IDENTIFICATION AND CHARACTERIZATION OF MUNICIPAL SOLID WASTE - MSW THROUGH GEOPROCESSING AND VISUAL ANALYSIS OF WASTE IN BRAZIL

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ABSTRACT:
This work sought to identify places with irregular dumping of solid urban waste and characterize them, assisting in the public management of these materials through a quick survey method. Belém, Capital of the State of Pará, Brazil, it was defined as a research area because it is observed that there are several places of irregular MSW dumping, impacting the quality of life of the population. Mapping and photographic survey and visual classification of the materials in the composition of the waste were carried out. The data were processed using the Quantum GIS software and Microsoft Excel. The analysis considered the relative frequency of identified materials, the most present: wood, construction waste, pruning and clearing materials, plastic materials and the presence of residential waste. 95.6% of the materials are from residential origin. Those materials have a great economic potential 61.6%. The presented methodology is a quick and practical solution for places with few technical and human resources in a way that assists in environmental management meeting a demand for a quick classification of the types of materials that will be sent to the final destination of solid waste or an adequate system screening.
Key-words: Municipal solid waste; Description; Integrated Solid Waste Management; Geoprocessing; Visual analysis.

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IDENTIFICAÇÃO E CARACTERIZAÇÃO DE RESÍDUOS SÓLIDOS MUNICIPAIS - MSW POR MEIO DE GEOPROCESSAMENTO E ANÁLISE VISUAL DE RESÍDUOS NO BRASIL

RESUMO

Este trabalho buscou identificar locais com despejo irregular de resíduos sólidos urbanos e caracterizá-los, auxiliando na gestão pública desses materiais por meio de um método de levantamento rápido. Belém, Capital do Estado do Pará, Brasil, foi definido como área de pesquisa porque se observa que existem vários locais de despejo irregular de RSU, impactando na qualidade de vida da população. Foram realizados mapeamento e levantamento fotográfico e classificação visual dos materiais na composição dos resíduos. A análise considerou a frequência relativa dos materiais identificados, os mais presentes: madeira, resíduos de construção, materiais de poda e limpeza, materiais plásticos e presença de resíduos residenciais. 95,6% dos materiais são de origem residencial. Esses materiais apresentam um grande potencial econômico de 61,6%. A metodologia é rápida e prática para lugares com poucos recursos técnicos e humanos de forma que auxilia na gestão ambiental atendendo a uma demanda por uma classificação rápida dos tipos de materiais que serão encaminhados para a destinação final de resíduos sólidos ou um sistema adequado de triagem.

Palavras-chave: Resíduos sólidos urbanos; Descrição; Gestão Integrada de Resíduos Sólidos; Geoprocessamento; Análise visual.

IDENTIFICATION ET CARACTÉRISATION DES DÉCHETS SOLIDES MUNICIPAUX - DSM PAR GÉOTRAITEMENT ET ANALYSE VISUELLE DES DÉCHETS AU BRÉSIL

RÉSUMÉ

Ce travail visait à identifier les lieux de décharges irrégulières de déchets solides urbains et à les caractériser, en aidant à la gestion publique de ces matériaux grâce à une méthode d'enquête rapide. Belém, capitale de l'État du Pará, au Brésil, a été défini comme une zone de recherche car on observe qu'il existe plusieurs lieux de déversement irrégulier de DSM, impactant la qualité de vie de la population. Une cartographie et un relevé photographique et une classification visuelle des matériaux entrant dans la composition des déchets ont été réalisés. L'analyse a considéré la fréquence relative des matériaux identifiés, les plus présents: bois, déchets de construction, matériaux d'élagage et de déblaiement, matières plastiques et présence de déchets résidentiels. 95,6% des matériaux sont d'origine résidentielle. Ces matériaux ont un grand potentiel économique de 61,6%. La méthodologie est rapide et pratique pour les lieux avec peu de ressources techniques et humaines d'une manière qui aide à la gestion de l'environnement répondant à une demande de classification des types de matériaux qui seront envoyés à la destination finale des déchets solides ou un système adéquat dépistage.

