9.73%	74.34%	4.77%	89.38%	52.21%	62.83%	84.07%
4.	96.92%	26.87%	83.58%	1.91%	95.52%	68.66%	53.73%	95.52%
5	98.34%	30.00%	90.00%	1.41%	90.00%	70.00%	30.00%	100.00%
6	100.00%	100.00%	100.00%	1.36%	100.00%	100.00%	0.00%	100.00%

Pop! = population; SPS = public waste; ODR. = household waste.
Source: Self-authored with data from: (SNIS, 2021).

A **Erro! Fonte de referência não encontrada.Erro! Fonte de referência não encontrada.**Table 6 reinforces the statement that MRSU services are still little granted to private companies, and occur mainly in more populous municipalities (Tracks 4, 5 and 6). To BRAZIL (2020b)However, the adoption of measures to ensure the recovery of costs with the services, for remuneration by the users, coupled with the concession of the services, allows medium to long term investments by the concessionaires, increasing the chances of effective implementation of effective solutions for the improvement of the management of MSW.

With regard to selective collection, on average, 57% of the municipalities that have adopted the collection have this service, demonstrating a value 2 times higher than the 22% of the municipalities where there is no collection, but provide the selective collection service. While MRSU costs increase when selective collection service is provided (Campos-Alba et al., 2021; Chifari et al., 2017), these costs can be minimized by implementing economies of scale and aggregating demand in consortia (Galavote et al., 2023). Furthermore, the expansion of selective collection is a target of PLANARES, which aims to recover 20% of dry recyclables, in relation to the total mass of MSW, by 2040 (BRAZIL, 2020b).

Although the recycling rate shows values lower than 10% for all the population groups employed by the National Sanitation Secretariat, it is important to highlight that the average rate of utilization of the dry recyclable residue in Brazil was only 1.65% (SNIS, 2021). In this respect, studies show that the adoption of collection may favor not only the segregation of waste at the source of generation, but also the increase of recycling rates (Chung & Yeung 2019; Gradus et al. 2019; Grazhdani 2016; Slavik & Pavel 2013).

To Matheson (2022), developed countries with financial self-sufficiency in MRSU exhibit high recycling rates as they can fund several programs to promote recycling actions in their territories. On the other hand, developing countries such as Brazil have shortcomings such as insufficient financial resources, lack of political will and insufficient policies on recycling and the circular economy (Araya-Córdova et al., 2021; R. M. de S. Dutra et al., 2018).

Moreover, by the interpretation of **Erro! Fonte de referência não encontrada.Erro! Fonte de referência não encontrada.**Table 6 it can be seen that the municipalities that have implemented collection systems have a better organization of the services with separation in the collection of public waste coming from the urban cleaning of household waste, with the use of container lifting, which facilitates the operation of waste collection, use of scales for measuring the quantities collected and availability of the night time collection service.

Night-time collection, particularly in densely populated regions, optimizes waste collection by reducing operating costs and avoiding congestion (Miftahadi et al., 2024), and is present in 92% of the municipalities with a population above 100 thousand inhabitants (Ranges 3 to 6) and that have collection.

In relation to the use of scales, (SNIS, 2022) the practice of weighing the collected waste is perceived in less than half of the brazilian municipalities, and it is common to carry out an estimate of the generation instead of the measurement, a fact that occurs mainly in municipalities with less than 30,000 inhabitants (Band 1).

Similar fact is seen as to the collection of SPS being carried out along with the collection of RDO, which prevents an evaluation of the generation of each plot separately, where only Ranges 5 and 6 have the majority of municipalities doing the segregation in the collection.

