Evaluation of municipal solid waste management in the state of Amazonas

Avaliação da gestão de resíduos sólidos urbanos no estado do Amazonas

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ABSTRACT
The improper management of solid waste and the absence of resources and environmental education software are threatening the rivers of the Amazon region, that together form the greater freshwater basin in the world. In these terms, the general objective of this research is to evaluate the current situation of the management of urban solid waste in the cities of that state. The present research is organised in bibliographic and documental search, characterization of the area of investigation, and elaboration and application of questionnaires for data collection. Of the 62 towns that belongs to the territory of Amazonas, the research has collected information about 31, which corresponds to 50% of the area of investigation. The results indicate that 68% of the cities have the Municipal Plan for Integrated Solid Waste Management, while 32% did not elaborate their plans, failing to receive resources of the Federal Government which would be destined specifically to the services of management and operation of the solid waste. It was observed similar characteristics in the cities that did not have their plans elaborated, being all of minor size and located in isolated areas of the Amazon region, with access only by transport by river, fact that complicates the actions pertinent to the theme, as occurs with the final disposition of the solid waste. Among the cities that were investigated, none of them arrange their solid waste in appropriate environmentally conditions, prevailing the archaic way of disposal, the open sky landfills, that causes the degradation of the ground and hydric bodies, which are the top means of subsistence of the amazon population. The conclusion is that the management of solid waste represents one of the biggest challenges of basic sanitation in the state of Amazonas and such matter requires to be prioritized urgently, given the risk of the degradation of the natural resources of the region.

Keywords: solid waste, amazon region, waste destination, circular economy.

RESUMO
A gestão inadequada dos resíduos sólidos e a ausência de recursos e softwares de educação ambiental ameaçam os rios da região amazônica, que juntos formam a maior bacia de água doce do mundo. Nestes termos, o objetivo geral desta pesquisa é avaliar a situação atual da gestão de resíduos sólidos urbanos nos municípios daquele estado. A presente pesquisa está organizada em pesquisa bibliográfica e documental, caracterização da área de investigação e elaboração e aplicação de questionários para coleta de dados. Dos 62 municípios pertencentes ao território amazonense, a pesquisa coletou informações sobre 31, o que corresponde a 50% da área de investigação. Os resultados indicam que 68% dos municípios possuem Plano Municipal de Gestão Integrada de Resíduos Sólidos, enquanto 32% não elaboraram seus planos, deixando de receber recursos do Governo Federal que seriam destinados especificamente aos serviços de gestão e operação do lixo sólido. Foram observadas características semelhantes nas cidades que não tiveram seus planos elaborados, sendo todas de menor porte e localizadas em áreas isoladas da região amazônica, com acesso apenas por transporte fluvial, fato que dificulta as ações pertinentes ao tema, como ocorre com a disposição final dos resíduos sólidos. Dentre as cidades investigadas, nenhuma delas dispõe seus resíduos sólidos em condições ambientalmente adequadas, prevalecendo a forma arcaica de disposição, os aterros a céu aberto, que provocam a degradação do solo e dos corpos hídricos, que são o principal meio de subsistência da população. a população amazônica. A conclusão é que a gestão de resíduos sólidos representa um dos maiores desafios do saneamento básico no estado do Amazonas e tal assunto necessita ser priorizado com urgência, dado o risco de degradação dos recursos naturais da região.

Palavras-chave: resíduos sólidos, região amazônica, destinação de resíduos, economia circular.

1 INTRODUCTION

The environmental impacts that occur in the Amazon region are not only caused by forest deforestation and illegal mining, but also come from the inadequate disposal of solid waste, which reaches not only the urban areas of the municipalities where they are disposed, but also water bodies, compromising its quality. Although economically and technologically developed regions have been seeking to structure circular economy models, in which solid waste is destined for maximum use, most of the planet still lacks adequate solutions for its waste.

In recent years, rapid economic development and exponential population growth have resulted in a significant increase in the amount of solid waste. As can be seen in the last panorama ABRELPE (2021), in Brazil, between the years 2019 and 2020, the generation of urban solid waste (MSW) increased from 79 million to 82.5 million tons generated annually, of which 40% had their final disposition inadequate.

With the increase in the amount of waste generated and its diversity, the efficient management of solid waste has been considered one of the great challenges in today's society. Mismanagement of solid waste contributes to the depletion of natural resources and the degradation of ecosystems, in addition to causing multiple damages to human health (ZOLNIKOV et al., 2018).

In Brazil, the management of solid waste, as part of one of the basic sanitation services, is the main responsibility of the municipalities, as provided for in art. 30, inc. I and V of the Federal Constitution, as well as in art. 10 of Law 12,305/2010, with municipal entities responsible for managing solid waste generated in their respective territories (BRASIL, 1988; BRASIL, 2010).

In the State of Amazonas, it is difficult to know what the current situation of solid waste management is, as a minority of municipalities provide public information relevant to the subject.

In view of the richness and biological and cultural diversity of the Amazon, it is important to pay attention to the management of solid waste in this region, in order to preserve natural resources, minimizing environmental contamination and the proliferation of diseases and, thus, promoting the health of the population. (IBICT, 2022).

The objective of this research is to evaluate the current scenario of municipal management of solid waste in the State of Amazonas, the critical evaluation of municipal public management of waste can serve as an important instrument for promoting actions and government programs aimed at the sustainability of the region.

