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Scientific Paper

Cartography of solid waste management in Southern Bahia, Brazil

Cartografia da gestão de resíduos sólidos no sul da Bahia, Brasil

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ABSTRACT

Although the Brazilian Solid Waste Policy is in force, cities continue to face difficulties in complying with it, thus perpetuating negative environmental impacts caused by solid waste. This study analyzed, from a cartographic perspective, the deficits and the implications of inadequate urban solid waste management in an area of the Brazilian northeast. A questionnaire structured in 3 sections and 26 questions (management of public cleaning services, waste collection, and solid waste disposal) was applied to eight managers of the municipal agencies responsible for solid waste areas. The quality index of landfills was applied, and the gravimetric characterization of solid waste was performed by the technique of quartering and segregation of waste in visits to the disposal sites of each city. It was identified that 75% of the cities do not have hierarchical strategies for prevention, reduction, reuse, recycling, and adequate treatment of urban solid waste, with insufficient budget. Only one city collects throughout its perimeter, and the waste collected is destined to open dumps considered inadequate or of low quality. The waste mass is composed, on average, of 50% organics, 20% rejects, 15% plastics, and 9% paper and cardboard. The recent Brazil sanitation regulation can be a way to reduce the aggravation and regularize the collection, transportation, and disposal of solid waste.

Keywords: landfill; gravimetric characterization; waste management; public health.

RESUMO

Embora a Política Brasileira de Resíduos Sólidos esteja em vigor, as cidades continuam enfrentando dificuldades para cumpri-la, perpetuando assim os impactos ambientais negativos causados pelos resíduos sólidos. Ou seja, o Brasil já está lidando com essa questão, mas o processo está longe de ser bem-sucedido. Este estudo analisa, com base em uma perspectiva cartográfica, os déficits dessa gestão e as implicações da gestão inadequada dos resíduos sólidos urbanos no nordeste brasileiro. Analisamos as estruturas dos órgãos municipais responsáveis pela coleta, transporte e destinação de resíduos sólidos por meio de entrevistas estruturadas com gestores ambientais, avaliação da qualidade dos locais de disposição final e caracterização gravimétrica dos resíduos sólidos. Os dados comprovam que 75% dos municípios não possuem estratégias hierarquizadas de prevenção, redução, reaproveitamento, reciclagem e tratamento ambientalmente adequado dos resíduos sólidos urbanos, que são dispostos em lixões a céu aberto. A matéria orgânica compõe, em média, 50% da massa de resíduos coletados nas cidades, tendo potencial de geração de renda com a aplicação de tecnologias de reciclagem. A autocorrelação espacial indicou relação negativa e fraca entre as variáveis. A política brasileira de gestão de resíduos é insuficiente, pois os gestores municipais não conseguem afastar esse material das áreas urbanas, da degradação ambiental e do agravamento da saúde pública.

Palavras-chave: aterro; caracterização gravimétrica; gestão de resíduos; saúde pública.

INTRODUCTION

The growing generation, diversification, and proper management of municipal solid waste (MSW) pose challenges for public management around the world. The growth of cities, migration from the countryside to urban areas, and environmental modification are factors that reinforce an unsustainable society and the continuous increase in waste generation (UNEP, 2016; RODRIGUES, 2021). Worldwide, 2 billion tons of waste are generated per year, with each person being responsible for 1.2 kg of waste in the same period. The trends are chaotic, as estimates for 2025 point to 4.3 billion inhabitants in urban areas, generating 1.42 kg per day (UNEP, 2016; MOHAN; JOSEPH, 2021).

The scenarios are alarming, and the countries are well aware of them, but the topic is still a taboo since it directly correlates with the population's lifestyle, investment, and economic development. For Rodrigues (2021), the tendency is for lower-income countries to have their waste production doubled in the next twenty years, driven by pollution and population growth. In Brazil, in turn, it reached 66,695,720 t/year in 2010, 79,000,000 t/year in 2018, 79,069,585 t/year

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in 2019, and 82,477,300 t/year in 2020 (ABRELPE, 2019; 2020; 2021). Brazil has a large territorial area, with 5,570 municipalities, and 53% of them disposing of waste in inappropriate places, directly on the ground, without any treatment structure. This leads to ecological, social, economic, and public health impacts (ZOHOORI; GHANI, 2017; ABRELPE, 2019; SINGH, 2019; CARVALHO, 2020; YOSHIDA, 2020).

