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Evaluation of selective collection with sustainability indicators in Brazilian cities

Avaliação da coleta seletiva por meio de indicadores de sustentabilidade em cidades brasileiras

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ABSTRACT: In Brazil, door-to-door selective collection is the responsibility of municipal administrations and may be operated by municipalities, contracted companies and/or waste picker organizations. However, the regulatory framework created by the country's National Solid Waste Policy prioritizes selective collection operated by waste picker organizations. This article analyzes two modalities of municipal selective collection, from the perspective of the various dimensions of sustainability: one operated in partnership with waste pickers and the other operated without this partnership. A total of 20 municipalities in the states of São Paulo (11) and Minas Gerais (9) were selected, which operate with waste pickers (SP=7 and MG=4) and without them (SP=8 and MG=1) and semi-structured questionnaires were applied face-to-face with their respective selective collection managers from January to April 2014. Although the data refer to a different context in comparison to the current situation, considering the profound changes that have occurred in the inherent public policies and the transformations arising from the pandemic that ravaged the country, the proposed comparative study remains up to date and relevant for the management of urban solid waste. The outcomes of the questionnaires fed a set of selective collection sustainability indicators (12), resulting from the research by Besen et al. (2016). Both modalities were shown to be very favorable in promoting education and dissemination, shared management and the establishment of partnerships. Unfavorable results were found, in both cases, for the indicators of *self-financing*, *recovery rates of recyclables and rejected material*, *environmental work conditions*, and *worker health and safety*. As determinant factors for the sustainability of selective collection: the need for investments in infrastructure, logistics and in the improvement of working conditions and worker

health was highlighted, as well as an urgent need to promote financial sustainability, based on charging for the services provided.

Keywords: sustainability indicators; solid waste; waste pickers; selective collection.

RESUMO: No Brasil, a coleta seletiva porta a porta é atribuição das administrações municipais e pode ser operada pelas prefeituras, por empresas contratadas e/ou por organizações de catadores de materiais recicláveis. Por outro lado, o marco regulatório trazido pela Política Nacional de Resíduos Sólidos do país prioriza a coleta seletiva operada por organizações de catadores. Este artigo analisa duas modalidades de coleta seletiva municipal, na perspectiva da sustentabilidade em suas diversas dimensões: a operada em parceria com e a operada sem essa parceria. Foram selecionados 20 municípios nos estados de São Paulo (11) e Minas Gerais (9), que operam com catadores (SP=7 e MG=4) e sem (SP=8 e MG=1) e aplicados questionários semiestruturados presenciais junto aos gestores da coleta seletiva no período de janeiro a abril de 2014. Embora os dados refiram-se a um contexto distinto do atual, considerando-se as profundas mudanças ocorridas, tanto nas políticas públicas inerentes como nas transformações decorrentes do período pandêmico que assolou o país, o estudo comparativo proposto permanece atual e relevante para a gestão de resíduos sólidos urbanos. Os resultados dos questionários alimentaram o conjunto de indicadores de sustentabilidade da coleta seletiva (12), resultantes da pesquisa de Besen *et al*. (2016). Ambas as modalidades mostraram-se *muito favoráveis* em promover a educação e divulgação, a gestão compartilhada e o estabelecimento de parcerias. Em ambos os casos, denota-se resultado *desfavorável*, associado aos indicadores de *autofinanciamento, taxas de recuperação de recicláveis e de rejeito*, e *condições ambientais de trabalho* e *saúde* e *segurança do trabalhador*. Como fatores determinantes para a sustentabilidade da coleta seletiva foram encontrados a necessidade de investimentos em infraestrutura, logística e a melhoria das condições de trabalho e de saúde do trabalhador, assim como a urgência de promover a sustentabilidade financeira, a partir da cobrança dos serviços prestados.

Palavras-chave: indicadores de sustentabilidade; resíduos sólidos; catadores; coleta seletiva.

1. Introduction

The concentration of the world population in urban regions is increasing, with the patterns of production and consumption leading to an increase in the amount of waste generated and collected. Estimates indicate that this urbanization rate could reach 60% in 2030 and 70% by 2050 (World Bank, 2010). Data from the 2010 Census, the most recent carried out in the country, indicate that, in Brazil, 84% of the population live in cities (IBGE, 2010). According to the National Solid Waste Plan, 183,481 tons of urban solid waste were generated daily in the country, with 31.9% corresponding to dry waste (Brasil, 2011).

On the global agenda, the themes of solid waste and social inclusion of waste pickers are directly related to the United Nations' Sustainable Development Goals (SDGs) (UNRIC, 2015; Besen & Fracalanza, 2016); therefore they cannot be dissociated.

According to an estimate by the World Bank, approximately 15 million people live by collecting recyclable material from solid waste in the world, with 4 million in Latin America (UNBR, 2014). Aparcana & Salhofer (2013) stated that the informal recycling sector plays an important role in urban solid waste (USW) management in low-income countries, while Spies & Scheinberg (2010) also highlight its contribution in middle-income coun-

tries. In Brazil, a study by the Institute of Applied Economic Research, based on data from the 2010 Demographic Census, indicated that 387,910 people declared themselves to be waste pickers (IPEA, 2013).