Mots clés: Déchets solides municipaux; La description; Gestion intégrée des déchets solides; Géotraitement; Analyse visuelle.

1. INTRODUCTION

Several technological innovations with intense cultural transformations stimulate consumption, which generates significant environmental pressure in cities (Mucelin & Bellini 2008, p.112). The global environmental issue challenges us to implement 'ecological reform', seeking the well-being of people in cities.

On the global stage, urbanization and the development of the social economy, added to new forms of consumption, resulted in an increase in the generation of MSW globally. Karak, Bhagat e Bhattacharyya (2012), explains that on average, developed countries generate 521.95 – 759.2 kg per person / year. For developing countries this figure is approximately 109.5 – 525.6 kg person / year. It is estimated that the generation of global MSW is greater than 2 billion tons per year, a major environmental risk.

In Brazil, most municipalities have dealt with the problem of municipal solid waste inefficiently. The Brazilian Association of Public Cleaning and Special Waste Companies - ABRELPE, reports that in 2016, the country had more than 3,331 municipalities, which sent 29.7 million tons of MSW to controlled dumps or landfills outside the technical specifications recommended by the treatment of these materials (ABRELPE 2016, p.14). Data from the Municipal Sanitation Secretariat - SESAN, report that 500 tons of solid waste are removed daily from irregular dumping sites in Belém capital of the state of Pará, Brazil, with a monthly operating expense of approximately R$ 2 million, reaching R$ 24 million per year (Agency Belém 2017), expenses that could be converted into an important investment for the city's population.

The Ministry of the Environment -MMA, together with agencies of the Federal, State and Municipal Governments, with the private initiative, non-governmental organizations and always with the participation of civil society, has been developing actions on several fronts in order to facilitate the implementation of the National Solid Waste Plan, which addresses the problem of the various types of waste generated, the management alternatives that can be implemented, plans of goals, programs, projects and corresponding actions. (Maiello, Britto & Valle, 2018) express the difficulties of implementing this policy in Brazil, pointing to political flaws and administrative measures on a national, regional and local scale, explaining that several metropolitan regions have few effective actions for the integral confrontation of municipal solid waste, and also highlight the discrepancy between the laws and the cultural practices and habits of the communities, emphasizing the need to increase dialogue with populations for significant changes.

For proper management and planning of the collection, transport and final destination of MSW, the classification and quantification of solid waste is essential. Thus, it is observed that there are several characteristics that influence the analyzes and actions, such as socioeconomic aspects of the population that produces, cultural issues that determine consumption; in addition to environmental care, climate, geomorphology of regions and places (BRAGA et al., 2010, p.302).

Barros (2012, p.17) explains that the characteristics of the waste produced must be observed, in order to determine the best management of them. Being physical characteristics (quantity per capita, moisture content and weight, for example), chemical (proportion of carbon / nitrogen, thermal use, acidity and nutrients) and biological (microbiology, organic degradation and gases produced). Thus, managers will have greater knowledge to implement the most appropriate forms of collection, transport, storage and treatment of materials with a later objective of the final disposal.

Knowing the variables in the management areas is essential. It is possible to design a MSW map using Geoprocessing, thus showing the spatial distribution of waste an area of interest, taking into account its generation, composition and variation throughout the year for example (Gallardo, Carlos e Colomer, 2014).

The problem of solid urban waste in Northern Brazil is a concern because it is an Amazonian environment, with heavy rains, high temperatures, predominance of waterway logistics and other factors that end up taking these materials to the rivers of the region, polluting them and through its natural flow to seas and oceans, causes environmental changes with the increased presence of plastics and microplastics.

The irregular dumping of municipal solid waste has impacted the quality of life of the population of the Marambaia neighborhood in Belém do Pará, Brazil. In view of this situation, the present work sought to identify places with irregular dumping of municipal solid waste and characterize it in the neighborhood, with the purpose of understanding aspects that can contribute to the proper management of this waste and also understand some factors that lead to the scenario current MSW pollution in public spaces.

