Journal of Environmental Science and Engineering B 11 (2022) 189-205
doi:10.17265/2162-5263/2022.05.003

# Contributions on Selective Waste Collection and Recycling Cooperatives in Municipalities in the State of São Paulo, Brazil

Clauciana Schmidt Bueno de Moraes [1], Larissa Senden Carnicel [1], Adriana Maria Nolasco [3], Giulia Malaguti Braghini Marcolini Martires [1], Cinthia Mara Vital Bonaretto [1], Willian Leandro Henrique Pinto [2], Bruna Ferrari Felipe[1,4], Felipe José Sasso [1] and Laís Araújo de Paula [1]

*1. São Paulo State University (UNESP), São Paulo 13506-900, Brazil*

*2. School of Technology, University of Campinas (UNICAMP), Limeira 13484-332, Brazil*

*3. University of São Paulo (USP), 13.418-900. Piracicaba, Brazil*

*4. Fehily Timoney and Company, D11 PXT0. Dublin, Ireland*

**Abstract:** The collection and proper disposal of MSW (Municipal Solid Waste) is one of the biggest challenges faced by Brazilian public managers. Dry recyclable waste represents about 33.6% of the gravimetric composition of MSW, with a tendency to increase in the next few years, due to the increasing consumption of processed products, with short life cycles and excess packaging. The inadequate management of these residues results in a series of social, environmental and economic problems. In recent years, there has been a great advance in Brazilian laws, assigning responsibilities and regulating waste management in the country, optimizing the use of infrastructure and human and financial resources. Scarce resources and insufficient infrastructure demand actions based on a lot of planning. One of the main limiting factors for the planning and development of public policies for the sector is the lack of reliable data and information on the generation and management of waste, that allow the creation of future scenarios and the definition of adequate strategies for minimization, valorization of waste and final disposal of waste that no longer can be processed. Thus, this work sought to analyze the current situation of selective waste collection and recycling cooperatives in 211 municipalities in the State of São Paulo, evaluating the issues and opportunities for the applicability of Law n. 12,305/2010, Brazilian PNRS (in Portuguese) (National Policy of Solid Waste) in the management of this waste in small, medium and large cities. A bibliographic research was carried out on the panorama of solid waste management in Brazil and in the State of São Paulo, as well as a contextualization on selective waste collection and recycling cooperatives. Following that, data from 211 municipalities taking part in the survey Solid Waste Management—Municipalities of the State of São Paulo were analyzed, focusing on answers that correlated with the topics covered in this research. For this work, questions were used in order to obtain a basic overview of solid waste management in the municipalities, identifying the characteristics of selective waste collection and recycling cooperatives in the municipalities and to verify the similarity, benefits and difficulties of selective waste collection and waste cooperatives in the municipalities studied. After tabulating and analyzing the data, a matrix was prepared to compare the results obtained in relation to selective waste collection and recycling cooperatives and the guidelines of the PNRS (National Solid Waste Policy) in urban environmental management, which allowed the conclusion that all municipalities participating in the research have a good understanding of solid waste management practices, as well as seek to comply with the guidelines of the PNRS. However, the results of this matrix indicated that there are important points that need to be considered in the planning of actions for a better management of recyclable waste, such as the implementation of inter-municipal consortiums in the management of solid waste, investment in environmental education, stimulation to create recycling cooperatives and adoption of social inclusion regulations for informal waste collectors.

**Key words:** Solid waste, Brazilian National Policy of Solid Waste, solid waste management, MSW, recycling, cooperatives.

**Corresponding author:** Clauciana Schmidt Bueno de Moraes, Ph.D., academic title, research field: solid waste management.

## 1. Introduction

The increase in the generation of MSW (Municipal Solid Waste), which is increasingly impacting urban centers, is directly related to technological advances, the economic development of countries, the concentration of population in cities, lifestyle and consumption habits, and the easy market access. The continuous creation of new products, linked to the enormous appeal and consequent growth of consumption and disposal, contributed significantly to the scenario currently experienced, of exhaustion of landfills and pollution from the incorrect disposal of the waste [1]. By 2050, world MSW generation is expected to grow to 3.4 billion tons annually [2].

In Brazil, according to the survey carried out by the ABRELPE (in Portuguese) (Brazilian Association of Public Cleaning and Special Waste Companies), the generation of MSW in the municipalities jumped from 67 million tons/year in 2010 to 79 million tons/year in 2019 [3]. The data in question indicate the need for proper management of solid waste and the implementation of plans and actions as indicated in the PNRS (National Solid Waste Policy). This policy was established by Law No. 12.305/2010, which provides for guidelines related to the integrated management of solid waste and the instruments for non-generation, reduction, reuse, recycling, treatment, and environmentally appropriate final disposal of solid waste. It arises to guide individuals or legal entities, of public or private law, with regard to the responsibilities for the generation and management of solid waste and for actions related to integrated management, as well as define objectives and instruments [4].

Dry recyclable waste corresponds to 33.6% of the composition of solid waste in Brazil. This waste, when poorly managed, is responsible for major negative impacts at local and global level, such as the pollution of the oceans by plastic materials. Although 74.4% of Brazilian municipalities have some type of selective waste collection initiative, they are, for the most part, local, of small scope and insufficient to solve the problem of the correct destination of these materials [5].

Among the main environmental benefits provided by the practice of recycling, the following stand out: the reduction in the use of virgin raw material for the manufacture of new products; the energy spent on reprocessing materials that is considerably less than on producing new ones; and the significant minimization of the amount of waste destined for dumps and landfills [6].

The implementation of the PNRS positively impacted the selective waste collection of Brazilian municipalities, as it not only made the elaboration and implementation of PMGIRS (in Portuguese) (Municipal Integrated Solid Waste Management Plans) mandatory, but also demanded the definition of forms of creation, support and inclusion of cooperatives and associations for the collection and sorting of recyclable materials in the management of MSW. The Decree No. 10.936/2022, which regulates the PNRS, in Title IV, Articles 36 to 43, reiterates this importance when it prioritizes the participation of recycling cooperatives and other forms of association in the collection, sorting and recovery of waste, both in MSW management, and in reverse logistics systems. To this end, it creates a series of instruments such as the Citizen Selective Waste Collection Program and the requirement for actions to include and support cooperatives in PMGIRS and inter-municipal plans [7].

Reverse Logistics also has a large part of its success based on the collection and sorting activities developed by cooperatives and recycling associations, which allow packaging, parts and components of post-consumer products, among others, return to the production chains as inputs, feedstock or new products, reduce the amount of materials landfilled as waste that no longer can be processed and prolong the useful life of landfills [8-10].

Recycling cooperatives have occupied an important role in post-consumption reverse logistics of various products, despite the legislation imposing that manufacturers are responsible for the return of products

and packaging in post-consumption, several production chains have not yet managed to implement their reverse logistics systems, and the return of materials ends up taking place through the action of public authorities, cooperatives and individual waste collectors [11].

This alone would be enough to show the importance of these cooperatives in the management of MSW. However, in addition to these environmental benefits, the collection and sorting of recyclable waste is an important generator of new enterprises, jobs and income, directly or indirectly, boosting new businesses at a local level, with an important social role and, feeding more complex production chains, on a macro scale, with significant economic results.

Thus, it is essential that the governments at the federal, state and municipal levels, as well as the private sector, support these entities in their technical-administrative training, in the necessary infrastructure for operation and in the recognition and remuneration for the environmental services provided.

