Critical Analysis of Solid Waste Information Systems in Brazil

Análise Crítica dos Sistemas de Informação de Resíduos Sólidos no Brasil

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ABSTRACT

The comprehensiveness and reliability of information on the current management of urban solid waste in Brazil is a challenge to the objectives of scientific research. In the introduction to this article, the main information systems are identified and their main limitations are briefly presented. ABRELPE's Panorama of Solid Waste in Brazil (PSWB) - as one of the main sources of information - was analyzed in detail regarding the statistical methodology used to determine its values. The results of this analysis revealed to be of low reliability in relation to the quantitative referring to the variables published on MSW - solid urban waste and Health Services Waste (HSW). Either because there are no complete descriptions about the application of the method, as well as the evidence of inadequacies of the model developed with the adopted statistical method. The present work allowed us to come to the conclusion of the importance of developing an independent national system for gathering information on the production, treatment and disposal of waste that effectively contributes to the search for solutions to the serious social, economic and environmental problem caused by solid urban waste and its poor management in general.

Keywords: Solid Waste; Information Systems; Statistical Methodology

RESUMO

A abrangência e confiabilidade de informações sobre a atual gestão de resíduos sólidos urbanos no Brasil é um desafio aos objetivos da pesquisa científica. Na introdução deste artigo são identificados os principais sistemas de informações e apresentadas brevemente suas principais limitações. O Panorama de Resíduos Sólidos do Brasil (PRSB) da ABRELPE – Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais – como uma das principais fontes de informações foi analisado minuciosamente quanto à metodologia estatística empregada para determinação de seus valores. Os resultados desta análise revelaram-se de baixa confiabilidade com relação aos quantitativos referentes às variáveis sobre RSU – resíduos sólidos urbanos e RSS – resíduos de serviços de saúde publicados. Seja por não haver descrições completas sobre a aplicação do método, bem como pela evidência de inadequações do modelo desenvolvido com o método estatístico adotado. O presente trabalho permitiu concluir a importância do desenvolvimento de um sistema nacional de levantamento de informações de produção, tratamento e disposição de resíduos independente e que contribua efetivamente na busca de soluções para o grave problema social, econômico e ambiental causado pelos resíduos sólidos urbanos e sua má gestão, de forma geral.

Palavras-chave: Resíduos Sólidos; Sistemas de Informação; Metodologia Estatística

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1 INTRODUCTION

The efficient management of solid waste is still a major challenge for Brazilian municipal authorities. Annually, 1.3 billion tons of Municipal Solid Urban Waste (MSUW) are produced on our planet, with a total of 2.2 billion projected for 2025. In Brazil, despite regional differences, the per capita generation of waste is close to 1 kg / inhab. day with an organizational performance similar to that of underdeveloped countries (SHAH et al.; KAMARUDDIN et al., 2017).

Northern European countries, Japan and the USA have been greatly reducing the sending of waste to landfills. Brazil, however, is still in the construction phase of supposedly sanitary landfills and in the unsuccessful attempt to close the dumps. Federal Law No. 12,305 of 2010 - National Policy on Solid Waste (NPSW) - went through almost 20 years in the National Congress, reflecting great difficulties and bureaucratic barriers. Unfortunately, the effectiveness of the law has not yet been seen. According to PSWB, "dumps" should be eradicated by the year 2014, however, according to FERNANDES (2015), in a survey conducted in 2014 with 5,570 Brazilian municipalities, only 844, or 15%, destined the waste in supposedly sanitary landfills, 1,775, or 32%, of the municipalities declared to dispose of the waste in dumps and, 2,951, 53%, did not even answer the survey.

One of the important factors for improving waste management is the existence of efficient and reliable information systems, which enable any citizen to obtain clear, safe and accurate data. First, it is a legal requirement provided for in the law on access to information, since the treatment with waste is an activity carried out by the municipal government (directly or indirectly) and uses public money. Likewise, for the citizen to be able to participate actively in the waste management system, it is necessary that he / she knows the details and information regarding the solid waste management and management actions. One of the principles of the National Solid Waste Policy (Law 12,305 / 10) is the right of society to information and social control (BRASIL, 2010; BRASIL, 2011; MAHLER & MENDEZ, 2018).