2. METHODOLOGY

2.1 STUDY AREA

The research was carried out in the capital of the State of Pará, in the city of Belém, Brazil, more specifically in the neighborhood of Marambaia (figure 1). This neighborhood, according to the Brazilian Institute of Geography and Statistics - IBGE, in 2010 had a population of 62,370 inhabitants, in 10 years, this population grew approximately 6.95%, reaching the number of 66,708 residents. For municipal management, this neighborhood is part of the Entroncamento Administrative District - DAENT, the district with the most squares in the city (LUZ & RODRIGUES, 2014, p. 48-49), and the Belém district, which has a considerable amount of green areas, highlighting Belem Ecological Park, Gunnar Vingren, with 44 ha of preserved green area.

Figure 1 - **Map of the neighborhood of Marambaia.**

Source: Development and Administration Company of the Metropolitan Area of Belém, 2017.

2.3 THE CHARACTERIZATION OF URBAN SOLID WASTE AT IRREGULAR DISPOSAL POINTS

In order to characterize municipal solid waste at irregular dumping points in the neighborhood, field research was carried out with photographic survey and subsequent visual verification of the images, observing the different materials in the composition of the waste. In this way, the main materials present at the various MSW irregular dumping points in the neighborhood were quickly identified.

As a classification method, the definitions of Braga, Ramos & Dias (2010, p. 299-300) were adopted. Visual classification was adopted, without using laboratory resources or even physical-chemical analysis of the identified materials. The objective was to identify the presence of materials and their spatial distribution in the neighborhood in an expeditious way, which can be an easy and appropriate method. for MSW management in small cities for example and by neighborhoods in the case of large cities. Thus, the classification for later statistical analysis did not deal with the quantity of materials (weight and / or volume), but the presence of a certain material.

The classification used took into account the following parameters:

a) Origin, source and place of production: domestic, residential or home, commercial, hospital, special, radioactive, industrial, public, urban and rural;

b) Treatability: biodegradable, disposable and recyclable;

c) Degree of biodegradability: high, moderate, slow and non-degradable;

d) Economic pattern and source: high, medium and low;

e) Possibility of reacting with the medium: inert, organic and reactive;

f) Economic aspect: usable, unusable and recoverable;

g) Possibility of incineration: fuel and non-fuel; h) Energy recovery / generation: high, medium and low;

i) Health aspect: contaminated and not contaminated;

j) Physical nature: dry and wet;

k) Chemical composition: organic and inorganic.

Table 1 shows how the classification of the types of materials identified at each point was carried out, without considering their quantity, but the presence of these materials. It should be emphasized that the percentage refers to points with the presence of materials a, b or c. Thus, for example, materials such as tires were identified in 2% of the total irregular dumping points, ie their relative frequency. The data were processed using the Excel 2016 program, from Microsoft (R).

Table 1 – **Example of classification**

Material	Tire
Origin / Source	Commercial
Treatability	Recyclable
Degree of biodegradability	Slow and non-degradable
Economic standard	Low
Reaction with the environment	Inert
Economic aspect	Usable
Possibility of incineration	Fuel
Recovery, energy generation	High
Health aspect	Contaminated
Physical nature	Dry
Chemical composition	Inorganic

Source: Prepared by the author based on the classification by Braga *et al.* (2010)

The field survey took place on the main roads in the neighborhood and also on secondary roads. The Global Positioning System (GPS) receiver, GPSMAP 78s from Garmin (R) was used,

and a photographic survey of each point with identification of MSW dumped irregularly was also carried out. The field research took place in July and August 2018. A total of 51 points were identified. The location data were subsequently treated in the Quantum GIS geoprocessing program, making it possible to observe the distribution of the points identified on the georeferenced satellite image of the study area imposed via Google Earth. It was also sought to reveal whether any concentration of the locals observing its prevalence in different areas. Information such as neighborhood limits and drainage aspects were also added to the project, especially Igarapé São Joaquim, the northwest, and its course on the Ecological Park of the Municipality of Belém 'Gunnar Vingren', in addition to the Canal Água Cristal with east-west flow, flowing into Igarapé São Joaquim and covering practically both ends of the neighborhood.