In Brazil, although door-to-door selective collection is the responsibility of municipal administrations, this service can be operated directly by municipal governments, by contracted companies or in partnership with waste picker organizations.

The public policy model for the social inclusion of waste pickers in the USW system has advanced in the country over the years, having been strongly driven by the regulatory framework of the National Solid Waste Policy (*Política Nacional de Resíduos Sólidos* - PNRS), which includes as one of its objectives "the inclusion of pickers of reusable and recyclable material in actions that involve shared responsibility for the life cycle of products" (Brasil, 2010, p.5) and establishes as one of its instruments "the encouragement of the creation and development of cooperatives or other forms of association of pickers of reusable and recyclable material" (Brasil. 2010, p.6), which prioritizes the selective collection of recyclable material operated by waste picker organizations. However, there have been certain setbacks in recent years, due to new government guidelines and the impacts resulting from the Covid-19 pandemic, which caused profound changes in the daily life for the entire society.

In this context, based on data collected in 2014, this article presents a comparative study between two types of municipal selective collection, considering the perspective of sustainability in its various dimensions:

i) selective collection operated in partnership with a waste picker organization and

ii) selective collection operated without this partnership.

The data refer to a different context from the current one, when considering the profound changes that have occurred since then, both in the transformations of the country's political life, with significant reflections on public policies aimed at the sector, and in the socio-environmental changes resulting from the pandemic period. However, the proposed comparative study remains current and relevant and can contribute to USW management.

In 2013, more than 180,000 tons of USW were collected daily in the country (Brazil, 2015), produced by 205 million inhabitants, corresponding to an average per capita generation of 1 kg/day^{-1}. Only 3% was selectively collected and sent for recycling, indicating that the economic, environmental and social benefits of waste recovery could be significantly increased (IPEA, 2010).

The fulfillment of the goal, established in the PNRS, of sending only what cannot be recycled and reused to landfill sites, depends directly on the efficiency of the selective collection systems, a public service of municipal jurisdiction. The implementation of selective collection, in the 5,570 Brazilian municipalities, in a universal, efficient way with adequate working conditions, represents an enormous challenge for governments, the private sector and society. A study by the Institute for Applied Economic Research (IPEA, 2010) confirmed the contribution of selective collection and recycling of material to the reduction of greenhouse gas emissions, which cause climate change, and highlighted

that resources exceeding R$8 billion in recyclable material is buried annually in the country.

Although the PNRS has conceptualized selective collection as the collection of solid waste previously segregated according to its constitution or composition, in Brazil, in general, only the portion called dry waste is considered recyclable, which represented 31.9% of USW, in 2010 in the country (Brasil, 2010).

In the 2010s in Brazil, the public policy on solid waste prioritized municipal selective collection systems operated by waste picker organizations, with the application of non-refundable public resources for these programs. In 2003, the creation of the Interministerial Committee for the Social Inclusion of Waste Pickers (*Comitê Interministerial de Inclusão Social de Catadores* - CIISC), with a view to articulating public policies to support and promote the waste picker segment, and the contribution of resources from the federal sphere, confirmed the State's capacity to promote public policies for social inclusion in the sector. The preliminary version of the 2011 National Solid Waste Plan (Brasil, 2011) already indicated the allocation of more than R$280 million to actions aimed at waste pickers, for the period from 2003 to 2010. Financial resources from Ministries, Banks and Petrobras, as well as international projects, contributed to the construction of sorting centers, acquisition of equipment, training and qualification courses, improvements in sanitary and working conditions in the sorting centers and the strengthening of commercialization networks between the organizations. The contribution from municipal administrations included the provision of areas or the rental of warehouses for the installation of sorting centers, acquisition of collection trucks and payment of water and energy expenses (Campos, 2014; Besen *et al*., 2014; Dias & Samson, 2016).

For this type of support, the term "partnership" is used, since, unlike contracting for the provision of services, as is the case with private companies that operate the service, most of the waste picker organizations live off the income obtained from the sale of the recyclable material and are not remunerated for the services provided. However, there are hundreds of municipalities in the country that carry out selective collection directly or through contracting service providers (Brasil, 2017).

In the last decade, studies on urban solid waste management have been published, especially on the management of selective collection and the informality under which the sector operates, including waste picker and their importance in cities (Scheinberg, 2012; Ezea *et al*., 2013; Dias & Ogando, 2015; Rutkowski & Rutkowski, 2015). The study by Campos (2014) considered that there was a significant advance in recycling in the country, however, its progress was based mainly on informality, carried out by waste pickers in precarious working conditions, compromising the health and safety of these workers.

Scheinberg (2012), when systematizing the literature on informal workers and solid waste management, from 1995 onwards, concluded that most of the works focused on social vulnerabilities, however, failed to place these workers within the scope of solid waste management systems as economic actors in the recycling chain and in solid waste management systems. The author highlighted that, since 2006, there has been a greater effort in this direction and considered that, in addition to academic works, the period from 2005 to 2011 produced several lines of activism to reduce the

vulnerability of informal workers in the context of solid waste intervention projects. Specialists in the field and diverse networks have sought to integrate empirical studies and/or activist experiences into a theoretical framework in order to contribute to the academic field of study (Scheinberg, 2012; Velis *et al*., 2012; Dias & Samson, 2016).