2 RESEARCH METHOD

The present study was carried out in the State of Amazonas, the territory is part of the North region of the country with an estimated population of 4,269,995, in an area of 1,559,167.878 km², accounting for 62 municipalities and a demographic density of 2.23 inhabit/km² (IBGE , 2022).

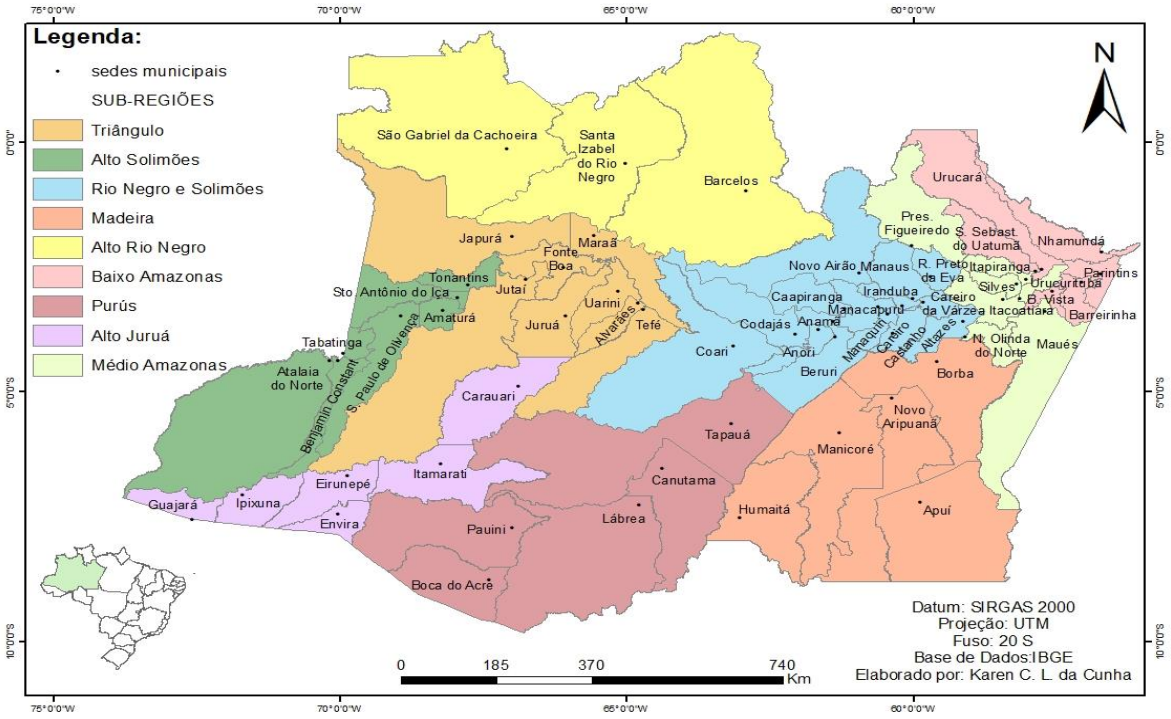
The Amazon still has 98% of its forest cover preserved, in addition to having one of the largest freshwater water reserves on the planet, influenced by several factors, such as precipitation, vegetation and altitude. Most of the Amazonian rivers are navigable throughout the year and the Amazon River is internationally known as the largest in the world, with a course estimated at 6,300 kilometres, with its Atlantic arc extending for 400 kilometres (BRASIL, 2021; IBGE, 2010).

The Amazon borders to the north with Venezuela and the State of Roraima (RR); to the northwest with Colombia; to the East with the State of Pará (PA); to the southeast with the State of Mato Grosso; to the south with the State of Rondônia (RO) and to the southwest with Peru and the State of Acre (AC) (AMAZONAS, 2017).

The climate is humid equatorial, with an average temperature of 26.7º. Relative air humidity is around 70% and the state has only two well-defined seasons: rainy (winter) and dry or less rainy (summer) (IBGE, 2022).

Being a State bathed by rivers, lakes and streams, administrative and political planning favored the division of its 62 municipalities by river channels, with the intention of bringing together territories with similar characteristics to encourage local development (PAREDIO, 2012). Their locations can be seen in Figure 1.