3. RESULTS AND DISCUSSIONS

3.1 SURVEY AND VISUAL ANALYSIS

Regarding the identified materials, these are diverse, being found furniture, tires, plastic materials, electronic materials, food scraps, materials resulting from pruning and weeding, debris from civil works, among others (figures 2 and 3). It was also observed that among the places that there is a greater presence of irregular MSW dumping points are close to public schools and / or related to the sides of public institutions (figures 4 and 5).

Figure 2 - **Irregular dumping point of MSW, next to Canal Água Cristal, in the neighborhood of Marambaia, Belém-PA**.

Figure 3 - **Irregular dumping point of MSW, in front of São Jorge Cemetery, in the neighborhood of Marambaia, Belém-PA**.

Source: Pereira, 2018.

Source: Pereira, 2018.

Figura 4 - **Irregular dumping point of MSW, on the side of the Francisco da Silva Nunes State Integrated High School, in the neighborhood of Marambaia, Belém-PA**.

Source: Pereira, 2018.

Figure 5 - **Irregular dumping point of MSW with water accumulation, on the side of the Leonor Nogueira State Elementary School, in the neighborhood of Marambaia, Belém-PA**.

Source: Pereira, 2018.

Even with some actions of inspection and correction of problems presented in some specific points, this situation still remains in the study area. Mucelin & Bellini (2008, p.113) deal with the relevance of studying the habits given in daily life, which ends up being considered "normal" in the practices of the communities, which for them hide other realities, and even environmental aggression, it is then naturalized, with no ethical perception of the acts performed, even if there is information on the environmental issue.

The water courses Canal Água Cristal and Igarapé São Joaquim collaborate with the drainage of rainwater in the neighborhood of Marambaia, the first of which is the most impacted by the irregular dumping of solid waste on its banks.

Such drainage system is impacted by the irregular dumping of MSW, the presence of plastic bags, plastic bottles and furniture remains. The surroundings of this water body, present high population density and still low infrastructure, where the majority of the low-income population resides. During the research, the concentration of irregular dumping points for solid waste was identified (figures 6 and 7) and also the use of margins as places for the deposit of construction materials (figure 8), and wood (figure 9).

Figure 6 - **Result of irregular MSW eviction in the Água Cristal Channel, in the neighborhood of Marambaia, Belém-PA**.

Source: Pereira, 2018.

Figure 7 - **Irregular dumping of MSW on the banks of Canal Água Cristal, in the neighborhood of Marambaia**,

Source: Pereira, 2018.

Figure 8 - **Canal Água Cristal margin, in the neighborhood of Marambaia, Belém-PA, being used as a deposit for construction materials**.

Source: Pereira, 2018.

Figure 9 - **Canal Água Cristal margin, in Marambaia neighborhood, Belém-PA, being used as a wood deposit**.

Source: Pereira, 2018.

Larger studies are lacking in Brazil to demonstrate quantitative data on solid residues that are retained in the drainage systems of cities (TUCCI, 2002, p.8), and are still few in other countries. However, the impacts caused by this problem are well observed, resulting in floods and contamination, for human populations. The main problems would be material / economic losses, loss of human life, interruptions in activities in flooded areas; proliferation of diseases, such as leptospirosis and cholera; and the spread of various other diseases through contact with human populations in contaminated waters.

Due to the heterogeneous characteristic of the materials existing in the identified points, it was clear that the public management lacked guidance and encouragement in the orientation and encouragement of recycling actions in the neighborhood, for example, which would reduce the amount of materials and the number of places with irregular dumping. (Figures 11 and 12).

Figure 11- **Image of irregular solid waste dump point in the neighborhood of Marambaia**.