Most recycling cooperatives have autonomous management, which requires their members to train and develop skills such as leadership, teamwork and knowledge about administration, accounting, environmental and organizational management, in addition to the operational technical basis for identification, sorting and waste commercialization.

The challenges that the solid waste agenda imposes on the country involve the synergy between legislation and public policies, as this inseparable articulation will be the strong point that will provide the recovery of the delay in the solid waste management in the country [12].

Another important action is the involvement of municipal governments in sectoral reverse logistics agreements. Integration aims to give effective material meaning to the recycling effort—linking it to shared responsibility for the life cycle of products whose responsibility is associated with reverse logistics [13]. However, it is necessary to make it clear that one of the objectives of reverse logistics is exactly to exempt the public power from the responsibility and costs of the decisions taken by the industry that define the quantity, danger and risks involved with the waste of its products. The government must be a partner in the reverse chains, acting to help implement reverse logistics actions in the municipality, but the operationalization must be the responsibility of the manufacturer, including its costs.

The COVID-19 pandemic brought up several issues related to the management of MSW, but mainly with regard to the health of urban cleaning service workers, especially the most vulnerable, such as cooperative members and informal collectors. The collection of waste during the pandemic has become a way of transmitting the virus, showing the need for intervention by the public authorities to educate the population about the contaminated waste generated, as well as the provision of PPE (Personal Protective Equipment) for workers and sanitation of sanitary facilities [14, 15].

In the role of agent, the State, through the various levels of government, has sustainable practices such as the use of clean technology, purchases of more sustainable products, research and development in the area, evaluation of products and behaviors (rankings), adoption of indicators of sustainability, certifications, training and education for the sustainability of its employees, encouraging public participation, participation in international pro-sustainability organizations and treaties, etc. [16]. It is possible to verify the magnitude of shared responsibility as a tool for solid waste management, since the management of the negative impacts caused by a given product becomes simpler when responsibility is imposed on all the authors involved by it, from the manufacture until final disposal [17].

Regarding environmental issues, cooperatives have great importance in relation to the life cycle of recyclable materials, when reintroducing them to the market as raw material for new products. In addition, collectors contribute to reducing municipal expenses with solid waste management and reducing the amount of waste sent to landfills [18].

Considering the scenario described, the objective of the present study was to diagnose and analyze the panorama of selective waste collection and recycling cooperatives in 211 municipalities in the State of São Paulo and its contribution to the applicability of Law No. 12.305/2010 PNRS and for the management of MSW. Specifically, it aimed to (i) characterize selective waste collection and recycling cooperatives in municipalities in the State of São Paulo; (ii) identify similarities, benefits and difficulties of selective waste collection and recycling cooperatives in the studied municipalities; and (iii) present a comparative matrix with the panorama of selective waste collection and recycling cooperatives and the PNRS guidelines in urban environmental management.

The work was developed as part of the research project "National Policy of Solid Waste: Methodological Proposal with the Use of Legal, Administrative and Technological Instruments as a Subsidy for Its Implementation and Sustainable Management" [19].

Additionally, there is a correlation between the selective waste collection activities encouraged by the PNRS and the SDGs (Sustainable Development Goals) of the UN (United Nations), which can be understood as an indication of the efforts of the municipalities of the State of São Paulo in the search for sustainable development. The SDGs are macro indicators that aim to guide the development of local indicators as they encourage the establishment of objectives and more sustainable public policy goals and agendas within the scope of common global themes. It was possible to directly associate the selective waste collection actions studied with seven of the 17 SDGs. They are: (i) SDG 1: Poverty eradication; (ii) SDG 6: Drinking water and sanitation; (iii) SDG 8: Decent work and economic growth; (iv) SDG 10: Reduction of inequalities; (v) SDG 11: Sustainable Cities and Communities; (vi) SDG 12: Sustainable consumption and production; (vii) SDG 17: Partnerships and means of implementation [19].

## 2. Methodology

The research approach refers to the data collection method; in this regard, the present study has a qualitative approach. Qualitative research is based on the analysis and understanding of a social group or an organization [20]. This analysis depends on several external factors, such as the nature and extent of the data, collection instruments and theoretical hypotheses that involve the research [21]. This approach is presented in the research as it will be applied in the questionnaire as a database.

Regarding nature, it is a basic research, as there will be no practical application of the content studied, but it will bring useful knowledge to science, bringing only truths and universal interests [20].

The objectives have an exploratory and descriptive character. Exploratory research "aims to provide greater familiarity with the problem, in order to make it more explicit or to build hypotheses" [22]. It also aims to describe or characterize the variables studied [23]. This type of research studies the relationship between variables or also aims to analyze information about a certain group, such as: education level, crime rate, efficiency of public agencies in a given city [22, 23].

Descriptive research was used through the use of data collection, from the research "Solid Waste Management—Municipalities of the State of São Paulo" using the Google Forms tool (https://forms.gle/TToE6UiGbAcCDcTd8), a tool that allows the application of the online questionnaire, through the generation of a link [19]. The link was disseminated through e-mails sent to the municipalities of the State of São Paulo, through the PMVA (in Portuguese) (Coordination of the Municipality VerdeAzul Program) with support from the CIRS (in Portuguese) (Solid Waste Integration Committee) of the SIMA (in Portuguese) (Secretariat of Infrastructure and Environment of the State of São Paulo).

This questionnaire is part of the research "National Solid Waste Policy: Methodological Proposal with the

Use of Legal, Administrative and Technological Instruments as a Subsidy for its Implementation and Sustainable Management" and aims to diagnose the different aspects of solid waste management in the municipalities and the applicability of the PNRS (Law No.12.305/10), as well as other legislation and public policies in the Municipalities of the State of São Paulo, Brazil [19, 24].

The questionnaire contains 155 questions, divided into ten blocks, each block referring to a topic on the management of MSW. The blocks are listed from A to J and cover the following questions: general data on municipal administration in the management of solid waste in municipalities; what plans and programs are in effect; the existence of environmental education programs; participation in inter-MSW consortiums; compliance with legislation related to solid waste management; the application of technologies and regulatory instruments to aid management; the existence of selective waste collection and recycling cooperatives; specific questions about the management of construction waste and healthcare waste; and changes in solid waste management with the COVID-19 pandemic [19].

For this work, 211 responses were analyzed, received until January 20, 2022, that is, 32.71% of the municipalities in the state, and it is with this data sample that the diagnosis on the issues addressed in the work was developed.

Based on these research questions, only those related to the objectives proposed in this work were selected [19]. These questions are located in blocks A, B, G and J and will be presented in the results. The types of questions found in the questionnaire are: open questions, checklist and multiple choice, some mandatory and some not.

Subsequently, an analysis of the data obtained through the research was carried out, aiming to identify the characteristics of selective waste collection and recycling cooperatives, and what are the similarities, benefits and difficulties faced by the municipalities.

A comparison of the results obtained with the guidelines of the Brazilian National Policy of Solid Waste was also carried out, through a matrix, aiming to deepen the analysis, taking into account the applicability of the PNRS.

In "Block A: GENERAL DATA", comprehensive questions were used to provide an idea of the size of the municipality, characteristics of MSW management and also what successful practices and actions were adopted that involved the theme of selective waste collection and recycling cooperatives.