The Northeast was the region with the lowest waste collection coverage index in the country; its 1,794 municipalities generated 53,975 t/year in 2018, of which 81.1% were collected. Of these, 64.4% were destined for controlled landfills and dumps, which corresponds to 18,183 tons per day that are deposited in inadequate locations (ABRELPE, 2019). In 2020, the region figured as the second that contributed the most to waste generation (24.7%), behind the Southeast region, with a production of 0.971 kg.inhab.day, waste collection of 16,575,614 t/year, and proper disposal of 36.3% (ABRELPE, 2021).

Initiatives and actions aimed at waste management have become even more complex and deficient due to the diversification of waste generation (KHAN *et al*., 2016; FRANCESCHI *et al*., 2017; YOSHIDA, 2020). The country lacks strict criteria for waste policies and must imperatively abandon the traditional view that waste correlates with the reduction of economic activity, which focuses on final disposal rather than on the initial stage of waste management (MANNARINO; FERREIRA; GANDOLLA, 2016; MMEREKI; BALDWIN; LI, 2016; ANSHASSI; LAUX; TOWNSEND, 2019; COSTA FILHO; DE SOUSA; DE CARVALHO JUNIOR, 2020; RODRIGUES, 2021).

From this perspective, in developing countries such as Brazil, waste reduction at source is almost nonexistent. In addition, when it exists, it is ineffective, since waste management occurs at the municipal level. Management is thus hindered by constant institutional and administrative limitations, with technical deficiencies, budgetary and financial restrictions, discontinuity of political management (LIMA *et al*., 2018; THANH, 2019; ZAMBON; LIMA, 2019; FIDELIS *et al*., 2020; YOSHIDA, 2020).

In Brazil, the National Solid Waste Policy (*Política Nacional de Resíduos Sólidos* — PNRS), created in 2010, instituted the Basic Sanitation Framework. The country also established deadlines for the closure of irregular dumpsites and promotion of environmental recovery of contaminated areas, but it was insufficient to remedy the problems at the municipal level. Compliance with regulations requires knowledge of the structure of public cleaning services provided at the municipal level, the quali-quantitative characteristics of the waste generated and disposed of, and the operational and environmental conditions of the final disposal site. This knowledge is often nonexistent in many Brazilian cities.

The search for a technical solution for waste generation also involves issues of citizenship, social inclusion, safety, work, and sustainability. Therefore, the institutional and structural problems of society, especially the lack of awareness and social participation, increase complexity in the scenario of solid waste generation (SILVA; FUGII; SANTOYO, 2017; MARINO; CHAVES; DOS SANTOS JUNIOR, 2018; ZAMBON; LIMA, 2019). Technically, the use of cartography and the Geographic Information System allows for the evaluation of heterogeneity, spatial, and social pattern of the solid waste structure in cities (FITZ, 2008a). Thus, the possibility of these geotechnologies for analyses that contemplate spatial aspects, represented by thematic maps, opens the perspective for the use of these tools to manage decision-making for environmental management (FITZ, 2008b; BRAGA *et al*., 2008; AGUIAR *et al*., 2021).

Given the Brazilian conjuncture, this research aimed to analyze, from a cartographic perspective, the management of urban solid waste in the northeast region of Brazil. The study also contributes to the consolidation of a set of information on urban solid waste management, serving as an instrument and data source for the development of public policies and optimization of strategies for adequate integrated environmental management.

METHOD

Study area

The study analyzed eight cities (Belmonte, Eunápolis, Guaratinga, Itabela, Itagimirim, Itapebi, Porto Seguro, and Santa Cruz Cabrália) in the so-called Discovery Coast, comprising an area of 12,118.31 km^2, or 2.14% of Bahia State, in Northeastern Brazil. Total population in the region is 381,727 inhabitants, with a demographic density of 236.12 inhabitants/km^2 (IBGE, 2020). The region is under three climatic variations: wet to subhumid, subhumid to dry, and humid climate. Average temperature is 24°C, with the coldest months being June, July, and August, and the warmest months being December, January, and February. Average annual rainfall is 1,263 mm. It is located at the Atlantic Forest Central Corridor, with water resources and protected areas. Its economy is based on tourism and the forest sector and eucalyptus production. The cities were investigated due to their regional importance and the influence of a touristic fluctuation that considerably increases solid waste production, though none of them have adequate waste landfills to attend to the permanent or touristic population.

Characterization of urban solid waste management

The present study analyzed waste management by collecting data from the government databases of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geogafia e Estatística* — IBGE), the National Sanitation Information System (*Sistema Nacional de Informações sobre Saneamento* — SNIS), and the National System of Information on Solid Waste Management (*Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos*). Subsequently, structured questionnaires were applied on an online platform to eight municipal managers responsible for public cleaning services in each city, who were also contacted by telephone to provide information on solid waste management. The questionnaire was subdivided into 3 sections and 26 questions (management of public cleaning services, waste collection, and solid waste disposal).

