EFFECTS OF THE DECOMMISSIONING OF A GARBAGE DUMP ON SOLID WASTE MANAGEMENT AND GRAVIMETRIC STUDY IN A RURAL COMMUNITY IN BAIANÓPOLIS, BAHIA

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ABSTRACT

Objective: The aim of this study is to evaluate the changes in solid waste management and to carry out a gravimetric study in the rural community of Tabua, in the municipality of Baianópolis-BA, following the decommissioning of a landfill site.

Method: The methodology adopted for this research was divided into: a gravimetric study and the identification/analysis of irregular waste disposal points. The gravimetric study was carried out by quartering and separating the waste. The identification of irregular waste disposal points near the community was carried out over a distance of around 5 km on the BA430.

Results and Discussion: The results showed that the community's per capita waste generation is 0.171 kg/inhabitant per day, with the gravimetric composition of the sample corresponding to: 34% glass, 28% organic, 22% reject, 11% plastic, 3% metal and 2% paper. The most representative specific weight was observed for organic waste, followed by glass and waste. Four irregular solid waste disposal points were found near the community of Tabua, developed and intensified after the sudden closure of the dump in 2022.

Research Implications: This research has practical implications as it presents a diagnosis of poor waste management in a rural community, as well as proposing alternatives for more inclusive and comprehensive management.

Originality/Value: This study contributes to the literature by addressing the generation and disposal of solid waste in rural areas, an issue that has been little discussed in the academic sphere and which is generating growing concern for the rural environment and for guaranteeing the health of the rural population.

Keywords: Gravimetric Composition, Irregular Waste Disposal, Rural Area, Non-Sanitary Landfill.

EFEITOS DA DESATIVAÇÃO DE UM LIXÃO NA GESTÃO DE RESÍDUOS SÓLIDOS E ESTUDO GRAVIMÉTRICO EM UMA COMUNIDADE RURAL DE BAIANÓPOLIS, BAHIA

RESUMO

Objetivo: O presente trabalho tem como objetivo avaliar as alterações na gestão de resíduos sólidos e realizar estudo gravimétrico na comunidade rural de Tabua, no município de Baianópolis-BA, após a desativação de um lixão.

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Método: A metodologia adotada para esta pesquisa foi dividida em: estudo gravimétrico e identificação/análise de pontos de descartes irregulares de resíduos. O estudo gravimétrico foi realizado por meio de quarteamento e separação dos resíduos. A identificação de pontos de descarte irregular de resíduos próximos à comunidade foi realizada em cerca de 5 km na BA430.

Resultados e Discussão: Os resultados obtidos revelaram que a geração per capita da comunidade é de 0,171 kg/hab.dia, sendo que a composição gravimétrica amostrada corresponde a: 34% vidro, 28% orgânico, 22% rejeito, 11% plástico, 3% metal e 2% papel. O peso específico de maior representatividade foi observado para resíduos orgânicos, seguidos de vidro e rejeito. Foram encontrados quatro pontos de descarte irregular de resíduos sólidos próximos à comunidade de Tabua, desenvolvidos e intensificados após a interdição repentina do lixão em 2022.

Implicações da Pesquisa: Essa pesquisa possui implicações práticas ao apresentar um diagnóstico da gestão de resíduos deficiente de uma comunidade rural, além de propor alternativas para uma gestão mais inclusiva e abrangente.

Originalidade/Valor: Este estudo contribui para a literatura ao abordar a geração e o descarte de resíduos sólidos em zona rural, uma questão pouco discutida no âmbito acadêmico e que vem gerando uma crescente preocupação para com o meio rural e a garantia de saúde da população do campo.

Palavras-chave: Composição Gravimétrica, Descarte Irregular de Resíduos, Zona Rural, Aterro Não Sanitário.
1 INTRODUCTION

In the process of population growth in the world, waste generation grows in parallel every day. In this sense, the problem of solid waste generation related to inadequate waste and waste disposal practices causes great concern nationally and worldwide (Aguiar and Veiga, 2020). This concern also affects the rural area, considered one of the biggest current problems, due to the lack of assistance for the adequate disposal of their waste, often deposited in inappropriate places by the resident himself (Ceretta, et al., 2013), such as on his properties and burning them or at irregular disposal points on the slopes of roads.