With "Block B: PLANS AND PROGRAMS", we sought to understand more about the vision of municipalities on the PMGIRS (in Portuguese) (Municipal Plan for Integrated Management of Solid Waste) and its applicability in the management of MSW, given that the PMGIRS is mandatory, according to the PNRS, and it contributes significantly to the structuring and implementation of actions related to selective waste collection.

"Block G: SELECTIVE WASTE COLLECTION/COOPERATIVES" was analyzed to obtain various information about recycling cooperatives, such as quantity, coverage of collection, practices adopted by municipalities for the social inclusion of cooperative members, among others.

Finally, the "Block J: SOLID WASTE MANAGEMENT DURING THE PANDEMIC (COVID-19)" has the intention to complement this study, bringing current data about the management of MSW during the pandemic. The study sought to identify changes in the quantity, gravimetric composition and operational procedures for collection, sorting and final disposal of recyclable waste. Education and communication actions promoted by municipal governments aimed at the population and urban cleaning workers were also analyzed, with the objective of reducing risks associated with the management of this waste.

## 3. Results and Discussion

### *3.1 Selective Waste Collection and Recycling Cooperatives in Some Municipalities of the State of São Paulo, Brazil: Diagnosis and Analysis*

All the blocks described above are interconnected by common themes and the data obtained through these questions were analyzed with a focus on the central objective of this study, which aims to characterize selective waste collection and recycling cooperatives in some municipalities in the State of São Paulo, Brazil and raise the main similarities, difficulties and benefits faced in these two matters. Each block will be discussed separately below.

3.1.1 General Data (Block A: Research)

In questions 01 and 04 of block A, the basic items were considered in order to draw the profile of the municipalities with their general data. In all, 211 cities responded to the survey.

The population range was established according to the division of the CETESB (in Portuguese) (Environmental Company of the State of São Paulo) [25], and it was possible to observe that most of the municipalities, 138 (65.4%) are small and have up to 25,000 inhabitants; 49 (23.22%) have a population between 25,001 and 100,000; 22 (10.22%) municipalities cover the range from 100,001 to 500,000 inhabitants and only 2 (0.94%) municipalities have a population greater than half a million inhabitants.

In questions 9, 18, 19 and 20, the primary information on the collection and final disposal of MSW, as well as the good practices adopted by the municipalities in the matter of environmental management, was selected.

Question 9 identifies how many employees work directly in the management of solid waste in the city, including operational and administrative employees. It is worth mentioning that because it is an open question, there was no standard of answers, some municipalities did not consider administrative employees in the count and there were also municipalities that did not respond to the question. For a better understanding of the matter, it was divided into ranges with employee numbers.

Of the 208 municipalities that answered the questions related to selective waste collection, 7 (3.36%) have more than 100 employees working in the management of MSW, and one of them has more than 200 employees. It is interesting to note that all municipalities in this range have a collection coverage of more than 91%, a subject that will be addressed in question 18 about MSW collection.

Evaluating questions 9 and 18 together, among the respondents who cover the ranges from 11 to 100 employees, it can be observed that there are 17 (8%) of them in which the collection coverage ranges from 81% to 90%. In the range of 6 to 10 employees, there is 1 (0.47%) municipality in which the collection reaches 71% to 80% of the population and finally; in the range of up to 5 employees, there are 1 (0.47%) municipality where the collection reaches only 41% to 50% of the population; 1 (0.47%) where the collection reaches 61% to 70% of the population and 3 (1.42%) municipalities where the collection covers from 71% to 80% of the population.

Question 18 aims to understand the percentage of the population served by the MSW collection service in each municipality. It was possible to observe the number of responding municipalities in each percentage range. There is only 1 municipality, equivalent to less than 1%, which is in the range of 61% to 70% of the population and one in the range of 41% to 50% of the population.

Besides, 73 of the 211 municipalities (34.6%) said that the collection does not include the rural population (question 19). This reveals the negligence suffered by rural areas setting public policy priorities, which causes a large part of the population located in these areas to dispose of waste in a totally inappropriate way, such as burning or burial, generating several environmental and health problems.

Question 20 deals with the destination of MSW in the municipalities. Considering that the final disposal envisaged in the PNRS is the landfill, there are 161 (76.3%) municipalities that are in accordance with the law, of which only 5 (2.36%) said to use consortium landfills. Regarding inadequate disposal, 8 (3.8%) municipalities use controlled landfills; 40 (18.9%) landfills in ditches and 1 (0.47%) uses transshipment to then proceed to the landfill. Only 1 municipality of the participants declared disposing of their waste in a dump, a destination prohibited in Brazil since 2010.

These data show that even in a developed region such as the State of São Paulo, Brazil, there are still municipalities that need more investment in the MSW management sector, including planning and infrastructure, in order to effectively collect and adequately dispose. It is important to emphasize that in the objectives of the PNRS, Article 7, the "universalization of the provision of public services for urban cleaning and solid waste management" is established, which should guarantee the collection and adequate final destination of MSW for the entire population, including those located in rural areas.

3.1.2 Plans and Programs (Block B: Research)

Block B aimed to understand the environmental plans and programs in force in the municipalities. Question 4 sought specific information about the PMGIRS (in Portuguese) (Municipal Plan for Integrated Management of Solid Waste) and the PRGIRS (in Portuguese (Regional Plan for Integrated Management of Solid Waste). PRGIRS replaces PMGIRS if the municipality is a member of an inter-municipal consortium. The answers to this question can be seen below (Fig. 1).

Of the analyzed municipalities in São Paulo, 178 (about 84% of the total number of respondents) have PMGIRS or PRGIRS already implemented. Of these, 32 (15%) have the Plan included in the PMSB (in Portuguese) (Municipal Basic Sanitation Plan), as they are municipalities with less than 20,000 inhabitants and are not located in areas of tourist interest or in Conservation Units.

In total, there are a significant number of municipalities, 33 (16%), that either do not have a plan nor are in the process of being elaborated. Of the 16 (8%) which do not have one, 14 (6.6%) fall within the first population range, from municipalities with up to 25,000 inhabitants, and two (0.94%) in the second range.

At this point, it is worth mentioning that access to Union resources for public cleaning services and solid waste management is conditioned on municipalities having a municipal plan for the integrated management of solid waste.