Characterization of final disposal sites

On-site inspections were carried out in the final disposal sites of the cities, in which the quality of waste landfills was assessed according to CETESB (2019). This index considers the situation observed during technical inspection of the final disposal site, allowing the preparation of the environmental conditions evaluation, as well as the comparison between the evaluated areas.

A checklist technique was used with predetermined technical, operational, and structural parameters and criteria to assess the conditions of the disposal site of collected solid waste and generate a quality index. Thus, 33 items were analyzed regarding: structural and operational characteristics (22 items); presence of waste pickers and burning of residues and the like (7 items); useful life characteristics (4 items). The assessed locations were scored on a scale of 0 to 10, where values < 7.00 denote inadequate conditions, and values > 7.0 and

< 10.00 denote adequate ones (CETESB, 2019). Geographical coordinates and photographic records were also collected for analysis.

Gravimetric characterization

Each city was characterized by visiting the final disposal site, on different days and times, according to the procedures determined by Stech (1990), using the technique of splitting and segregation of different types of waste according to ABNT NBR 10.007 (ABNT, 2004). The sampling of collection vehicles considered those used in the most representative routes between the commercial and residential sectors of the cities, including those used for collection in rural areas. For Porto Seguro, gravimetric data collected by Carvalho (2020).

The waste was unloaded from the vehicle in a flat, clean, and moisture-free place at the final disposal site. Bags, sacks, boxes, and other conditioned materials were opened for mass homogenization, and five 120-liter samples were removed, four from each side of the quadrant of the pile base and one from the top. This amount resulted in a new pile of waste, which was again homogenized by overturning.

Splitting was done by separating the pile formed into four equal parts, with subsequent disposal of diagonally opposite parts. This process was repeated twice, resulting in an approximate volume of 75 liters. The resulting sample was weighed and deposited in a container waterproofed with plastic canvas. Then, the waste fraction was separated, identified, and weighed according to ABNT NBR 10.007 (ABNT, 2004). Solid waste fractions were weighed and recorded and the steps of this procedure were taken in January 2021.

RESULTS AND DISCUSSION

The cartography of solid waste management in the cities and the spatial dimension shown in Figure 1 demonstrate that these cities have similar characteristics in terms of structural and managerial aspects of waste treatment.

Despite performing daily waste collection, the municipalities have several bottlenecks in the management process. Among which the lack of landfills, composting units, and solid waste sorting stand out, making the regional structure deficient in solving the solid waste problem. This situation corroborates the reports on the administrative and management difficulties of some municipalities regarding public cleaning services, exemplified by the absence of documents or control of the services provided, or even by the lack of knowledge of the scope by the responsible sector (ZOHOORI; GHANI, 2017; COSTA; DIAS, 2020).

Six municipalities (75%) have no specific plans, programs, or public policies on the management and handling of MSW. Public cleaning services are thus limited to collection and disposal in areas far from urban centers, perpetuating damage and socioeconomic and environmental impacts resulting from irregular disposal. Data show that these cities are out of step with the construction of policies aimed at solving environmental problems, further evidencing the absence of social participation in the decision-making process.

Porto Seguro, Itagimirim, and Itapebi cities reported having a Municipal Solid Waste Plan. Notwithstanding, its elaboration did not reflect any changes in managerial aspects or improvements in the services already provided with regard to MSW (Figure 1A). In other words, even with a drawn up plan, the management of MSW hardly differs in effectiveness from the management of other cities where the services provided are also limited to the removal of collected waste to an inappropriate location. This situation shows a scenario already reported for many Brazilian cities which, despite having their municipal plans, are unable to satisfactorily meet the guidelines or execute the actions established in these plans (ZAGO; BARROS, 2019).

All cities reported that the budget allocation for the execution of public cleaning services is insufficient. Allied to this, the lack of claiming by the population and the low price of irregular disposal are obstacles to management effectiveness. Insufficiency of financial resources is the main reason to justify noncompliance with the policy. However, in the city of Porto Seguro, Carvalho (2020) identified that even with financial investment for the implementation of a landfill, the presence of technical, operational, and municipal administrative deficiencies transformed the treatment unit into an open-air dump. This situation also occurs in cities that apply financial resources to management units (ZOHOORI; GHANI, 2017; ANSHASSI; LAUX; TOWNSEND, 2019; ZAGO; BARROS, 2019).