Figure 12- **Image of irregular solid waste dump point in the neighborhood of Marambaia**.
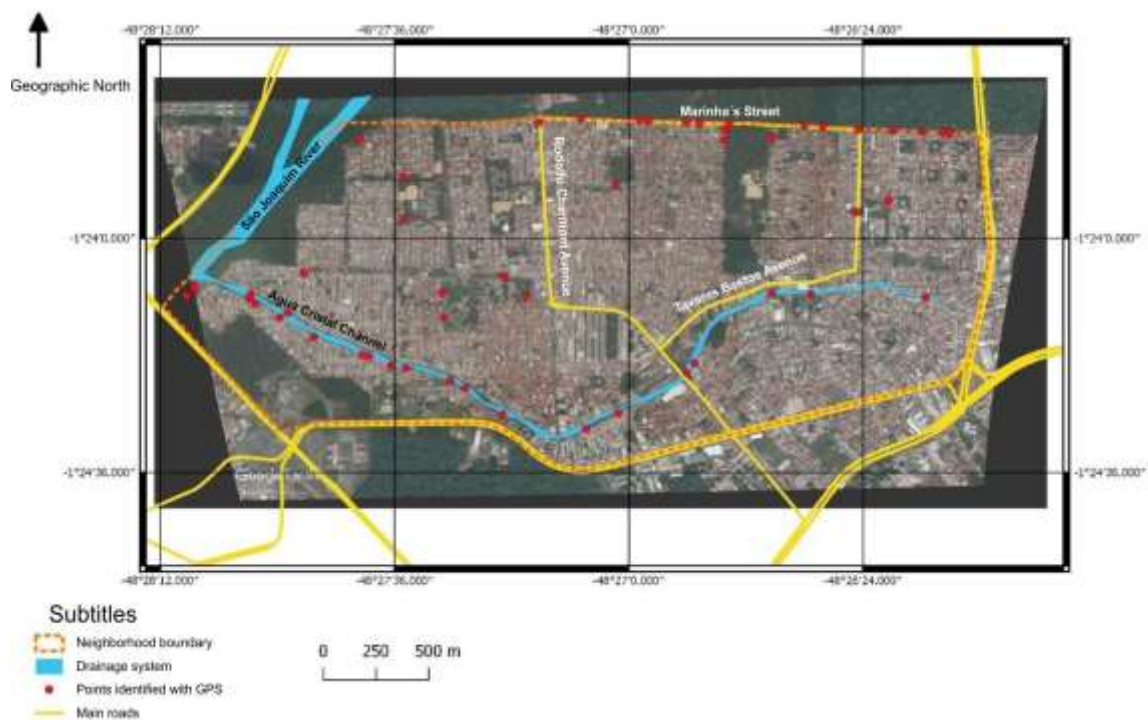

Source: Pereira, 2018.

Source: Pereira, 2018.

3.2 CHARACTERIZATION OF MSW AT IRREGULAR DUMP POINTS IN THE NEIGHBORHOOD OF MARAMBAIA

The images obtained in the field survey, in a total of 51 identified points (figure 17), were then analyzed, one by one, and the information extracted from the observations organized in a table to aid in the results. As explained in the methodology of the present study, Braga et al. (2010).

Figure 14 - **Map of irregular solid waste disposal points in the Marambaia neighborhood, Belém-PA.**

Source: Pereira (2018).

The map above indicates that there is a significant majority of irregular dumps located along the channel Água Cristal and on the northern limit of the neighborhood, highlighting the first case, there is a contribution to the increase of the environmental stress factor around the watercourse and a important contribution to the pollution of the city hydrographic network. The results of the analysis of the images (figure 14), highlight the presence of the following materials in the identified points: wood, residues from residential works, residential waste, pruning / mowing, plastic, paper / cardboard, electronics, furniture, metal, tires, leftover food, tissues and açaí lump. The most prominent materials were residential waste, wood, plastics, pruning and construction waste with the highest and similar percentages.

