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Difficulties in performing selective waste collection in the city of Manaus, Brazil

Dificuldades para a realização da coleta seletiva de resíduos na cidade de Manaus, Brasil

Dificultades para realizar la recogida selective de residuos en la ciudad de Manaus, Brasil

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Abstract
Scientific studies have increasingly shown that what is garbage is wasted resources, solid and of other natures. Much of this waste is generated inside urban and rural households, forcing citizens to rethink their commitment to reusing what many still consider garbage. This study aimed to explain the main difficulties in managing selective waste collection in Manaus, Brazil. It used the survey method to generate an in-depth explanation of how these difficulties occur, inverting the traditional logic of this method. Data were collected through an electronic questionnaire with open questions, organized and analyzed using semantic techniques, and the results were generated with the recommendations of the scientific-technological method. The conclusion presents six distinct and interconnected types of difficulties that prevent the effectiveness of selective waste collection in the city.
Keywords: Selective collection; Reverse logistic; Society participation; Waste collection; Solid waste.

Resumo
Estudos científicos cada vez mais têm mostrado que o que se chama lixo na verdade são recursos desperdiçados, tanto sólidos quanto de outras naturezas. Grande parte desses resíduos são gerados no interior dos domicílios urbanos e rurais, o que força os cidadãos a repensarem seu comprometimento com o reaproveitamento do que muitos ainda consideram como lixo. Este estudo teve como objetivo explicar quais são as principais dificuldades para a realização da coleta seletiva de resíduos na cidade de Manaus. Utilizou o método de levantamento, mas com a finalidade de gerar explicação aprofundada sobre como essas dificuldades acontecem, invertendo-se a lógica tradicional desse método. Os dados foram coletados através de um questionário eletrônico, com questões abertas, organizados e analisados com o uso de técnicas semânticas e os resultados foram gerados com as recomendações do método científico-tecnológico. A conclusão apresenta seis tipos distintos e interconectadas de dificuldades que impedem a efetividade da coleta seletiva de resíduos na cidade.
Palavras-chave: Coleta seletiva; Logística reversa; Participação da sociedade; Coleta de resíduos; Resíduos sólidos.

Resumen
Los estudios científicos han demostrado cada vez más que la basura atrae más la verdad que otros recursos, así como los sólidos de la naturaleza. Gran parte de estos desechos se generan dentro de los hogares urbanos y rurales, lo que obliga a los ciudadanos a comprometer el uso de lo que muchos todavía consideran basura. Este estudio tuvo como objetivo identificar las principales dificultades para explicar la recolección selectiva de residuos en la ciudad de Manaus. Se utilizó el método de encuesta, pero con la finalidad de generar el método tradicional sobre cómo se dan estas dificultades. Los datos electrónicos se calcularon utilizando técnicas semánticas abiertas, se organizaron y analizaron utilizando resultados técnicos generados con frecuencia como lo hacen. La presentación presenta tipos distintos e interconectados de dificultades que impiden la recolección selectiva de muestras en la ciudad.
Palabras clave: Recogida selectiva; Logística inversa; Participación de la sociedad; Colección de basura; Residuos sólidos.

1. Introduction

Every day organizations are convincing themselves that the planet's natural resources are not infinite. It has become increasingly challenging to all sectors of the economy and governments. As a result, albeit rudimentary, a new mentality of purchasing or consumption relationships is being built in almost the entire planet. The unbridled search for wanting to have, to

the detriment of what is necessary, still prevails. So much so that in practically all planetary urban areas, the excess of products thrown away, in conditions of use and reuse, has grown enormously. Scientific studies have increasingly shown that what is called garbage are wasted resource, solid and of other natures (Dhamayanthie; Bimantara; Asminah, 2021; Hendrarso, 2021; Okoro et al., 2020). We need to reverse the flow. Instead of a one-way street (from the withdrawal of resources from nature to waste in dumps), countless forms of reuse are being created and practiced.