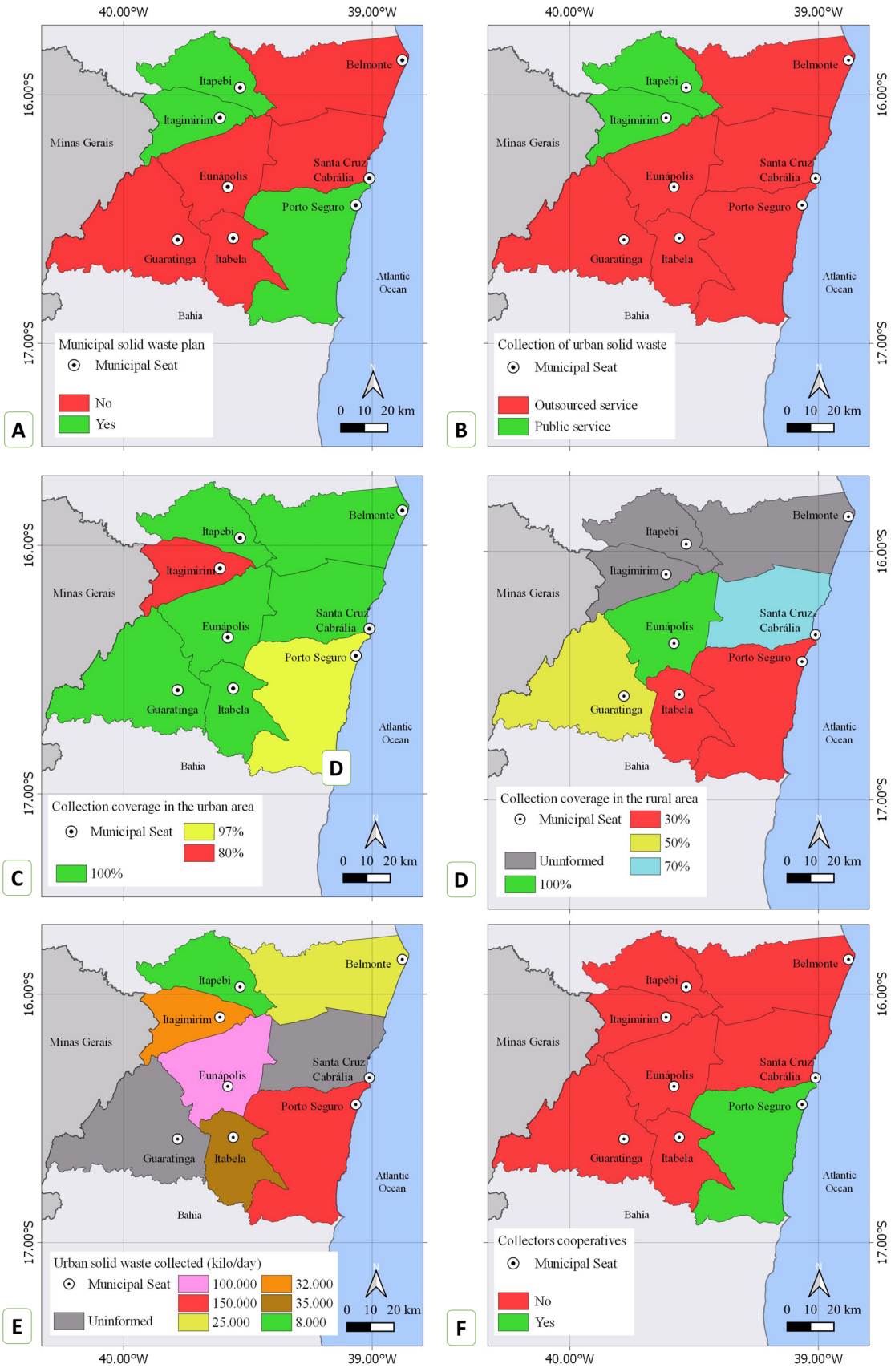
Even with managerial limitations, cities with collection coverage of approximately 100% in urban areas mostly opt for public cleaning services to be carried out by outsourced companies. This situation requires the transfer of resources to subsidize collection and transport services to the final destination (Figures 1B and 1C). Cities that invest in the provision of services tend to show deterioration and reduced quality of service for the population. This is because they need an administrative and technical structure that is nonexistent or cumulative among public sector employees in city halls, as observed in Itagimirim city, where collection is nonexistent in 20% of the urban area.