When analyzing research on the subject in Brazil, Besen *et al*. (2014) highlighted studies that investigated the socioeconomic and environmental impacts of the work of waste pickers in the recycling chain and in the provision of environmental services, as well as the working conditions of waste picker, from the perspective of the development of indicators and indexes of management and sustainability of selective collection and waste picker organizations. Scheinberg (2012) considers that the term "integration" dominated this discourse and indicates a shift in focus towards the design of interventions that promote the sustainable integration of informal workers into solid waste management systems that are being modernized.

Dias & Samson (2016), when studying the informal sector of waste pickers in five cities: Belo Horizonte (Brazil), Bogotá, (Colombia), Durban (South Africa), Nakuru (Kenya) and Pune (India), highlighted the important role of government public policy to catalyze processes for the formation of waste picker associations and cooperatives and encourage other government institutions to do so. The selective collection operated by waste pickers is considered by Rutkowski & Rutkowski (2015) to be a successful social technology. The authors warn, however, that it is necessary to consider the cultural diversity of the countries studied and the lack of workers specialized in urban solid waste management in developing countries, when replicating the processes of inclusion of informal waste pickers.

In Brazil, the category of waste picker has been recognized since 2002 by the Brazilian Classification of Occupations (CBO), through Ordinance No. 397 of 09/10/2002 of the Ministry of Labor and Employment, which defines waste pickers as people that collect, select and sell recyclable material. They are professionals who organize themselves autonomously or in cooperatives/associations, with their own administration and management.

Research carried out in the Metropolitan Region of São Paulo compared door-to-door selective collection between 2004 and 2010 (Besen *et al*., 2014) and corroborated the increase in municipalities that implemented selective collection and organizations of waste pickers who worked in the region. The work of the pickers, although it subsidizes the formal solid waste system with the reduction of its costs, becomes economically unsustainable when the proper remuneration is not received. This fact reveals that waste pickers are not yet legitimized as actors in the recycling production chain (Scheinberg, 2012; Rutkowski & Rutkowski, 2015; Gutberlet, 2015).

Gutberlet (2015) considered that the number of picker cooperatives in the management of selective collection is still modest in the country and occurs in a local and disconnected way, with there still being difficulties related to the social and economic exclusion of the workers. There is still a lack of political will on the part of municipal governments to hire picker associations and cooperatives to operate door-to-door selective collection and there is a lack of working capital for investments in infrastructure and technological modernization (Jacobi & Besen, 2011; Campos, 2014). In their study, Ferri *et al*.

(2015) emphasized the strong presence of waste pickers and the need for their inclusion in waste management systems in the country. It appears that the situation has not improved in recent years, especially with the extinction, in 2019, of the Ministry of Labor and the transfer of the attributions of the former National Solidarity Economy Department (*Secretaria Nacional de Economia Solidária* - Senaes) to the Ministry of Citizenship, restricting the jurisdiction related to the solidarity economy to the social welfare and income policy, associated with the concept of citizenship. With this change and the new government guidelines, public policies to support this category of work were also extinguished, unfavorably modifying the advances achieved so far.

Therefore, considering the context of the past decade and seeking to investigate which strengths and weaknesses are found in selective collection modalities operated by the municipality, in partnership with waste picker organizations or not, it was possible to design a comparative study that was based on the application of the sustainability indicators proposed and validated by Besen (2011) and later improved by Besen *et al*. (2016). Although there has been a significant growth in studies about selective collection in Brazil, over the previous few years, studies similar to this proposal were not identified.

The results presented here are part of the wider research project "Selective collection: management models with and without the inclusion of waste pickers, advantages and disadvantages from the perspective of sustainability", which also involves the application of sustainability indicators to waste picker organizations that are partners of the municipalities studied. Coordination of the Department of Environmental Health of the School of Public Health of the University of São Paulo, in partnership with the Institute of Energy and Environment – IEE/USP and with Women in Informal Employment: Globalizing and Organizing – WIEGO, and funded by the National Health Foundation – FUNASA (Besen *et al*., 2016).

2. Methods and techniques

From extensive documentary and telephone research on selective collection carried out in the states of São Paulo and Minas Gerais and in the metropolitan regions of São Paulo and Belo Horizonte, 20 municipalities were selected for the study. Of these, 11 municipalities operated selective collection in partnership with pickers and 9 municipalities carried it out without integrating pickers, These were distributed in the states of São Paulo (15 municipalities, 7 with pickers and 8 without) and Minas Gerais (5 municipalities, 4 with pickers and 1without), and present different population groups (Table 1).

The states of São Paulo and Minas Gerais were the object of the research, as they are the headquarters of the institutions that participated in the aforementioned inter-institutional project on selective collection, and they had a history of almost three decades, at the time, of implementing selective collection programs.

The criteria for selecting the municipalities involved:

i) high or medium level of selective collection coverage, which presupposes greater commitment from municipal councils and,

TABLE 1 – Characteristics of the municipalities selected.