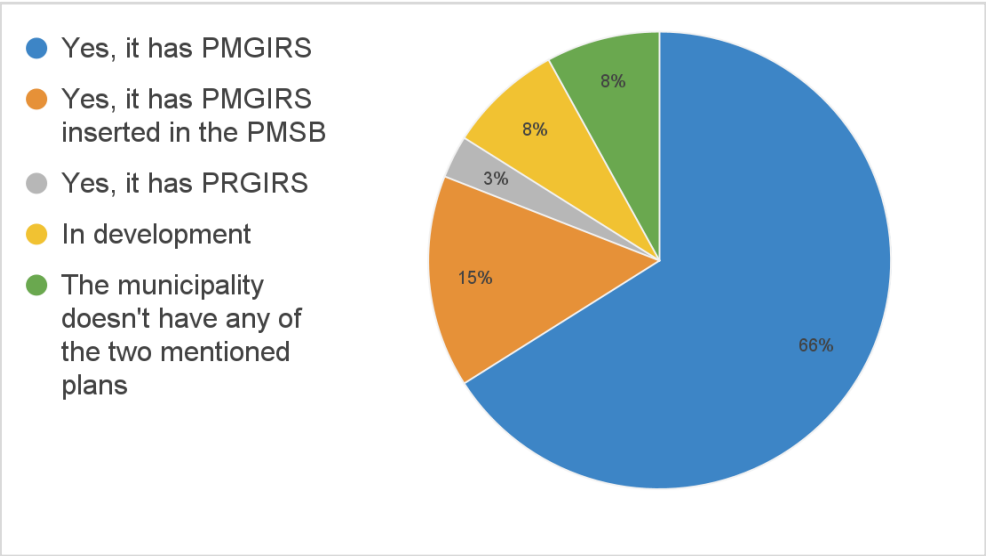


**Fig. 1 Number and percentage of PMGIRS or PRGIRS instituted and in operation (Block B: question 4).**

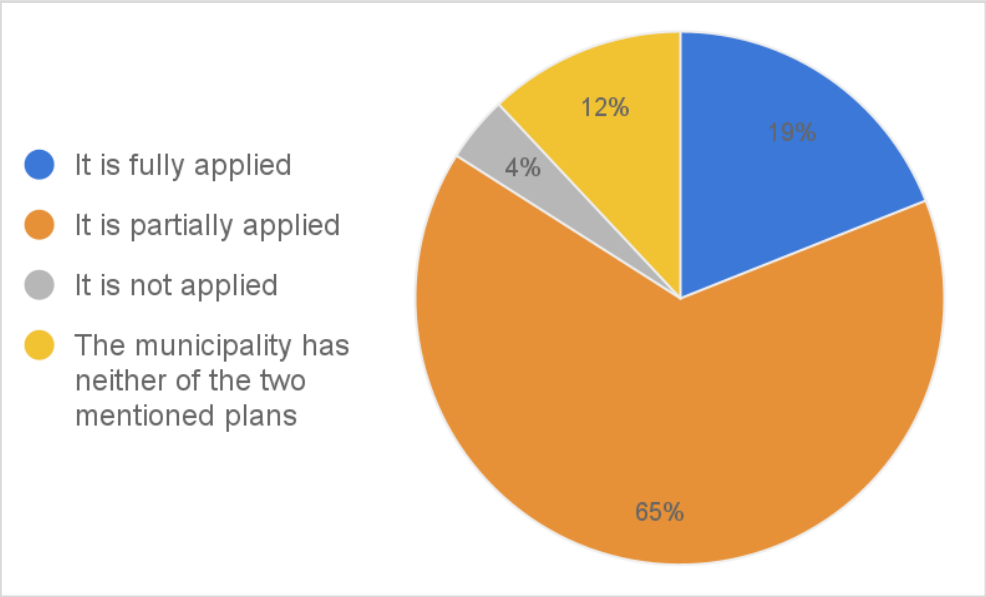


**Fig. 2 Applicability of PMGIRS or PRGIRS (Block B: question 6).**

Question 6 dealt with the applicability of these plans. In Fig. 2, the responses of the municipalities can be verified, with 41 (19%) stating that the plan is fully implemented, 136 (65%) said that it is partially applied, 9 (4%) do not apply the plan and 25 (12%) do not have the plan. The complete applicability of PMGIRS or PRGIRS is essential for successful MSW management in the municipality.

Question 14 of block B specifically addressed the items described in Article 19 of the PNRS, referring to the minimum content of the PMGIRS, in order to assess whether they are being properly addressed in each plan. The most cited items were "Diagnosis covering origin, volume, characterization, destination and final disposal"; "Environmental education programs and actions"; and "Operational procedures and minimum specifications to be adopted in urban cleaning and solid waste management services" with 171 municipalities (81%), 150 municipalities (71%) and 131 municipalities (62%), respectively. Apart from these, 119 (56.4%) stated that they included in their plans goals on "Targets that aim to reduce the amount of waste that no longer can be processed sent for environmentally adequate final disposal" and also on "Favorable areas for environmentally adequate final disposal", 118 (55.9%) addressed questions about "Solid waste and generators liable to specific plans or reverse logistics processes", 112 (53%) address topics related to "Preventive and corrective actions", 109 (51.6%) about "Control and local inspection", and 107 (50.7%) dealt with issues regarding the "Periodicity of the review".

The other 10 items of the PMGIRS minimum content were less addressed by the municipalities, for example: 102 municipalities (48.3%) cited "Rules for transportation and other stages of solid waste management"; 101 (47.8%) the "Possibility of consortium or shared solution"; 96 (45.5%) "Performance indicators of urban cleaning services and solid waste management"; 92 (43.6%) "Identification of environmental liabilities related to solid waste"; 84 (39.8%) "Definition of responsibilities regarding its implementation and operationalization"; 82 (38.8%) "Description of the forms and limits of the participation of local public authorities in selective waste collection and reverse logistics"; 68 (32.2%) "Sources of business, employment and income through the valorization of solid waste"; 66 (31.3%) "Programs and technical training actions for their implementation and operationalization"; 57 (27%) "System for calculating costs and collection methods" and, finally, 50 (23.7%) "Programs and actions to participation of interested groups".

It is possible to notice that these items involve an in-depth study of the theme, but not necessarily a high investment on the part of public management, which can be observed in other items, not so marked, such as: Programs and actions for the participation of interested groups; System for calculating costs and forms of collection; Technical training programs and actions for their implementation and operation; Sources of business, employment and income through the valorization of solid waste.

Question 16, also from block B, aimed to understand the difficulties encountered by municipalities in the preparation and implementation of plans. Among the most cited, 147 municipalities (69.6%) claimed the "Lack of financial resources"; 145 (68.7%) a "Lack of enough employees"; and 130 (61.6%) the "Lack of awareness among the population about the importance of participating in the process".

Besides these, 111 (52.6%) reported "Lack of technical training"; 109 (51.6%) "Low rate of popular participation in public hearings"; 101 (47.8%) "Insufficient infrastructure and equipment (compactor trucks, tractors, scales, conveyors, etc.); 89 (42.2%) "Insufficient waste recovery processes (reuse, recycling and/or composting)"; 85 (40.3%) "Low acquisition of equipment/investments for alternative management of waste destined for landfills" and also "Difficulty in establishing sectoral agreements for the implementation of reverse logistics".

Of the total, 77 municipalities (36.5%) stated "Lack of environmental inspection and application of the relevant legislation"; 71 (33.6%) "Absence of participants in sectoral Agreements or Terms of Commitment for the implementation of Reverse Logistics"; 68 (32.2%) "Lack of information and data available at the city hall"; 66 (31.3%) "Insufficient strategies to reduce the volume of generated waste"; 63 (29.8%) "Insufficient social inclusion of collectors"; 62 (29.4%) "Low incidence of programs aimed at environmental education"; 55 (26%) "Difficult access to data from different sectors of the city hall", and 49 (23.2%) "Integration into an inter-municipal consortium".

Finally, 12 municipalities (5.7%) do not have it and 10 (4.7%) said they did not encounter difficulties.

Thus, it can be observed that even though public administrations are aware of their responsibilities under Article 19, there is a lack of preparation on the part of the municipalities regarding political, administrative, technical and budgetary-financial issues to comply with what is proposed by the PMGIRS. The reported "lack of awareness among the population" reflects once again that managers do not invest enough in public policies in order to make the population aware of the issue.

3.1.3 Selective Waste Collection/Cooperatives (Block G: Research)

Block G addressed the central theme of this article: recycling cooperatives. In this item, questions 1, 2, 3, 4, 5, 6, 8 and 9, referring to this topic, will be discussed.