This fact may be explained, among other factors, by the absence of an adequate collection plan or collection itinerary, absence of adequate access, insufficient number of vehicles, or even the use of these vehicles for other purposes. In smaller cities, cart or dump vehicles used in public cleaning services are often used to transport materials and supplies for public works, prioritizing collection in the central area. Different techniques for the collection and transportation of solid waste are presented for urban areas for developing countries (door-to-door, curbside/alley, dumping at designated place, and backyard) with the possibility of using mathematical techniques and models to improve the solid waste sector in the cities studied, highlighting ways to improve the solid waste management service (YADAV; KARMAKAR, 2020).

All cities showed discrepancies regarding service coverage in rural areas, in which only Eunápolis reported having 100% collection in urban and rural territory. In contrast, Guaratinga, Itabela, Porto Seguro, and Santa Cruz Cabrália partially carry out the service, which can be explained by the distance of rural districts or inadequate access conditions that make it difficult for vehicles and cleaning teams to move to these locations (Figure 1D).

Porto Seguro stands out in this scenario of difficulties. Even though the city has a Municipal Plan for Solid Waste (*Plano Municipal de Resíduos Sólidos* — PMRS) and outsourced services, waste collection only covers 30% of its rural area, comprising, among others, the districts of Arraial D'ajuda, Trancoso, and Caraíva. These locations are highlighted as important tourist destinations on the international scene. Thus, a deficiency of these services in these districts can result in significant negative impacts on public health and the environment, especially in the high tourist season, in which the waste more than doubles in quantity (CARVALHO, 2020).

Porto Seguro is the only city to have a road scale system for weighing vehicles and, consequently, controlling the mass of collected waste. The other cities attribute values based on the volumetric capacity of the collection vehicles and



Source: the authors (2022).

Figure 1 – Cartographic representation of solid waste management.

the daily amount of final disposal, resulting in imprecise estimates (Figure 1E). The city of Eunápolis daily collects an amount of waste equivalent to the sum of those collected by the cities of Belmonte, Itabela, Itagimirim, and Itapebi. Noteworthy, Porto Seguro and Eunápolis are the largest waste generators in the region under study, as they are the most populous cities, accountingfor 38.9 and 29.7% of the total population of the territory, respectively. The absence of control over the collected volume confirms the findings of Zohoori and Ghani (2017) and Costa and Dias (2020), when reporting the administratives and managerial difficulties of some municipalities about public cleaning services, exemplified, among others, by the absence of documents or control of the services provided, or even by the lack of knowledge of its scope by the responsible sector.

The presence of waste pickers both in urban and in landfill areas of these cities is remarkable, although the administration of Itagimirim has denied this occurrence in their city. The density of waste pickers in the urban perimeter and in final disposal sites correlates with the absence of public policies to encourage selective collection and organization of these workers, with predominating individual and informal activities. According to Coelho, Beck e Silva (2018), the emergence of waste pickers is a consequence of the immense social and economic inequality that occurs in Brazil, as well as the current consumption patterns that generate more and more waste. In these scenarios, people without education and with low or no professional qualification are subject to living off what is discarded. These workers were subject to a myriad of occupational and environmental risks, involving exposure to contaminated water, included diarrhea, intestinal worms, hepatitis A, and leptospirosis, which significantly affects health and quality of life. A relationship is conditioned by people who lived in unregulated areas and by women (CRUVINEL *et al*., 2019; MOHAN; JOSEPH, 2021).

This situation intensifies with the work of recyclable material intermediaries who buy waste from collectors at low cost (lower than market values), which negatively influences monthly profits and increases the socioeconomic vulnerability of these workers (DAGNINO; JOHANSEN, 2017).

Only Porto Seguro has a cooperative of waste pickers who collect, sort, and sell the waste collected at the final disposal site (Figure 1F). However, the absence of policies or actions that encourage the segregation of waste at the generating source (with differentiated collection) significantly contributes to the devaluation and reduction of the volume of potentially recyclable waste. This is because, when collected together with urban waste, this recyclable material is contaminated by contact with wet residues. The cooperative only collects and sorts waste that has greater added value in the recyclables market, such as plastic, paper, cardboard, and aluminum cans, dispensing with glass, metal, and other materials that can be recycled.

The creation of cooperatives or associations of waste pickers is one of the instruments of the 2010 PNRS, established as the main means for the strengthening and social inclusion of this class of workers. However, the situation diagnosed in Porto Seguro reveals that the absence of technical, operational, and even financial support from the government may reflect on low productivity and little use of recyclable waste. This situation further affects the sale of directly collected materials for recycling companies, with interference from intermediaries and the consequent reduction in the income of waste pickers.

Although there is a legally established deadline for the closure of dumpsites, the definition of a strategy and project for the continuity of the work and maintenance of the income of these workers dispenses with the deactivation of these irregular waste deposits.