State	Selective collection with pickers	Urban Population (inhab.)	Partner waste picker organizations	Selective collection without pickers	Urban Population (inhab.)
SP	1-Salesópolis	9,954	Ares	1-Nova Canaã Paulista	880
SP	2-Biritiba Mirim	24,525	Cooperalto	2-Corumbataí	2,093
SP	3-Assis	90,991	Cocassis	3-Iacanga	8,726
SP	4-Santana do Parnaíba	108,813	Avemare	4-Itajobi	12,142
SP	5-Barueri	240,749	Cooperyara	5-Andradina	51,649
SP	6-Santo André	676,407	Coopcicla Cidade limpa	6-Indaiatuba	199,592
SP	7-São Bernardo do Campo	752,658	Associação Refazendo; Associação Raio de luz	7-Mogi das Cruzes	357,313
SP				8-São José dos Campos	617,106
MG	8-Mateus Leme	24,679	Ascaleme	9-Itabira	106,783
MG	9-Brumadinho	28,642	Ascavape		
MG	10-Pedro Leopoldo	49,953	Ascapel		
MG	11- Itaúna	80,451	Copert		

ii) municipality with selective collection implemented for at least two years. Continuity was considered a determining factor, so a period of less than two years of operation would not provide sufficient data for the sustainability analysis.

Data collection involved the face-to-face application of semi-structured questionnaires with municipal selective collection managers in the 20 selected municipalities, from January to April 2014, whose data fed the 12 selective collection sustainability indicators defined by Besen *et al*. (2016). Qualitative-quantitative methodology was used (Creswell, 2010) and the median values of the indicators were presented (Figure 1).

In the study by Besen *et al*. (2016), the definition of the 12 sustainability indicators considered as the *Sustainability of the selective collection*: the ability of the municipality to operate selective collection efficiently, with legal guarantees and technical resources, incorporating the goal of universalization of the services and obtaining the following results: *environmental* (permanent environmental education and reduction in the disposal of USW in dumps and landfill sites), *social* (social inclusion, and democratic and participatory management) and *economic* (resources from fees or Urban Territorial Tax-IPTU). In the study, for each indicator, a calculation formula was defined and validated, or a qualitative assessment (Table 2) was applied to the municipalities studied. A gradation of trends towards sustainability was also associated with each indicator, which ranged from 0 to 1, in which the sum of points received by the indicator

placed it on the scale: very favorable (1.0), favorable (0.75), unfavorable (0.50) and very unfavorable (0.25) (Table 3).

The importance of applying the Selective Collection Sustainability Indicators is noted by the association of some of these indicators, which

TABLE 2 – Selective collection sustainability indicators and respective calculation formulas.

Sustainability indicators	Calculation formula
1. Service to the population	No. of inhabitants served by selective collection $_{x\ 100}$ / Total No. of inhabitants of the urban area of the municipality
2. Self-financing of USW management	Form of financing
3. Education/dissemination	Annual frequency of activities carried out
4. Shared management	Existence or not of effective channels for the participation of civil society and waste picker organizations *
5. Partnerships	No. of effective partnerships$_{x100}$ / No. of partnerships desirable **
6. Population adherence	No. of households that adhere to selective collection / Total No. of households covered by the selective collection $_{x100}$
7. Recyclable Material Recovery Rate – RMRR	Q. of selective collection - Q. of rejected material$_{x100}$ / Q. selective collection + Q. regular collection
8. Rejected material rate – RMR	Q. of selective collection - Q. sold$_{x100}$ / Q. of selective collection
9. Working conditions at the sorting center	No. of requirements met$_{x100}$ / No. of requirements desirable ***
10. Worker Health and Safety	No. of requirements met$_{x100}$ / No. of requirements desirable ***
11. Service cost/selective quantity	Total cost of selective collection (R$/ton.) / Amount of selective collection
12. Selective collection/regular collection and final destination cost	Cost of selective collection (R$/t) $_{x100}$ / Regular collection + and final destination cost (R$/t)

LEGEND: No.=number; Q.=quantity

* 1) Management Committees linked to waste management 2) Waste and Citizenship Forum 3) Technical Chamber or Waste Working Groups in 4) Environment Councils, 5) Agenda 21 Forums.

** 1) Waste picker organizations (networks), 2) Between municipal departments, 3) State public sector, 4) Federal public sector, 5) Private sector, 6) Non-governmental organizations, and 7) Bodies representing waste pickers.

*** 1) Existence of cafeteria, 2) Daily cleaning of the cafeteria, 3) Existence of toilets, 4) Daily cleaning of toilets, 5) Periodic rodent control, 6) Periodic fly control, 7) Periodic cockroach control, 8) Adequate covering of the sorting center, 9) Adequate ventilation, and 10) Control of unpleasant odors.

****1) Existence of fire extinguishers, 2) Existence of an emergency plan, 3) Use of Safety Equipment -PPE, and 4) Identification of hazardous material.

SOURCE: Besen *et al*. (2016).

TABLE 3 – Scale of trends towards sustainability and respective gradations, associated with the selective collection sustainability indicators.

