



(REVIEW ARTICLE)



## Theoretical analysis of the selective collection process in the city of Manaus

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World Journal of Advanced Research and Reviews, 2023, 19(02), 414–422

Publication history: Received on 26 June 2023; revised on 05 August 2023; accepted on 07 August 2023

Article DOI: <https://doi.org/10.30574/wjarr.2023.19.2.1581>

### Abstract

This article presents a theoretical analysis of the selective waste collection process in the city of Manaus. The methodology adopted follows a qualitative approach, employing investigative resources derived from bibliographical and documentary research. The overall objective of this study is to comprehend, verify, and describe the operational aspects of the selective waste collection process in Manaus. By examining existing literature and relevant documents, the study aims to gain insights into the functioning and effectiveness of the city's waste collection system. The analysis will contribute to the understanding of key factors that influence the success of selective collection initiatives, providing valuable information for future urban waste management strategies. The findings may pave the way for sustainable waste management practices in Manaus and serve as a reference for other cities facing similar challenges.

**Keywords:** Selective collection; Waste management; Manaus; Qualitative analysis

### 1 Introduction

Urban waste, as produced by the city of Manaus, due to its inexhaustible nature, becomes a serious problem for the government agencies responsible for public cleanliness and the service-providing companies in the field of household and selective waste collection.

Daily, large volumes of waste of all kinds are discarded in the urban environment, leading to the need for the implementation of a system that provides an appropriate and safe final destination. In this process, it is essential for the variable of selective waste collection to be contextualized, considering its enormous economic potential, both for its importance in preserving resources, the environment, and the social inclusion of a large portion of the population engaged in this aspect of sustainable development.

The scarcity of technical, financial, and qualified human resources has limited the efforts to organize and definitively implement selective waste collection and waste disposal as a whole in the city of Manaus, resulting in their improper disposal. This situation in itself causes pollution in the environment and, in turn, reduces the quality of life in our city.

The production of urban waste as a whole results from the daily activity of humans in society, and the factors governing its origin and production are the increase in population and the intensity of industrialization. The automatic expansion of these two vectors requires an immediate response from the government to provide means and resources aimed at collecting the waste generated by the mentioned segments and giving them the treatment required by current legislation.

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The methodology employed for the development of this article is characterized by a qualitative approach, using investigative resources developed from bibliographical and documentary research. These research activities were conducted through consultations in sources related to the studied theme, such as books, newspapers, magazines, official documents, and other relevant sources.

The general objective of this study is to understand, verify, and describe the operative aspects of the process of selective waste collection in the city of Manaus, focusing on details of the operational system, advances in benefits, applicable municipal legislation, and the challenges of modernizing selective waste collection and its interface with sustainable development.

These are the specific objectives of this study: To analyze the legal framework and regulations governing the disposal of solid waste in the city of Manaus, aiming to understand the compliance requirements and implications for waste management practices; To categorize and characterize the different types of solid waste generated in the city of Manaus, providing an in-depth understanding of the composition and potential environmental impacts; To examine the step-by-step process of selective waste collection in Manaus, identifying key stages, stakeholders involved, and challenges faced to assess the efficiency and effectiveness of the current system; To trace the historical development of selective waste collection initiatives in the city of Manaus, investigating the key milestones, policies, and strategies that have influenced the evolution of the system; To assess the social, economic, and environmental benefits resulting from the implementation of selective waste collection in Manaus, highlighting its positive contributions to sustainable waste management and community engagement.

This article is structured into four sections. The first section is the introduction, where the research objectives are explained. The second section is reserved for the methodology. The third section is the theoretical framework, which promotes discussions related to the researched theme, and the fourth and final section presents the concluding remarks.

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## 2 Material and methods

The methodology employed for the development of this article is characterized by a qualitative approach, using investigative resources developed from bibliographical and documentary research. These research activities were conducted through consultations in sources related to the studied theme, such as books, newspapers, magazines, official documents, and other relevant sources.