The results presented by the agencies contrasted with the data available in SNIS, revealing a disparity in waste management between the different government spheres (BRASIL, 2019). This may also occur due to lack of knowledge of the mandatory use of information, technical limitations for accessing the federal platform, technical limitations for understanding the inquiries made by SNIS, partial existence of qualitative and quantitative information on municipal services, and changes of municipal managers with the discontinuity of the actions carried out.

The diagnosis carried out at MSW final disposal sites showed that they were inappropriate, inadequate, and lacked the minimum conditions necessary to guarantee environmental protection, with the consequent perpetuation of socioeconomic, ecological, and public health impacts. These sites consist of dumps that lack the minimum infrastructure necessary for operationalization or environmental protection (Figure 2).

Only Porto Seguro had a support structure, consisting of an ordinance for access control, a road scale system for weighing vehicles, physical and visual isolation around the perimeter of the area, and internal access to the disposal site in satisfactory conditions. These structures are important and necessary, as they allow for statistical control of the amount of waste deposited at the site, preventing access by animals or unauthorized people (Figure 2A).

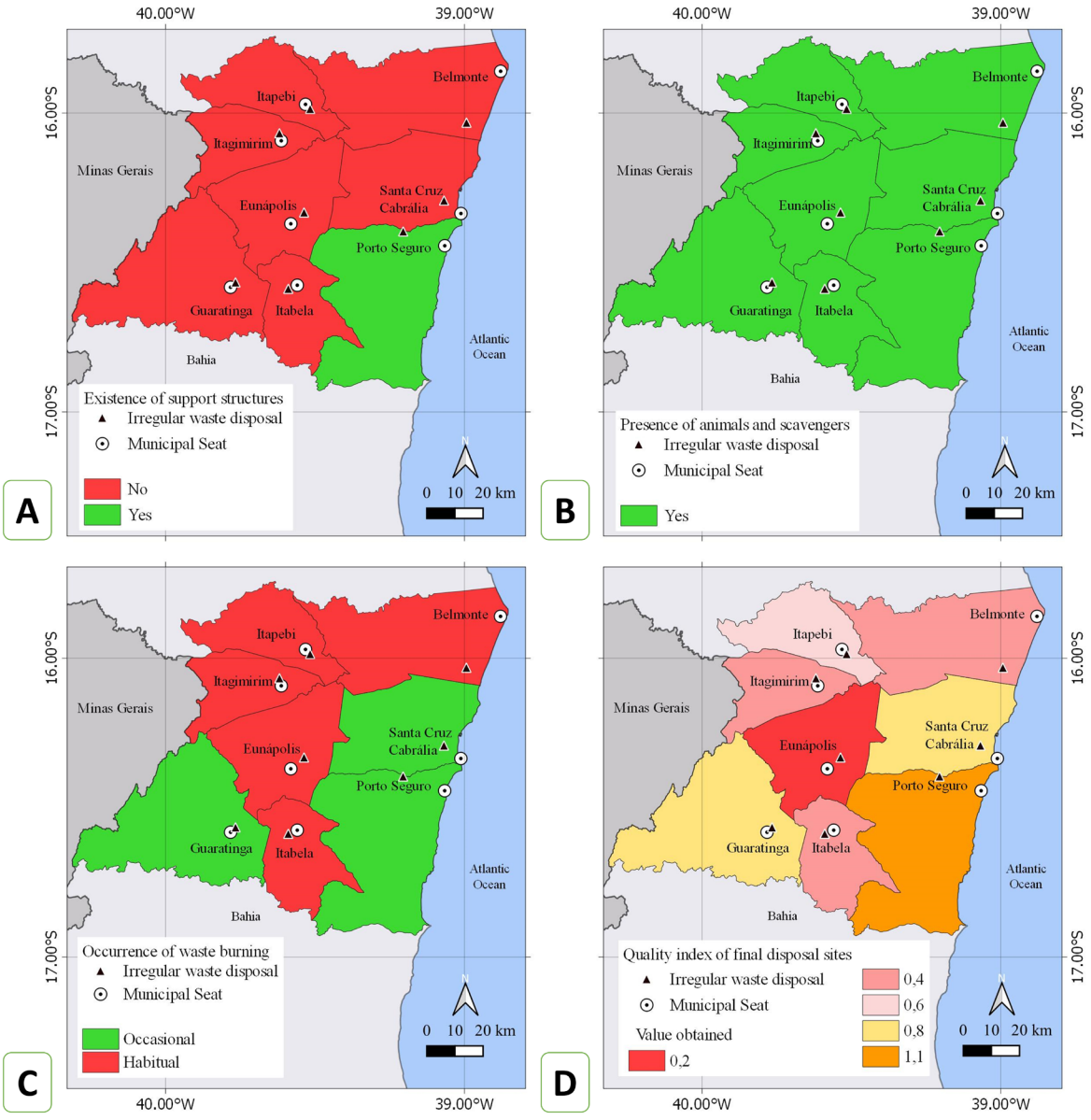
Within the perimeter of the dumps there are no elements of environmental protection or any practice to attenuate or mitigate aspects of irregular waste disposal. There are also no soil waterproofing, slurry drainage, or gas drainage systems. Moreover, the absence of control over the slope of the terrain or drains to keep away rainwater allows for leachate drainage and the carrying of residues to neighboring areas. The inexistence of plant barriers around these sites also allows the contamination of neighboring areas with the transport of light residues by the wind, further contributing to the aesthetic-visual depreciation of the area.