4.2 ANALYSIS OF MUNICIPAL LEGISLATION FOR THE FINANCIAL SUSTAINABILITY OF THE MRSU

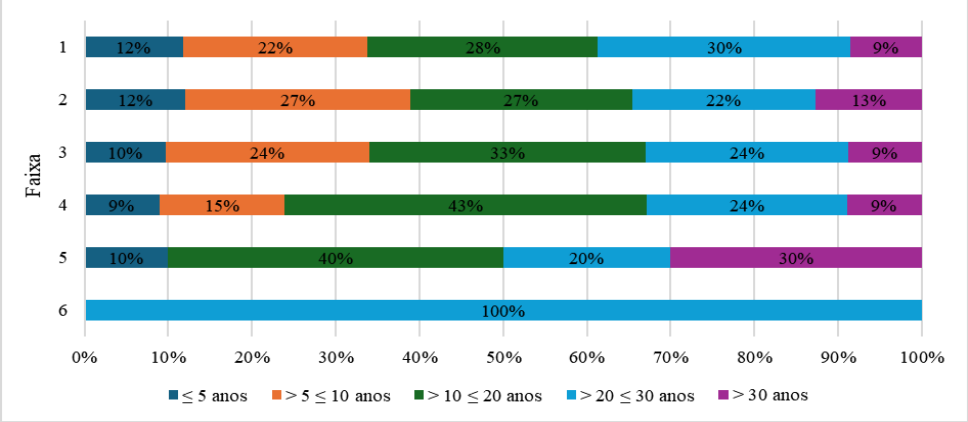
The evaluation of the municipal legislation that instituted the collection in each of the 1,511 municipalities assessed made possible an analysis not only of the present legislation, but

also of the services covered in the collection, types of taxpayers, calculation basis and collection document. At the same time, the non-localization of the legislation of 339 municipalities highlights the need for transparency of the collection rules to which users are submitted. To Mannarino et al. (2016) the availability of information is vital for the provision of the MRSU service, while Soós et al. (2017) highlights the need for financial transparency so that users and operators are aware of the cost of services and the available budget, uniting them in a service-payment relationship.

With the analysis of the data obtained, it was possible to show the time of publication of municipal legislation that implemented or updated the collection in municipalities, in which it is verified that there are Laws that date from the year 1960 until the year 2022, the year in which the data collection was carried out. Due to this large time lag, the legislations were classified in the range of 5, 10, 20, 30 and more than 30 years, as shown by the Figure 5.

Figure 5

Time of publication of the last legislation that implemented/updated the MRSU charge



Source: Self-authored (2024).

In Figure 5 we note that most of the municipal legislation was published more than 10 years ago (between 1993 and 2012). It should be noted that the documentary research sought the most recent municipal legislation regarding the collection by MRSU services, so that municipalities cataloged as legislation in the last 5 years, may have started their collection at an earlier date.

Looking at the federal legislations considered as milestones for the theme, we found that 95% of the legislations were published after Federal Law 11,445/07, when it was established that MRSU services should have their economic and financial sustainability ensured, whenever possible, by charging the services (BRAZIL, 2007). Already 79% of the

legislations were published at a date later than Federal Law 12.305/10, which established the PNRS, in which the system of collection by the MRSU became the mandatory content of municipal integrated waste management plans BRAZIL, 2010. While 12% were published after Federal Law 14.026/20, which updated the legal framework for basic sanitation and provided penalties for municipalities that did not propose a collection instrument for MRSU services (BRAZIL, 2020a).

However, the existence of legislation, which is necessary to initiate collection, is not sufficient for its implementation, since there are a number of challenges for its implementation, such as the need for municipal managers to be trained to manage the costs of MRSU services and the revenues measured with collection (Alzamora & Barros, 2020; International Finance Corporation, 2014). There is also a need for proper planning for MSW management (Ferreira & Barros, 2021) and that the public is properly made aware (Rodi'c & Wilson, 2017; Slavik & Rybova, 2017).

Regarding the empowerment of municipal managers, Chaves et al. (2014) They highlight that in Brazil municipal secretaries, as well as their assistants, are political appointments or motivated by self-interest and generally do not imply technical capacity to perform a specific function. To Razzaq et al. (2021) and Vargas-Terranova et al. (2022) technical capacity is essential for the choice of the charging model to be adopted and for defining the investments needed to improve the MRSU system.