Regarding the qualitative approach, Sousa and Santos (2020, p. 02) state:

In the academic field, the qualitative study of a social phenomenon has accompanied research in various areas, along with the debate on the path to be taken, the steps to be followed, which techniques and instruments to use in knowledge production. The fact is that in the process of constructing and reconstructing a given reality, the objective question allows for the definition of the method [1].

Soares, Picoli, and Casagrande (2018, p. 10) argue that bibliographical research:

Seeks to know, analyze, and explain contributions on a specific subject, theme, or problem. Bibliographical research is an excellent means of scientific training when carried out independently - theoretical analysis - or as an indispensable part of any scientific work, aiming to construct the theoretical platform of the study [2].

The documentary research was conducted with the purpose of describing the investigated social phenomenon through documents related to the researched theme. Prodanov e Freitas (2013) states that research of this nature is carried out based on contemporary or retrospective documents considered scientifically authentic [3].

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## 3 Literature Review

### 3.1 Legalization of Solid Waste Disposal

When conducting any study on selective and household waste collection, the researcher will not find a lack of legal instruments to provide sustainability to the public sector, fulfilling its mission to society. The public sector, economy, and community have the responsibility for the effectiveness of measures to ensure compliance with the National Waste Policy. According to the Federal Constitution, the municipality is responsible for ensuring that the city is clean and that waste is collected and disposed of properly. With the National Waste Policy Law, the task of municipalities gains a more

solid foundation with principles and guidelines within a set of responsibilities that have the potential to transform the waste landscape in Brazil [4].

Law No. 9.605 of Environmental Crimes, enacted in February 1998, provides for penal and administrative sanctions for conducts and activities harmful to the environment, and other provisions. Its article 54, paragraph 2, item V, states: "The penalty for the discharge of solid, liquid, or gaseous waste in violation of the requirements established by law or regulation." In paragraph 3 of the same article, the law penalizes those who fail to adopt precautionary measures in case of the risk of serious or irreparable damage to the environment, when required by the competent authority [5].

The Municipal Law of Manaus, promulgated on April 5, 1990, reaffirms the competence reserved to the Municipality to organize and provide, directly or indirectly through delegation or concession, the following services, among others: "(1) water supply and sanitation; and (2) public cleaning, collection, treatment, and final disposal of waste (article 8, item VII, subparagraphs "b" and "f"). It is also the responsibility of the municipality to set the rates of public services" [6].

According to the Environmental Code of Manaus, Law 605 of July 24, 2001:

Article 81, item VI, the objective of the environmental policy is to adopt all necessary measures to ensure compliance with the environmental guidelines established in the City Master Plan, a basic instrument of the policy for full development of social functions, urban expansion, and guaranteeing the well-being of society.

Article 21, item XIV, it is the responsibility of SEMMA to establish environmental guidelines for the development of urban land parceling projects, as well as for the installation of activities and enterprises in the scope of waste collection and disposal.

Article 8, item II, awards and incentives will be granted to individuals and communities that participate in selective waste collection programs or cleaning of rivers, lakes, and streams.

Article 102, the municipality must implement an adequate system for the collection, treatment, and disposal of urban solid waste, except industrial waste, encouraging selective collection, segregation, recycling, composting, and other techniques that promote the reduction of the total volume of solid waste generated.

Article 103, the disposal of any waste in the soil, whether liquid, gaseous, or solid, will only be allowed with proof of its degradability and the soil's capacity for self-purification, taking into account the following aspects: I Percolation capacity; II Guarantee of non-contamination of underground aquifers; III Limitations and control of the affected area; IV Reversibility of negative effects.