Figure 14 - **Relative frequency of the types of materials viewed at irregular solid waste dump points in the neighborhood of Marambaia, Belém / PA, in August 2018**.
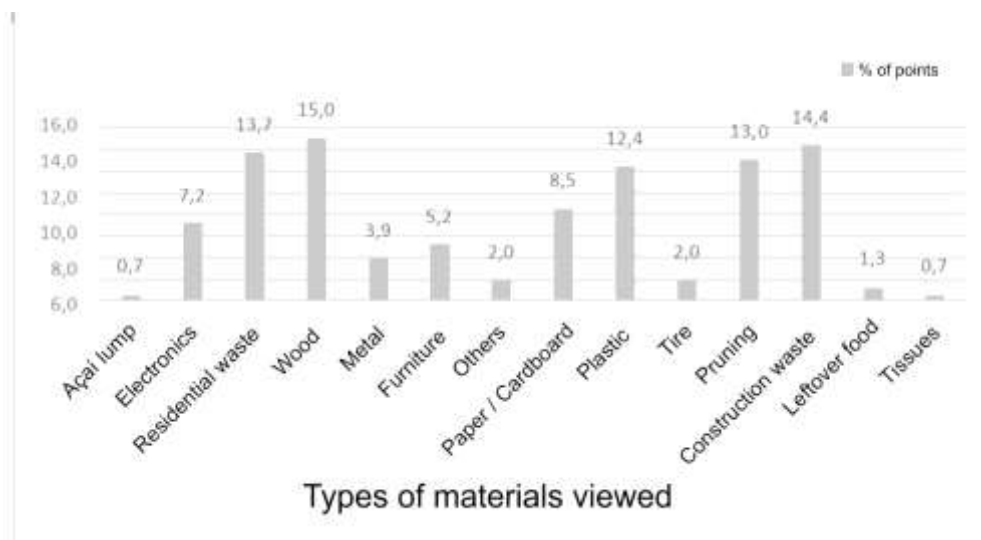
Source: Pereira, 2018.

Apart from residential waste, the other identified materials should be sent to appropriate places for receiving and proper disposal for recycling purposes. Plastics and paper / cardboard should be sent for selective collection, and electronics for reverse logistics programs, for example. The presence of residential garbage reinforces an alert to increase inspection and environmental education, guiding residents to the appropriate times for the disposal of such materials for collection by trucks and public cleaning workers.

The materials characterized as of commercial origin took place by deduction, taking into account the proximity of shops and services, such as tire shops and maintenance of

electronics identified during the field study. Thus, in relation to the origin or source of the identified materials, 95.6% have an aspect of residential origin.

In 44% of the identified points there is the presence of residential waste, which is a significant contamination. Observing that, if the materials removed from the MSW irregular dumping points were removed and sent to spaces dedicated to sorting for recycling, this would be compromised, due to the high rate of contamination by residential waste presented.

Considering the treatability, in 41.9% of the points there is the presence of recyclable materials, presenting a potential for projects integrated with the community in the sense of generating income, through associations of residents and recycling cooperatives.

The presence of biodegradable materials was observed, above 30%, which indicates the possibility of their use for composting projects and use in community gardens and / or landscaping. Disposables were identified, represented, by deduction, by the presence of bags with residential waste and also some materials outside bags (figure 15).