While Rebehy et al. (2017) underline that the lack of planning and up-to-date information impacts on the self-sufficiency of MRSU systems, making it impossible to increase revenues Ferreira & Barros (2021) costs of the MRSU rise and damage to the quality of life of the population and the environment.

On social participation Brumatti et al. (2024) they show that without knowing the impacts of their actions, the population becomes less motivated to take part in recycling programs. What can be solved by adopting educational programs that foster behavioral change and the awareness of the population (Byamba & Ishikawa, 2017).

In relation to the type of legislation that made possible the institution of collection in the municipalities assessed, in 55% of them the collection was instituted by law, while in 45% by Complementary Law**Erro! Fonte de referência não encontrada.**. The evaluation of the 122 municipalities evaluated that are self-sufficient (IN005 ≥ 1) and had legislation available online, shows similar values, with 60% of the municipalities with the collection instituted by Law and 40% by Supplementary Law.

Second Oak & Aquino (2020) supplementary laws have a prominent position in tax matters and are more stringent in terms of quorum for approval because they require approval by an absolute majority of the plenary, while ordinary laws require a simple majority of those present at the session in which they are voted. Thus, the need for a smaller number of councilors to pass the ordinary law can justify its greater use in the deployment of user billing by MRSU.

For the services covered by the legislation that imposed the collection, the analysis of the data shows the execution of divisible services of handling (collection, transport, final disposition), as well as of indivisible services of urban cleaning (sweeping, conservation of roads, cleaning of streams, cleaning of galleries among others) (

Figure 6). This shows that the legislation of many municipalities does not yet differ between the services of handling and urban cleaning.

In

Figure 6 We can verify that the services of collection, transportation and destination are covered in the collection of 99% of municipalities on average, being present in 100% of the 78 municipalities that are in Ranges 4, 5 and 6. Urban cleaning services are included in the collection of 71% of the municipalities on average.

When considering only the 122 self-sufficient municipalities assessed, it is found that the collection, transportation and destination services are covered on average in the same 99% of the legislations and the urban cleaning services in 61%, indicating that the municipalities with better financial health have a better division of the costs of handling and urban cleaning.

The preponderance of collection and transportation services in legislation is explained by the fact that these steps corresponded to between 80 and 95% of the total cost of MRSU services (Benitez-Bravo et al. 2021; Colvero et al. 2020; Franca et al. 2019; Jaunich et al. 2016). It should be noted that, unlike drinking water and sewage services, the operational costs of services (OPEX) in the MRSU system are substantially higher than the capital costs for investment (CAPEX) because of the logistical nature of the activity and are often the most difficult to sustain (Dutra et al., 2020; Kaza et al., 2018). This Brazilian practice is in line with what is carried out in other countries of the world where OPEX is funded by collection systems through the payment of fees and tariffs (Kaza et al. 2018; Soós et al. 2017; Wilson et al. 2017).

With regard to the categorization of taxpayers, the laws consulted usually categorize the beneficiaries of the services in residential, commercial, industrial, service provision or land (Figure 7). It is possible to note that in almost 100% of the ranges there is the category "residential" and "commercial", followed by the category "industrial" in 95% of the municipalities, "provision of services" in 74% and "land" in 46%. Similarly, the assessment of the 122 self-sufficient municipalities shows that in 100% of the legislations there are the

categories "residential" and "commercial", in 95% there is the category "industrial", in 81% the category "provision of services" and in 44% the category "land".

Although the responsibility of the public authorities lies solely with the provision of MRSU services, PNRS allows waste generated by commercial, industrial and service providers establishments to be managed by the public authorities by charging the costs of the services (BRAZIL, 2010, 2020a), which justifies the presence of these types of taxpayer in the legislation consulted.