In this scenario, reverse logistics is a process that adds value to companies, governments, and societies. It aims not only at market competitiveness but also at social and environmental responsibility. Reverse logistics is not just a concern of companies and governments. It is an issue that affects all individuals living and those who will exist in the future on planet Earth. The benefits that reverse logistics generates tend to contribute to delineating new processes, techniques, and the use of all types of materials, commonly called waste. Much of this waste is generated in urban and rural households.

In this sense, this study aimed to explain Manaus's main difficulties in managing the selective waste collection. For this, it used the survey method to generate an in-depth explanation of how these difficulties occur, inverting the traditional logic of this method. Data were collected through an electronic questionnaire with open questions, organized and analyzed using semantic techniques, and the results were generated with the recommendations of the scientific-technological method (Nascimento-e-Silva, 2012; 2020a; 2020b; 2021a; 2021b; 2021c). The conclusion presents six distinct and interconnected types of difficulties that prevent the effectiveness of selective waste collection in the city.

2. Reverse Logistics: Scope and Process

The literature review showed that reverse logistics could be defined as a process (Bayramov, 2021; Matusinec et al., 2022). Reverse logistics as a process is a sequence of activities that uses a set of movement tools aiming at the return or return of the product. These activities are redesigned to manage the flow of products or parts to use resources effectively. The study by Delipinar and Durdag (2021) shows that the activity, in the context of reverse logistics, increases the efficiency of returning these products sustainably. This activity is the action that makes the development of this process possible.

Another term found in the literature as equivalent to reverse logistics was the return (Bataghin, Melo & Borges, 2021). In this case, after-sales and post-consumer goods return to the business or production cycle, which constitutes one of the main characteristics of reverse logistics. Return was another term found to mean taking products and materials from the point of consumption to the beginning of the supply chain. For recycling, reuse, remanufacturing, repair, or safe disposal purposes, return is essential for materials to efficiently return to their proper disposal (Hidayat et al., 2022).

Like every phenomenon studied scientifically, reverse logistics has specific attributes that differentiate it from other logistics modalities. Attributes are fundamental characteristics of something because each thing that exists has an identity that distinguishes them from others. In this case, one of the attributes of reverse logistics found in the literature was dealing with a particular product (Bayramov, 2021; Delipinar & Durdag, 2021; Hidayat et al., 2022; Matušinec et al., 2022; Panya & Marendi, 2021). The product is directly linked to reverse logistics because its cycle is managed along the entire distribution chain until its collection and return, destination or reuse. It is considered that the materials originate from different post-consumer products so that the resulting material can be reintegrated into the production cycle of a product that will be different from the original product, configuring the process called an open cycle.

Another attribute of reverse logistics found was the cycle (Sanches et al., 2022; Bataghin et al., 2021.) A cycle is carried out over a set period, where various specific, practical, or initial activities are performed and repeated. The process is somehow related to the idea of repeated progression, continued restoration, to reuse of the material or its part. When applied to reverse logistics, this idea denotes the cyclothymia that can be expected in the continued reuse of many materials.

The third attribute found was "discard" in the studies by Koc and Okudan (2021) and Matušinec et al. (2022.). Discard is an action that implies the activity or impact of playing something that is no longer useful or can no longer be used. Discarding denotes an attitude of leaving out material that is currently not valuable or is currently not wanted. The fourth attribute was devolution, found in studies by Hidayat et al. (2022), Panya and Marendi (2021), and Lima et al. (2022.). It is a crucial feature of reverse logistics because it describes the need to relocate a product again for reuse. The flow was the other reverse logistics attribute found in the studies by Lima, Salum, and Cruz (2022), Matušinec et al. (2022), Delipinar and Durdağ (2021), and Bayramov (2021). The idea of flow is a sequence of essential processes to ensure that products and services reach consumers in an agile and efficient way and, after being used, return to their point of origin for reuse or final destination. The idea of flow is closely related to the cycle, denoting different but complementary concepts of the same phenomenon.