Sustainability indicators	Very favorable	Favorable	Unfavorable	Very unfavorable
1. Service to the population	100%	75.1%- 99%	50.1% - 75%	≤ 50%
2. Self-financing of management	Fee or tariff	IPTU	Budget and IPTU	Budget only
3. Education/dissemination	Permanent Biweekly or Monthly	Bimonthly and Quarterly	Annual/one-off	None
4. Shared management	It exists and works	There is only one channel and it works partially	It exists, but it does not work	None
5. Partnerships	≥ 80%	50.1% - 79.9%	20.1 - 50%	≤ 20%
6. Population adherence	≥ 80%	50.1% - 79.9%	30.1% - 50%	≤ 30%
7. Recyclable Material Recovery Rate (RMRR)	≥ 25%	15.1% -24.9 %	5.1 - 15.0%	≤ 5%
8. Rejected material rate (RMR)	≤ 5%	5.1% - 10.0%	10.1- 29.9%	≥ 30%
9. Working conditions at the sorting center	100%	75.1%- 99%	50.1% - 75%	≤ 50%
10. Worker Health and Safety	100%	75.1%- 99.9%	50.1% - 75%	≤ 50%
11. Service cost/selective quantity	≤ R$ 200.00	R$200.00 - R$ 350.00	R$351.00 - R$500.00	≥ R$ 500.01
12. Selective collection/regular collection and final destination cost	≤ 50%	50.1% - 99.9%	100 -199.9%	≥ 200%

SOURCE: Besen et al. (2016).

represent determining sustainability dimensions in the operationalization of Municipal Selective Collection, such as Institutionality (Ind. 1, 2, 3, 4 and 5); Efficiency and effectiveness (Ind. 6, 7, 8); Work conditions and workers' health (Ind. 9 and 10); and Costs (Ind. 11 and 12).

For better visualization and communication of the results, the numerical scale of the intervals of trends towards sustainability was associated with a color code, defined as follows:

i) red: very unfavorable (0.00 to 0.25);
ii) yellow: unfavorable (0.26 to 050);
iii) blue: favorable (0.51 to 0.75); and
iv) green: very favorable (0.76 to 1.00).

Data analysis was performed individually by indicator (12) and in a comparative way between both types of selective collection: municipalities that operate selective collection with pickers (11) and municipalities that do not integrate pickers into the selective collection (9), regardless of the State to which they belong.

3. Results

The results of applying the selective collection sustainability indicators to the 20 selected municipalities are shown in Figure 1.

Three indicators obtained very favorable results regardless of the type of selective collec-

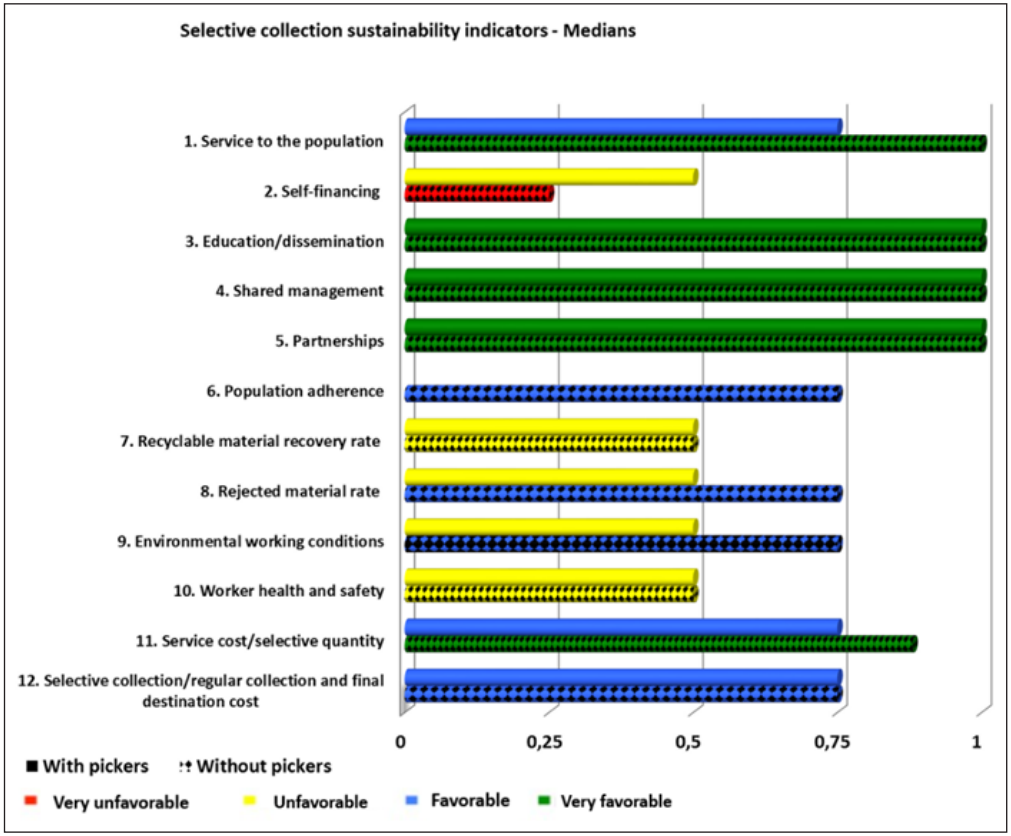

FIGURE 1 – Assessment of selective collection sustainability indicators, by type of selective collection.
NOTE: In indicator 6, adherence was measured only by one municipality that practiced selective collection without pickers.

tion: ISCS 3- *Education and Dissemination*, ISCS 4- *Shared Management* and ISCS 5- *Partnerships*. Selective collection, carried out with or without pickers, was very favorable in promoting education and dissemination (65% of municipalities), shared management (58% of municipalities) and the establishment of partnerships (60% of municipalities). These three factors are essential for the successful implementation of selective collection and indicate that, in terms of their *relationship with society*, the municipalities had sought to mobilize citizens and promote channels of participation and social involvement, even when there was no partnership with pickers.