The objective of this work was to analyze the information systems currently available. First, with an overview of the main sources. Then, in detail, a critical analysis was developed on the methodology presented in the ABRELPE documents in order to observe the reliability of the information provided. This analysis covers the years 2015 to 2017 (published in 2018). Although the document for the year 2017 has been analyzed without its respective attachments, because they have not been available on the website since its launch in 2018, nor were they sent to the authors of this work as requested. The other annexes, from previous years' information books, were sent by e-mail, which helped in the work, in which the authors are grateful to the public.

2 SOLID WASTE INFORMATION SYSTEMS IN BRAZIL

Currently in Brazil there are some waste information systems at the national level. The National Sanitation Information System - NSIS is a database under the institutional coordination of the Ministry of Regional Development that contains information and indicators on the provision of Water Supply, Sanitary Sewage, Urban Solid Waste Management and Water Drainage services. Urban rainwater. (BRAZIL, 2020)

The information contained in the NSIS is provided annually by the providers of sanitation services, whether they are the municipalities themselves in the form of direct provision of services or companies that are part of the indirect public administration or public service concessionaires. The NSIS database for solid waste contains important information such as estimates on the coverage of the collection service by region, the profile of the providers of waste management services, the types of collection carried out, the percentage of disposal of waste in landfills toilets and dumps, in addition to other relevant information on the characteristics of waste management in the municipalities and regions of Brazil.

The number of municipalities participating in the SNIS has increased substantially in the past two decades. In 2002, 108 municipalities participated in the SNIS, in 2010 this figure was already 2070 and in 2016, the total number of

participating municipalities was 3670. Despite the importance of the data released and the significant increase in the participating municipalities, the SNIS is a self-reporting information system, that is, sanitation service providers inform the indicators, without a known and comprehensive methodology for verifying the veracity of the information provided. It is noteworthy that, through the Self-Declaration Information System (SNIS), there has been no improvement in the indices related to waste management in Brazil in recent years. Another critical point is that, with the recent reductions in funds and changes / cuts in the staff of federal agencies linked to environmental and waste management, it is expected that the situation, which is no longer good, will become even worse. (MAHLER & MENDEZ, 2018)

Another institutional information system is NISSWM (SINIR in Portuguese) - National Information System on Solid Waste Management, which is one of the instruments of Law 12.305 / 2010, the National Policy on Solid Waste. According to information from the Ministry of the Environment (2018) managing body of the referred system, "to SINIR, the Waste Inventory will be added, which will be added to the Annual Solid Waste Declaratory System, which will be filled out and updated by the industries, signaling the origin, transport and final destination of the waste. IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) is the executing agency for the National Environmental Policy, of which the National Solid Waste Policy is an integral part. Considering that IBAMA is responsible for coordinating the National Register of Hazardous Waste Operators and for promoting their integration with the Federal Technical Register of Potentially Polluting Activities or Users of Environmental Resources and with SINIR, IBAMA has a fundamental role not only in inspection, as well as the availability of data related to hazardous waste (CAPISTRANO FILHO, 2013). IBAMA will be responsible for coordinating this register and is already promoting its integration with the Federal Technical Register of Potentially Polluting Activities or Users of Environmental Resources to SINIR "(SINIR, 2018). Although, to date, no substantial change has been made to SINIR, everything indicates that, as well as other criteria of environmental restrictions, this will also be relaxed by the current government, which may postpone even more the existence of a registry of hazardous

waste operators really consistent with reality. However, the National Inventory of Industrial Waste has not yet been prepared, although CONAMA Resolution 313/2002 already established this need. SINIR, in the first eight years of its existence, has not yet evolved as expected. It is necessary that the objectives outlined for this important waste information system at the national level be reached as soon as possible. The Brazilian Institute of Geography and Statistics - IBGE, published in 2008 the last National Sanitation Survey, but it is already somewhat out of date and there is no sign of publication of the next edition.