For this study, reverse logistics is a process composed of activities, methodology, and techniques used to enhance the return of materials to their point of origin after customers use them. Reverse logistics focuses on reusing waste for the organization or some other creation cycle with a satisfactory final objective of the material collected. It is a system for the planet's economic advancement, as it considers the reuse of materials and the reduction of resupply from nature's sources. As a process, reverse logistics is carried out from certain stages.

The literature review does not present a uniform and consensual way of reverse logistics. There is no standard process with all the steps established. Some are more supportive of certain products, while others are more successful in others. Also, the number of steps is different. For example, studies by Santos, Duarte and Gomes (2012) and Giese et al. (2021) present seven stages, where none coincide with each other; that is, the logical sequence of these steps in the first study is different from that of the second. This differentiation remains throughout the procedural chain of these stages. Although the studies by César, Sacomano Neto and Farah (2018) and Giacobo, Estrada and Ceretta (2003) present five steps of reverse logistics, again, no coincidences were found between them. It reinforces the confirmation that reverse logistics remains a phenomenon whose continuous step-by-step is still undetermined.

The ordering of the steps allowed the creation of a logical scheme of the reverse logistics process consisting of five steps: collection, sorting, disassembly, recycling, and distribution. However, a closer examination allows us to perceive that, although the stages are not coincident, all of them, in some way, configure a logical scheme that can be demonstrated. It means that the steps are in different sequencing orders, as is the case of the first step in the study by Giacobo et al. (2003) about the one by Araújo et al. (2012), but which can be considered similar (not the same).) to that pointed out in the study by Giese et al. (2021). Another finding is that often only the orders are different, but the steps are practically the same, as can be seen by comparing the sequencing presented by Lima et al. (2021) with that of César et al. (2018).

The stage is called collection because it is the initial activity to obtain the material that will be worked. This step demonstrates its importance through how it is characterized, performed, and developed. The collection activity can be defined as the activity responsible for collecting the correct mix of products (Giacobo et al., 2003) in their proper quantities from the storage area to satisfy the needs of the destination of a particular product or act responsible for its goal. In the literature, the collection appears as activity, evaluation (Santos, Botinha & Leal, 2013), and product analysis (Santos et al., 2012). Product analysis is generally carried out to discover the material's potential for other forms of use. In large cities, it can be done by collectors or by specialized companies.

The second stage is sorting and separating waste of different types. It is an activity that requires organization and attention. The sorting process also defines the part that cannot be recycled but is destined for co-processing (Carmo, Mascarenhas & Marçal, 2017). The methodology used to separate waste influences the time and quality of sorting. They are collected by categories (depending on the product), and when they arrive, they are stored in different areas, to be later separated by type of material (Giacobo et al., 2003). It is a primary operation so that waste is correctly directed and reused in

the future. This initial assessment consists of separating the materials according to their physical and chemical characteristics and which can be reused (Santos et al., 2013). When the collection is done correctly, the sorting step is facilitated. And this facility helps to achieve the success of the next step.

The third step is the process of disassembling a product depending on various parameters, such as manual force effort for disassembly, degree of precision required for effective tool positioning, material weight and size, the shape of disassembled components, and the use of hand tools (Araujo et al., 2012). It can precede sorting (recycling stage) by analyzing which items can be recovered, reused as raw material, reused for producing new products, and which will be discarded (Giese et al., 2021). The objective is to make a particular product go through this process with the highest efficiency of its reuse, demanding more excellent skill of the function of who executes it. Here, the products that will be parts and accessories for the reverse logistics process are dismantled.