Partnerships can be established by municipal administrations with waste picker organizations or networks, between municipal departments, with the public sectors - state or federal, with the private sector, with non-governmental organizations and with bodies representing waste pickers.

According to Besen *et al*. (2016, p. 30), "partnerships are decisive, as they help to obtain financial

and institutional resources to support the selective collection". Given the political reality in Brazil in which elected municipal managers, in general, do not continue the actions of the previous administration, and with no integration between selective collection and municipal systems of urban solid waste management, partnerships represent an important factor for the maintenance and expansion of selective collection, as well as a significant support factor when changes occur in municipal administrations. Gutberlet (2008) emphasized the need for participatory public policies in the management of solid waste and in the operation of selective collection, considering the channels of participation and social involvement as strategic.

In both types of selective collection, a high frequency of partnerships was observed. The most frequently reported, through a multiple-choice question, were: partnerships between municipal departments (90%), with waste picker organizations and waste picker networks (85%), with the state public sector (85%), private sector (85 %), federal public sector (75%), non-governmental organizations (75%) and bodies representing pickers (75%).

The participation of sectors of society in councils and technical committees related to the environment, health and solid waste is also a support factor, so that selective collection is not just an action of a single management with only temporary implementation, but is incorporated by the community in a permanent and irreversible way. Accordingly, most municipalities declared that they had technical committees or working groups that dealt with the issue of solid waste in councils related to the environment.

The indicators that presented very favorable results for municipalities with selective collection without pickers and favorable for municipalities with partnerships with pickers were: ISCS 1- *Service* and ISCS 11- *Cost of selective collection*.

As one of the previous criteria for selecting the municipalities to participate in the study was *to have a medium or high rate of selective collection service for the population*, justified by the requirement of universal service by the national Basic Sanitation and Solid Waste Policies, a significant coverage by the municipal selective collection service was expected, as verified.

In the research carried out, the mean cost per ton of recyclable material from selective collection, when considering the aggregated data for both modalities (with and without pickers), was R$453.90 (US$201.73)[1]. When separated by modality, the mean cost per ton in the modality with pickers was R$389.60 (US$173.16), while the cost without pickers was R$539.61 (US$239.83) (Table 4). Regarding the variable related to the cost of the services, this question remained unanswered by some municipalities. Among the 15 municipalities that responded about costs, the resulting evaluation was: 8 (53%) very favorable; 1 (7%) favorable; 2 (13%) unfavorable and 4 (27%) very unfavorable.

There are few records regarding the cost of selective collection, both in academic studies and in government research in the country, due to the lack of concern with the recording of these data, making it difficult to compare the present result. The mean values obtained in the present study (Table 4) are similar to the results obtained by that research, where the mean cost of selective collection in the country was US$195.23 (or R$439.26). From prac-

[1] Considered US$1 = R$2.25

TABLE 4 – Mean cost of selective collection and range of variation, in total and by type of selective collection, 2014.

Municipalities	Selective Collection Cost	
	Mean cost per ton (R$/US$)	Variation in cost per ton (R$/US$)
All responding municipalities	453.90/201.73	60.00 to 1,698.60/26.67 to 754.93
With pickers	389.60/173.16	60.00 to 1,040.00/26.67 to 462.22
Without pickers	539.61/239.83	153.84 to 1,698.60/68.37 to 754.93

tice in general, it is known that the cost of selective collection is much higher than the cost of regular collection. Research by CEMPRE (2014) indicated that, in the country at that time, selective collection had a cost 4.6 times higher than conventional USW collection. Additionally, it is important to emphasize that practically all the municipalities studied that carry out selective collection in partnership with pickers do not remunerate the organizations for the services provided. If this were considered, the cost of selective collection would increase, presenting a more realistic value.

The indicators referring to costs resulted in a favorable score for collection with and without pickers: *Cost of selective collection/regular collection + final disposal.* This indicator helps to show, from an economic point of view, the advantage or disadvantage of selective collection in relation to regular collection/transport and final disposal of USW.

Considering the ratio between the cost of selective collection and regular municipal USW collection of 4.6 times in the country, obtained by CEMPRE (2014), municipalities that presented a relationship of ≤ 50.0% were considered very favorable, favorable if the ratio was between 50.1% and 99.9%, unfavorable between 100.0% and 199.9% and very unfavorable for municipalities in which the ratio was ≥ 200.0%.

Among the 18 municipalities that answered this question, 3 (17%) had a very favorable evaluation, 7 (39%) favorable, 6 (33%) unfavorable and 2 (11%) very unfavorable. Considering this variability, it can be inferred that the evaluation was positive (favorable or very favorable) for the majority (10/56%) of the responding municipalities.

For two indicators, the result was favorable in the municipalities without a partnership with pickers and unfavorable in those with pickers in selective collection programs: ISCS 8- *Rejected material rate* and ISCS 9- *Environmental working conditions*.