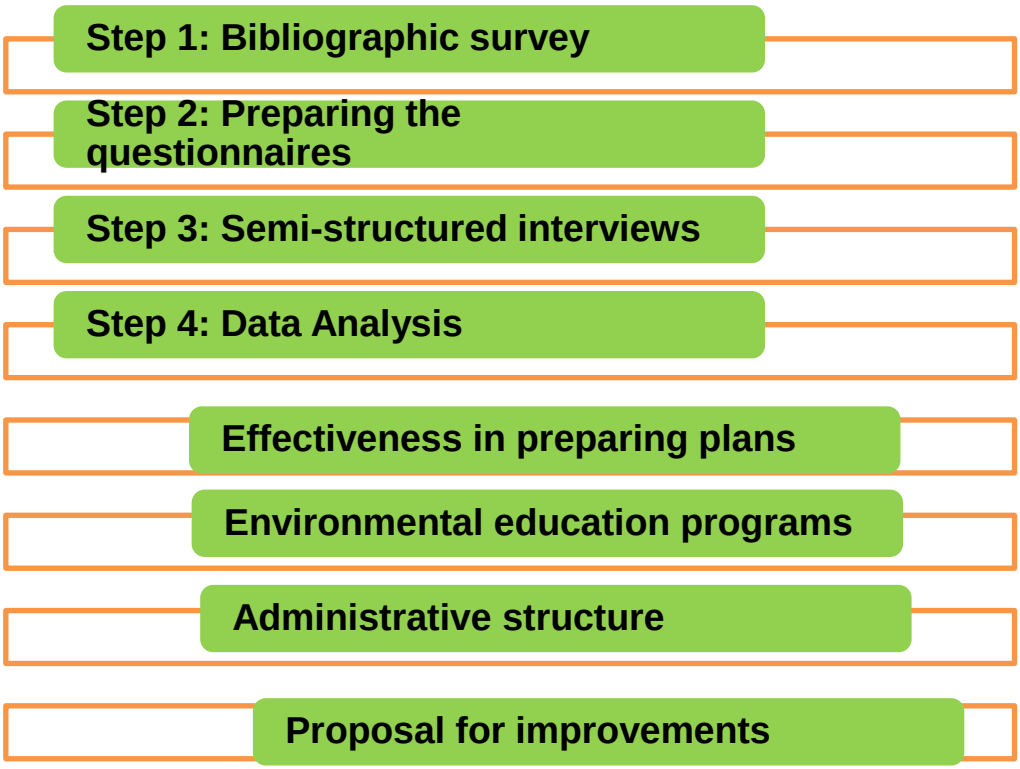
Figure 1. Location Map of the State of Amazonas



Source: Adapted IBGE (2022).

The research development stages are shown in the flowchart in Figure 2.

Figure 2. Methodological steps for research elaboration



Source: Own authorship (2022).

For the construction of this research, a bibliographic survey was carried out on the topic addressed. For this, documents on the subject were consulted, such as files and technical reports from municipal and state public authorities, legislation and standards of Integrated Solid Waste Management, national and international scientific articles, accessed by the Capes platform (scopus), Google Scholar, in addition to census statistics from the Brazilian Institute of Geography and Statistics (IBGE), the National Information System on Solid Waste Management (SINIR) and the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE).

In order to gather information about the current solid waste integrated management system, a questionnaire structured in 20 questions was elaborated using the Solid Waste Management Index (IGR) as a reference, according to the methodology proposed by the Secretary of Environment of the State of São Paulo. Paulo (SEMA-SP, 2021). The questions used in this research address the main aspects of municipal solid waste management linked to the objectives and instruments of PNRS Law 12,305/2010.

For the application of the questionnaire, it was analyzed by the National Commission of Ethics in Research - CONEP. Thus, the procedures adopted in this

research comply with the Criteria of Ethics in Research with Human Beings according to Resolution Nº. 196/96 of the National Health Council.

After passing through the ethics committee, semi-structured interviews were carried out with those responsible for the management and management of solid waste in the Amazonian municipalities. For the dissemination of the questionnaires, support was requested from the State Secretariat for the Environment of Amazonas (SEMA-AM), which promptly provided the telephone and e-mail contact of those responsible for the secretariat then requested.

Due to the fact that internet access in the interior of the State of Amazonas is almost non-existent, the interviews were carried out by email, phone calls and the WhatsApp messaging application from September 2021 to June 2022.

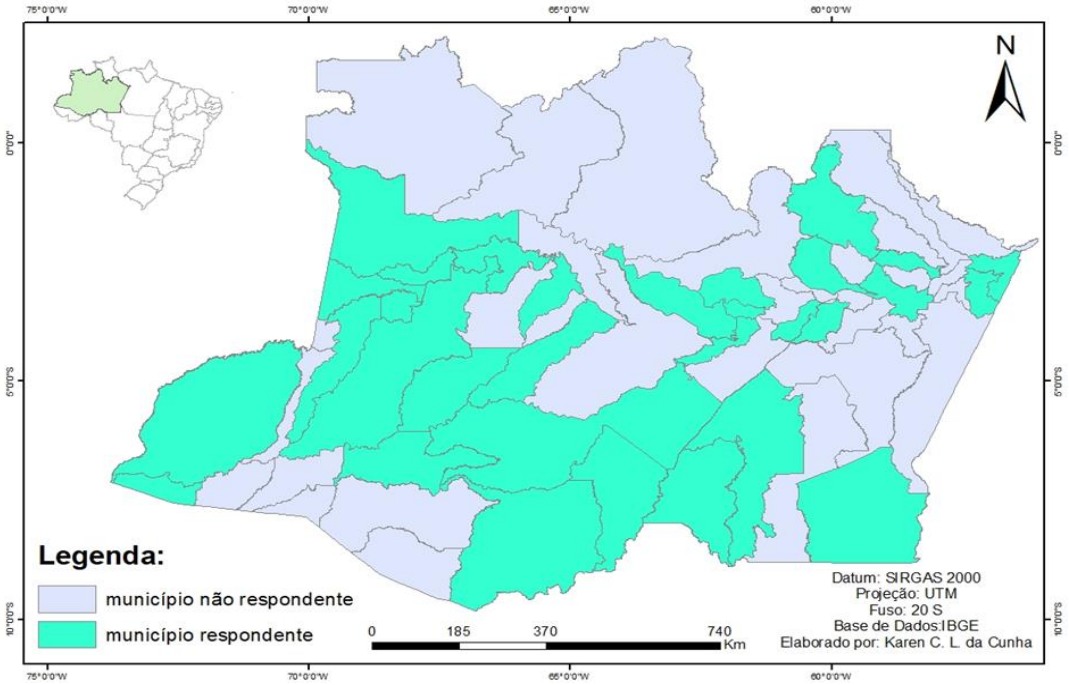
For the answers obtained, compliance of data on packaging, collection, transport and final disposal of solid urban waste was verified with the PNRS, Law 12.305/2010, and other legal provisions responsible for the management of solid waste. The legal apparatus was of fundamental importance to assess the compliance or non-compliance of municipalities with the topic addressed.

