

# Evaluation of the Efficiency of Selective Collection in a Small Town on the State of Rio Grande do Sul – Brazil

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**Abstract.** With the increase of population concentration in urban areas, there is an increase in the solid waste generation, which demands the search for alternatives and solutions for the environmentally correct destination of these. In this context, this work presents an evaluation on the forms of organic and selective domestic waste collection and the potential for the recyclability of the waste destined to the same, based on the physical characterization and gravimetric composition of the solid wastes generated in the town of Antônio Prado, located in the state of Rio Grande do Sul, Brazil, between 2014 and 2016. It is observed that the population has significant information regarding the correct disposal of waste in the selective collection, since 60% of the waste destined to the same is effectively recyclable. Plastic (24.8%), paper (10.9%), glass (8.8%) and cardboard (8.4%) are the most representative materials in recycled waste samples in the urban area. The importance of continuity and improvement of environmental education programs is essential, due to the evolution in the quantity and complexity of products and materials currently manufactured, and to the method of mechanized waste collection used by the municipality.

## 1. Introduction

Modern society is constantly evolving and, as a result, the concentration of people in urban areas and the generation of solid waste is increasing. One of the current challenges is the search for alternatives and solutions for the final destination of these wastes, especially with regard to the prevention of soil, air and water pollution, since the inadequate management of these wastes is one of the causes of environmental, social, economic and health problems [1]. The fast growth of population, economy, consumption pattern, product obsolescence and new packaging accelerated the rate of urban solid waste generation, provoking a great challenge to their management [2], mainly at the municipal level. For public managers around the world, the management of solid urban waste (MSW) has become, in the last decades, a matter of concern, due to the complexity of the materials and the quantity generated. According to the United Nations (UN), the current generation of waste in the world is around 12 billion tons/year and, by 2020, the estimated volume is 18 billion tons/year. A survey conducted by the Brazilian Association of Public Cleaning and Special Waste Companies shows that the volume of MSW generated in Brazil was 60 million tons/year in 2010, 6.8% higher than the previous year [3]. According to the National Solid Waste Policy [4], the Brazilian law about this subject, "selective collection and recycling are key instruments for the implementation of shared responsibility for the product life cycle, in addition to being fundamental to enable hierarchy in the solid waste management and the socioeconomic inclusion of scavengers". In this way, the Brazilian law directive establishes that the selective collection should be strongly considered in the plans, both federal and regional, and should have its viability encouraged.



According to [5] solid waste management must be offered by local public agencies, but it depends heavily on the active participation of the population that generates them. For this reason, environmental education is extremely important for the effectiveness of management. With it, it is likely that the rules of correct separation of residues are obeyed, materials that were previously discarded precipitously are reused and, even, there is a decrease in the generation of these materials.

The effectiveness of selective collection programs and initiatives necessarily requires the involvement of citizens and need for information and dissemination of programs and initiatives implemented. The community must be sensitized and motivated, and the concepts and practices must be assimilated and incorporated into the daily life of the population involved, with the purpose of ensuring its operationalization, viability and continuity, which are fundamental factors in achieving the expected results and durability [6].

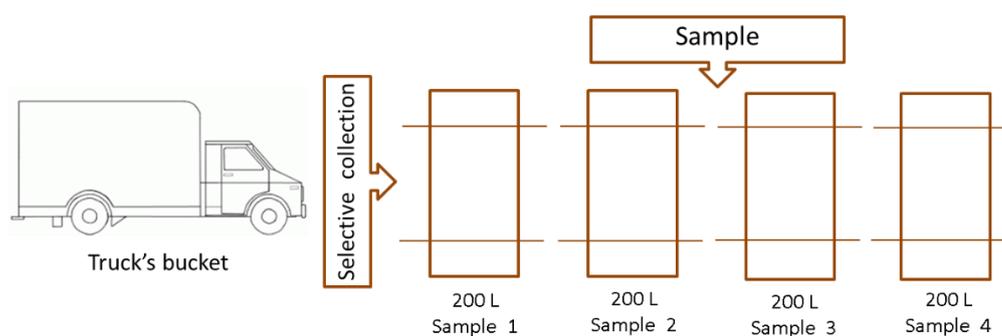
Considering the need to evaluate the effectiveness of selective collection and community sensitization, this paper presents an evaluation on the forms of collection, the potential of solid wastes recyclability and the polymeric materials destined to the same, from the physical characterization and gravimetric composition of solid waste generated in the town of Antônio Prado, Rio Grande do Sul State - Brazil, between the years 2014 and 2016.