The survey evidenced the absence of actions aimed at minimizing the generation, segregation, and proper disposal of waste. In this scenario, waste pickers are the only ones responsible for recovering a nonsignificant portion of recyclable materials at disposal sites. Moreover, various birds and animals share the location, increasing the possibilities of vector placement (Figure 2B).

The results also point to the burning of tree pruning residues at the sites, performed by waste collection employees (Figure 2C). Traces of ash observed during visits to the site show the occurrence of possible fires, intentionally caused by visitors, or unintentionally caused by the heat generated by exothermic reaction resulting from the aerobic decomposition of the organic fraction, which can reach temperatures of up to 70°C, or even by the release of gases resulting from anaerobic decomposition of biodegradable waste associated with the incidence of sunlight on objects.

The quality of the waste disposal site was unsatisfactory in all cities, which did not even reach 20% of the maximum score of the applied index. The city of Eunápolis had the lowest score, 0.2, and the city of Porto Seguro, the highest score, 1.1. This evidences the high degree of inadequacy and of solid waste collection and disposal in the cities (Figure 2D).

Solid waste in these places is diverse, and gravimetric characterization presented heterogeneous results, reflecting the socioeconomic characteristics of the municipalities under study and the practice or nonexistence of differentiated management in the segregation and collection of generated waste. Table 1



Source: the authors (2022).

Figure 2 - Characterization of final disposal sites for urban solid waste.

shows the results of this survey, as well as a summary of the descriptive statistics of the values obtained.

The high values for the standard deviation and sample variance for the organic fraction and tailings reveal high heterogeneity in waste generation in the municipalities studied. For organic waste, although the variation between the maximum and the minimum was approximately 48%, the mean and median values were close to 50%. For the recyclable fraction of waste, especially paper, cardboard, and plastics, the differences between the maximum and minimum reflect the economic differences between the cities under study, with results influenced by the greater relevance of the commercial and tourist sectors.

Organic waste accounts for the largest percentage of waste sampled, confirming data from the main scientific studies on municipal waste gravimetry (ALVAREZ *et al.*, 2012; REZENDE *et al.*, 2013; SUTHAR; SINGH, 2015; ADENIRAN; NUBI; ADELOPO, 2017; SAIDAN; DRAIS; AL-MANASEER, 2017; MENEZES *et al.*, 2019; CARVALHO, 2020). In developing countries, the rate of organics also equals 50%, reinforcing the potential for reuse and high energy and nutritional value of these residues when invested in technology for processing and reuse (MOHAN; JOSEPH, 2021). The city of Guaratinga was the largest generator of this type of waste, with a predominance of food and household gardening waste.

On the other hand, segregation at source in some establishments that generate organic waste implied a lower representation in Eunápolis. In this city, restaurants, supermarkets, and fairs carry out a differentiated collection and send these residues to rural producers who use it for animal feed or in the formation

Table 1 – Gravimetric composition of urban solid waste and descriptive statistics of the results.

Cities	Gravimetric composition solid waste (%)						
	Organic	Paper/cardboard	Plastics	Metals	Glass	Inert	Tailings
Belmonte	57.50	9.65	13.75	0.75	0.55	1.05	16.75
Eunápolis	30.88	11.29	15.88	1.35	5.18	0.00	35.42
Guaratinga	64.24	6.43	12.86	0.00	1.00	0.00	15.47
Itabela	48.83	7.88	14.00	1.76	3.24	0.00	24.29
Itagimirim	43.24	7.05	12.59	3.24	7.41	0.00	26.47
Itapebi	54.50	8.50	14.75	1.65	1.75	0.00	18.85
Porto Seguro[1]	41.90	19.02	24.00	1.00	3.80	3.50	6.78
Santa Cruz Cabrália	55.36	9.29	14.28	1.07	0.00	0.00	20.00
Standard deviation	10.59	3.99	3.68	0.94	2.54	1.24	8.49
Sample variance	112.10	15.96	13.53	0.89	6.47	1.54	72.14

[1]Adapted from Carvalho (2020).

of organic compounds for soil application. Waste from public services of pruning and weeding is collected separately from the others, but disposed of in the same area as the dumps.