The Code also applies several penalties to those who do not comply, as highlighted below:

Article 163, items VI and VII, it is considered a mild offense to discharge unauthorized debris and deposit inert waste improperly or in a non-permitted location. Article 137, item II, depositing drainage gallery cleaning waste in a non-permitted location is considered a serious offense. Article 138, item XXV, depositing any liquid, gaseous, or solid waste on the soil without proof of its degradability and self-purification capacity is considered a very serious offense. Article 141 stipulates parameters for inspection, processes, resources, and penalties.

These instruments, without mentioning others at the state and federal levels, alert us and demonstrate that the legal support to make comprehensive selective and household waste collection a reality exists.

## **3.2 Types of Solid Waste**

Beyond the imperative need for us to acquire knowledge regarding the three fundamental classes, it becomes unavoidable to master the typologies inherent to these materials, aiming for an enriching complement and an enhanced understanding of the subject matter.

### *3.2.1 Special Waste Type*

This type of waste, being composed of toxic and hazardous substances, requires more specialized treatment. Improper handling will result in significant environmental damage. Included in this category are batteries, cells, fluorescent and mercury vapor lamps, oils, expired purchased medications, tires, solvents, paints, varnishes, and household appliances with components made of toxic substances.

They mainly originate from residential, industrial, and construction waste in larger volumes. Special waste poses certain challenges in its proper identification, given the difficulties in perceiving it when mixed with large volumes of other waste. Inadequate treatment of this waste type, combined with amateur handling, will undoubtedly have adverse impacts on environmental sustainability due to its hazardous characteristics.

### 3.2.2 Industrial Type

These are objects or substances that have been obtained through the industrial production process, transformation, utilization, consumption, or cleaning, and have been discarded by the user.

According to Alves and Medeiros (2021, p. 09),

Understanding the main types of waste within a specific sector, particularly in the industrial sector, becomes evident when striving to provide proper disposal methods that encompass the highest number of enterprises possible. Notably, the recyclable/compostable waste (plastic, paper, glass, metal, organic) represents the predominant percentage in this category [7].

Excluded from this typology are waste derived from mining, radioactive waste, hospital and clinical domestic waste, non-industrial waste from agricultural or livestock activities, gaseous effluents, and residential wastewater. It is common to observe the improper disposal of industrial waste in open areas and water bodies, leading to severe problems for agencies responsible for selective and household waste collection, as well as for the control of liquid effluent discharges.

### 3.2.3 Hospital waste type

This waste originates from hospitals, clinics, health centers, or establishments identified as emergency care facilities. According to Chimaqui, Elavaco, & Domingos (2022, p. 01),

Hospital waste comprises the residues resulting from interactions between patients and healthcare professionals, both within the hospital premises and beyond. It poses a serious problem for the population, as incorrect disposal can lead to irreversible impacts on people in terms of diseases [8].

Due to the significant risks associated with the disposal of this type of waste, it is imperative that it is eliminated through an incineration system, specifically a hospital waste combustion-type incinerator equipped with a thermal motor or post-combustion chamber for the generated gases. Waste generated from healthcare services is classified into three classes, as shown in the table below.

**Table 1** Classes and Hospital Waste

<b>Class A INFECTIOUS</b>
A.1 Biological waste; A.2 Hematological and derivative waste; A.3 Surgical waste; A.4 Sharps waste; A.5 Contaminated animal waste.
<b>Class B SPECIAL</b>
B.1 Radioactive waste; B.2 Pharmaceutical waste; B.3 Hazardous chemical waste.
<b>Class C COMMON</b>
C.1 General waste.

Source: [9]

Those involved in the treatment and collection of these wastes, particularly in the context of selective collection, must necessarily be acquainted with the characteristics of hospital waste and the techniques for handling them, considering the inherent health risks.

### 3.3 Radioactive Type

These are waste materials derived from the development of nuclear activities for both peaceful and military purposes. Currently, the utilization of such materials is common in nuclear power plants, employing plutonium and enriched uranium; in specialized hospitals and clinics utilizing nuclear technology, where cesium and cobalt are present.