Question 1 sought to identify who carries out the selective waste collection in the municipality and the result can be seen in Fig. 3. This was a checklist-style question, therefore, the municipalities could mark all the agents participating in the selective waste collection. Of the respondents, 109 (51.6%) stated that informal collectors are collection agents; in 71 municipalities (33.6%) recycling cooperatives are responsible; in 36 (17%) they are associations and in 28 (13.3%) it is the municipal government. It is also worth noting that 19 municipalities (9%) said they did not have selective waste collection, which is one of the main instruments of the PNRS, provided for in its Article 8. It is worth mentioning that municipalities that have selective waste collection with the active participation of cooperatives and associations are a priority to receive resources for urban cleaning, coming from the federal government.

Question 2 aimed to understand the number of cooperatives that exist in each municipality, the number of associated collectors and the percentage of female workers. As it is a non-mandatory and open

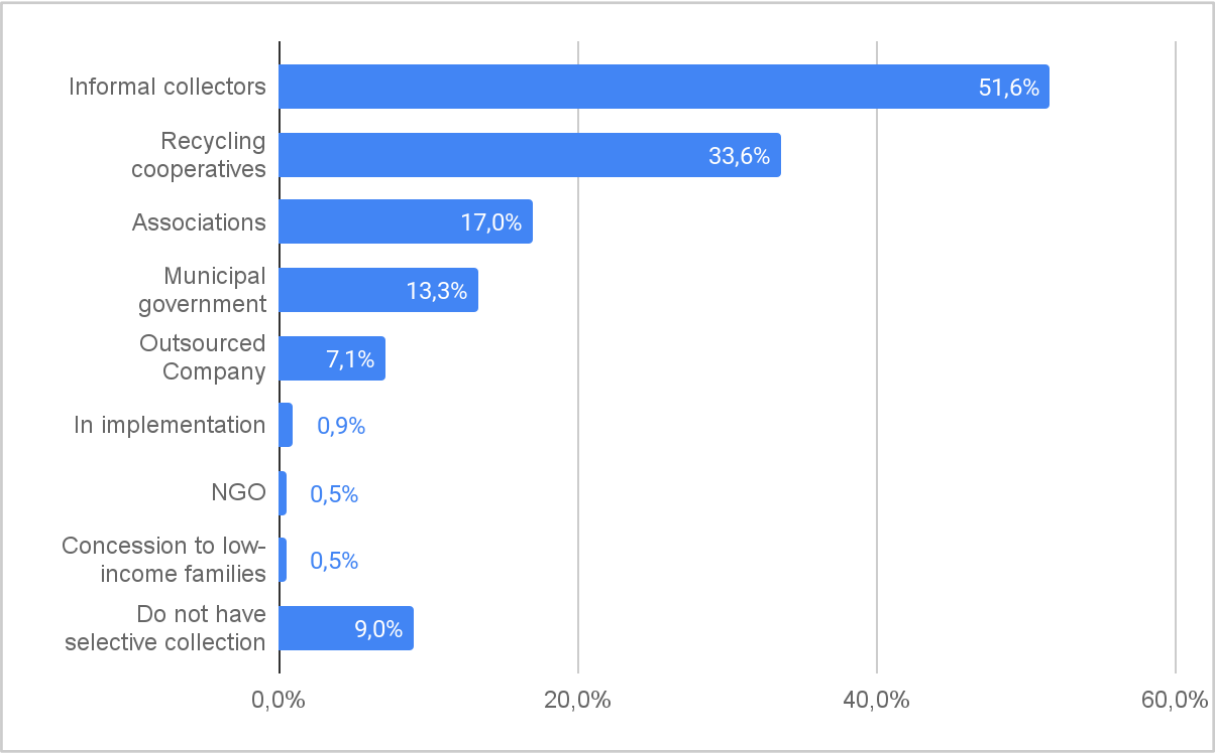


**Fig. 3 Persons responsible for selective waste collection in the participating municipalities (Block G: Question 1).**

question, there was a lot of inconsistency in the answers and extremely incomplete answers, which compromised the understanding of the real scenario. Thus, some conclusions based on the complete responses are cited below.

In total, 10 municipalities claimed to have two recycling cooperatives. Of these, only two fit the classification of small municipalities with, respectively, 36,185 and 41,318 inhabitants; the other 8 municipalities have more than 86,000. In addition, the number of cooperative members usually increases as the size of the municipality increases, which indicates that the larger the municipality, the greater the need it has in relation to the service provided by the cooperative and, also, it has more resources for assistance and its implementation. Among the municipalities that correctly answered the question, all of them have at least 50% of female workers, which shows a very significant representation of the social impact and income generation for women in recycling programs.

Question 3 dealt with the population served by selective waste collection in the municipalities. Selective waste collection in 88 municipalities (41.7%) covers more than 91% of the population; 34 (16.1%) declared having between 71% and 90% of the municipality covered by selective waste collection; 20 (9.47%) responded having from 51% to 70% covered; 29 (13.4%) reported covering only 21% to 50% of the population and 40 (18.9%) covering less than 20% of the population.

Correlating to question 18 of block A, of the 109 municipalities (51.6%) that have selective waste collection coverage greater than 81% of the population, 108 (51.2%) have from 81% to 100% of their population covered by regular curbside collection, with only one municipality responding to the alternative of 71% to 80%. And with question 4 of block B, of these 109 municipalities, 94 (44.5%) have the PMGIRS or PRGIRS, 7 (3.3%) are preparing and 8 (3.8%) do not have Plans. In this way, the contribution of the plans to reach the universalization and effective management of solid waste is evident.