3 RESULTS AND DISCUSSIONS

The present diagnosis on solid waste gathered information from 31 municipalities belonging to the State of Amazonas, covering 73% of the urban population of the State, half of the municipalities that the present research proposed to study.

On the map in Figure 3, the Municipalities of the State of Amazonas that participated in the survey are displayed, being presented as “responding municipalities” and the “non-responding” Municipalities correspond to those that did not provide public information regarding the management of solid waste.

Figure 3. Maps of the municipalities participating in the research.



Source: Own authorship (2022).

As shown in Figure 3, the highest participation rate was present in the sub-regions of Alto Solimões, Triângulo, Purus, Alto Juruá, Madeira and Rio Negro and Solimões. On the other hand, in the Upper Rio Negro and Middle Amazon regions, the lowest response rate was obtained. It is noted that the low rates of return were present mainly in extreme and isolated locations in the Amazon, such as São Gabriel da Cachoeira, Barcelos and Santa Izabel do Rio Negro.

It was noted that the vast majority of Amazonian municipalities are small municipalities, according to data from IBGE (2018) this is a peculiarity of the Amazon region, in which most are made up of municipalities with a population of up to 20,000 inhabitants. It is also noted that the small municipalities are located, for the most part, in areas far from the capital Manaus, with access only by river and with trips that usually last up to 10 days, depending on the weather season.

These are peculiarities that must be taken into account when addressing the issue of basic sanitation, especially those involving the management of solid waste. According to Pereira et al. (2017) and Bozonni et al. (2022), small municipalities have found it more difficult to adapt to Law 12,305/2010, mainly due to the lack of financial resources and qualified professionals.

In addition to these difficulties, according to the Brazilian Institute of Information in Science and Technology - IBCIT (2021), federal legislation often does not consider the

fact that small cities have a more fragile technical and organizational structure, unlike medium and large cities, which are generally better structured. This is the case of the National Solid Waste Policy, which needs to be customized to the context of small-sized cities with different characteristics, as is the case of municipalities located in the Legal Amazon territory. Many of these cannot execute the regulation because they do not fit the standard for which the legislation was created. Therefore, in the case of waste management, it is necessary to think about policies and norms with local action, which meet the specific needs of the population and the territory (IBCIT, 2021).

3.1 SOLID WASTE MANAGEMENT ANALYSIS

As a premise, it is important to highlight that the Amazonian municipalities do not make any kind of charge for MSW collection and final destination services. Charging for this type of service has been increasingly encouraged since the publication of the new basic sanitation framework (Law No. 14,026/2020, Article 7), as a way of collaborating with the economic self-sufficiency of solid waste management and encouraging the reducing the generation of such waste.

Municipalities in the interior of the State do not have active participation in collegiate bodies, only the State capital participates in municipal councils, such as the Municipal Council for Development and Environment (COMDEMA) and the Municipal Council for Urban Development (CMDU). Participation in these collegiate bodies is fundamental for the formulation and implementation of public and control policies, granting social participation in urban cleaning services and solid waste management.

3.1.1 Administrative structure

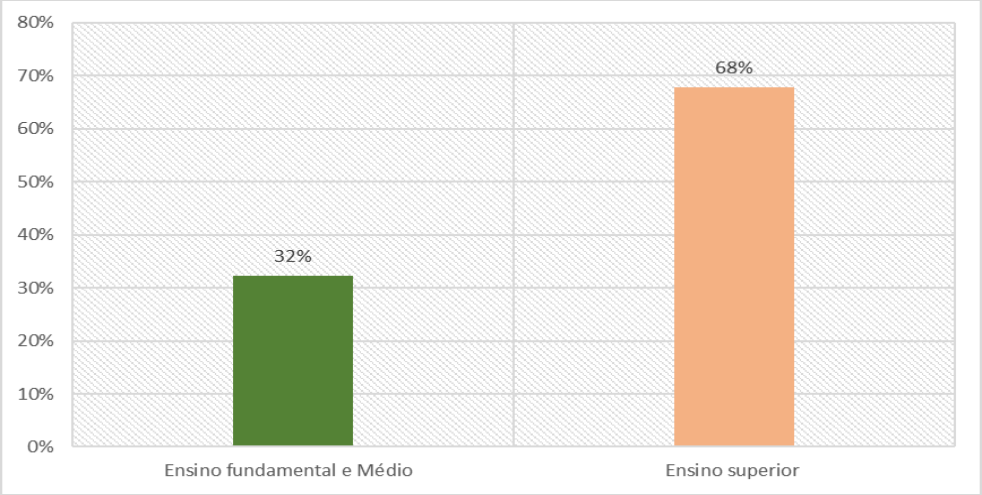
Some determining factors that influence the quality and efficiency of solid waste management are the legal aspects and administrative organization, responsible for organizing and executing the actions of waste management and urban cleaning services.