The Technical Standards of the National Nuclear Energy Commission (CNEN) regulate the entire cycle of radioactive materials, including their fabrication, use, transportation, and final disposal, which is strictly controlled to prevent potential accidents. An example of the importance of strict disposal regulations is the incident that occurred in Goiânia, where non-compliance with appropriate cesium-147 disposal measures was observed.

#### 3.3.1 Rural Waste Type

The residues generated in rural environments have significantly increased due to the expansion of agribusiness. At the core of this agricultural growth are agrochemicals, which, besides having negative impacts on the environment, also compromise the health of rural workers. These types of residues can be divided into two groups: Agricultural Group: This group comprises organic residues, similar to urban waste, as well as agrochemicals and fertilizers. The typology is specified in Table 2 below.

**Table 2** Organic and Inorganic Residues

Organic	Solids	Excess
	Semi-Solids	Poultry excrements
	Liquid	Liquid manure, untreated urine, and effluents
Inorganic	Predominantly toxic, poisonous, and hazardous substances	

Source: [9].

Livestock Group: The management of Brazilian livestock has experienced significant growth in the last decade, playing a crucial role in the production of meats, milk, and their derivatives. As a result of this advancement, there has been a considerable increase in the use of agrochemicals, fertilizers, and veterinary medicines for soil and pasture management, as well as the disposal of packaging from these products. Furthermore, the industrialization of the sector has led to the generation of large volumes of waste. Currently, there is a noticeable and concerning rise in work-related disease reports attributed to unskilled labor and a lack of adequate training.

### 3.4 Process of Selective Waste Collection in the City of Manaus

The process of selective waste collection in Manaus is centered around projects and actions aimed at increasing the involvement of communities, public agencies, schools, waste pickers' associations, and recycling companies included in the municipal selective collection program.

Silvestrim et al. (2022, p. 03) report that: "Currently, there are 20 waste pickers' entities in the city of Manaus working with plastic waste recycling. Unfortunately, this number of entities is too low to substantially reduce the amount of plastic waste in the city's landfill" [10].

In this process, waste is collected and delivered to waste pickers for proper separation. Once the sorting phase of marketable materials is completed, the remaining waste, which is of no interest to the waste pickers and recycling companies, is transported to the landfill by the Municipality.

The selective waste collection process does not have fixed collection points in all neighborhoods of the city. The process has evolved, and two types of waste collection have been implemented: "point-to-point" and "door-to-door." In the former, users deliver recyclable waste to collectors provided by the Municipality at some marketplaces, schools, and public institutions, while in the latter, trucks collect the same types of waste from residential complexes, condominiums, schools, and public offices.

All recyclable materials collected through the selective process are directed to four groups of waste pickers operating and residing in the vicinity of the municipal landfill. It is observed that the responsibility for the selective waste collection process lies directly with the municipal authorities. However, community involvement in addressing relevant issues related to waste management has been more significant given the magnitude of the problem. It is hoped that the relationship between the Municipality and the Manaus society will continue to evolve and strengthen, fostering the development and enhancement of selective waste collection as a whole, advancing further by embracing new ideas and devising more effective alternatives for a problem that should have been solved long ago.

It is worth noting that, especially in the city of Manaus, waste pickers also play a crucial role in keeping the city clean, having collected 7.2 million tons of urban solid waste monthly between 2013 and 2020, growing at an annual rate of 1%. This ensures the collection of a total of 8,938 tons of waste. This amount corresponds to a per capita production of solid waste of approximately 1.3 kg, with only 2.2% of generated waste being recycled [11].

### 3.5 Development of Selective Waste Collection

Municipal selective waste collection has evolved primarily due to the human contingent that engages in this activity as their livelihood and the sole source of income for themselves and their families. These agents of selective waste collection growth initially emerged in the outskirts of the municipal landfill, where they lived in precarious conditions under canvas tents. Over time, it became evident to the managers, society, and the waste pickers themselves that a change in the status quo was necessary, as well as the relocation of this group to a less hazardous area, along the AM-010 highway.