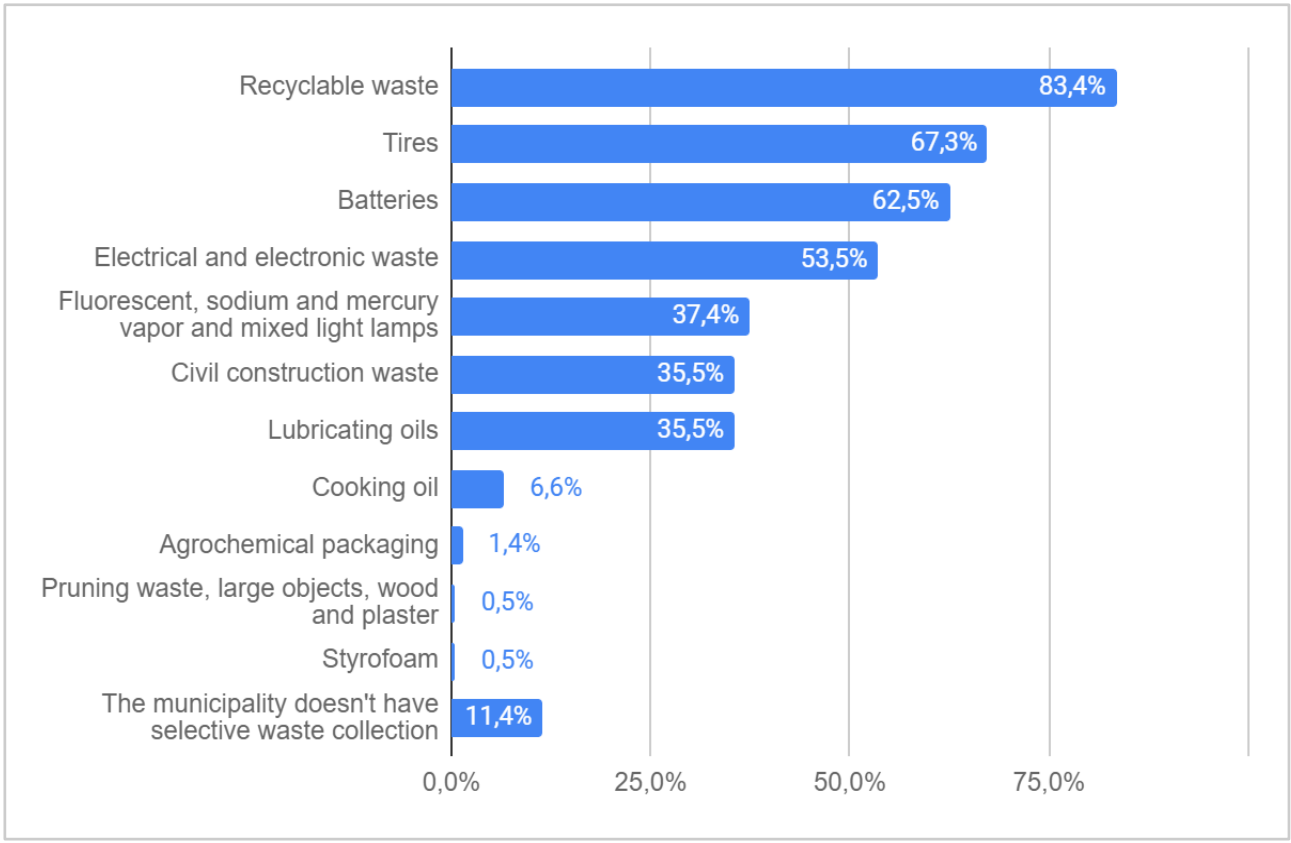


**Fig. 4 Waste collected by selective waste collection in the municipalities (Block G: Question 4).**

Question 4 aims to understand the types of waste collected by selective waste collection in the participating municipalities. In this regard, 176 (83.4%) respondents said they collect recyclable waste; 142 (67.3%) collect tires; 132 (62.5%) collect batteries; 113 (53.5%) have reverse logistics for WEEE (Electrical and Electronic Equipment Waste); 79 (37.4%) fluorescent, sodium and mercury vapor and mixed light lamps and 75 (35.5%) reported collecting civil construction waste and lubricating oils (Fig. 4). These results indicate the reverse logistics programs that are reaching greater coverage in the State of S ão Paulo and those that need greater commitment to implementation, as they are not present in most municipalities.

Article 33 in the PNRS guarantees the obligation, on the part of manufacturers, importers, distributors and traders, independently of the public service of urban cleaning and solid waste management, to carry out the reverse logistics of the following products: packaging of pesticides and herbicides, batteries, tires, lubricants, oils and packaging, lamps and WEEE [4]. Several municipalities reported that these collections are made by informal collectors or from some specific PEVs (in Portuguese) (Voluntary Delivery Points) for this waste, as guaranteed by Section III of the same article.

In addition to these wastes, one municipality declared that it collects biodegradable waste from urban afforestation and bulky waste composed of large objects, wood and plaster. Another municipality reported collecting styrofoam for recycling. Apart from these, 24 municipalities (11.4%) stated that they did not have selective waste collection, which shows some inconsistency with the number presented previously in Fig. 4.

It is also important to highlight the correct separation of waste at the source and the impact that this represents in the amount of material that can be recycled or reused.

Information campaigns on the selective waste collection system developed by municipalities and whether these campaigns are addressed in formal and informal environmental education were addressed in question 5 (block G). Formal education is an institutionalized educational process, which takes place within the school environment, with the aim of training citizens to act more proactively and responsibly regarding the segregation and disposal of waste, so that they correctly fulfill their part in the process. Informal education, on the other hand, occurs through publicity material, art education actions, among other ways, with the main objective of alerting, sensitizing and/or giving objective and specific guidance to the population, on procedures under their responsibility that must be adopted in the management of solid waste.

Regarding the practices adopted for the dissemination of the selective waste collection system, of the cities surveyed, 94 (44.5%) respondents stated that they used digital media perform campaigns; 33 (15.6%) said they used formal or informal environmental education programs and actions, but did not specify how; 28 (13.3%) distribute information folders or pamphlets; 26 (12.3%) work directly in schools and 45 (21.3%) make use of other means of communication such as radio, newspaper, television and sound cars (advertisement cars with speakers that circulate around the residential areas). Out of these, 10 municipalities (4.7%) specified awareness campaigns as workshops, lectures or training; 10 (4.7%) deliver pamphlets door-to-door, an alternative that is almost unfeasible for large municipalities and 9 (4.3%) use signage in public places such as banners, posters or billboards.

Question 6 aimed to find out how the city hall helps cooperatives or associations of formal reusable and recyclable material collectors existing in the municipality. About 160 municipalities (75.8%) made concessions or donations of the place, machinery or recyclable material collected, in order to encourage cooperatives; 74 (35%) invested in training or professional development of the collector and 39 (18.5%) provided financial assistance to the cooperative. In addition, 16 (7.6%) said they did not help and 78 (37%) said there was no cooperative or association in the municipality.

Finally, questions 8 and 9 were analyzed, which deal with measures for the inclusion of informal collectors in MSW management. Of the 211 participating municipalities in São Paulo, only 63 (30%) claimed to have some type of measure for the inclusion of recyclable material collectors in the solid waste management system. Of these, 9 (4.3%) claimed to promote training and qualifications; 9 (4.3%) register the collectors; 6 (2.8%) promote public meetings and assemblies with the participation of collectors; 6 (2.8%) offer logistical support, whether in collection or transport and, 5 (2.4%) seek the creation or formalization of cooperatives and recycling associations. In addition, 3 (1.4%) fetch to include collectors in cooperatives and 3 (1.4%) hire collectors, contributing to the generation of formal employment.

3.1.4 Solid Waste Management during the COVID-19 Pandemic (Block J: Research)

The purpose of this block was to analyze the impacts suffered by the management of MSW due to the COVID-19 pandemic. Thus, the first question refers to the generation of waste during this period (years 2020-2021). Practically half of the municipalities (48%) noticed the increase in the generation of MSW as a result of the pandemic, 9 (4%) said that the amount had decreased, 76 (36%) did not notice a difference and 26 (12%) did not know how to respond.

Question 2 (block J) investigates whether guidelines were offered to the population on the correct management of Solid Waste during the COVID-19 pandemic. This was an open question and therefore the answers were treated only in textual form. Approximately half of the municipalities said they had not oriented the population in any way about the correct management of this waste. Other municipalities stated that they had provided orientation, whether through a pamphlet, folder, social media, city hall website, sound

cars or even the health agents themselves, about the correct disposal of protective masks and how to seal and identify packaging and waste contaminated with coronavirus. There were also municipalities that said they did informal environmental education campaigns, with the help of recycling cooperatives, and dissemination of guidelines, door to door, through employees of selective waste collection trucks.

Regarding the security measures offered to employees of the urban cleaning service during the period (question 3), approximately 170 municipalities (80.5%) said they offered reinforcement in PPE(Personal Protective Equipment); 59 (28%) said they restricted the face-to-face work only to essential services; 20 (9.5%) increased the frequency of collection; 14 (6.6%) increased the number of employees in collection/sorting and disposal and 18 municipalities (8.5%) did not implement any security measure for employees.