Brazilian municipalities have several difficulties in operationalizing a competent solid waste management system, which is due to administrative inconstancy, in which changes in municipal departments are often made, in addition to the lack of commitment or participation of city halls for the implementation of plans and the resulting lack of financial resources and qualified professionals to implement actions and programs that enable efficient management.

In the institutional structure of the Municipalities of Amazonas, the Municipal Environment Secretariat (SEMA) is the only body in charge of cleaning services and solid waste management.

The level of education of managers in the municipalities studied was analyzed, making it possible to identify that the vast majority of managers have higher education (68%) in different areas of training and 32% have schooling at elementary and secondary level, without any other complementary training in the area. area, which can directly influence decision-making regarding MSW management (Graph 1).

Graph 1. Schooling of municipal managers.



Source: Own authorship (2022).

Asked to the managers what was the biggest difficulty encountered for the occurrence of an efficient MSW management system, in their entirety the answers were the same, “the lack of financial resources for the construction of the sanitary landfill”, making it understood that the adequate management supposedly would be limited to final disposal in landfills. Bear in mind that landfill disposal is just one way to minimize the environmental damage caused by waste.

Having managers as the main technicians responsible for creating public policies aimed at environmental sustainability and the inspection of potentially polluting activities, it is evident the need for technical training of the local administration to continue the work.

The lack of technical capacity with regard to waste management was evident in the interviews carried out, in which many were unable to provide basic data on the municipal situation that encompass solid waste management, such as the amount and

types of waste collected, the infrastructure of the management, the forms of final treatment of solid waste and, mainly, demonstrated the lack of knowledge of essential technical documents such as the PMGIRS.

3.2 MUNICIPAL STATE PLANNING

The State of Amazonas has the State Policy for Solid Waste of the State of Amazonas (PERS/AM) Law No. 4457/2017, which defines principles and objectives for the integrated management of solid waste in its territory and emphasizes the importance of preparing the PMGIRS.

The PMGIRS is the main instrument of municipalities for planning and organizing public services for cleaning and managing urban solid waste. The document surveys the current situation of solid waste management in all its stages, from generation to final disposal. Failure to draw up this instrument prevents obtaining Union resources specifically intended for these services.

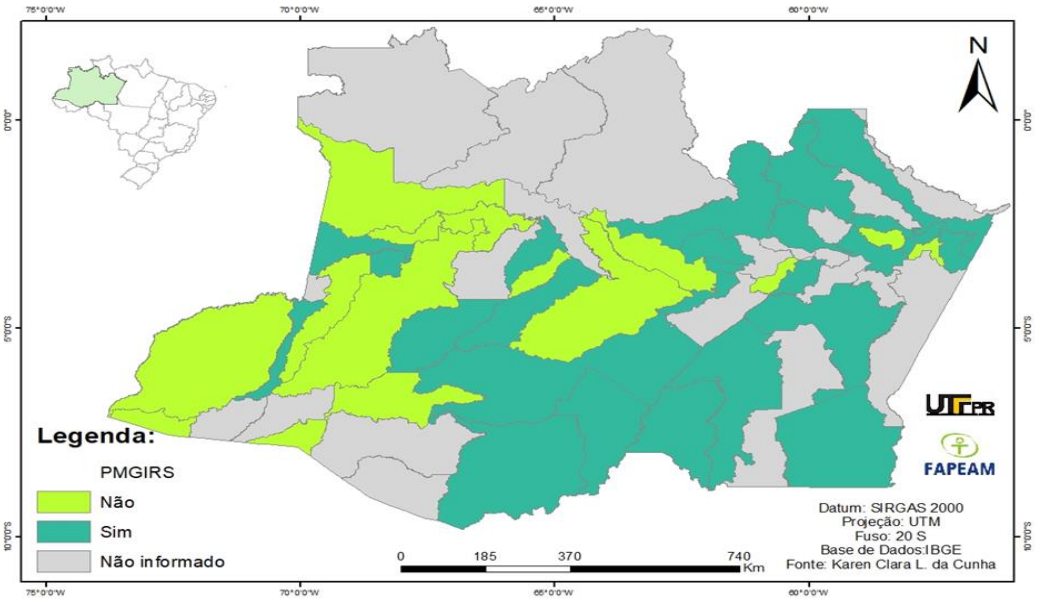
To analyze the effectiveness of the elaboration of municipal plans in the study area, the survey questionnaires and the SINIR-2019 database were used as a basis, with which it was possible to evaluate the entire territory of the studied region.

With the survey carried out, it was possible to verify that 61% of the municipalities of Amazonas prepared the PMGIRS established as a legal document, while about 39% did not comply with the basic requirement of Brazilian legislation, thus failing to receive resources from the Union, a fact that made it even more expensive. actions in solid waste management and urban cleaning services in the state.

To view the information mentioned above, on the map in Figure 4, it is possible to observe the sub-regions that obtained the highest rates of plan elaboration. In this it is noted that the vast majority of municipalities that prepared the plans are located in the sub-regions of Madeira, Purus, Middle Amazon, Lower Amazon and Rio Negro and Solimões, municipalities that have as particular characteristics the highest population density, in addition to having land access to other states and the capital Manaus via the BR-319, as in the cases of Humaitá, Lábrea, Manicoré and Apuí.