Disassembly is related to collection activities mainly due to the quality of preparation and handling of the material: the higher the quality of the waste, the greater the probability that disassembly will be carried out correctly. Disassembly can be defined in two categories: the stage of definition of the concept of disassembly and the stage of establishment of alternatives (Giese et al., 2021). Some disassembly concepts must be raised to include in a product project, such as disassembly without force, by a simple mechanism, without tools, without repetition of use or similar part, ease of recognition of disassembly points, structure product design simple and no use of toxic materials. Product design has many advantages that, even for recycling, require planning how the activity will be carried out. Key benefits include reduced labor required in recovering parts and recyclables, uniformity and predictability in product configuration, simple and quick disconnect operations, ease of handling removable claims, easy separation and treatment of removable materials and waste, and reduced product variability (Araújo et al., 2012).

The fourth step is called recycling because it presents a methodology that involves reusing discarded materials (Lima et al., 2021). The purpose of recycling is to reintroduce discarded materials into the creation chain so they can be reused, reducing waste generation, expanding the protection of normal heritage, and working for individuals' satisfaction. The recycling process is a cycle of change applied to materials that can return to their state, turning into items that are similar in all their qualities, being an alternative to reuse (Cesar et al., 2018).

Recycling involves reusing a specific material that has already been handled with different qualities. To illustrate the contrast between these ideas, we can refer to the reuse of paper and glass, which, after undergoing this interaction, do not return to having physical-composite attributes similar to those they had before handling (Araujo et al., 2012). Anyway, the term reuse is used for things that can be returned to their state. Reuse, in its most direct structure, transforms waste into potentially valuable materials or items (Peixoto, 2019). With the reuse of waste, it is feasible to reduce costs, generate financial benefits for the organization, and gain notoriety in the market. Recycling already begins with the activities of collecting the materials and their proper preparation for the later stages.

The fifth and final stage is when the finished product, following the waste design, is ready to be distributed. It is forwarded according to its classification. Distribution constitutes a set of activities that correspond to the management of goods, from the assembly line or the moment the product leaves the recycling factory to its final customer. Distribution helps improve the products or services made available to customers (Araujo et al., 2012).

Reverse logistics is a management interaction that explores organizational structure and resources to meet the organization's needs. The reinsertion of waste and other post-purchase materials into new creation cycles has been a challenge that many organizations have successfully faced. This process saves the economy and life because, in addition to increasing the useful life of the waste, it reduces the extraction of raw materials from nature. In this way, it enables the design processes that make it possible to reuse materials in a new product. For this study, reverse logistics defines and groups the work that must be

performed, with definition and delegation of responsibility and authority, to allow more effective ways to achieve objectives. In the specific case of this study, reverse logistics has its starting point in the selective collection of waste made in the homes of residents of cities and communities, which are increasingly producing waste.

3. Methodology

This study used the survey method to explain the difficulties encountered by residents of Manaus in practicing selective waste collection. Five guiding questions were elaborated on for the fieldwork to achieve this goal: 1) what are the main difficulties for the practice of selective collection? 2) How do these difficulties happen in everyday life? 3) What examples can be provided of how difficulties happen? 4) Which actors could help to reduce these difficulties? 5) What could these actors do to help reduce the identified difficulties? This section presents the technical and operational aspects of how each response was constructed.

The main characteristic of this research was the challenge of understanding in depth the problem of selective garbage collection, which is typical of qualitative studies, as shown by the studies by Shelton, Philbin and Ramanadhan (2022), Taquette and Souza (2022), Harley and Cornelissen (2022) and Shaw et al. (2022). It took as a unit of analysis the individuals residing in the city of Manaus, with a level of organizational analysis and perspective of synchronic analysis.

3.1 Study design

The study design consisted of nine steps. The first was elaborating an empirical data collection plan containing the specific objectives, guiding questions, and the data collection strategy. The second was planning a protocol for collecting and organizing data and another for generating and interpreting results, as Silva et al. (2020) recommended. The third stage consisted of building and testing the data collection instrument. The fourth stage was the data collection itself, and the fifth stage dealt with the criticism and organization of the data. The sixth stage was data analysis, followed by the generation and interpretation of results, respectively, in the seventh and eighth stages. The new and last step was the writing of the final report.