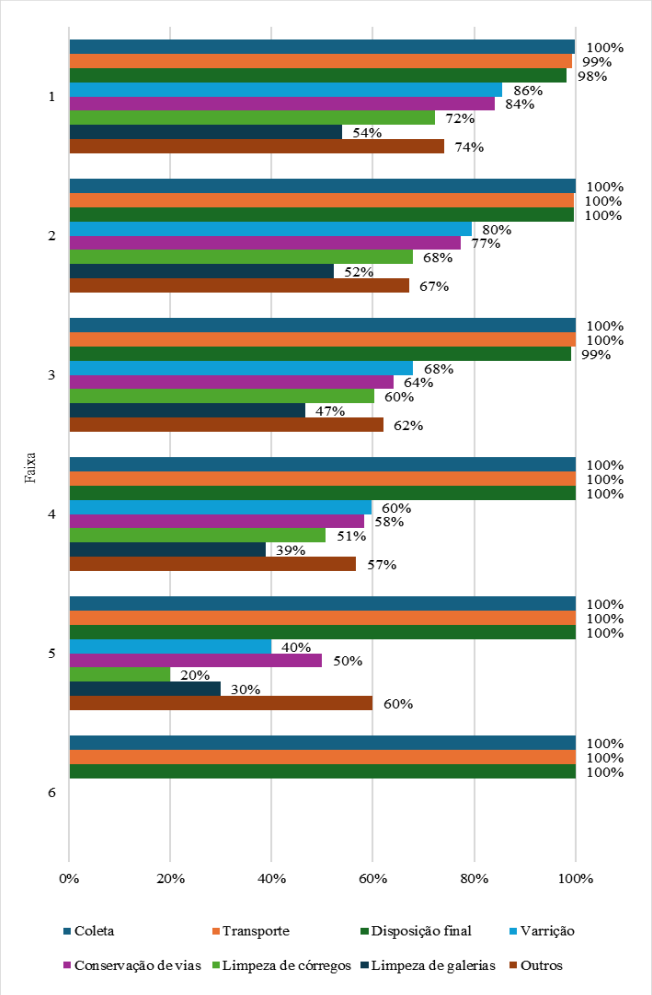
In addition, waste from service providers if characterized as non-hazardous may, by reason of its nature, composition or volume, be treated as household waste and managed by the municipal public authority (BRAZIL, 2010, 2020a).

Another fact to be highlighted is that the Brazilian legislation allows charging because of the potential generation of waste, as in the case of land and garages, since the MRSU services can be charged because of the simple disposition to the user (Favacho & Souza, 2020).

One point observed in the legislation is that although they make it possible to charge generators, which PNRS would be responsible for the solid waste generated by them, the possibility of non-payment of the charge in the cases where the generator does the management itself has not been verified.

Figure 6

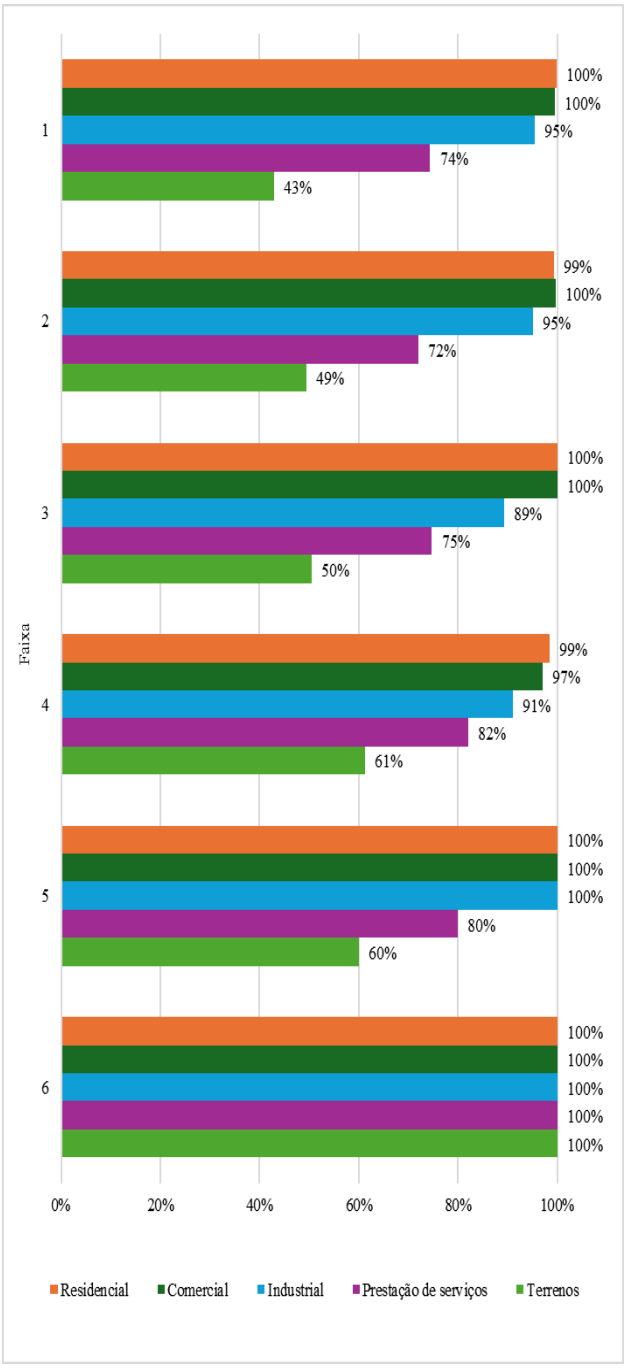
Services covered by the collection.