The Rejected Materials Rate (RMR) indicator measures the efficiency of separating recyclable material at the source and sorting site. To achieve the PNRS goal of sending only rejected material to landfills, the efficiency of the selective collection is very important, with better separation at source and sorting equating to less rejected material. Adequate separation at the generating source optimizes the collection and sorting stages, as less rejected material is transported and needs to be sorted, further reducing the costs of transporting rejected material from the sorting site to final disposal (landfill sites). Indirectly, the RMR indicator can be associated with the population's awareness of the correct separation of recyclables, as well as adequate communication of the collection logistics, which leads to the proper presentation of the segregated material on the days scheduled for selective collection.

Of the 18 municipalities that reported the RMR indicator, 2 (11%) had a very favorable assessment,

6 (33%) a favorable assessment, 7 (39%) an unfavorable assessment, and 3 (17%) a very unfavorable assessment. Therefore, most of these municipalities (10/56%) presented an unfavorable score, in general, for this indicator, which means that they had a rejected material rate above 10%.

TABLE 5 – Mean rejected material rate and variation range, in total and by selective collection modality, 2014.

Municipalities	Rejected material rate	
	Mean rate %	Variation range (%)
All responding municipalities	21	5.6 to 66.0
With pickers	20	5.6 to 35.0
Without pickers	24	7.9 to 66.0

There was a significant difference between the states and between the selective collection modalities (with and without pickers). In both states, the median of rejected material rate was *favorable* for municipalities without partnerships with pickers, while in the municipalities with pickers it was *unfavorable*.

Several factors can explain the situation found (Table 5). Campos (2013), who studied 12 waste recovery facilities (WRFs), stated that in the WRFs operated by waste picker organizations, there was only separation for commercialization of waste that has a market value, where the cost-benefit ratio of sorting is favorable. This fact occurs due to the non-payment of waste picker organizations for selective collection and sorting services, which have their only source of income from the resources obtained from the sale of the sorted material. The author also emphasized that recyclables only become secondary raw material when the recovery costs are equal to or less than the market value of virgin raw material, a determining factor for what and how to separate, as well as where to send it.

The *Environmental working conditions* indicator measures the number of requirements, related to the conditions of the working environment, met in relation to the desirable ones. Of the 10 desirable requirements considered, the most met by the municipalities, considering the possibility of multiple answers to this question, were: existence of toilets (94%), daily cleaning of toilets (83%), adequate ventilation (83%), existence of cafeteria (78%), periodic rodent control (78%), periodic fly control (78%), periodic cockroach control (78%), sorting center with adequate covering (72%), daily cleaning of the cafeteria (67 %), and control of unpleasant odors (39%). With the exception of this last requirement, all the others had a high degree of implementation in the municipalities studied, regardless of their condition, denoting greater concern with hygiene and sanitary aspects. Among the 18 municipalities that responded to this question, 3 (17%) had a very favorable assessment for this indicator, 7 (39%) favorable, 6 (33%) unfavorable and 2 (11%) very unfavorable. Only one municipality that practiced selective collection in partnership with collectors reported monitoring the conditions of the work environment at the sorting center.

Unfavorable results in municipalities with and without partnerships with pickers were verified for the indicators: ISCS 7- *Recyclable Materials Recovery Rate* (RMRR) and ISCS 10- *Worker Health and Safety*.

The ISCS 7 indicator represents the recovery potential of recyclables that arrive at the sorting center, as it deducts the rate of rejected material then measures the efficiency of the selective col-

lection system and the diversion of dry (recyclable) waste from the landfill site. Higher recovery rates of recyclable material equate to greater economic, social and environmental gains from the selective collection. Among the 19 municipalities that answered this question, 3 (16%) had a favorable result, 12 (63%) an unfavorable result and 4 (21%) a very unfavorable result. Therefore, the majority (16/84%) cannot be considered efficient in the recovery of recyclables, which shows the continuing unsatisfactory condition of selective collection and sorting when compared to its potential. The mean value found for this indicator was 0.49, while the median was 0.50, both *unfavorable*.

Observing the results, in both states (Table 6), it appears that the evaluation of this indicator is unfavorable, indicating a maximum RMRR of 15%, both for selective collection practiced in partnership with pickers or not. However, in the state of Minas Gerais, in the municipalities that operated with pickers, the median was favorable.

TABLE 6 - Mean recyclable material recovery rate (RMRR) and variation range, in total and by type of selective collection, 2014.

Municipalities	Recyclable Materials Recovery Rate (RMRR)	
	Mean rate %	Variation range (%)
All responding municipalities	9	1 to 25
With pickers	10	1 to 25
Without pickers	8	1.3 to 18

According to Besen *et al*. (2016), the low recovery rate of recyclables may be associated with a set of factors such as:

i) inefficiency of the collection system;
ii) use of inappropriate collection vehicles;
iii) lack of regularity in the collection service;
iv) deficiency in the separation of recyclable material at the generating source (household, retail trade, companies, public institutions, among others);
v) high rate of rejected material;
vi) low adherence of the population;
vii) lack of education/communication about selective collection; and
viii) low productivity in the sorting stage.

Campos (2013, p. 191) stated that: "For WRFs[2] to function legally and with high productivity, a structuring reform must be carried out that takes into account the management dimensions, including the technological, economic, environmental and social aspects".

Indicator 10, *Health and Safety*, measures the working conditions to which pickers are subject in the sorting center, portrayed by the number of requirements met in relation to the desirable ones related to this issue.