3.2 Subjects, population, and sample

Two prerequisites were used as criteria for selecting subjects: living in the city of Manaus and being an adult between 18 and 60 years old. The respondents selected were mainly housewives and housewives to represent a sample of the population that deals directly with the daily tasks of the house, whose experiences with the attempts to carry out the selective collection in the city would be essential to answering the proposed questions. But the study's intention was not to quantitatively encompass the population but to extract a sample that could provide data and in-depth information about the difficulties of selective garbage collection in the city.

After 48 hours, available on the internet, using Google Forms, 30 respondents filled out the questionnaires, which were considered for generating the survey results. This number was deemed satisfactory to have a reasonable idea about the problem under study. The sample size calculation for an infinite population, which is the case of the city of Manaus, with more than 1.4 million inhabitants, would give a total of 400 people, with a margin of error of 5% and a significance level of 95 %, as recommended by Barbetta (2010).

3.3 Data collection instrument

The electronic questionnaire was used as a data collection instrument, divided into two parts. In the first, the respondent filled in their data such as e-mail and age. As they were mandatory, the respondent would only have access to the

next stage of the questionnaire if the first was answered. The second consisted of five specific questions about your experience (or lack) with selective garbage collection in Manaus.

In the first question of the second part, the respondent should briefly write their three main difficulties in collaborating with the selective collection. In the second question, based on the previous answer, I would have to summarize how each of these difficulties occurs. In the third question, the respondent was directed to think about the solutions to these difficulties so that he could point out two ways to solve these obstacles according to his perception of life. Then, it was asked which and who are the agents responsible for the appropriate treatments for minimization of these obstacles and who could help solve each previously pointed out difficulty. In this fourth question, the interviewee could relate the problem individually to an agent that he considered relevant to assist. He could choose a maximum of three agents per difficulty. In the last question, the respondent pointed out what actions the agents should take to help overcome the challenges of selective collection in Manaus.

3.4 Data collection strategy

Data was collected using the Google Forms application so respondents could respond to the survey online. Data collection was carried out over 48 hours with the link disclosure for respondents to express their answers. The form and link were sent from 8 am on a Thursday and finished at midnight on a Friday, as it was expected that, as it was a weekend, the invited people would have more time to answer the questionnaire. The most significant difficulty encountered in the collection was the disclosure of the survey response link. The pool reached a sample of 30 individuals selected by the researchers, composed of people who deal daily with household tasks. The questionnaire was disseminated only in groups of the WhatsApp chat application and via a post in the social network's "Story."

3.5 Data organization and analysis techniques

Once collected, the data were criticized. Some questionnaires and responses were invalidated because they did not comply with the protocol requirements, such as the need to point out difficulties and avoid ambiguities accurately. Afterward, the questionnaires were organized into double-entry tables, called the mass of data by Nascimento-e-Silva ((2012; 2020a; 2020b; 2021a; 2021b; 2021c). The answers for each question were placed in the left column; in the right column, the number cited. Another way of organizing the data was through categorization, in which data of the same semantic content were grouped, such as the characteristics of the collection points being distant, small quantity, and lacking equipment, among others.

The data were then analyzed to generate the answer to each guiding question. For example, the question that aimed to identify the main types of difficulties in carrying out waste recycling allowed the classification of these difficulties into six different types: 1) knowledge of the population, 2) action by the population, 3) treatment of the material, 4) collection points, 5) government actions and 6) equipment. The answers were grouped into each type, and then the results were discussed. Content analysis was used to identify the cores of each response obtained. One example was when the respondent answered "knowledge" or "population action" or both together in the question about difficulties; this answer was framed in the classification "knowledge" and "population action." Based on this procedure, the other research results were constructed.