The National Solid Waste Policy – PNRS, established by Law No. 12,305 of 2010, addresses a set of principles, objectives, guidelines, instruments, goals and actions for the integrated management and environmentally correct management of solid waste (Brazil, 2010). Its approval brought to Brazil a series of innovations for the management and management of solid waste, applying the concept of shared responsibility for the life cycle of products (MMA, 2022).

According to art. 14 of Law No. 12,305/2010, municipalities are required to create Municipal Plans for Integrated Solid Waste Management (PMGIRS), carrying out planning of actions that can be carried out by municipal public authorities to combat the irregular disposal of solid waste in the municipality and avoid, or reduce, environmental problems resulting from this problem (Brazil, 2010). However, the PNRS emphasizes waste generated in urban areas, the main contributor of waste due to greater demographic density, but does not highlight rural residences, made up of families that increasingly consume industrialized products, and that generate increasingly greater amounts of waste in their homes, properties, with no ideal location for final destination (Ceretta, et al., 2013).

Therefore, rural inclusion in Municipal Solid Waste Management Plans is essential for tackling this problem, promoted through research that facilitates this management. The gravimetric study of solid waste (RS) facilitates waste management, as it allows a greater understanding of the quantity and quality of waste generated in the municipality based on the gravimetric composition, per capita generation and specific weight of the waste. Furthermore, it enables the planning of measures that promote the city's socioeconomic development through the use of waste through treatment alternatives, such as composting or recycling (FEMA, 2019), and can also be applied in rural areas.

According to data from the National Sanitation Information System - SNIS (2021), in Brazil, around 89.93% of the total population is served by household waste collection.
However, the percentage of environmentally appropriate disposal of this waste in landfills is still small. In the state of Bahia, in the Northeast region, of the 417 municipalities in Bahia, 286 still use landfills for final disposal, which corresponds to 68.5% (Gitel, 2020). In recent years, waste management has advanced in Brazil. According to data from the Panorama of Solid Waste in Brazil (ABRELPE, 2022), the percentage of municipal solid waste (MSW) correctly disposed of grew from 60.5% in 2021 to 61% in 2022, this small increase mainly involves the deactivation of landfills and construction of new landfills.

In the western region of Bahia, this process began in 2022, in which, after the construction of a private sanitary landfill in the city of Barreiras, some landfills in nearby municipalities were closed. However, this transition to the appropriate disposal of solid waste is still a major challenge for municipal managers, as it involves increased costs and improved solid waste collection logistics. On the other hand, few studies have evaluated the influence of this change on solid waste management in Brazilian rural communities, generally outside of integrated and adequate RS management. According to Ramalho (2018), the poor management of RS in rural areas allows inadequate solid waste disposal practices to be frequent. Furthermore, municipal public authorities must invest not only in the collection and final disposal of rural solid waste (RSR), but above all, in the environmental education of the population by encouraging a reduction in consumption and valuing the reuse and recycling of materials (Roversi, 2013).

Therefore, the objective of this work is to carry out an analysis of changes in the management of solid waste generated in a rural community in the municipality of Baianópolis, after the deactivation of a landfill, based on a gravimetric study of solid waste collected in that community and the identification of irregular disposal points in its proximity and qualitative analysis of this waste.

2 METHODOLOGY

2.1 CHARACTERIZATION OF THE STUDY AREA

The municipality of Baianópolis, in the extreme west of Bahia, is located approximately 826 km from its state capital city, Salvador, and has an area of approximately 3,320.723 km². Its population was assessed by the last census at 13,614 people, of which approximately 74% reside in the rural area of the municipality (IBGE, 2022). In this sense, the municipality's solid waste management must pay special attention to the rural area, as this represents an important
portion of the municipality's waste generation.

Until May 2022, around 1,711.59 t/year of RS generated in the municipality of Baianópolis were destined for an open-air municipal dump. The scenario changed after the start of the allocation of RS to a private company's landfill, located in the municipality of Barreiras. However, only 48% of Baianópolis residents are served with waste collection (SEDUR, 2022; IBGE, 2022). The collection and proper disposal of solid waste is carried out only at the municipal headquarters and in two other rural communities: Tabua and Várzeas, shown in Figure 1, located closer to the city of Baianópolis and with a greater population of residents.