## 2. Methodology

The municipality of Antônio Prado has an estimated population of 13,296 inhabitants [7] and is located in the northeastern region of the Rio Grande do Sul State - Brazil. For the physical characterization and gravimetric composition of domestic solid waste generated in this town, a methodology based on the prerogatives of Brazilian Standard "ABNT NBR 10,007/ 2004" was used. Six samples were taken between December 2014 and November of 2016, covering urban and rural areas, mechanized collection and door-to-door collection, as well as selective and regular collection.

Solid waste samples were composed using three trucks: two compactors with capacity of 17 and 21 m<sup>3</sup>, and one with capacity of 14 m<sup>3</sup>, which operationalize the collection of waste in the town. The collection route followed specific routes in the areas defined by the municipal technical team, alternating streets and neighborhoods, so that the collected solid wastes were distributed homogeneously in the internal area of the truck. This procedure was adopted, because the town doesn't have a landfill making it impossible to discharge the waste collected from the truck. It should be noted that for this procedure the residues weren't compacted.

The residuals were collected directly from the truck's bucket for the composition of homogeneous and representative samples, stored in four 200 L barrels, totaling 800 L. Figure 1 shows the method adopted for the composition of the samples.



**Figure 1.** Methodology used to compose waste samples.

After the composition of the samples, the residues were segregated by type of material, weighted on a scale and grouped according to the treatment criteria defined by [8]:

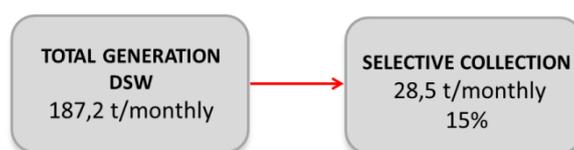
- biodegradable: materials that can be reincorporated into biogeochemical cycles by decomposing organisms;
- recyclable: materials that can be reincorporated into industrial production cycles;
- disposable: materials for which there are still no processes that allow the return of their constituents to the natural or artificial cycles in a short time, or that their recycling is not economically viable.

For the per capita generation calculation of domestic solid waste destined to the selective collection, the information of resident population in the rural and urban area obtained in the 2010 population census [7], and the average of the weights of the months of July to November 2014, and from June to November 2016. For the identification of the percentages of materials found in the waste samples, the materials of the six characterization campaigns were added, the average of these values being calculated, also being calculated the percentage in relation to the total of residues sampled.

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### 3. Results

The amount of solid waste generated in the town was obtained from data provided by the Municipal Department of Agriculture, Environment and Industrial Development of the Municipality of Antônio Prado, referring to the average weight of the trucks that carry out the selective collection, in the period from July to November of 2014 and June to November 2016. Figure 2 shows the monthly amounts of solid waste generated in the town, destined to the selective collection.



**Figure 2.** Monthly waste generation

As shown in Figure 3, 15% of the solid waste generated in the municipality of Antônio Prado is destined for the selective collection. It should be emphasized that in this quantification are included waste from the sorting center for recyclable waste that have no potential for recycling or are economically unviable to be recycled.