Some entities and associations publish studies and surveys related to solid waste management in Brazil. The Union of Urban Cleaning Companies - SELUR has an index called the "Sustainability Index", which has points to be questioned, such as the fact that it has only 4 indicators (Percentage of the population served by urban cleaning services, Financial sustainability, Recovery of collected resources and incorrect destination on the population served by the services). In addition to little to represent a municipal waste management system, they are generic indicators, that is, in the case of the environmental impact dimension: Quantity of Waste Incorrectly Disposed / Population Served, it is not clear what is the wrong disposal. It is not common to measure the incorrect disposition, considering that it occurs in dispersed areas and even if it occurs in a few areas, it is not common to have equipment or conditions to carry out these measures. (SELURB, 2018)

The indicators for assessing waste management must reflect reality. In the case of the SELUR index, there is an indicator called the financial dimension, calculated as follows: service expense x specific collection / total expenditure. A municipality that collects a lot from waste collection fees, spends a lot and badly to provide waste management services and has total expenditure not so high for not investing in other areas of the management system, will have a high indicator. What the indicator calls specific collection is actually the amount collected from fees for the cost of waste management services.

An important entity in the solid waste area is ABRELPE - Brazilian Association of Public Cleaning and Special Waste Companies ", which annually publishes the"

Panorama of Solid Waste in Brazil "(ABRELPE, 2018/2019). This paper analyzes the 2015 and 2016 publications of this association and provides arguments, from a methodological point of view. It identifies the estimates of some variables referring to MSW and HSW for which the methods that generated them are not made explicit, or in other cases, are made explicit, but without the formal presentation of the results of their application.

In the analysis section of this annual information book by ABRELPE, arguments are presented in the form of a discussion about the use of the simple linear regression method and its results. In this work, the conclusions section presents a general assessment of all the available content of this information source and highlights its deficiencies.

It is important to note that the problems of waste management, although it is a service whose owners / providers are the municipalities, have regional and international scope. Mainly because the destination of many irregular drains is the watercourses (rivers and seas), which implies harmful consequences for the whole Brazilian society, neighboring countries, as well as all future generations.

3 ABRELPE'S PANORAMA OF SOLID WASTE IN BRAZIL

In this section, this source of information is described in detail for all the MSW and HSW variables provided. All variables for which there is no complete or partial specification of the method used to supply their quantitative are also identified. The analysis elaborated in the following section refers to the discussion of the simple linear regression method used for two variables on MSW: the total quantity collected per day and the quantity per capita collected per day.

A first aspect of this analysis of the methodology adopted in the PSWB 2015 and 2016 information books refers to the percentage of municipalities that adopt selective collection. On page six, of both annexes, of each of the two appendices, the PSWB of 2015 and 2016, it is read that the "chi-square methodology" was used by ranges of the population quantity of municipalities, Qpopulation. This procedure it is

assumed that only the Qpopulation has an influence on the practice of selective collection. It should be added that the methodology, referred to with the term chi-square, is not specified as to the results with its use to establish the percentages found in the two appendices mentioned above, PSWB 2015 and 2016. There is also no specification, in these two annexes, of how the mentioned projections were obtained, at the level of municipalities, federative units and the five major Brazilian regions, of the amounts on the final destination of MSW, of the expenses incurred with services collection, as well as the number of jobs generated in the sector.

By the way, the following highlighted text, found on page seven of both annexes of the publications PSWB 2015 and 2016, on the methodology used, mentions the final destination of the MSW, although the terms are not sufficiently clear:

"For the federative units, the available samples, when confronted with the quantity and density of the data collected, enabled the elaboration of projections regarding the collection, generation and final destination of the MSW."

Following with the analysis, information on health services waste (HSW) is also partial. Because there is no record of the amounts collected from these wastes by private companies. In this way, there are no records by municipalities on the total HSW collected, as well as on the quantities previously prepared before the final destinations are processed in the different technology modes currently available. So, there is no complete information on how much or how the handling of HSW occurs, until the final destination of the municipalities, that answered the ABRELPE questionnaires.

However, based on this partial information from the municipalities that responded to the questionnaires, in a self-declaratory manner, the PSWB information books, 2015 and 2016, contain tables, graphs and projections of the collected HSW amounts and the final destination amounts by different technologies for all of Brazil, in the respective regions and federative units. Thus, the most relevant thing to emphasize is that there is no methodological description for these projections at any

of these levels, including the lowest of them, at the level of the municipalities. It is only mentioned that the methodology applied to HSW is the same used for MSW.