**Figure 1**
*Location of the communities of Tabua(2) and Várzeas(4) in the territory of Baianópolis-BA.*

The chosen study site was the community that receives waste collection closest to the municipal headquarters, Tabua, about 12km from the headquarters and which has a population of around 538 people (IBGE, 2010). The community of Tabua is one of the best served in the municipality, with several businesses such as markets, bakeries and snack bars, bars, clothing/shoe stores and a pharmacy, which generate greater amounts of solid waste during weekends. From Friday to Sunday the community receives more visitors, both people from other communities and former residents visiting family.

To understand the effect of deactivating the municipal dump on the community's waste management, the research was divided into two stages: (i) gravimetric study of solid waste collected in the rural community of Tabua and (ii) identification of irregular disposal points of solid waste existing close to the community and qualitative analysis of this waste.
2.2 GRAVIMETRIC STUDY

Before municipal solid waste collection began in the community of Tabua in 2022, residents were themselves responsible for managing and disposing of their waste, almost always in inappropriate locations. In addition to disposing of and burying waste in trenches made on the property or burning it, some residents went to the municipal dump or to some irregular disposal point close to roads to dispose of their waste, just as the practice occurred in other communities, rural areas of the municipality.

After implementing the collection system in the village of Tabua, collections are made by a single employee of a private company who carries out urban cleaning and collects solid waste, this resident of the community. Solid waste is collected weekly (Monday, Wednesday and Friday) and stored in a local warehouse. Waste is only transported at the beginning of the week (between Monday and Wednesday) after local collection. The company collects waste in communities and deposits it in a transshipment center in the urban area of the municipality, until all accumulated waste is taken to the landfill, close to the city of Barreiras, approximately 43.3 km away from the transshipment zone. As the largest agglomeration of material stored in the Tabua community warehouse is at the weekend, the quantitative analysis was carried out randomly on a Saturday, obtaining a sample of waste from two collections carried out during the week.

All RSR collected during the last week of June 2023 and which were stored in the warehouse were transported outside and their mass determined with the aid of an electronic hook scale, to obtain the total mass. The quartering technique was then started until only one sample with a volume of approximately 1 m³ was obtained, according to NBR 10007 (ABNT, 2004). The waste separated for sampling was subjected to sorting, separating it into six different classifications: organic waste, plastic, paper, glass, metal and waste. The classified waste was placed, without promoting compaction, in individual plastic containers and subjected to mass determination. Using the mass of the fractions, it was possible to determine the percentage of each class in weight, the specific weight (kg/m³), the per capita generation (kg/inhabitant/day).

2.3 IDENTIFICATION OF IRREGULAR DISPOSAL POINTS OF SOLID WASTE

In the vicinity of the Tabua community, some irregular solid waste disposal points can be identified, which intensified after the closure of the municipal dump due to the disposal of waste from residents of other rural communities where there is no waste collection. In this way,
approximately 5 km of BA 430 were covered in a straight line, close to the community, and the points of irregular disposal of solid waste deposited near the road were identified. The identified locations were photographed and recorded by GPS. The waste deposited at these points could be identified in terms of material and type, through a visual and qualitative observation of the waste that is inappropriately deposited at these locations.

3 RESULTS AND DISCUSSIONS

3.1 GRAVIMETRIC COMPOSITION, PER CAPITA GENERATION AND SPECIFIC WEIGHT OF RURAL SOLID WASTE – RSR

The gravimetric composition of waste from the Tabua community is presented in Table 1, together with other studies cited. The highest values are for glass, organic waste and waste, respectively. The waste classified as “glass”, with the highest percentage in the waste sampled, was represented mainly by bottles of alcoholic beverages, probably due to the period after traditional June festivities that preceded the research, in which there was a greater number of visitors to the community. Another factor that may have influenced this high percentage for glass is the number of bars in the community, with around eight in total, busier during the weekends.