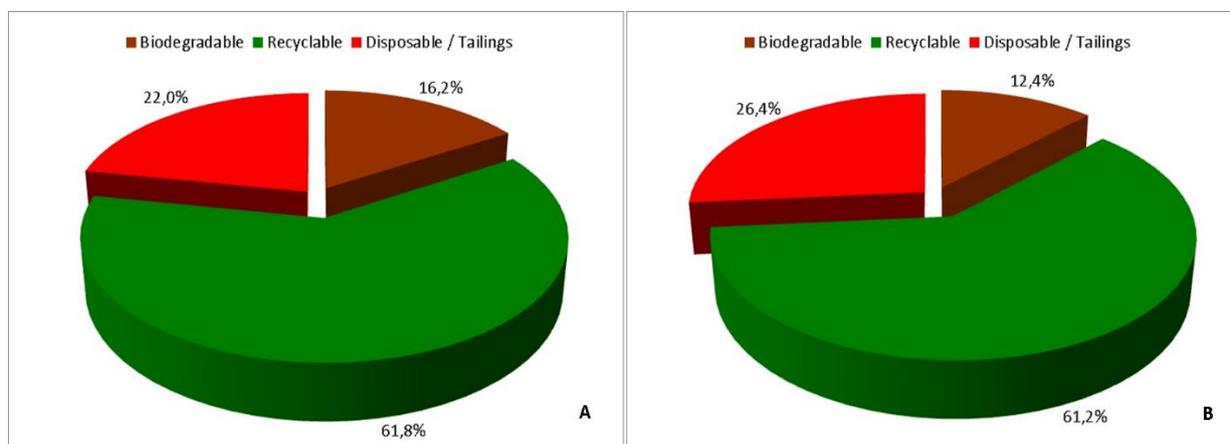
The per capita calculation of the solid waste sent to selective collection was 0.074 kg/hab.day (11.4% of the total generated in the town) of a total generation of 0.647 kg/hab.day of domestic waste. The total value obtained is in the range of values disclosed by [8], which establishes generations between 0.10 and 2.55 kg/hab.day, for municipalities with up to 30,000 inhabitants.

Figure 3 shows the percentage of representativeness of the categories of solid waste destined to the selective collection in the urban area (Figure 3 - A), which comprises the neighborhoods with door - to - door collection and the central area and neighborhoods with mechanized collection (containers) and in the rural area (Figure 3 - B).

The category of recyclables corresponded to 61.8% of the waste sampled from the selective collection in the urban area and 61.2% in the rural area. The biodegradable class accounted for 16.2% and 12.4%, and the disposable/waste class represented 22% and 26.4% respectively in urban and rural areas. It was assumed that the amount of biodegradable waste generated in the rural area and destined to the selective collection was smaller, since the use of this type of waste through composting is quite common in rural communities.

Considering the average percentage of the materials destined to the selective collection in the urban area, in the five campaigns carried out, it is observed that plastic (24.8%), paper (10.9%), glass (8.8%) and paperboard (8.4%) are the most representative materials in the samples of recyclable waste in the urban area. In the polymer material category, the highest percentages of PEBD - Film (6.2%), generally used in food packaging and PET - bottle (3.5%) were verified, represented by soft drink and water packages. It is observed that there is a tendency of the polymeric materials generated and

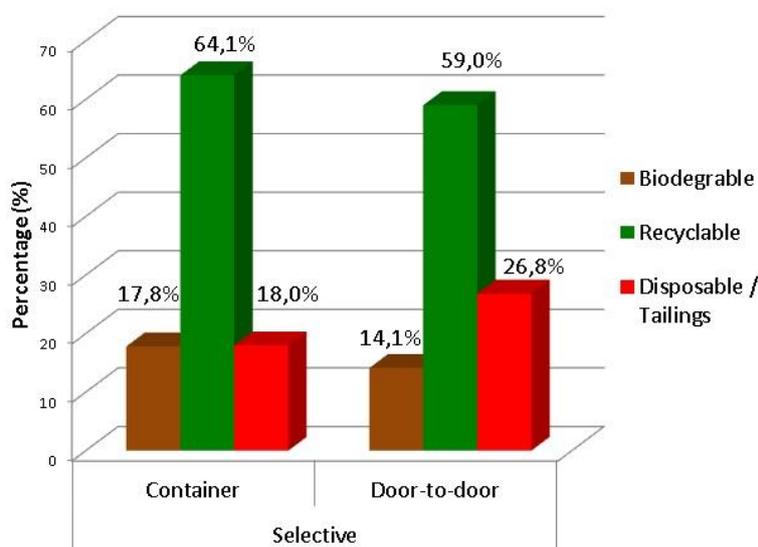
segregated by the population, to be destined to selective collection, regardless of whether they are rigid or film