Source: Self-authored (2024).

Figure 7

Types of contributors to the collection.



Source: Self-authored (2024).

One of the major points of attention of the collection formulation is the definition of the parameters that will be used in the calculation methodology for each taxpayer. In this respect, the study showed the existence of the 10 main parameters that can or cannot be used together (

Figure 8).

In

Figure 8 we found that the most used parameters for charging are the "built-in area", the "area range" and the "frequency of service". It should be noted that the "built area" factor is practically excluded from the "area range" factor, only occurring in the same legislation in less

than 1% of the consulted legislations. Added together, the factors that involve calculating the "area" are present in 36% of the municipalities surveyed. Similarly, when the factor ‘water consumed’ is used the factors of ‘built-up area’, ‘area factor’, ‘location zone’, ‘tested’ and ‘standard construction’ are not used.

A similar result was seen for self-sufficient municipalities that present in their formulations for calculating the charge the "built area" in 97% of the cases, the "frequency of service" in 33%, "others" in 25%, "area factor" in 20%, "tested" in 18%, "location zone" in 16%, "garbage production coefficient" in 15%, "area unit" in 14%, "water consumption" in 4% and "construction standard" in 0%.

An important aspect verified in Brazilian legislation is the poor use of parameters that make mention of the quantity of waste generated, which would make possible a fairer collection of the users. The use of parameters related to the quantity of waste generated also brings a stimulus to the reduction of generation, since it provides for payment proportional to the quantity benefited by the service offered (Dutra et al., 2020; Wright et al., 2019).

In this respect, charging by MRSU based on water consumption bands has been presented as a valid alternative to the use of area factors (Franco et al., 2014), particularly where there are no up-to-date building registers. While for L. Dutra et al. (2020), water-based charging can only encourage a reduction in water consumption and not necessarily the generation of waste.

One parameter that was not verified in the consulted legislations is the consumption of electrical energy, which can be used in a similar way to the consumption of water. Second L. Dutra et al. (2020) Electric power consumption has been used successfully in Bogotá, the capital of Colombia, where it has been noted that default has decreased.

In relation to the document used for collection, 83% of the municipalities surveyed collect the services of MRSU in the same billet of the Tax on Urban Land and Property (IPTU), a fact that occurs in 100% of the municipalities of Strips 5 and 6 (Figure 9). The collection in billet of water and/or sewage occurs in 168 municipalities, mainly in Belt 3, where corresponds to 21% of the municipalities of the Belt. Charging by way of Tarifa occurs in only 4 municipalities researched of which, 3 belong to the state of Santa Catarina (Itajaí, Balneário Camboriú and São Francisco do Sul), besides Carmópolis de Minas-MG.