In Eunápolis and Porto Seguro, recyclable waste consists mainly of paper, cardboard, and plastics. These are the hub cities of the territory under study, with a strong presence of the commercial sector, which reflects an increasing generation of dry recyclable waste, especially in the central region of the cities. Plastic concentration is greater in all cities, with a predominance of PET packaging, sacks, and bags. However, the absence of policies or actions on the part of cities to reduce generation and for segregation at source and differentiated collection make its recovery or reuse difficult. The surveys carried out allow us to affirm that the work of plastic recovery by waste pickers, after disposal in municipal dumps, is incipient and focuses on PET packaging, as this material is easy to sell.

As for paper and cardboard, most cities have previous collection at commercial points, carried out by self-employed waste pickers or by the public cleaning team itself. When previously segregated, this waste has greater added value and is easily resaleable in the recyclables market. Metallic waste has low gravimetric representation, resulting from the prior collection of larger metals by scrap dealers. In turn, smaller metals are previously segregated by waste collection workers, self-employed waste pickers who work in the city, and often by the generators themselves.

The cities of Itagimirim and Eunápolis were the most representative in terms of glass generation. In Santa Cruz de Cabrália, this material was not detected in the samples separated by the splitting process. All cities have differentiated collection services for inert waste arising from construction, demolition, and renovation works. As a result, as they are collected and disposed of separately from other waste, they were the least representative among all the categories surveyed. Occasionally, when generated in small quantities, generators store them in bags or sacks, which are then destined for public collection, a fact that may justify the detection of these materials in Belmonte and Porto Seguro.

Among the waste under study, the results referring to the generation of tailings were expressive. Tailings consist of sanitary waste, diapers, personal hygiene products (tampons and condoms), dead animals, feces, styrofoam, pieces of leather, fabrics, and materials that, due to their physical characteristics and dirtiness, have become unusable for another purpose. In this context, tailings accounted for the second most representative category in seven of the eight cities. The exception of Porto Seguro is justified by the noninclusion of the tailings category among the residues sampled in the work carried out by Carvalho (2020), considering only diapers, styrofoam, and fabrics.

Strategies for cities to proceed with tailings management may include, in addition to regularization and disposal to landfills, the use of technology to explore material composition, stratification and refinement, promoting an economy in cities based on products with higher percentages of recyclables and reusables, and implementing a holistic approach, as already suggested in mineral waste management, 1) reduce, 2) reprocess, 3) downcycle, and 4) dispose (LÈBRE; CORDER; GOLEV, 2017; KINNUNEN *et al.*, 2022). It is worth remembering that high rates of disposed tailings are associated with human toxicity and ecotoxicity of aquatic and terrestrial ecosystems, but the use of tailings in construction materials allows environmental benefits (BEYLOT *et al.*, 2022).

The diagnosis of MSW management in the municipalities revealed a deficient and inadequate picture, with negative impacts on the social, economic, ecological, and public health context. The predominant practice of collection and removal of waste from urban centers shows the incapacity or disinterest of municipal managers in promoting programs, actions, or incentives aimed at reducing generation and at waste reuse, valuation, proper destination, and treatment. The reversal of this scenario, with consequent compliance with the terms of the solid waste policy, is complex, and appears as the greatest challenge to be faced by cities in the current century.

CONCLUSIONS

Cartographic analysis evidenced the unsustainability of MSW management, with noncompliance with legislation. The cities collect between 25 thousand and 150 thousand kg of waste per day, being disposed of, on average, 50% organics, 20% rejects, 15% plastics, 9% of paper/cardboard and 6% other of waste in open-air dumps disposal, with greater predominance of collection in urban areas.

The absence of waste disposal units in all cities prevents differentiated segregation and municipal government hinders the work of waste pickers.

This decreases the potentially recyclable portion and prevents efficient production of biogas and compost from organic waste, which accounts for more than 50% of the discarded waste. The suggestion is regional articulation and intermunicipal consortium as a strategy for sustainable solid waste management.

AUTHORS' CONTRIBUTIONS

Silva, M.V.: Conceptualization, Methodology, Software, Investigation. Zanchi, F.B.: Writing – review & editing. Lopes, E.F.R.: Conceptualization, Methodology, Software, Supervision.

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