In addition to these responses, some municipalities stated that they held the DDS (in Portuguese) (Daily Safety Dialogue) on precautions and social distancing during work and social activities; promoted lectures given by health professionals; provided hygiene kit; and rescheduled working hours to reduce the flow of employees.

Question 4 dealt with the issue of interruption of urban cleaning services. About 81% of the municipalities stated that they had not interrupted any type of service; 10% interrupted the collection of recyclable materials and 3% of the bulky waste, activities in civic amenities and in sorting units.

Finally, question 5 addressed the social and economic assistance provided to employees, in case of interruption of services. Many municipalities stated that they had not provided any type of assistance, as the interruption was very short and soon the work resumed normally. Others said they had provided basic food baskets, maintained their salary and benefits, such as food and transport allowance, and there was also a municipality that provided members with professional courses grants.

### *3.2 Comparative Matrix of Results Obtained with the PNRS Guidelines*

Table 1 presents the results of the analysis of the answers discussed above, based on the guidelines established by the PNRS, focusing on selective waste collection and recycling cooperatives, in order to deepen the diagnosis of research on the management of MSW in the municipalities of São Paulo.

The topics covered were divided into analyzed aspects, having as a reference the main themes dealt with in the PNRS articles. Such articles were correlated with the answers obtained in the questionnaire and, later, a descriptive analysis was performed considering the two central columns.

The first aspect analyzed concerns the objectives and instruments of the PNRS with regard to selective waste collection. For this, the scope of selective waste collection reported by the municipalities was discussed and some solutions were proposed to improve this rate, such as investment in environmental education and inter-municipal consortiums.

The second aspect sought to identify in the legislation the articles referring to recycling cooperatives and the inclusion of recyclable material collectors. For this, the types of assistance provided by the municipalities to recycling cooperatives and the social inclusion practices adopted by them were analyzed.

The third aspect addressed the theme of the Municipal or Regional Plan for Integrated Management of Solid Waste according to the PNRS, focusing on the participation of recycling cooperatives and informal collectors, as well as the practices of reduction, reuse, recycling and recovery.

Finally, the last aspect of the matrix aimed to discuss the shared responsibility for the life cycle of products, with regard to the participation of collectors in the collection of some specific waste, and in the prioritization by municipalities in the organization and operation of cooperatives of recycling.

**Table 1 Comparative matrix between the PNRS guidelines and the data obtained from the research related to selective waste collection.**

| Analyzed aspect | PNRS guidelines | Data obtained (Research) | Descriptive analysis |
|---|---|---|---|
| Selective waste collection: PNRS Objectives and Instruments | Article 7, Section X; Article 8, Section III | 90% of the participating municipalities have coverage of regular MSW collection above 91% of the population, whereas selective waste collection is limited to 41% of municipalities for the same range of coverage. | Regular collection has a high coverage rate, but is not universal in the State of São Paulo. One possibility would be to implement public-private or consortium solutions by municipalities to achieve this objective; another solution would be to improve the dissemination of information on the selective waste collection system, in addition to investments in formal and/or informal environmental education. |
| Recycling cooperatives and inclusion of recyclable material collectors | Article 7, Section XII | 30% of the municipalities stated that they have some type of measure for the inclusion of recyclable material collectors in the solid waste management system. | Low rates of social inclusion of autonomous collectors in management systems, requiring work to identify, quantify and characterize these collectors, as well as to understand their way of acting, in order to develop public policies that integrate them into the urban cleaning system. |
| | Article 7, Section IV; Article 19, Section XI; Article 42, Section III | A large part of the municipalities stated that they have practices to help recycling cooperatives, whether in the concession or donation of location, machinery or material, investment in the training or qualification of the collector and/or financial assistance. | Among municipalities that have recycling cooperatives, few said they did not provide some form of support. And these ways of assistance mentioned are consistent with the needs of cooperatives and associations of reusable and recyclable material collectors, but insufficient to achieve more expressive rates of recycling of MSW. |
| Municipal or Regional Integrated Solid Waste Management Plan in accordance with the PNRS | Article 18, Paragraph (§) 1, Section II | 52% of the municipalities have the participation of informal collectors, 34% of recycling cooperatives and 17% of associations. | Considering the economic incentive with the priority concession of federal resources to those municipalities that included cooperatives or associations in selective waste collection, the number of adhered municipalities should be considerably greater, since many claim lack of financial resources for the implementation of selective waste collection in a universalized way. |
| | Article 19, Section XIV | 80 municipalities said they have waste generation reduction practices, 97 have reuse practices, 162 have recycling practices and 71 have recovery practices. As for the formalized reduction, reuse, selective waste collection and recycling goals, 135 said they had them. | The weaknesses of the MSW management system are denoted in the contradiction of the municipalities that said they have goals, but do not have defined programs and/or projects, which actually allow them to be achieved. |
| Shared responsibility for the product lifecycle | Article 33, Section III | Performance of collectors reported in the collection of this waste by some municipalities. | Although some municipalities have reported the participation of collectors in this type of collection, little is known about their number, characteristics and the way they work, which makes it impossible to formulate public policies for these actors in urban cleaning. |
| | Article 36, Section II, Paragraph (§) 1 | Initiative to register collectors and differentiated support based on gender and/or gender identity, participation of collectors in PMGIRS decision-making; financial assistance to cooperatives or associations and to collectors; training or qualification of collectors; exclusive collection by low-income families. | Various forms of organization and operation of cooperatives and associations were mentioned by the municipalities, showing the commitment of some municipalities to comply with Article 36, also seeking to hire and register collectors. |

## 4. Conclusion

For the accomplishment of this work, the answers obtained in the survey questionnaire "National Policy of Solid Waste: Methodological Proposal with the Use of Legal, Administrative and Technological Instruments as a Subsidy for its Implementation and Sustainable Management" were used as a database which aimed to diagnose the different aspects in solid waste management and also the applicability of the PNRS (Law No. 12.305/10), as well as other laws and public policies in the Municipalities of the State of São Paulo [19].

The research addressed several issues involving the theme, such as: general data, plans and programs adopted, environmental education, inter-municipal consortium, legislation, technologies and administrative instruments, selective waste collection and cooperatives, construction and demolition waste, health service waste and solid waste management during the COVID-19 pandemic.

For this article, the 211 responses obtained from the survey until January 20, 2022 were considered, and the diagnosis performed corresponded to the sample range of about one third of the municipalities (32.7%) in the State of São Paulo, Brazil, of different characteristics and sizes.

In general, due to the fact that the municipalities are located in the most developed region of the country, in the State of São Paulo, the results obtained are within the expected range, demonstrating that several municipalities manage their MSW in a satisfactory way, which have knowledge of Law 12,305/10 PNRS (Brazilian National Policy of Solid Waste), and the plans that assist in waste management planning.

The vast majority of the municipalities researched have a high range of environmentally appropriate collection and final disposal.

Based on the results, one can also verify the importance of the PMGIRS (Municipal Plan for Integrated Management of Solid Waste) and the PRGIRS (Regional Plan for Integrated Management of Solid Waste) for an efficient management of MSW, in addition to the need for public and private interaction and for greater participation by civil society, especially in planning and monitoring the execution of actions.

