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## Article

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## Evolution on the solid urban waste management in Brazil: A portrait of the Northeast Region

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### Abstract

The discussion on the management of urban solid waste gained global contours in the 70's, but its interest in some developing countries is relatively recent. Namely in Brazil, the legislation was only approved in 2010 (Law 12,305). Almost 10 years after the approval of this policy instrument, a low evolution is identified with regard to the 4 basic management processes (generation, collection, selective collection and final disposal of waste). The impacts of inefficient management offer irreparable damage to the environment, including the uncontrolled emission of gases such as methane (CH<sub>4</sub>) which, although one of the main responsible for global warming, has great potential for electricity generation. Although Brazil already has technologies for power generation, the exploration of this sector, as well as others aimed at reuse, depend directly on the efficiency of the basic waste management processes. This paper aims discussing the evolution on the characterization of Urban Solid Waste Management — USWM in the Northeast Region of Brazil in a period from 2007 to 2017. The results and conclusion show the low application of the more recent legislation (deliberations of Law 12,305) on the Northeast Region, materialized on the low effectiveness in the processes, as well as the small evolution concerning the guidelines of the National Waste Plan of the year 2012 and the present objectives in the Agenda 2030 for Sustainable Development published by the United Nations Organization in 2015. The identified scenario points to the urgent need to fill the gaps in the Northeast, in order to make legislation more effective, reduce environmental impacts and boost waste reuse sectors.

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## 1. Introduction

The management of urban solid waste is of utmost importance from the point of view of health security, and contributes substantially to climate change. The efficiency of basic management processes such as collection, transportation and disposal is directly related to the reduction of greenhouse gas emissions [1]. Improvements in waste management can be achieved through effective approval and implementation of waste management policies.

The National Solid Waste Policy (PNRS) of Brazil approved in 2010 through Law 12,305/2010, determined the responsibilities of generators and public authority, as well as other important challenges. However the optimization on the waste management is not yet a reality [2]. The PNRS represents a major milestone for the country since for the first time some specific guidelines related to integrated solid waste management involving the responsibilities of generators and public power and the applicable economic instruments were introduced in national legislation [3].

For the construction of the PNRS we may notice the influence of current concepts from developed countries, particularly Europe countries, namely the topic that concerns the hierarchy of waste treatment. This influence does not weaken national politics since it is based on the principle of mirroring in successful experiments in this field of study. The counterpoint to be weighed in this respect is the need to take into account the specificities of each country and/or region with regard to economic, political, social, financial and structural aspects. This requirement is especially important when dealing with a country such as Brazil with its great diversity, territorial extension and clear divergences between regions in the most varied aspects. As a middle-income country, Brazil differs from a large part of the developing countries in terms of per capita waste generation. In a large part of its territory, the quality of waste management is as poor as in some other countries with low incomes. This is explained by the different cultural and socioeconomic contexts of each region ([4] apud Marshall and Farahbakhsh, 2013).

The application of the right Sustainable Waste Management is motivated by international pressures in both developed and developing countries. The attained desired level of management values and the consideration of waste as a resource follows the recommendations by the European Union about its treatment in the hierarchical order: to prevent, to minimize, to reuse, to recycle, to recover and in the last case to go to the final disposal (Halkos and Petrou 2016). The consequences of the mismatch faced by Brazil, in the global context, with regard to the creation of normative instruments and their implementation is a factor that needs to be studied. The establishment of regulatory instruments for waste management in Brazil is considered to be late compared to other countries, such as the European Union countries which, with its Directive adopted in 1975, influenced the origin of more specific policies or instruments aimed at the sustainable management of waste Member States in their respective years: France/1957, Germany/1986, Spain/1998, Portugal/1997 [5]. In this context, the USA is also worthy of note, having adopted its law in 1965 and Japan in 1970. This temporal gap in Brazil, in terms of the effectiveness of the legislation offers numerous challenges for the municipalities with regard to the adequacy of their management waste models. In addition there is also a physical and structural distance, proven by statistical data, between the Brazilian public policies related to the Management of Urban Solid Waste (USWM) and its real implementation [6].