Despite the percentage of 28% of waste sampled, “organic” is still characterized as low when compared to gravimetric studies carried out in large urban centers in developing countries (Boscov, 2008), which represent the highest value in the percentage of MSW sampled. For example, in the city of Juiz de Fora-MG (Menezes, et al., 2019), around 44% of waste is classified as organic. In rural communities, values vary between 9.46% and 24.05% (Table 1). According to Nascimento (2021), this lower value in rural communities can be justified due to the custom of allocating organic waste to animal feed.
Effects of the Decommissioning of a Garbage Dump on Solid Waste Management and Gravimetric Study in a Rural Community in Baianópolis, Bahia

Table 1

Comparison of gravimetric composition of rural communities

<table>
<thead>
<tr>
<th>Location</th>
<th>Reference</th>
<th>Organic</th>
<th>Plastic</th>
<th>Paper</th>
<th>Glass</th>
<th>Metal</th>
<th>I reject</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabua Community, Baianópolis-BA</td>
<td>Martins, <em>et al.</em> (2009)</td>
<td>28.0</td>
<td>-</td>
<td>2.0</td>
<td>34.0</td>
<td>3.0</td>
<td>22.0</td>
<td>-</td>
</tr>
<tr>
<td>Luz Rural Settlement, Luiziana-PR</td>
<td>Silva, <em>et al.</em> (2016)</td>
<td>-</td>
<td>11.0</td>
<td>9.0</td>
<td>50.0</td>
<td>23.0</td>
<td>-</td>
<td>1.0(1)</td>
</tr>
<tr>
<td>Rural Carnaúba do Ajudante, Serra Talhada-PE</td>
<td>Nascimento (2021)</td>
<td>-</td>
<td>38.90</td>
<td>11.27</td>
<td>6</td>
<td>6.37</td>
<td>37.46(2)</td>
<td>-</td>
</tr>
<tr>
<td>Umburana Community, Crateús-CE</td>
<td>Santos, <em>et al.</em> (2022)</td>
<td>-</td>
<td>27.02</td>
<td>8.11</td>
<td>17.57</td>
<td>11.75</td>
<td>37.84</td>
<td>-</td>
</tr>
<tr>
<td>Santo Amaro-BA</td>
<td></td>
<td>24.05</td>
<td>24.54(3)</td>
<td>11.28</td>
<td>5.55</td>
<td>7.36</td>
<td>11.89(4)</td>
<td>15.33(5)</td>
</tr>
</tbody>
</table>

Values in %. (1) Percentage found for “rubbers, slippers and old shoes” in the study. (2) Percentage found for “footwear, electronics and others” in the study. (3) Merging percentages (hard plastic + soft plastic). (4) Identified in the study as “sanitary waste/fraud”. (5) Combining percentages of materials identified as “multilayer (Tetra Pak), dangerous/electronic, rags/textiles/leather”.


In the study carried out by Santos et al. (2022) in Santo Amaro-BA, the values found for organic waste were 24.05% for rural areas and 52.03% for urban areas, the difference being justified by the fact that the use of organic material is greater in rural locations. For Martins et al. (2009) the low value of organic waste comes from the destination process immediately after generation, for animal feed and composting. This custom is also observed in the Tabua community, where only organic waste that cannot be used or when it comes from homes that do not keep animals and do not compost is discarded.

Waste classified as “reject” had one of the highest values among the categories (22%). A similar result was observed by Nascimento (2021). According to the author, this is related to the lack of separation of waste and inadequate conditioning, causing a mixture with other materials that could be used and which end up classified as waste. This class is mainly characterized as hygiene material (bathroom/fraud) and is considered household waste that may present health risks. The high percentage of this material (22%) draws attention due to its potential for contamination, especially in rural environments where adequate basic sanitation often does not exist. Rodrigues et al. (2023) found a percentage of 16.48% for rejects in the study carried out in the municipality of Carmo de Minas-MG, and consider this value a worrying factor due to its potential to cause public health problems, in addition to the possible contamination of animals that could come into contact with waste when disposed of inappropriately.
The paper (2%) and metal (3%) classes presented lower values in the total waste sampled. The low percentage of metal can be explained by the custom of some residents and, mainly, business owners to separate cans and other metals for sale. Waste classified as “plastic” obtained a moderate amount, with 11%, when compared to results from other studies in rural communities (Table 1). When compared to other studies (Table 1), it is observed that the values for “paper” are always surpassed by the values obtained for “plastic”, with a considerable difference (≤ 10%). In the study carried out by Nascimento (2021), he considered that the highest percentage of plastic waste corresponds to the increasing modernization of rural areas. Martins, et al. (2009) observed that plastics and paper were the materials found in greater quantity, but with less weight, commonly related to personal hygiene and kitchen products.