Figure 15 - **Relative frequency according to the treatability of materials viewed at irregular solid waste dump points in the neighborhood of Marambaia, Belém / PA, in August 2018**.
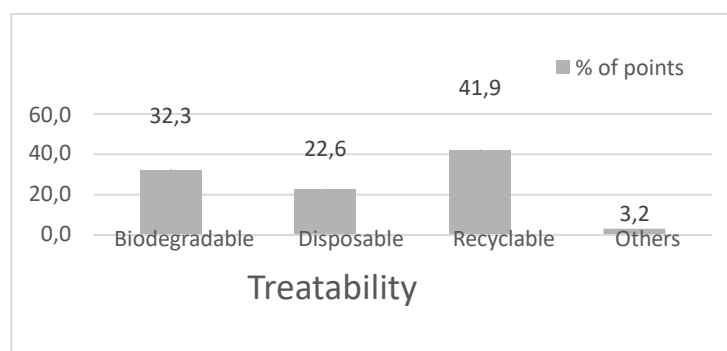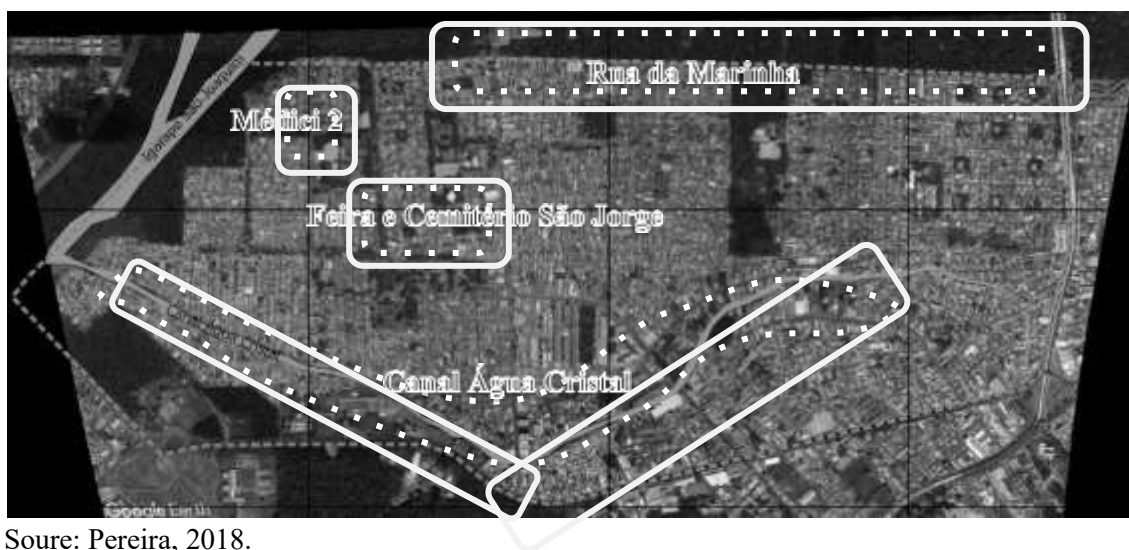

Source: Pereira, 2018.

Recognizing the degree of biodegradability and quantifying these materials will collaborate with the proper management of MSW, guiding the sizing needs of their final destination. The degree of biodegradability is represented by the time that the material, considering the locational characteristics (humidity, heat, biological action, among others), will take for its decomposition. In the study area, more than 50% of the types of identified materials are classified with moderate to high biodegradability (pruning / brushing, paper / cardboard, wood, food scraps, açaí stone, some types of fabrics, among others), 24% slow and non-degradable (plastic, rest of works, metals, tires, electronics, furniture, among others) and unclassified materials such as residential waste.

Regarding the economic standard in addition to visual identification, the location of the dump point was observed. More than 46.8% of the identified points present materials of medium or low economic standard, following mainly the Rua da Marinha and the right side of the São Jorge cemetery, 44.7% with characteristics of low economic standard in the vicinity of the Água Cristal channel, the fair and the São Jorge cemetery, and 6.4% located in the Médici 2 residential complex with a middle or upper class economic standard (figures 16).

Figure 16 - **Identification of concentration of irregular solid waste dump points in the neighborhood of Marambaia, Belém / PA, in August 2018**.

Soure: Pereira, 2018.

On materials that react with the environment due to the action of the weather, they are defined as inert, those with slow decomposition time or do not decompose, for example: metals, construction debris, tires, glass, plastics, mobile fabrics and scrap. The ones identified as reactive observed in the research are the electronics, which are capable of contaminating the environment and releasing heavy metals and substances present in its components, in addition to residential waste that is a potential contaminant. The others were organic (wood, pruning / clearing) and unclassified.

For the economic aspect of localized materials, we have more than 60% usable, and more than 5% recoverable, in the case of furniture. There is the presence of residential waste in several points, contaminating the materials, which ends up leaving more than 28% of the points with unusable materials.

For the possibility of incineration, there is a presence in almost 60% of the points, being wood, pruning / mowing, paper / cardboard, plastic. There is the presence of residential waste,

which can be incinerated. However, such material tends to hinder incineration due to the high humidity (NEGRÃO and ALMEIDA, 2010), apart from the socio-environmental impacts generated, with toxic gases and polluting ash. Economically, this solution has a negative economic impact for associations and cooperatives of collectors, reducing the availability of some recyclables.