**Figure 3.** Composition of waste sent to the selective collection in the urban area.

Considering the representativeness of the potentially recyclable materials destined to the selective collection in the rural area, it is observed that the polymeric materials represent 42.4% of the total samples, being that of these materials, the ones found in greater quantity were: PP - Film (9), PEBD - Film (8.1%), consisting of food packaging, PP buckets and pots (4.3%) and PET bottles (3.3%). It should be noted that the "other category", contemplated in the category of polymeric material, refers to materials that have more than one type of polymer associated in its composition. The amount of polymer waste generated by the municipality is not enough for the implantation of a mechanical recycling plant of polymers, since the daily generation is less than 1000 kg per day for any type of polymer. However, the option of forming partnerships with other municipalities in the region through consortia can make mechanical recycling economically viable.

Figure 4 shows the composition of solid waste collected in the urban area destined to the selective, by containerized and door-to-door collection systems, grouped on the basis of the potential for treatability (biodegradable, recyclable and disposable). The containers (33 sets / recyclable + organic) were deployed in the central area of the town in March 2014. In July 2015, containerization was expanded to the neighborhoods around the central area, and 40 more (recyclable + organic), totaling 73 sets.



**Figure 4.** Potential of treatability of the waste destined to the selective collection, in the urban zone, by the systems of collected container and door-to-door.

Results show that the segregation of recyclables made by the population of the waste destined to the containers, although the difference is not significant, presents a trend of better segregation when compared to the door-to-door system.

In order to evaluate the efficiency of segregation and destination, after the expansion of the area occupied with containers, the percentage of waste destined to the collection was evaluated. It is observed that after the expansion of the containerization system in the neighborhoods, located in the environs of the central area, the waste destined to the containers of the selective collection, in the center, as in the districts, was more efficient, due to the greater percentage of residues for this collection.

It is also observed that both the amount of waste belonging to the biodegradable category and also the disposable solid waste was reduced by approximately 50% in the central area containers from 2014/2015 to 2016. This result is directly associated with the environmental education campaigns carried out by town. On the other hand, door-to-door collection in the neighborhoods had a reduction in the percentages of recyclables destined, which demonstrated a reduction in the efficiency of segregation and destination.

In door-to-door collection, one of the factors influencing the results is the collection times and days, since the trucks can collect at the wrong time or the population can place the waste on public roads at times and days that are not compatible with the calendar.

#### 4. Conclusion

Considering the results obtained with six characterization campaigns of the town of Antônio Prado (December/2014, February/2015, June/2015, July/2016, September/2016, November/2016), it is concluded that, in general, the population has significant information regarding the correct disposal of solid waste in the selective collection, since 60% of the waste destined to it is effectively recyclable.

In the rural area of the municipality, which is attended by selective collection in 100% of its territory, consideration should be given to the implementation of incentive and environmental education programs for the practice of composting in rural communities. However, due to the presence of a representative quantity of biodegradable materials in the samples of the rural area, the need for more effective municipal programs for this practice is identified by the municipal management that the rural population performs the composting.

It is worth mentioning that the presence of biodegradable and disposable waste in the selective collection makes it difficult to segregate the sorting centers, generating odors, discomfort to the

segregators and the loss of the quality of the recyclable material, due to their contact and consequent contamination. With the presence of these materials in the plants, there is demand for transportation and final destination in landfills, resulting in increased costs in the waste management process.

The continuity and improvement of environmental education programs are essential, due to the evolution in the quantity and complexity of products and materials currently manufactured, and the relatively new method of collecting waste, adopted by the municipality (containers). In order to increase the efficiency of segregation, and consequently, in the management of domestic waste, it is indicated that the campaigns for the collection of recyclable materials, already developed by entities and public management in the municipality, are even more optimized, so that there is a greater dissemination of these information and greater adherence by the population.

## 5. References

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