Figure 2a presents the density of solid waste sampled in the community of Tabua and Figure 2b the generation per capita. Organic waste obtained the highest density value (213.9 kg/m³), surpassing inorganic waste precisely because it had a high percentage of moisture in its composition and smaller volumes. Furthermore, the shape of organic materials and the absence of large internal voids, when compared to glass and metals, for example, explain this high density value, as they allow for better organization in the container. The waste (104.9 kg/m³) also had a higher density than paper and plastic, due to the fact that their materials have higher relative humidity, mainly coming from bathroom waste that has a great absorbent capacity.

The per capita generation of rural solid waste (RSR) in Tabua was around 0.171 kg/inhabitant.day, different from the value found in the work of Silva, et al. (2016) who obtained a value of 0.05kg/inhabitant.day, but similar to the value of 0.183 Kg/inhabitant/day found for the rural population of the municipality of Mondaí-SC (Flach, et al. 2020), which they considered as a low value when compared to urban per capita generation, precisely due to the low percentage of organic waste in rural areas.
Figure 2

(a) Density of solid waste (kg/m³) in the community of Tabua, Baianópolis-BA; (b) Per capita generation of each class of waste

The value of approximately 0.171 kg/inhabitant.day of waste generated is mainly justified by the greater number of visitors that the Tabua community receives on weekends, also considering the festive period in June that preceded the sampling. From the sample data, the per capita production of each class of waste was obtained, showing a greater generation and disposal of glass (0.007691 kg/person day), followed by organic waste (0.006362 kg/person day) and waste (0.004875 kg/inhabitant.day), as shown in Figure 2b.

Unlike the values found in this study, Flach et al. (2020) observed much higher values of per capita generation of RSR for each class of waste, obtaining values of 0.127 kg/inhabitant.day for “organic”, 0.028 kg/inhabitant.day for “reject” and 0.022 kg/inhabitant.day for “plastic”. The low per capita generation of plastic and paper in the community of Tabua can be attributed to the fact that some residents still dispose of their waste irregularly in their backyards and burn these materials routinely, as waste collection is recent in the community, and many people still do not contribute to the environmentally appropriate disposal of solid waste. The practice of burning waste was also observed in rural communities in Ilha Solteira-SP, where waste that can be recycled (RPR) such as paper, metal, plastic and glass is burned by residents in the backyards of their homes, even if waste is collected. waste in the community (Leite, et al. 2014).

However, it was also observed that waste from community cleaning and pruning services is also disposed of incorrectly, being burned or disposed of in ditches or irregular disposal points. The irregular disposal of pruning waste generates environmental impact mainly due to the mixture with hazardous waste. Furthermore, because they are bulky, they require large areas for accumulation and disposal, which can attract vectors, generate the possibility of fire, and the loss of waste with very high potential for reuse (Souza et al., 2018).
3.2 IRREGULAR DISPOSAL POINTS OF SOLID WASTE

Despite the implementation of adequate collection and disposal of solid waste in the municipality of Baianópolis and some rural communities, the majority of the rural population that used the landfill as the final destination of their waste was restricted with the closure/closure of the site. In this way, the restriction on the use of the landfill caused waste produced in communities, where there is no collection, to be thrown into irregular disposal points, causing new environmental liabilities in the municipality.

When traveling along BA 430, entering the interior of the municipality of Baianópolis, it was possible to find around 4 points of irregular solid waste disposal, as shown in Figure 3, arranged in clearings that form in the vegetation close to the road.