Almost a decade ago, when the PNRS was approved, the Brazilian Institute of Geography and Statistics (IBGE) pointed out that in 2017 half of the 5570 Brazilian municipalities did not have an integrated plan for waste management. This context alone demonstrates the failure to comply with the deadline established by the PNRS for the inclusion of this legislation on municipal plans. The collection process still does not contemplate the country as one. According to the Brazilian Association of Cleaning Companies Public and Special Waste (ABRELPE), in 2017, approximately 7 million tons of waste generated had unidentified destination. Another worrying factor concerns the final waste disposal process. When analyzing the final disposal systems, the data is also alarming, since 3352 municipalities still direct their waste to inappropriate places (landfills or controlled landfills) and it is mentioned that still 29 millions of tons of waste is being directed to environmentally unsuitable locations. This is referring to another criteria contemplated in the PNRS 'determination that is not being fulfilled: municipalities must eradicate inappropriate systems of final disposal by the end of August 2014. The recommendation of the legislation is the implementation of landfills that even provide clean development mechanisms for the reuse of by-products from the decomposition of discarded organic matter, such as biogas. The use of biogas, besides being a renewable source of energy, also contributes to the reduction of methane and carbon dioxide emissions in the atmosphere, gases that aggravate the greenhouse effect (GEE). However, biogas is little explored in Brazil and its potential remains controversial, mainly due to the different evaluation methodologies adopted [7].

Concerning the data on selective collection are also concerning. Firstly because there are still around 1692 (30.37%) of the municipalities without any type of differentiated delivery initiative; secondly, because 3878 (69.63%) municipalities do not cover the total of the municipal area, representing, in many cases, isolated and disarticulated actions of the integrated waste management process recommended by the PNRS [8].

Brazil is the largest country in Latin America and the fifth largest in the world with 209 million inhabitants. The country is divided into 5 major regions: North, Northeast, Midwest, Southeast and South. The North and Northeast regions show the worst performance concerning USWM [8]. For all of the above, the research focused on the country's detailed analysis regarding the evolution of urban solid waste management is very relevant namely for the identification of the adoption of the standards established by the PNRS and for signaling the current weaknesses and potentialities of the system.

The present research has as general objective analyzing the evolution in USWM in the Northeast Region of Brazil, presenting an evolutionary framework that includes stages before and after the PNRS implementation in 4 specific processes: Generation, Collection, Selective Collection and Final Disposition of solid urban waste — USW. In order to choose which of the five regions in Brazil would be selected, two criteria were established: A. Criteria for the greatest number of inhabitants and B. Criterion for the worst performance in the year 2017 in the management processes proposed for the analysis. Of the 5 regions of Brazil, the most populous are the Southeast and then the Northeast regions, thus eliminating the other regions. The second criterion defined between the two most populous what would be the chosen region. The data of ABRELPE [8] reveal the following positioning of these two regions in the processes chosen for analysis: Generation (Southeast 1, largest generator of waste, Northeast, 2nd largest in generation); Collection Coverage (Southeast, 1st in performance, Northeast, 5th in performance, or worse performance among the 5 regions); Selective Collection Initiatives (Southeast, 2nd best performance, Northeast, 4th in performance); Final Disposition (Southeast, 1st in performance, Northeast 4th in performance). From these data and the established criteria, the Northeast Region would fit the criteria established for the selection of the Region. The aim of this study is to present a framework for the evolution of the Northeast Region in relation to the Urban Solid Waste Management processes from 2007 to 2017, in order to highlight weaknesses and potentialities regarding the adherence of this region to the precepts established in the PNRS, in the National Waste Plan and in the goals presented in Agenda 2030 for Sustainable Development prepared by the United Nations (UN) and with that contribute to the establishment of more specific public policies for the analyzed USWM processes in this region.

## 2. Characterization of the Northeast region

With a population of 209.3 million inhabitants, Brazil generated some 78.4 million metric tons of urban solid waste in 2017, and the collection coverage was 91.2%. Approximately 7 million tons of waste were disposed of unknown. 59% of the collected amount was destined to adequate systems (sanitary landfills-AS) and the remaining 41% were directed to inadequate final disposal systems (dumps-LIX and/or controlled landfill-AC). Of the 5470 Brazilian municipalities, 3352 still direct their waste to inadequate systems. The Brazilian per capita generation was 1.035 kg/inhab/day and the monthly per capita cost of the waste management operations reached the amount of R \$ 10.37. Generating 337 thousand jobs of public and private order, the waste management market moved in 2017 about 28 billion reais to the country. Divided into 5 regions, the collection is represented by North (6.5%), Northeast (22.4%), Midwest (7.3%), Southeast (52.9%) and South (10.9%).

The municipalities that have a selective collection initiative total 3923, or the percentage of (70.4%). The Northeast Region — NDE, the target of this study is formed by 9 States (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Piauí, Rio Grande do Norte and Sergipe), being the second most populous region with 56,560,081 inhabitants [9]. The analyses of the waste management processes were divided into 4 items in the following order (1 Final Disposal Systems, 2 Waste Generation, 3 Collection Coverage and 4 Selective Collection Initiatives), as follows.