In view of the above scenario, it is evident that the vast majority of municipalities seek to minimize environmental problems from environmentally adequate and economically viable solutions, but do not explore ways to correct the issues at the root cause, such as reducing the high generation of waste or reusing these waste, which involves a large participation of the private sector, which makes decisions regarding products, packaging, life cycles and, which is responsible for the implementation of Reverse Logistics Plans.

Another relevant point is the low coverage of selective waste collection which, considering all respondents, is far from universalization. In addition, the last block showed the low valorization of cooperatives and associations of recycled materials, as well as informal collectors, by many municipalities, a solution that linked formal and informal environmental education would significantly increase the quality and coverage of this service.

The legal, technical and social structuring for cooperativism will culminate in environmental gains, re-socialization of people, employment and income generation, value aggregation to waste and economic growth for the country.

Finally, the comparative matrix showed the importance of the PNRS for the effectiveness and implementation of universalized selective waste collection, with the action of recycling cooperatives or autonomous collectors, which significantly contribute to the increase in the coverage of selective waste collection, the reduction of municipal expenses in the management of MSW, and reduction of the amount of waste sent to landfills.

Considering that the way to achieve the objective of universal selective waste collection also depends on the

population's awareness about the importance of separating waste at the generating source, intense and constant work on environmental education is necessary, in addition to incentive programs reducing consumption and wastage. Such programs gain strength when they have partnerships with recycling cooperatives and also provide social inclusion of cooperative members and income generation.

## References


[1] Dias, S. G. 2012. "The Challenge of Urban Solid Waste Management." *GV Executivo* 11 (1): 16-20. https://doi.org/10.12660/gvexec.v11n1.2012.22776.

[2] Kaza, S. Y., Yao, L. C., Bhada-Tata, P., and Van Woerden, F. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development*. Washington, DC: World Bank. EUA: World Bank.

[3] Brazilian Association of Public Cleaning and Special Waste Companies. 2020. "Overview of Solid Waste in Brazil 2020." Accessed August 1, 2021. https://ABRELPE.org.br/panorama-2020/.

[4] Brazil. 2010. *Brazilian Federal Law n. 12,305, of August 2nd, 2010*. Brasília, Brasil.

[5] Brazilian Association of Public Cleaning and Special Waste Companies. 2020. "Overview of Solid Waste in Brazil 2021." Accessed January 10, 2022. https://ABRELPE.org.br/panorama-2021/.

[6] Waite, R. 2013. *Household Waste Recycling*, 1st ed. London: Routledge. https://doi.org/10.4324/9781315066356.

[7] Brazil. 2022. *Brazilian Decree n. 10,936, of January 12th, 2022*. Brasília, Brasil.

[8] Chiva, A. P. V., Freitas, L. B., Cunha, M. T., and Cândida, M. L. 2006. "Recycling Cooperatives: Solution to the Garbage Problem in Campinas." *Revista Ciências do Ambiente On-Line* 2 (1): 68-76.

[9] Ravanello, B., and Maas, G. 2017. "Socioeconomical and Waste Management Changes after Implementation of a Recycling Cooperative." *BIOFIX Scientific Journal* 2 (1): 22-31. http://doi.org/10.5380/biofix.v2i1.50488.

[10] Santos, A. M., Dantas, M. Z., and Teixeira, S. S. 2018. "The Work in Solid Waste Recycling Cooperatives: A Study of Recicla Conquista." *Geopauta* 2 (1): 26-42. http://doi.org/10.22481/rg.v2i1.3857.

[11] Okano, M. T., and Panza, G. B. 2020. "Reverse Logistics and Recycling Cooperatives: An Exploratory Study under the Theoretical Lens of the Business Model." *Revista Produção Online* 20 (2): 521-45. https://doi.org/10.14488/1676-1901.v20i2.3441.

[12] Machado Filho, J. V., and Penido, M. R. 2020. "Regulatory Framework for Solid Waste with a Basis for Public Policies: The Experience of the State of São Paulo, Brazil". In *Public Policy. Social Development and Interdisciplinary*, edited by Moraes, C. S. B., Gracioli, M. M., Souza, T. N., and Martino, V. F. Curitiba, Brazil: CRV, pp. 37-45.

[13] Pedro, A. F. P. 2020. "Public Policies Integrated to Sanitation." In *Public Policy. Social Development and Interdisciplinary*, edited by Moraes, C. S. B., Gracioli, M. M., Souza, T. N., and Martino, V. F. Curitiba, Brazil: CRV, pp. 37-45.

[14] Auad, G. A., Marques, R. F. P. V., Ritá, F. S., Alcantra, E., Oliveira, A. S., Freitas, A. S., and Rodrigues, L. S. 2021. "Reflections on the National Solid Waste Policy and the COVID-19 Pandemic: Proper Management." *Research, Society and Development* 10 (10): e42101018653. https://doi.org/10.33448/rsd-v10i10.18653.

[15] Santos, F. N. C., Borinelli, B., Flor, C. N. M., and Aligleri, L. 2021. "Public Policy Selectivity in Solid Waste in the COVID-19 Pandemic: Exponentiating the Vulnerability of the Waste Pickers' Cooperatives in Londrina-PR." *Revista Administração da UFSM* 14: 1201-20. http://doi.org/10.5902/1983465965023.

[16] Gavira, M. O., Moraes, C. S. B., and Dadario, A. M. V. 2017. *Administration and Sustainable Management: Context and Tools*, 1st ed. São Carlos, Brazil: Editora Rima.

[17] Pinto, W. L. H., Moraes, C. S. B., Capparol, D. C. A., Oliveira, J. C., Ansanelli, S. L. M., and Dolphine, L. M. 2020. "Municipal Solid Waste Management and Proposed Sustainability Indicators." *Brazilian Applied Science Review* 4 (1): 70-111. https://doi.org/10.34115/basrv4n1-006.

[18] Pinhel, J. R., ed. 2013. *Do Lixo à Cidadania: guia para a formação de cooperativas de catadores de materiaisrecicláveis*, 1st ed. São Paulo, Brazil: Peirópolis. (in Portuguese)

[19] Moraes, C. S. B. 2021. "Research on Solid Waste Management in the Municipalities of the State of São Paulo, Brazil." Department of Infrastructure and Environment of the State of São Paulo, São Paulo State University (UNESP), Rio Claro, SP, Brazil.

[20] Gerhardt, T. E., and Silveira, D. T. 2009. *Research Methods*, 1st ed. Porto Alegre, Brazil: Editora da UFRGS.

[21] Gil, A. C. 2002. *How to Write Research Projects*, 4th ed. São Paulo, Brazil: Atlas.

[22] Gil, A. C. 2017. *How to Write Research Projects*, 6th ed. São Paulo, Brazil: Atlas.

[23] Köche, J. C. 2011. *Fundamentos de metodologiacient fica:*

*teoria da ciência e iniciação à pesquisa*, 1st ed. Petrópolis, RJ, Brazil: Vozes. (in Portuguese)

[24] Moraes, C. S. B. 2019. "Brazilian National Solid Waste Policy: Methodological Proposal with the Use of Legal, Administrative and Technological Instruments as a Subsidy for Its Implementation and Sustainable Management." Institute of Geosciences and Exact Sciences (IGCE)/São Paulo State University (UNESP), Rio Claro, SP, Brazil.

[25] Environmental Company of São Paulo State (CETESB). 2020. *Inventory of São Paulo State Solid Waste*, 1st ed. São Paulo, Brazil: CETESB.