In a subsequent phase, efforts from residents near the municipal landfill, the Catholic Church, social assistance organizations, and the Municipality, through the administration of the landfill (SEMULSP and SEMMA), joined forces to improve the deplorable living conditions of the waste pickers who inhabited the highway margins. Various activities were developed to promote social inclusion, environmental education, entrepreneurship, associativism, and interpersonal relationships. After more than a year, no waste pickers remained in the area; they began operating a small sorting center for the materials collected through the selective waste collection program operated by the Municipality.

It is important to acknowledge the continuous efforts of the Municipality of Manaus to find beneficial solutions for the waste pickers. Another group of waste pickers operated in the city center and outskirts, supported by *Cáritas* Diocesana and some aluminum purchasing companies for cans, papers, cardboard, and recyclable plastics, which stimulated their growth. Later, they founded three associations to consolidate their efforts collectively and avoid fragmentation.

In 2019, a study by Kieling et al. (2019) identified a potential of 13,495,000 kg of solid plastic waste in the city of Manaus. However, considering that in the same year, waste pickers sold only 91,080 kg of plastic waste, there remains a difference of 13,403,920 kg of idle plastic material that is being discarded without the possibility of recycling. This represents an economic value of R\$ 30,694,976.80 that is not being reinvested into the community [12].

Unfortunately, this waste issue is prevalent throughout Brazil, where only 2.2% of urban solid waste undergoes sorting in recycling plants, a significantly lower figure than in industrialized countries. For instance, in Germany, in 2014, 67.3% of waste was recycled through composting and recycling of other solid waste components. Another waste management approach used in Europe is the production of energy from solid waste, with 492 waste-to-energy plants in operation in 2017. In contrast, there were no such plants in Brazil [13].

The lack of employment opportunities combined with low levels of education, except for the growing interest in environmental knowledge and selective waste collection among university students, as well as the expanding population and consumption rates, have contributed to our city's heightened sensitivity to this problem. According to SEMULSP (2021), collection points currently gather between twenty to forty tons of materials per month, with paper being the main product, accounting for approximately 40% of the total collected. The development of selective waste collection is currently in a significant growth phase [14].

However, if the five key stakeholders - public administration, population, recycling companies, industries, and academic institutions - unite their efforts to work together towards development and strengthening of the system, undoubtedly, the city of Manaus will occupy a prominent position among the capital cities of our country that have implemented selective waste collection and recycling with universal standards of excellence.

### 3.6 Main Benefits of Selective Collection

#### 3.6.1 Social Benefit

Socially, this benefit shines in the integration of the population in the management of selective and household waste collection through three forms: participating as contributors to the services and their supervision; collaborating in cleanliness by reducing, reusing, recycling, or properly disposing of waste for collection, with the practice of selectivity; reinforcing educational practices for the younger generation to have an adequate understanding of social responsibility and sustainable development.

The collaboration of the population associated with active participation should be considered the main agent that transforms the efficiency of these services into operational effectiveness, budgetary benefits, and social advantages.

This type of selective collection introduces a new management model for recyclable waste within the scope of the Federal Public Administration, promoting proper environmental treatment of waste through correct separation, destination, sorting, and recycling of these materials. It also serves as a tool for social participation in selective collection, sensitizing and encouraging community involvement in the socio-environmental management of generated waste, while strengthening the principle of social inclusion by advocating for the allocation of waste to associations and cooperatives of recyclable material collectors [15].

The population can be encouraged to reduce the amount of waste produced by opting for ecologically friendly products with fully recyclable packaging, making waste collection economically and socially viable. Thus, these actions will elevate the collection system to a high level of excellence, with the contributing population becoming a powerful combination capable of solving the main problems associated with the collection system. These proactive initiatives that positively impact service development and quality should be intertwined with others that generate benefits, primarily aiming at the social inclusion of the less privileged layer involved in selective collection, the waste pickers.