### 2.1. Final disposal systems

The National Plan foresees the elimination of 100% of the landfills by 2031. Looking at the last 10 years (2008–2017), in Fig. 1, it is perceived that this target according to the rhythm of the last 10 years is impracticable. If we analyze the evolution of the last 10 years of all municipalities that make use of the *dumps* (LIX) in Brazil in 2008 we had 1657 municipalities and in 2017, 1610 still used this system. The reduction of the dumps in 10 years was only 47 municipalities, or 2.83%, which means that each year the reduction is only 0.23%. If this rate of reduction

a

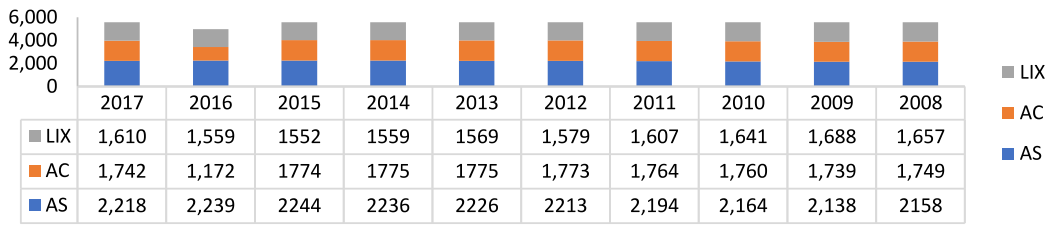


Fig. 1. Final disposal systems\_municipalities in the Brazil.

continues and we round the average reduction to 50 in every 10 years, it means that in 2027, we will still have 1560 municipalities making use of this system and in 2037 we will still have 1510 municipalities in this scenario. This average makes the target established in the National Plan unenforceable (100% eradication of dumps by 2031), as well as contrary to objective 11.6 of Agenda 2030 - “reducing the negative environmental impact of municipalities by 2030 with regard to waste management”.

When analyzing the Northeast region, according Fig. 2, the conclusions are more worrying containing unfavorable oscillations for the reduction of the dumps. The picture in 10 years did not change.

b

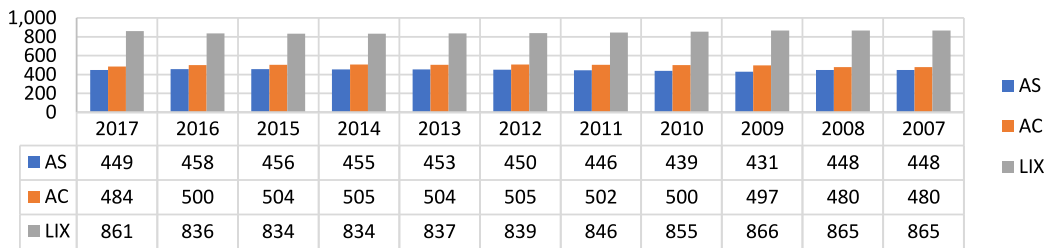


Fig. 2. Final disposal system\_Northeast region.

From 2007 to 2017, the reduction was only for 4 municipalities, failing to use this final disposal system. We had in 2007, 865 municipalities making use of this system and in 2017, 861 municipalities. If we include the scenario of the Controlled Landfill (AC), which is also a system that has negative impacts on the environment, the scenario in the Northeast region becomes even more worrying, since we will have 1794 municipalities, 1345 (484 + 861) municipalities or the equivalent to 74.97%, using the systems of inadequate final disposal.

At this rate the achievement of the goals for 2031 is much more unworkable for the Northeast region of the country. This scenario contradicts the objectives of the PNRS approved in 2010, paragraph II of Art. 7, - “to ensure the final disposal environmentally appropriate waste”, and the Art. 54. “The final environmental disposal of the tailings should be implemented in up to 4 (four) years after the date of publication of this Law 12.305/2010”. In general terms, 100% of the municipalities must maintain the Sanitary Landfill (AS) as the final disposal system.

c

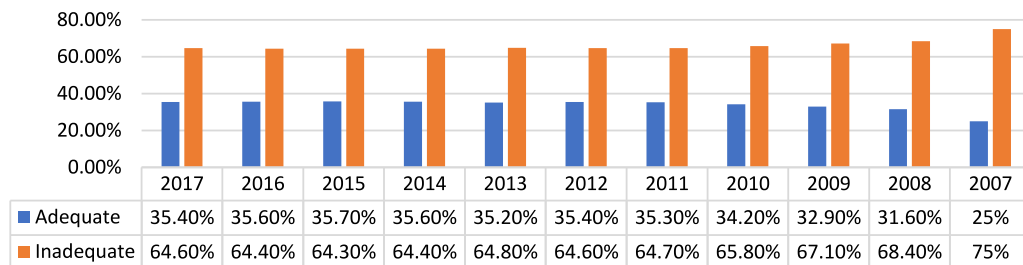


Fig. 3. Final disposal system (%) Northeast region.