3.6 Techniques for generating and interpreting results

The results were generated following the study's specific objectives and transformed into guiding questions. Therefore, each question had its data organized and analyzed in such a way that allowed the production of synthesizing tables where the desired answer would be explicit. For example, for the question that sought to find out who are the agents that could help overcome difficulties, the resulting table presented, in the column on the left, the name of the actors as a result of the stages of data organization and analysis; on the right side, the number of respondents who pointed to that data.

The results were interpreted comparatively with the scientific literature contained in the study's theoretical framework. The generation of results described the empirical situation portrayed with the observed data. The interpretation of the results sought to make sense not only of the reality of selective collection in Manaus based on the data collected but, in an inferential way, to try to place that reality in a global scientific context. In other words, there is a logistical process built from scientific knowledge whose operationalization is more or less likely to happen if the selective collection procedures follow their ordinary course. It means that when the difficulties of collaborating with the selective collection are insurmountable, the efforts to adapt the city's global logistics process are likely to be compromised.

3.7 Study limitations

Three are the most evident limitations of this study, but they do not invalidate the findings. The first is the sample size, composed of only 30 respondents. Large samples characterize survey surveys. The intention of this study was not directed toward inference but toward the depth of understanding of the phenomenon. Thus, instead of reaching a sample of 400 or more respondents, which would be recommended, we collected 30 who presented all the evidence necessary for understanding the five research questions formulated.

The second was the data collection strategy, performed only during 48 hours. More disclosures could be made to reach a more significant number of respondents. But, again, the intention was not to elaborate on a panoramic portrait but on the verticalization of the answers.

The third limitation concerns the structure of the questionnaire itself. More information could have been collected on the socio-demographic aspects of the respondents, such as gender, income, and neighborhood of the city in which they lived, as well as other explanatory questions. It would be an exciting procedure, but it would require much more time and technological resources that the research group did not have at that time.

4. Results and Discussion

It was decided to organize the findings following the guiding research questions to facilitate the understanding of the results of this study. Thus, the types of difficulties encountered will be shown, followed by how they occur and the prominent examples of these occurrences. Next, actors who could help overcome these difficulties and what they could do to do so are shown.

4.1 Types of difficulties

The results related to the guiding question that sought to identify the main types of difficulties in carrying out waste recycling allowed the classification into six types, as shown in the data contained in table 1. The first was the lack of knowledge (and action) of the population, followed by the lack of treatment of the material to be recycled, the nonexistence of selective collection in most neighborhoods, unknown collection points, lack of governmental actions for selective collection, and lack of equipment. The population is unaware of two things: a) how to handle the materials to prepare them for selective collection and b) where to take these materials. The ideal would be for private companies to make a schedule, with day and time, to collect and reuse these materials. As the population is unaware, the natural consequence is that the solid and liquid waste it produces is not reused. The public garbage collection workers mix these materials with other types of garbage, especially organic ones. It is almost always useless for the population to separate them because general cleaning will throw the materials in the same truck, crushing them with organic and non-recyclable ones.

Table 1 - Types of difficulties encountered.

Tipos de dificuldades	**Frequência**
Falta de conhecimento e ação da população	10
Falta de tratamento do material	8
Falta de coleta seletiva	8
Falta de pontos de coleta	7
Falta de ações governamentais	6
Falta de equipamentos	5

Source: Data collected by the authors.

There are rare collection points in the city, as pointed out in the study by Mafra, Nascimento e Silva (2020), Borges, Farias e Souza (2020), and Cabral and Nascimento-e-Silva (2022). Studies indicate that the number of these posts is naturally related to the size of the population. Our surveys show that no more than ten units are spread across a city with approximately 2.3 million inhabitants. The reference quantity varies from one gas station for every 600 or 1,000 inhabitants. Suppose bulky waste (such as refrigerators and sofas) and hazardous waste (such as oil) are considered. In that case, the ratio reaches one gas station for every 6,000 residents, as shown in the study by Gil et al. (2019). The survey by Rada et al. (2018), made in an Italian tourist city, also considers the number of tourists and the like, which is not the case here. Taking this last reference as a base, Manaus should have at least 384 selective collection points, which is very far from the reality of the city.