Another relevant aspect refers to the absence of any sampling planning. The PSWB 2015 information appendices, in virtual format, consists of three annexes. One on the methodology adopted, another containing the questionnaires used, and a third, with the identification of the participating municipalities. The introduction of the PSWB 2015 appendice reads that this last annex contains a list of the names of the municipalities that responded to the questionnaires. And, although this last annex was not made available by the association, this absence is of less importance in view of the absence of an explicit sampling plan capable of guaranteeing the inference presented in the document. The 2016 document has the same deficiency.

Finally, it is worth mentioning that, of the four hundred municipalities said to be questioned in a direct survey in the annex of the PWSB 2015 appendice, one hundred and ninety were not surveyed. Such municipalities, however, were taken as part of the sample with the justification of having been researched directly in the previous year. In addition, the projected values for the year 2015, of these one hundred and ninety municipalities (broken down only in relation to the total number of municipalities by large region, table 1.1.1.1 of the annex to the PSWB 2015 appendice), in order to compose this sample, derive from projections or inferences whose methodology is not specified. However, it can be read, with regard to these one hundred and ninety municipalities that "their trends were scientifically projected" (page 4 of the annex to the 2015 PSWB section).

The five models, respective for each major region, and used to provide projections for 5170 municipalities, or even those 190 municipalities, were the object of a critical analysis of the present work in the following section.

4 CRITICAL ANALYSIS OF THE SOLID WASTE PANORAMA IN BRAZIL – ABRELPE

This analysis of the Panorama of Solid Waste in Brazil - ABRELPE is complementary to the updated scenario provided in the introduction on the

information systems currently available. It is worth watching that there was no analysis of the chapters on Construction and Demolition Waste and Recycling of PSWB documents.

Based on the 2015 PSWB information appendice and its two annexes, there was total similarity, in terms of the content analyzed in this document and in the others, of the following years, 2016, 2017 and 2018 and the previous year of 2014. The unavailability of the annexes of the PSWB documents of 2017 and 2018, however, did not harm the study, since the variables used in the statistical analyzes are the same in all these documents.

According to the aspects described in the previous section and the present analysis, it can be said that the information on the used methodology is restricted to a variable on MSW: the per capita quantity collected per day.

The next section discusses the content of the annexes to the 2015 and 2016 PSWB documents relating to the methodology used to provide the projections of the total quantities of MSW collected, Qcollected. Although it is necessary to emphasize, initially, that the regression models used to provide the projections of Qcollected are adjusted models for the quantitative collected per capita of MSW, Qcollected-per-capita, as a dependent variable. This change in the response variable is explained by means of tables number one, chapters number two of the PSWB 2015 and 2016 information books. This is because the equations in these tables are also present in the graphs of each of the five regions, in subsequent pages of the same chapter, representing the equations obtained using the regression method, whose response variable is the quantitative collected of MSW, Qcollected-per-capita. Therefore, these same adjusted equations are being used to project another dependent variable, that is, the total quantity collected from MSW daily, Qcollected.

The quantities collected of MSW, Qcollected-per-capita, are represented in the dispersion graphs of each region. In addition to these graphs, the annex also documents that there is a positive trend between these variables, the Qcollected-per-capita and the Qpopulacional. This trend established based on the use of the least squares method, was validated only by the coefficient of determination indicator.

Such a procedure, however, with this change of variables is not consistent with the regression method.

The division, mentioned above, for each municipality, of the quantitative of the variable, the Qcollected by their respective quantitative of the explanatory variable, the Qpopulacional, thus creates, on the left side of the regression equation, a new response variable, the Qcollected-per-capita , which can be understood and accepted, as long as the procedure also occurs with the values of the explanatory or independent variable. That is, based on HILL et al (2006) it is known that this division procedure, on both sides of the equation, necessarily implies to first conceive a regression model in which the Qcollected is the dependent variable and the explanatory variable, the Qpopulacional, in its quadratic form. However, this hypothesis was not mentioned in the annex. And although it is reasonable to assume that the Qcollected depends on the square of the Qpopulation, it remains inappropriate that the equation adjusted for a given response variable is used to project another.

Still, this formulation of the model analyzed above for the Qcolleted-per capita is more appropriate for the quantity generated per capita of MSW. This is because the latter variable depends directly on the population quantity, obviously, but it does not depend exclusively on this. In Dias et al (2012), as well as in PISANI et al (2018), this variable, the quantity generated per capita of MSW, depends on other socioeconomic variables.