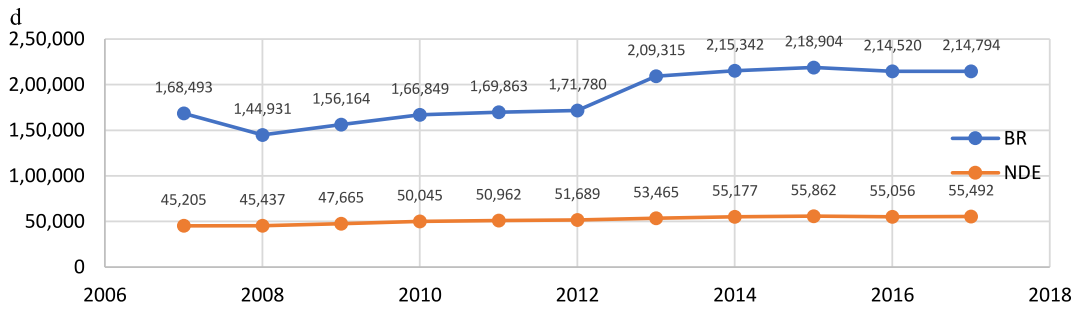


Fig. 4. Generation USW t/day.

e

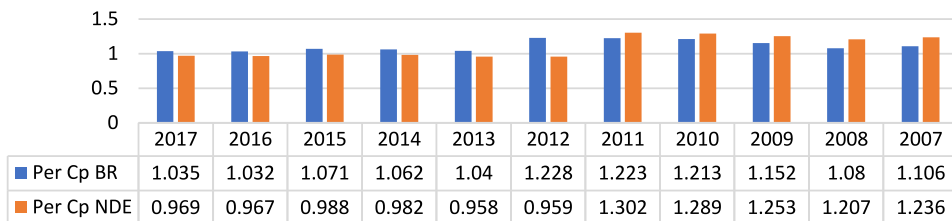


Fig. 5. Per capita generation kg/day BR and NDE.

As shown in Fig. 3, the Northeast Region in 2017 allocated 64.6% of its waste to inadequate disposal systems. In the last 10 years (2007–2007), the evolution was very low, changing little the picture about the disposition in this region.

### 2.2. Generation

The Figs. 4 and 5, points to a reality for generation against the guidelines of the three instruments used. The three instruments deal with the urgent need to reduce the production of waste. Even considering the gradual increase in population, it is not possible to see a considerable reduction in generation in the last 10 years. However, after the establishment of Law 12.305 in 2010, both for the national reality and for the reality of the Northeast Region — NDE, which increased by approximately 22.22% (2007–2017), according Fig. 4, of waste generated.

The increase in population obviously causes an increase in the generation of waste, therefore the effective guidelines for reduction should be directly proportional to this increase. It may be seen in Fig. 5 that the per capita generation index has decreased in the last 10 years for the Northeast Region. The Fig. 5 shows a reduction in per capita generation in the Northeast Region, between 2007 and 2017. In 2007, this index was 1.236 kg/day and in 2017 it increased to 0.969 kg/day of 21.6%. When analyzing the national index, it is noticed that each Brazilian generated in 2007 1106 kg/day of waste, passing in 2017 to generate 1035 kg/day. The reduction in the national index was only 6.41%. Although the Northeast has been able to reduce its per capita generation rate, it is not possible to notice the reduction in the total volume generated, which jumped from 45,000 t/day to 55,000 t/day in the analyzed period, according to Fig. 4 not reduction in generation contrary to the provisions of the PNRS in its Section 2 of art. 30, “reduce solid waste generation, material waste, pollution and environmental damage” and objective 12.5 “by 2030 to substantially reduce generation through prevention, reduction, recycling and reuse”.