#### 3.6.2 Environmental Benefit

According to the Solid Waste Management Manual (2001), this vector serves as a portrayal of the environmental benefit and the scope of action. It is worth considering that more than 70% of Brazilian municipalities have less than 20,000 inhabitants, and over 80% of the country's population resides in urban areas. This reinforces concerns about environmental issues, including the management of solid waste, which is the responsibility of the municipal sphere [16].

There is a clear trend in environmental legislation towards making companies increasingly responsible for the entire lifecycle of their products. This entails legal responsibility for their fate after delivery to customers, the environmental impact they may have, and guidelines for customers regarding the waste generated at the end of their use.

Another beneficial aspect concerns the increased ecological awareness of consumers participating in selective collection and recycling programs, expecting companies to reduce their negative impacts on the environment. This has led some companies to communicate a positive, institutional, and environmentally friendly image to the public.

As stated by Fialho et al. (2023, p. 05), "Development can be considered in terms of urban extension, economic growth, and an entire structure that involves the well-being of the population, i.e., the quality of life, not just per capita income [17]."

The greatest environmental benefit that public managers and city dwellers can offer regarding solid waste, including selective collection, is to be mindful of future generations. This entails popularizing selective collection, exhaustively researching processes for producing reusable items derived from careful selection, and avoiding the disorderly disposal of waste that could pollute soil and water resources without adhering to relevant legislation.

The extensive coverage of door-to-door and point-to-point selective collection in the city of Manaus, coupled with the quantities of recycled items, results in benefits from safe disposal locations, without jeopardizing environmental sustainability and the quality of life in this important Brazilian capital.

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## 4 Conclusion

In this study, titled "Theoretical Analysis of the Selective Collection Process in the City of Manaus," we conducted a comprehensive investigation into the selective waste collection practices in the city. The methodology employed a qualitative approach, utilizing bibliographical and documentary research as investigative resources to achieve our

overall objective of understanding, verifying, and describing the operational aspects of the solid waste selective collection process in Manaus.

The specific objectives allowed us to delve into various key aspects of waste management in the city. Firstly, the analysis of the legal framework and regulations governing solid waste disposal provided valuable insights into compliance requirements and their implications for waste management practices. Secondly, categorizing and characterizing different types of solid waste offered a detailed understanding of their composition and potential environmental impacts.

Furthermore, examining the step-by-step process of selective waste collection helped identify key stages, stakeholders, and challenges faced, allowing us to assess the efficiency and effectiveness of the current system. Additionally, tracing the historical development of selective waste collection initiatives shed light on the pivotal milestones, policies, and strategies influencing the evolution of the system.

Lastly, the assessment of social, economic, and environmental benefits resulting from the implementation of selective waste collection highlighted its positive contributions to sustainable waste management and community engagement in Manaus.

Our findings underscore the significance of a well-structured and legally compliant selective collection process to achieve sustainable waste management goals in urban settings like Manaus. Furthermore, the insights gained from this study can serve as a reference for other cities facing similar challenges, guiding them towards effective waste management strategies and fostering positive environmental and social impacts.

As the city of Manaus continues to grow, it is crucial to emphasize the importance of informed decision-making based on research and analysis to optimize waste management practices and ensure a cleaner, healthier, and more sustainable urban environment for both current and future generations. We hope that our theoretical analysis contributes to the ongoing efforts in promoting responsible waste management practices and strengthening community involvement in the city of Manaus and beyond.

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## Compliance with ethical standards

### *Acknowledgments*

The authors express their gratitude to the directors of the Postgraduate Program in Environmental Management at the State University of Amazonas, for their kind attention.

### *Disclosure of conflict of interest*

The authors assure that there is no conflict of interest with the publication of the manuscript or an institution or product mentioned in the manuscript and/or important for the result of the presented study.

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