It should be noted that the legislation of some municipalities allows more than one form of collection launch, as occurs in Jataizinho-PR, in which the Tax Code allows the Collection Rate and Disposition of Garbage to be released annually in the billet of IPTU or monthly in the billet of water and sewage of the Autonomous Water and Sewage Service of the municipality.

Different values were observed in the self-sufficient municipalities, where although the collection in the billet of IPTU is majority (70% of the municipalities), the collection of tax in billet of water and/or sewage increased to 25%, followed by the tax alone or in conjunction with other taxes in 3%, tax in specific billet in 2% and tariff in 2%, where also legislation allowing more than one collection document was observed.

Second Alzamora & Barros (2020)However, there is a tendency in Brazil for municipalities to charge in the same billet as the IPTU, almost always using the area of the property as the basis of calculation. In this sense, PLANARES (BRAZIL, 2020b) shows that there is a better collection performance through specific billet, since and the individualization of collection in a single bill facilitates control by municipalities and reduces the rate of default of taxpayers. It also points out that charging in specific billet allows to expand and improve the bases of calculation and incidence of collection, while the IPTU contemplates several exemptions and generally presents high default (BRAZIL, 2020b).

Figure 8

Parameters for the basis of calculation of the charge.

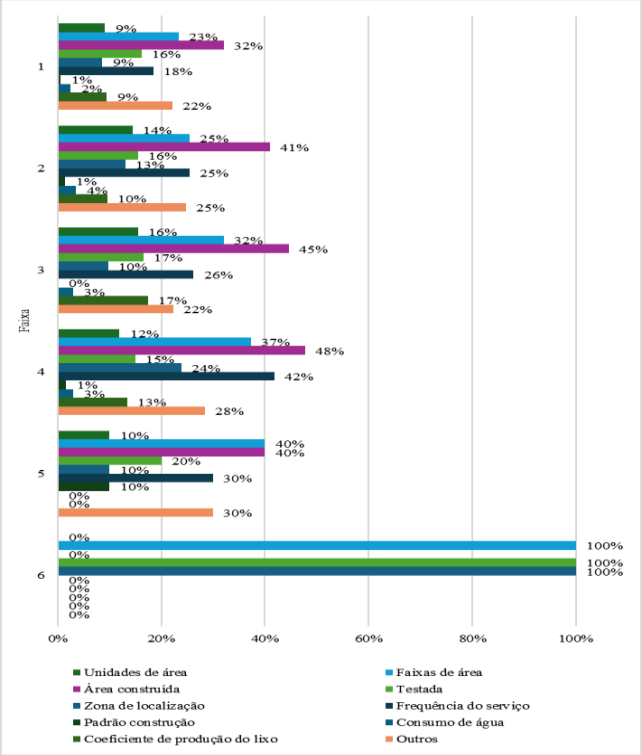
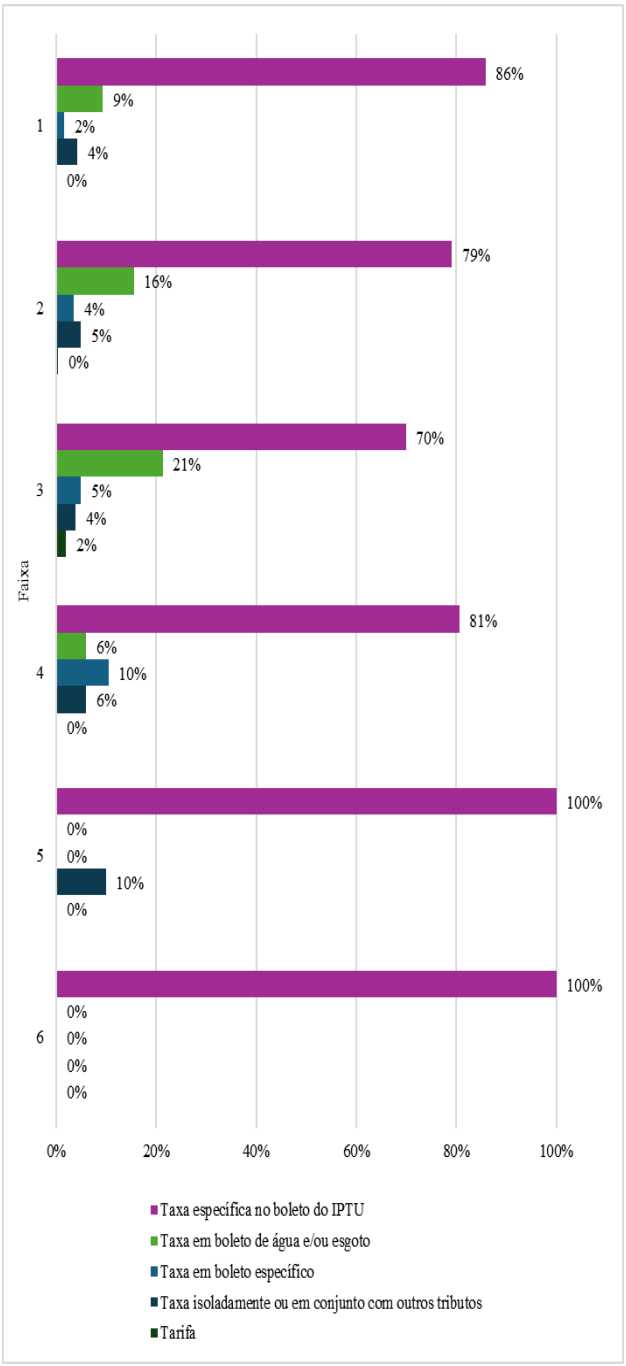