In addition, in these sub-regions to greater rigor in inspection by environmental agencies, mainly due to constant complaints of illegal mining activities and logging activities in indigenous and permanent preservation areas (APP), which should influence the charge for service of environmental legislation.

Figure 4. Map of municipalities with and without PMGIRS.



Source: Own authorship (2022).

The sub-regions that had the lowest rates of elaboration were the Alto-Solimões, Triângulo and Alto Juruá, located in isolated areas of the Amazon Basin, with access only by river, and being small municipalities. Such peculiarities make actions related to basic sanitation difficult, mainly because they entail inferior technical infrastructure and limited financial resources.

It should be noted that the municipal plans were prepared by the municipalities themselves, highlighting the need for the administrative body to have qualified professionals for the correct preparation, execution and revision of the plans.

It is also noteworthy that the municipalities in Amazonas that have prepared plans present them in the revision phase, meeting the specificity of the PNRS, which establishes the periodicity of its revision within a maximum period of 10 years. For this, the Secretary of the State for the Environment of the State of Amazonas – SEMA is training managers and their technical staff to carry out the review of the PMGIRS.

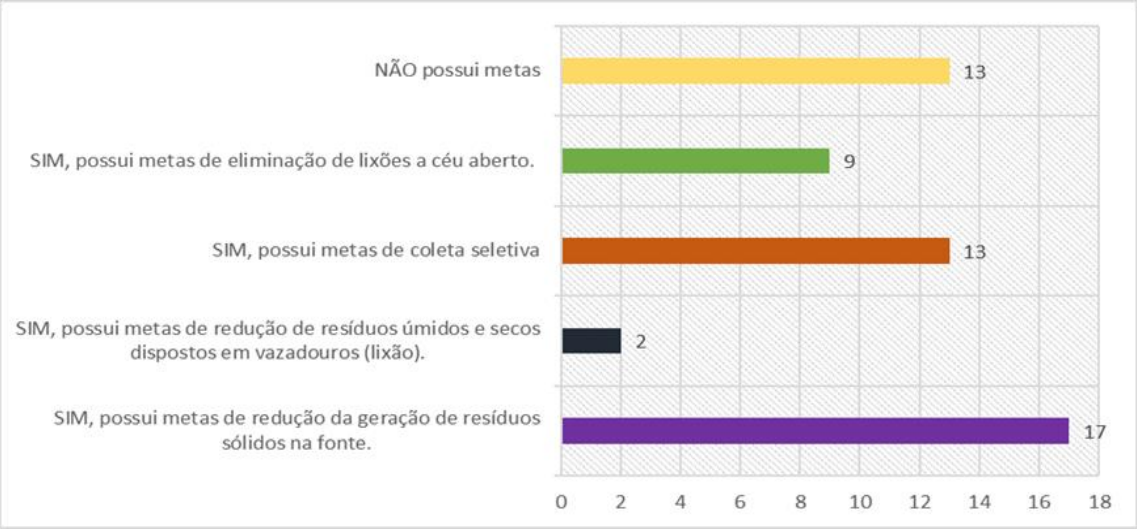
The results presented show the need for greater engagement and interest from city halls so that the municipalities of Amazonas as a whole elaborate their plans, including isolated and small municipalities that have greater difficulties, where the great challenge in the elaboration of the PMGIRS is in the planning of a set of measures that require knowledge of the municipal and regional reality, in addition to the search for joint action by the public and private sectors, with the development of models for the provision of services that enable its implementation (BRASIL, 2022).

3.3 PREDICTION OF PROVIDED GOALS IN PMGIRS

The PNRS, in its article 19, establishes the minimum content for the PMGIRS, in which are foreseen, in item XIV, the goals of reduction, reuse, selective collection, recycling, elimination and recovery of the areas of the old dumps, in addition to programs, projects and actions to meet medium and long-term goals.

The targets are an integral part of the PMGIRS, as it is through these purposes that programs and actions are defined so that municipalities can adapt to issues related to solid waste management. According to data obtained from municipal managers, thirteen (13) municipalities stated that they did not have any type of goal, nine (9) have goals for the elimination of open dumps, thirteen (13) aim at selective collection, two (2) have goals to reduce wet and dry waste disposed of in dumps and seventeen (17) have goals to reduce the generation of solid waste at source, as shown in Graph 2.

Graph 2. Targets provided for in the PMGIRS.



Source: Own authorship (2022).

A low percentage of goals established in the plans can be observed and, in addition to the difficulty of managers in answering the questions, divergences in their statements are also noted. According to data from the Environmental Protection Institute of Amazonas – IPAAM, only Parintins, Uarini, Tefé and Manaus have effective actions in line with the goals established in their plans.

It is also noteworthy the non-compliance with the goals established in the State Plan for Solid Waste of Amazonas (PERS-AM) published in 2017 as:

Eradication and recovery of areas of inadequate open-air MSW disposal; Environmentally adequate final disposal of waste in landfills;

- Society's universalized access to regular urban cleaning services; - Eradication of irregular areas of final disposal of RCC, by 2035;
- Eradication of inappropriate allocation of RSI, by 2035; Waste from RST sent to an environmentally appropriate destination;
- Environmentally adequate final destination of RSS, by 2035;
- Environmentally adequate final disposal of MSW;
- Environmentally adequate final disposal of RSA;
- Programs for the inclusion of users of GRSU services in municipalities;
- Project to strengthen state management of solid waste, through proactive policies and support for reverse logistics and Support for instruments for charging urban cleaning services and financial sustainability of MSW management in municipalities.