From THOMAZ (2016) and MAHLER et al (2017), it is known that not only income, but also seasonality related to climatic factors, festive periods and school holidays influence the quantity of MSW generated, both in terms of its specific weight (kg / m3) and its gravimetric composition.

On the other hand, Qcoletado or Qcoletado-per-capita depends directly on variables such as investments in collection services and equipment, strategies with the participation of the population, technology for optimizing routes and logistics in general.

As a result, the positive trend between Qcolleted per-capita and Qpopulacional, reflected by the coefficient of determination, is also due to the quantity generated per capita of MSW as an intermediate variable. In other words, the Qpopulacinal directly interferes in the quantity generated by MSW, and indirectly in the Qcolleted-per-capita or Qcolleted.

Another aspect derived from this analysis refers to the improper use of the adjusted regression equations, based on values of municipal magnitude, to project the Qcolleted within the scope of the five great Brazilian regions, according to table number one, of the number two chapters of both the PSWB appendices 2015 and 2016. This procedure is doubly improper. Be it because the dependent variable, which served to make the inference on the coefficients of the adjusted equations, was another, the Qcolleted per-capita, and also because the Qpopulation of any of the five major regions, does not belong to the domain of the adjusted lines. In other words, it means that the domain of the adjusted lines is of municipal magnitude and these lines, therefore, cannot be used for the purpose of projection outside the limits of the sample values used with the method for the adjustment.

The formulation of the model took for granted the hypothesis that the variance is constant, also known as homoscedasticity of the model's dependent variable. Such a proposition is not adequate, since there is greater uncertainty regarding the Qcoletado-per-capita of municipalities involving large and medium-sized cities. The "periphery phenomenon", in ANDRADE AND SERRA (1998), affects this variable. In these peripheral populations, basic sanitation is not available in the same way as the municipalities with the lowest population or without peripheries. Based on this concept, on homoscedasticity for Qcollected per-capita, as in HILL et all (2006), changes in the variability of Qcollected per-capita violate this assumption and nothing has been provided to circumvent.

It is also worth commenting on the scaling of the data, visible in table number one of chapters number two of the 2015 and 2016 editions. In them, there is the division by 1000 of the Qpopulation. From HILL et al (2006) it is known that there must be a compensation operation, in this case, of multiplying by 1000 the values of the

adjusted angular coefficients. This necessary operation, however, was not mentioned, raising doubts about the magnitude of the estimated slopes coefficients.

Finally, there is still a lack of information on the so-called 'consistency process' mentioned in the annexes. Such procedure refers to the eventual withdrawal of some municipalities from the sample. And from this exclusion procedure, it is not known the criterion for establishing a pattern in the form of intervals, as described.

5 CONCLUSIONS

This study allows us to conclude that the solid waste information systems in Brazil fall short in many aspects. Even though some standards have already dealt with the mandatory waste inventories for more than 15 years, there are difficulties, of a qualitative and quantitative nature, in obtaining and disseminating information.

The most complete information systems in the waste area are SNIS estimates, whose particularities have already been commented on in the introductory part of this work, and ABRELPE's annual information book, the Panorama of Solid Waste of Brazil. The latter, whose analysis and discussion were the object of this work, allows us to conclude that the inferences presented for the variables: Q collected per capita and Q collected on MSW and HSW, at the three geographic levels; national, of the five major regions, or municipal, need adjustments. In addition, the lack of complete exposure on the respective methods used of the other variables referring to MSW and HSW does not contribute to validate their quantitative.

Finally, it is worth noting that the association has suspended the sending of all attachments of the 2017 information appendices since its launch in 2018. While the 2018 information appendice (published in 2019) does not mention them. Even so, even with the incompleteness of the 2017 and 2018 edition, in relation to its annexes, there is, in the analyzed content, a total similarity of the 2014, 2015, 2016, 2017 and 2018 editions. And this evidence found in the systematization of the data along the time tends to repeat the distortions successively.

The relevance of this research work was to reveal the importance of developing an independent national system for gathering information on the production, treatment and disposal of waste in order to search for solutions to the serious social, economic and environmental problem caused by waste urban solids.

THANKS

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