Among the 18 municipalities that responded to this question, 1 (6%) had a very favorable evaluation, 5 (28%) favorable, 8 (44%) unfavorable and 4 (22%) very unfavorable. Considering the possibility of multiple answers to this question, the requirements most met by the municipalities, with regard to worker health and safety were: use of Personal Protective Equipment (PPE) (83%), existence of

[2] IRR – Installations for recovery of residues.

fire extinguishers (72%), existence of an Emergency Plan (33%) and identification of hazardous material (28%). It appears that most of the municipalities did not have an Emergency Plan and did not practice the identification of hazardous material, which constitutes a risk situation in the work.

The Indicator ISCS 2- *Self-financing* was one of the indicators with the most negative evaluation; obtaining an unfavorable result for municipalities in partnership with pickers and very unfavorable when there was no such partnership. This indicator measures the economic-financial sustainability of the administration and the USW management and, therefore, it includes the selective collection system. For this, the form of resource funding by the municipal administration was verified. Both the National Basic Sanitation Policy (PNSB) and the PNRS establish the need for the USW system, which includes selective collection, to have economic and financial sustainability so that services can be provided efficiently, universally and with social justice.

Among the 20 municipalities studied, 13 (65%) declared that the resources for financing selective collection came exclusively from the municipal budget; 4 (20%) reported that they came only from the IPTU collection, 1 (5%) stated that the resources came from the municipal budget and from a specific fee; and 1 other (5%) indicated the municipal budget and the IPTU as the source. Therefore, only 1 municipality claimed to charge a specific USW fee.

Of the set of indicators analyzed, this was the indicator with the most unfavorable result, evidenced both in the mean (0.45) and the median (0.38).

The lack of transparency of public administrations in justifying the costs of USW management for service users, associated with the population's resistance to the charging of fees, leads to a deficiency in the allocation of resources to cover the costs, including those of selective collection. As a result, resources that could be invested in other areas of municipal management are diverted to cover expenses with USW management and municipal selective collection. As the funds raised are primarily used to pay the costs of regular collection and final disposal of USW, support for selective collection remains in the background. This fact impairs the investment needed in selective collection and, in particular, the remuneration for the services provided by the pickers, whether in sorting or selective collection.

When the value of the USW management fee is added to the IPTU, the shared funding does not always fully cover the costs of the services performed. However, in most cases, the interviewees were not able to inform what portion of the IPTU was directed to cover the specific costs of the selective collection service, as the data are not divided. Furthermore, reverse logistic systems have not yet been implemented in the country, and in the case of selective collection, the companies responsible for the production and sale of packaging and post-consumer products do not bear the costs of their collection (Abramovay *et al*., 2013). Economic--financial sustainability is essential for expanding and improving the efficiency of selective collection and for paying for the services provided by waste picker organizations.

Selective collection, with or without the participation of pickers, presents a set of cost items that involves: acquisition and maintenance of collection vehicles, remuneration of the collection and sorting team, construction of the sorting center, investments in equipment and operation of the sorting unit, and transportation of commercialized recyclable mate-

rial and rejected material for final disposal. Campos (2013) highlights the importance of recovering these costs for economic-financial sustainability and continued provision of services, through the collection of specific fees or tariffs. Currently, with the new Sanitation Framework, this is a challenging issue that deserves special attention.

It is important to highlight the indicator of *Adherence of the population to selective collection*. Only one municipality that did not have a partnership with pickers had metrics and recorded data on population adherence to the municipal selective collection program. In the others, there are only estimated data, which were not considered in the study, considering the degree of uncertainty. There was a lack of importance attributed to the measurement of this indicator by the selective collection managers and a lack of methods to carry out the measurement.

4. Conclusions and recommendations

The application of sustainability indicators to the two modalities of municipal selective collection proved to be adequate, allowing a comparative evaluation between them and identifying the strengths and weaknesses of each modality.

Through the comparative study, there were no significant differences in performance between programs that work in partnership with waste picker organizations or do not. The study concluded that there is still a need to improve the management of selective collection in both modalities: operated with or without pickers.

The need to change the culture in municipal selective collection programs was evidenced, with regard to metrication and recording of data of interest for the evaluation of performance. In the evaluation through indicators, the existence of data and its registration based on specific parameters are fundamental and indispensable. In this regard, an example is the need to homogenize metrics on the *coverage and scope* of the programs, since, as they can be expressed in different ways (by area, by number of households covered, or by number of inhabitants involved), they often do not allow comparison.

A relevant indicator in the evaluation of performance and sustainability is the adherence of the population. The study revealed that most municipalities do not measure the population's adherence to the municipal selective collection programs implemented, whatever the modality. It is fundamental to identify the adhesion of the population and the factors that determine this, with its expansion towards universalization being strategic. This will increase the quantities and quality of recyclable material collected, which will make the municipal programs more sustainable. Therefore, the development of studies that focus on methods to measure adherence is recommended.

In most of the municipalities studied, there was a low rate of diversion of recyclables from landfill waste, when considering the potential, as well as a high rate of rejection of material collected as recyclable.

Finally, it can be concluded that there are positive environmental and socioeconomic impacts for formal selective collection, in the modalities with and without partnership with pickers, however, these are still below the needs and possibilities.

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