Regarding selective collection, its availability was found in only five municipalities (Manaus, Uarini, Parintins, Tefé and Tapauá), as well as the 12% coverage rate of voluntary selective collection in relation to the urban population of the municipalities. When analyzing the veracity of the data obtained, Tapauá showed inconsistency, since no information was found to prove the existence of this type of service in the municipality.

The capital Manaus includes voluntary and scheduled selective collection services, the latter available only in some neighborhoods of the city, for large recyclable materials. Also according to the Municipal Public Cleaning Secretariat (SEMULPS), in 2021 selective collection was responsible for collecting 12,320 tons of recyclable materials, serving an estimated population of 397,844 inhabitants, in 13 neighborhoods of the city, which represents a coverage rate of 18 .3% in relation to the Manaus population.

In the municipalities of Uarini and Tefé, selective collection is carried out on a voluntary basis and destined to collectors' organizations. In each locality there is only one cooperative of collectors of recyclable materials and the public administration was also unable to inform the amount of waste collected. Following the same logistics as Parintins, the materials are sent to the state capital.

According to PERS-AM (2017), the biggest problems encountered in relation to selective collection and throughout the solid waste management process that directly affect collection capacity, still stem from management deficiencies and are basically

associated with the following facts: management information is scarce and unstructured; operating rules are not well defined or disclosed to users; responsibilities are not clearly assigned; objectives and targets are not fixed; the costing of operations is not ensured by charging for services; operational resources are not scaled to meet targets; the human resources involved in operations do not receive proper training for the activity and the environmental liabilities arising from this activity are increasing over time.

Data regarding selective collection in Amazonas become even more worrying since investments were made in the area, in 2013 and 2014 the municipalities in the interior received 41 trucks of 12.5 m3, by federal parliamentary amendment. It is known that the donation of trucks, by itself, does not solve the problems of urban cleaning and selective collection of the municipalities, however, this action denotes a governmental and parliamentary concern with the theme and an operational opportunity for the contemplated municipalities (AMAZONAS, 2017).

According to data from SNIS-RS 2019 (base year 2017), in Amazonas, only 4 municipalities claimed to have waste picker organizations, with a total of 5 organizations and about 309 associated pickers in 2017.

According to the information observed, there are few organizations of collectors in Amazonas, the vast majority of which are concentrated in the city of Manaus, compared to the year 2017, organizations of collectors increased from 5 to 20 organizations of collectors in 2022 registered in the database of SEMULSP. Cooperatives in the interior are divided into three, located in Tefé, Parintins and Uarini.

Municipalities that have partnerships with collectors' entities contribute with financial support, providing a physical structure provided by city halls, concession and donation of equipment, technical support for raising financial resources and training of collectors.

According to the results presented, it is recommended that the public power encourage the creation and development of recyclable material cooperatives in the State of Amazonas, mainly in inland municipalities, in addition to strengthening existing associations, given the importance of the services provided by collectors who collect and sort all municipal waste sent for recycling, allowing a greater amount of waste to be reused and reintegrated into the industry's production chain.

In addition, it is necessary to monitor and verify the results achieved so that modifications and corrections can be applied, since non-compliance with established

goals can lead to problems at the government level, such as the transfer of financial resources.

3.4 EXISTENCE OF ENVIRONMENTAL EDUCATION ACTIONS AND PROGRAMS

Environmental education is one of the instruments provided for in the PNRS, Law 12.305/2010, art. 8th item VIII. EA programs and actions are the main means of raising awareness and internalizing good solid waste management practices among citizens, who are primarily responsible for the success and continuity of the programs developed.

The data obtained point to the existence of EE actions in 68% of the municipalities studied and the other 38% stated that they did not carry out any type of action aimed at raising the awareness of the population for the preservation of the environment. Also according to managers, environmental education programs only take place in schools and universities, often only on commemorative dates involving the environment, not addressing the specific topic of solid waste.

A low percentage of environmental awareness programs and actions is noted. Thus, it is recommended that municipalities develop a strong system of environmental education aimed specifically at solid waste, aimed at raising the awareness of civil society, such as public and private institutions and the business sector. Awareness should be made throughout the year, not just on Environment Day. According to Yadav et al. (2022), the United Nations and several countries are taking active measures in this regard to develop society's collaboration, such as awareness campaigns and community development programs.

3.5 SITUATION OF THE FINAL DISPOSAL OF MSW IN THE MUNICIPALITIES OF AMAZONENSES

The final disposal of solid waste is one of the serious problems found in all Brazilian municipalities, as incorrect allocation causes negative environmental impacts on the environment, on professionals who work with recyclable materials and on public health.

None of the 62 municipalities in Amazonas adhered to the National Solid Waste Policy (PNRS) regarding the elimination of open-air dumps and the environmentally appropriate disposal of urban solid waste, prevailing the usual form of disposal in dumps

(84%), followed by disposal in a controlled landfill (16%), there is no sanitary landfill in the Amazon territory that constitutes the appropriate form for the disposal of waste.