In terms of energy recovery, that is, the ability to generate heat, laboratory analyzes of the materials were not carried out, but identification through the photos of the field research. Based on Batista, Texeira & Silva (2004, p. 2-3) are materials that have greater capacity for thermal conversion such as wood, paper, plastic and cloths. Residential waste has a good conversion capacity, however, according to Negrão & Almeida (2010), it has, for the most part, a lot of humidity, having medium capacity and thermal conversion. Low-capacity ones are metals, construction waste, scrap and.

For the physical nature of the materials were considered dry: plastics, metals, tires, construction waste, paper / cardboard, electronics, furniture, fabrics; equivalent to 51.3% of points with these types of materials. And 44.7% wet, with the presence of organic materials. The results presented are complementary in relation to the characterization of the materials, since considering that the solid residues located in the points identified in the study area are in uncovered areas, subject to rain these materials have great possibilities of containing moisture, influencing the weight, transport and final disposal.

4. CONCLUSION

Analyzing the results presented in the survey of irregular solid waste dumping points for the Marambaia neighborhood, we developed the following observations:

a) The methodology presented is a quick and practical solution for places with few technical and human resources in a way that assists in environmental management meeting a demand for a quick classification of the types of materials that will be sent to the final destination of solid waste or an adequate system screening.

b) The most identified materials are wood, construction waste, pruning and clearing materials, plastic materials and the presence of residential waste. It is necessary to implement suitable locations for receiving these materials, in addition to encouraging the segregation of these, which would reduce the problem of irregular dumping of solid waste in the

neighborhood. Offering diverse gains, such as reduced public spending and economic use of these materials;

c) The origin of the waste is mostly residential, 95.6%. Environmental education and guidance actions are needed with neighborhood residents, seeking greater participation in terms of community support, via associations and schools, together with municipal public agencies for sanitation and the environment. Observing the shared responsibility of government and population;

d) The presence of residential waste in 44.7% of the identified points was a highlight, even with the regular public collection service in the neighborhood.

e) There is a strong devaluation of public spaces. This was observed by the identification of a large number of irregular solid waste dump points in the neighborhood in these spaces;

f) There is no effective Integrated Solid Waste Management in the study area, which provides for selective collection, and which in the district of Marambaia is little stimulated by municipal management;

g) Four critical sectors were identified, that of the São Jorge cemetery and Feira da Tavares Bastos, that of the side of public schools in the Médici complex, and the most intense, on the banks of Canal Água Cristal and along Rua da Marinha. These areas have in common having public spaces, far from the front of residences and / or the entrance and exit of public or private institutions;

h) The amount of waste generated in the neighborhood was not provided by the municipal secretariat, showing an important management problem, as it certainly has costs for its collection;

i) A possible solution to the problem presented in the study area, which is repeated in the other neighborhoods of Belém. The solution it would be the creation of Ecopoints. These are structured to receive small volumes of solid urban waste, such as leftover works, pruning, bulky materials, among others, which are sent by the carters / truck drivers and also by the population. Assisting in this way in the reduction of areas with irregular dumping of solid waste, being a relevant solution for this urban environmental issue. There is still the possibility of integrating as a point of voluntary delivery of materials for recycling, being an opportunity to integrate associations and cooperatives of waste pickers, with the possibility of training, income generation and social inclusion. Regarding the characterization of MSW at the

identified points, it was clear that, if Ecopoints were implemented in the neighborhood, apart from the environmental gain, it would enable income generation, with 61.6% of the points having economically usable materials, thus having the potential to stimulate actions of recycling and selective collection. And also increasing the useful life of the landfill because such materials would be directed to recycling;

j) Belém is going through an important crisis regarding the treatment and final destination of the MSW produced, in the Capital and in the Metropolitan Region, the materials collected in the streets, known as "rubble", those defined here as MSW in irregular dumping points , are sent to Aurá Landfill still (the one that had its operation finished), according to reports collected by outsourced urban cleaning workers, and the said residential garbage, contaminated material for the Sanitized Landfill in Marituba. In this research it was possible to identify that there is an important presence of contaminating residential garbage next to the material collected at the points by the public service and thus still sent to Aurá Landfill, which is close to the capital's water treatment system for distribution to the population.

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