Figure 3
Location of irregular solid waste disposal points near the community of Tabua, Baianópolis-BA

Point 1, closest to Tabua (about 750 m), is one of the largest points of irregular waste disposal and, apparently, the most recent (Figure 4a,b). It was identified that a large part of the waste deposited comes from pruning and street cleaning services, but there is also the presence of tires, bags with bathroom waste, civil construction and demolition waste (RCDC), plastic and paper and cardboard. Despite there being collection in the community, there is still inadequate disposal of cleaning and pruning waste in this location, which is carried out both by residents and by the cleaning and collection service provided by the city hall.
At point 2 (1.5 km from Tabua), it appears to be older, as it is covered by non-native vegetation such as castor beans and herbaceous plants (Figure 4c,d), but it extends along part of the road, observed as several small points of irregular waste disposal. Remains of trees, plastics and tires were identified, as well as remains of household appliances, furniture, among others.

It can be seen that there is a large amount of tree remains in this second point (Figure 4c), laid out for a long time. However, other types of waste that can be recycled or disposed of in an environmentally appropriate manner are also found.
At point 3, approximately 2.1 km from Tabua (Figure 5a) and at point 4, approximately 3.1 km from Tabua (Figure 5b), basically plant residues related to pruning were found, with small portions of household solid waste. At point 4. These correspond to the most distant points of the Tabua community, but are still relevant due to the improper disposal of solid waste.

Figure 5
Points 3 (a) and 4 (b) of irregular solid waste disposal identified near the community of Tabua, Baianópolis-BA

This large amount of waste found in the 4 irregular disposal points causes great concern for the population and the environment in the region. The accumulation and inadequate disposal of RS can cause several socio-environmental problems such as the proliferation of disease vectors and contamination of water, air and soil, in addition to visual pollution (Araújo and Pimentel, 2016).

The formation of “addicted points” intensified mainly after the closure of the municipal landfill in May 2022, when solid waste collected in the municipality began to be sent to a private landfill near the city of Barreiras. It is believed that these points are fed mainly by residents of communities further away from the headquarters, who previously disposed of their waste in the landfill, but with its ban, they began to dispose of their waste in irregular points, precisely because they do not benefit from the collection and adequate disposal of RSR in their villages.

According to a survey carried out by the Secretariat of Urban Development of the State of Bahia – SEDUR (2022), a production of around 1,711.59 t/year of waste was estimated in the municipality of Baianópolis, obtaining a per capita generation of between 0.97 kg/ hab.dia. However, it was estimated that in 2022, only 48% of the municipality’s population was served.
by adequate collection and disposal of solid waste, due to the difficulty in serving rural areas due to the distance and difficult access. In the municipality, a large part of the population is rural, being represented by around 74% of Baianopolenses. In this way, collection is carried out only for the urban population and for a small percentage (24%) of the rural area, ignoring the majority of the waste-generating population, without promoting any intervention or mitigation measures for this problem. Furthermore, until the development of this study, the municipality does not have a Municipal Basic Sanitation Policy (MUNIC, 2017) or Municipal Plan for Integrated Solid Waste Management – PMGIRS.

4 CONCLUSION

The population of the Tabua community, in Baianópolis-BA, generates approximately 0.171 kg/inhabitant.day, with glass being the material with the highest representation (34%), followed by organic waste (28%) and waste (22%), respectively. When compared to gravimetric studies of urban centers, the percentage of organic waste is considered low, due to the common practice of rural communities of using these compounds as animal feed. The low percentage found for plastic (11%), metal (3%) and paper (2%) can be explained by the non-contribution of some residents to the solid waste management services initiated in the municipality, despite there being adequate collection and disposal, some residents still burn or improperly dispose of their waste.

This problem may be related to the lack of environmental education in the municipality's rural communities, indicating that Environmental Education in rural locations is as important as the planning and adoption of measures that improve the management of solid waste in the municipality. It is necessary for the information to be taken to the entire rural population of the municipality and for strategies to be developed to minimize the impacts generated by the accumulation of solid waste, whether through reducing consumption, recycling or reusing discarded materials.

By starting the collection and environmentally appropriate disposal of municipal solid waste for only 48% of its population and closing the municipal dump with due planning, the creation of other environmental liabilities was created, as observed in the identification of four points of irregular solid waste disposal near the community of Tabua. The importance of developing PMGIRS is highlighted, including the entire waste-generating population, without exclusion, benefiting rural communities that do not yet have collection or promoting actions
that reduce or eliminate irregular waste disposal. More gravimetric studies must be developed, expanding the seasonal variation in waste generation.

REFERENCES


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