Figure 9

Collection document used.



Source: Self-authored (2024).

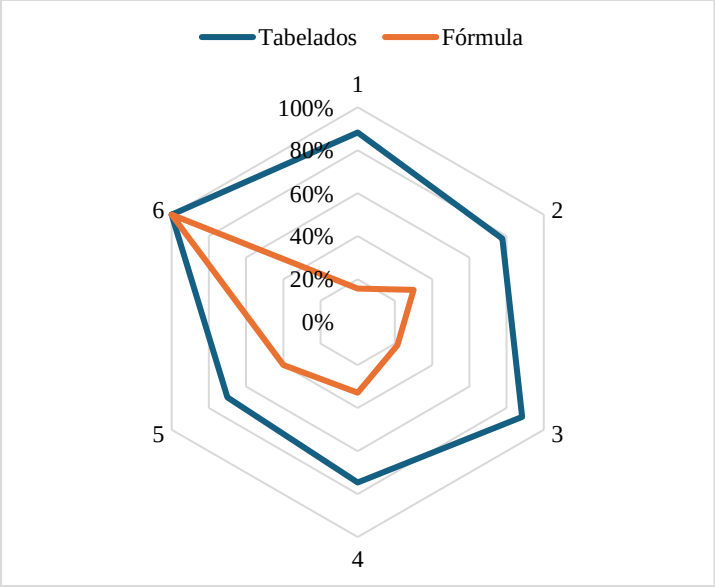
Another point analyzed in municipal legislation is whether the collection is done by means of a formula where the amount of the charge is the result of a mathematical equation or by means of tabulated values, where bands are adopted on the basis of one or more parameters and the amount charged depends on the band in which the consumer fits.

In Figure 10 we found that 86% of brazilian municipalities adopt charging by means of tabulated values, and there are also cases in which there is a combination of charging methods, as in the municipality of Rio de Janeiro (Band 6) where the calculation of charging uses a

formula that has as variables a reference value, a coefficient by group of districts and a coefficient by use of the property, whose values are divided into tabulated bands. This figure remained close to the evaluation only of self-sufficient municipalities, in which 82% adopt charging by means of tabulated values.

Figure 10

Method of calculating the MRSU charge.



Source: Self-authored (2024).