The two forms of final disposal used in Amazonas are characterized as inadequate, due to the disposal of waste directly on the ground or in ditches without prior preparation required by the competent environmental agencies and in disagreement with ABNT technical standards, in which there is an indication of the need to implementation of gas and leachate drainage systems, which are the main contamination agents from MSW. In addition, many of these sites are in permanent preservation areas (APP), watercourses, empty areas and urban areas, as shown in Figure 5.

Figure 5. MSW final disposal areas (A and B final disposal in the municipality of Tonantins -AM) (C and D final disposal in the municipality of Humaitá-AM).

Source: Own authorship (2022).

The municipalities that claimed to have controlled landfills were the city of Manaus and the municipalities of Parintins, Humaitá, Anamã and Carreiro Castanho, and many of them face problems due to the incorrect disposal of MSW. Humaitá and Parintins have their airports closed or partially functioning due to the proximity of the landfill, which leads to the presence of birds in areas close to the airfield (SEDEMA, 2022).

According to the PNRS, the collection, disposal and treatment of solid waste are the exclusive obligations of municipal governments. Therefore, the questionnaire asked

managers about the rate of households served by MSW collection services and about 90% of municipalities provide these services in up to 70% of households. The other 10% serve less than 40% of households. This rate can be explained by the fact that the rural zone is not served by these services, as it is flooded for more than half of the year, preventing the trucks used in collection from reaching these areas.

Some municipalities have difficulties that go beyond financial and logistical issues, with problems related to regional characteristics being found. According to the National Confederation of Municipalities (CNM, 2019), the areas occupied by dumps in the municipalities of Barreirinha, Carreiro da Várzea, Manaquiri, Nhamundá and Benjamin Constant are subject to flooding during the flood period in the state, causing the waste there to be intended are spread, reaching the water bodies of the municipalities.

In addition to the final disposition, the steps that precede this service also face serious problems. Irregular disposal points are commonly found on the sidewalks, in addition to vacant lots that are used for the storage of solid waste, which tend to remain on these lands for long periods, causing the proliferation of disease vectors.

These problems can be seen in Figure 6, where it is possible to verify the scenario that can commonly be found in the vast majority of Amazonian municipalities, such as dumpsters overflowing with waste on the sidewalks, with the presence of animals and disease vectors, in addition to excess waste, making pedestrian traffic difficult, and may even cause serious accidents.

Figure 6. Irregular solid waste disposal point in urban areas in the municipalities of Amazonas (A and B located in the city of Manaus-AM), (C municipality of Humaitá-AM, (D municipality of Tonantins -AM).

Source: Own authorship (2022).

Another landscape that unfortunately can be seen in the study area is that of thousands of waste being disposed of in water bodies located in the urban perimeter of the municipalities. Only in the water bodies of the city of Manaus, which have springs in the largest surface fresh water reserve on the planet, about 8 thousand tons are collected annually (SEMULPS, 2022), as shown in Figure 7.

Figure 7. Solid waste discarded in Manaus streams (A, B, C and D).

Source: Own authorship (2022)

According to the Amazonas State Secretariat for the Environment (SEMA AM, 2019), it is common in the Amazonian municipalities to have two open-air dumps, one for the final disposal of urban solid waste and the other for bulky waste from pruning, weeding and construction waste, a fact observed by Cunha et al. (2022). In the municipality of Tonantins, located in the interior of Amazonas, in the sub-region of Alto Solimões, the collected waste is destined for two dumps that are located in the urban perimeter of the municipality.

As noted, pruning and weeding waste has the same destination as MSW and the vast majority of municipalities do not reuse this type of waste (65%), while another portion reuses it through composting (29%) and the rest forwards for lining (6%), a worrying fact, since this waste is generated in large volumes, causing a decrease in the useful life of these places.

In view of the above, there is an unfavorable scenario for the final disposal of urban solid waste in the state of Amazonas, requiring urgent actions so that the

applications provided for in the environmental legislation are met, especially in small municipalities in the interior of the state, which require actions specific and appropriate to the local reality.

Taking into account the new legal framework for sanitation, Law No. 14,026/2020, for the environmentally appropriate final disposal of MSW, Amazonian municipalities with less than 50,000 inhabitants have 2024 as a deadline to dispose of their waste in an environmentally appropriate manner, with the exception from the capital Manaus, which, as it is the state capital and has more than 2 million inhabitants, must comply with federal law.

4 CONCLUSIONS

When evaluating solid waste management in the municipalities of Amazonas, it was found that all municipalities only have basic solid waste management services, which in many cases occur in an inefficient way. There are many shortages detected, highlighting the persistence of disposal in landfills, lack of resources, lack of qualified technical professionals, in addition to the difficulties that exist in the region, such as being difficult to access municipalities and constantly suffering from flooding of rivers.

Another deficiency that can be highlighted is the lack of elaboration of the Municipal Plan for Integrated Solid Waste Management (PMGIRS). The Amazonian municipalities that have not prepared their respective plans are small municipalities located in extreme areas of the Amazon region, which makes it difficult to carry out actions related to solid waste management.

It is notorious that solid waste management is not treated as a priority in the Amazonian municipalities, given the total lack of preparation of municipal managers, who are the technically responsible agents in charge of creating programs aimed at environmental responsibility and the inspection of potentially polluting activities, evidencing the need for technical training of local administration.

It is concluded that the management of solid waste constitutes one of the greatest challenges of basic sanitation in the State of Amazonas and that it needs to be prioritized urgently due to the risk of degradation of the region's natural resources and the public health of the population.

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