### 2.3. Collection coverage

Regarding the scope of collection in the country, the data show gains for the country and for the Northeast region. Currently, collection coverage in Brazil has a percentage of 91.24% and in the Northeast Region 79.06% according Fig. 6. The increase in the percentage of collection in the Northeast Region in the last 10 years was only

f

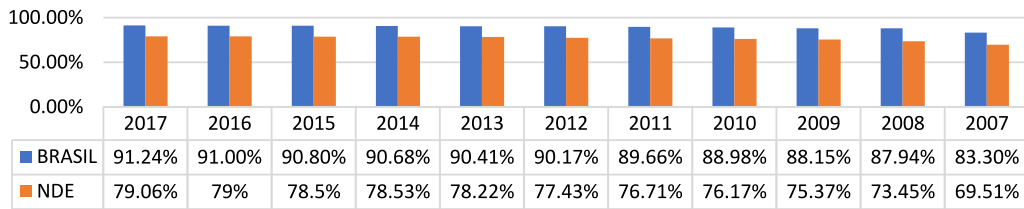


Fig. 6. Scope of the collection\_BR and NDE (%).

13.73%, considering that in 2007 the collection was 69.51% and in 2017 reached the percentage of 79.06%. If the pace continues in this percentage, in 2027 the collection coverage will be 88.61% and in 2037 the total collection coverage will not be reached with a percentage of 98.16%. Regarding the scope of collection in the country, the evolution show positive trends for the country and for the Northeast region. This projection places the region in a scenario of still not meeting the precepts of Law 12305/2010 and the objectives defined in the UN Agenda 2030.

#### 2.4. Selective collection initiatives

Regarding the municipalities with selective collection initiatives, the Northeast region still shows a low performance in this area, of the 1794 municipalities only 50.2%, according Fig. 7. It should be noted that the evolution on this issue is slow and that most of the initiatives are in the actions of collectors or groups of waste pickers who work without adequate infrastructure and who resell the materials collected to recycling companies. Some organizations created have no sustainability and for this reason do not stay active for a long time and sometimes this scenario causes oscillation in the evolution of the selective collection data.

g

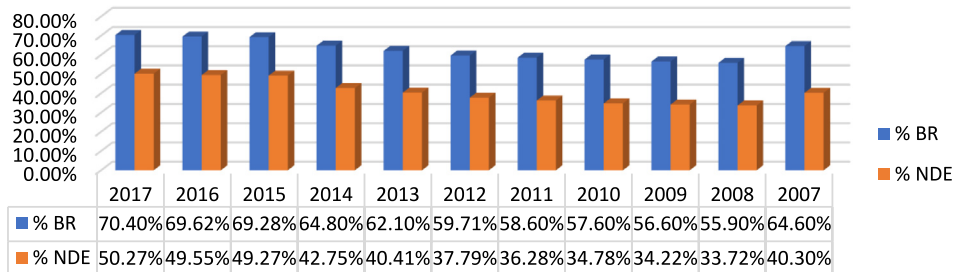


Fig. 7. Municipalities with selective collection (%).

The data show that from 2007 to 2017 (40.30% – 50.27%), the percentage increase in the Northeast region of the selective collection initiatives was 24.73%. If this percentage is 25% (for every 10 years) in 2027 we will have 62.83% of the municipalities contemplating these initiatives and in 2037 we will have the percentage of 78.53%. This scenario contradicts Item 30 of the PNRS, which states that the country, states and municipalities should “promote the use of solid waste by directing them to its productive chain or to other productive chains” and objective 12.5 of Agenda 2030 “ by 2030 to substantially reduce the generation of waste through prevention, reduction, recycling and reuse”.

### 3. Conclusions

The results of this study indicate that the implementation of PNRS in the Northeast has not had the desired range since there is a distance between what is established in Law and transactions involving the processes of

generating, collecting, recycling and final disposal of municipal solid waste. The gap identified may suggest the need for revision of the PNRS that although behold one chapter that verse on the bans, a chapter specific to the bans, does not provide a chapter to penalties to regions that do not have adhered to the precepts of the law. The lack of a monitoring incisive by environmental agencies is another factor that could undermine advances in management and this can be attributed to the absence of a definition in PNRS periodicity of supervision followed by elements of sanctions for violators.

In addition, the absence of clear targets in PNRS aimed at reducing waste generation and emissions of polluting gases, or for the generation of energy from biogas and selective collection initiatives, has weakened the adequacy of the Northeast region of Brazil and consequently aggravated the environmental impacts. The municipalities and states of the Northeast Region, although having autonomy to set missing targets in the PNRS, face bottlenecks such as lack of technical knowledge, negligence or lack of financial resources, which has compromised both the implementation of legislation and advances expected by the country in the urban solid waste sector. The satisfactory evolution of the waste sector depends primarily on the efficiency of the most basic management processes (generation, collection, selective collection and final disposal). It is this efficiency that can favor the implementation of more complex processes, such as clean development mechanisms that include technologies to reduce greenhouse gas emissions and contribute to the diversification of the country's energy matrix, from production energy from biogas.

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