4.3 GOOD PRACTICES FOR SETTING UP THE CHARGE BY THE MRSU

In the interests of fair and equitable collection, the implementation of the levy should be preceded by updating the database of the services provided for each generator and their respective costs (Alzamora & Barros, 2020; Mannarino et al., 2016). As well as reading the local socio-economic conditions, making the population aware that it is effectively responsible for the amount of waste it generates and evaluating its willingness to pay for MRSU services (Chung & Yeung 2019; L. Dutra et al. 2020; Hornsby et al. 2017; Soós et al. 2017).

Next, it is necessary to define the charging model to be implanted and the calculation parameters (property category, collection frequency, built-up area, water consumption, among others) (ProteGEEr, 2021), which shall be assessed through public consultations (Chung & Yeung, 2019; Rodi'c & Wilson, 2017)

Charge deployment can be done in a staggered manner, providing the need for complementations with other sources of revenue during its implementation (International

Finance Corporation, 2014; Kaza et al., 2018). It should also provide tariff modicity and total or partial exemption for low income users (Kaza et al., 2018). To be successful, collection must be preceded and run in parallel with social and environmental communication programs that encourage the participation of the population in the segregation of waste (Slavik & Rybova, 2017).

The verification of the efficiency of the adopted model should be carried out by means of indicators such as revenues raised from collection, default rates and the evaluation of user satisfaction (Alzamora & Barros, 2020; Slavik & Rybova, 2017) and should provide compliance with the local environmental agenda (Bing et al., 2016; Chaves et al., 2014; Rodi'c & Wilson, 2017).

To improve the collection, actions should be foreseen to review the model and to expand the MRSU services to unattended areas and new allotments (Slavik & Rybova, 2017), and incentives may be provided for participation in voluntary delivery programs (Mannarino et al., 2016) and compensation for communities near MSW disposal sites (Rodi'c & Wilson, 2017).

A Figure 11 provides a summary of best practices for billing deployment analyzed in the literature organized according to the PDCA cycle.

Figure 11

PDCA Cycle for Proposition of Charging by MRSU Services

Source: Self-authored (2024).

5 FINAL CONSIDERATIONS

The performance of this study allowed a better understanding of the reality of the Brazilian municipalities faced with the need to make effective their systems of collection to the generator by MRSU services and achieve the defense financial self-sufficiency.

Of the 1,851 municipalities that instituted that declared the existence of collection for MRSU services in 2021, only 151 managed to balance costs and revenues through collection, and of these 40% still show values less than 20% of collection pointing to insufficient revenue to recover the costs of MRSU services. This also indicates a great effort to reach the target foreseen in the PLANARES, which aims to reach 68% of municipalities with financial balance in the cost of urban cleaning and solid waste management services by 2040.

In relation to the municipal legislations that instituted collection in municipalities, there were municipalities in which the legislation has not been updated for more than 40 years, although 95% of the consulted legislations were published at a later date than the federal legislations for basic sanitation and integrated management of solid waste. These legislations mainly aim at recovering costs from the collection, transportation and final disposal activities of MSW, although many do not differentiate MRSU services from urban cleaning, which prevents the actual financial self-sufficiency of municipalities from being calculated only with MRSU services.

In the formulation of the charge municipalities have employed the categorization of their users in residences, businesses, industries, service providers and land and the charging methodology has been based on 97% of the cases studied in the area of the property, without measuring the real generation of solid waste by the user, which would make possible a fairer collection of the users and a stimulus to the reduction of the generation.

The municipalities that achieved financial sustainability in the MRSU have implemented collection systems that recover the costs of collection, transportation and disposal services of solid waste in 99% of the municipalities, with the division of users into residential and commercial in 95% of the cases, using their calculation base in the built area of the properties.

It was found that the collection is mostly done in the same billet of the Urban Property and Territorial Tax (IPTU) which makes it difficult to control the default of taxpayers, and prevents the improvement of the bases of calculation and incidence of collection, since in Brazil the IPTU contemplates several social exemptions.

The studies consulted also made it possible to identify good practices for the deployment of the MRSU collection for fair and equitable collection.

For future studies, it is suggested to formulate dynamic systems to better understand the synergy between the studied variables and the effectiveness of the actions of qualification of managers and education and awareness of the population.

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