If there are no collection points, selective collection effectively does not exist. This finding considers the theoretical framework of this study, which places selective collection as one of the stages of reverse logistics. If the waste is destined for reuse, it follows a path that culminates in its transformation into raw material; if they go to final packagings, such as sanitary landfills, they follow other steps. In the city, these possibilities are undefined. The existing posts are open places for the population to deposit their non-organic materials. However, what can be seen is that there is only the separation of organics from inorganics. Paper, glass, plastic, metal, and various other materials are placed in the same plastic bag, often dirty with residue. This material suffers the action of autonomous collectors searching for papers and metals most valued in the city. When they do that, they tear the packaging and mix it up again. From the point of view of science, therefore, there are no selective collection points in the city.

The results also showed a lack of government actions aimed at selective collection. According to the respondents, these actions could be directed towards two fundamental focuses. The first is the organization of a collection system in line with the principles of reverse logistics: destination for reuse or final destination. It would require the institutionalization of the process, with the stages duly defined, with procedures and actors involved, including the necessary equipment. The second would be intensive and permanent work to educate the population about each step of the reverse logistics process and each stage of the city's selective collection procedures. It is recommended that both the instructions and the practice of selective collection be done via application, which would work similarly to transport by applications. Each resident would schedule the day and time when collectors duly registered and identified by the public agency would come to pick up the material. In this same application could be the demonstrations of types of materials, their preparation, packaging, packaging, and handling. Table 2 details how every difficulty manifests itself, according to the respondents.

Table 2 - Types of difficulties and forms of manifestation.

Types of difficulties	Forms of manifestation
Material treatment	Lack of material selection Lack of suitable place for destination The population mixes the materials The population does not separate materials daily The population does not clean materials for disposal The population does not shelter material from rain The guidance booklet is missing There is a lack of a protocol for treating the materials
Knowledge and action of the population	Not aware of recycling sites Lack of awareness Don't know about recycling Lack of information to the population Need to disclose the collection points Lack of space in homes Lack of time Population is uninformed Lack of patience Lack of guidance on what to recycle Lack of habit Lack of public support for recycling
Collection points	They are distant They mix the materials They are insufficient They are filthy They are unprotected from the rain Missing points for electronic material Difficult access to existing points
Selective collect	There is no collector There is no collection company Lack of practicality It is sporadic, discontinuous There is no classification of materials Insufficient staff for collection No specific collection locations There is no selective collection
Equipment	Appropriate bins are missing Disorganized containers Recycle Bins are not flagged correctly Appropriate bags are missing The clothing equipment is missing
Government actions	Lack of government support Political disinterest There is no government incentive Lack of awareness programs There are no public collection cars in quantity Lack of political support

Source: Data collected by the authors.

Finally, there is a lack of equipment for selective collection. The equipment available today in other cities varies and can be organized into gear for the population, collection, collectors, and collection points. For example, the population lacks bags containing each type of material, such as oils, chemicals, and solid materials. For selective collection, no application or information and communication system allows the transmission of guidelines and collection schedules. The collectors lack adequate equipment, especially gloves and face protection, given the large number of autonomous collectors injured by glass, metal, and injection needles. The collection points lack adequate packaging materials, on-site guidance on where to allocate each type of material, and safety equipment and materials, mainly to avoid entering insects.

4.2 How difficulties happen

We found ten ways of expressing difficulties in carrying out the selective waste collection in Manaus, as shown in the data in table 3. Lack of information was the most frequent manifestation (with 6 citations); if combined with the lack of disclosure (with 4 references), there is a lack of knowledge as the most effective way of seeing what does not exist for 2 respondents. In contrast, for 4 others, there is no selective collection and 4 considerations that there is not even collection of waste. If there is no knowledge, collection, or interest of the population, as stated by 4 respondents, using these materials or their proper packaging is unlikely to happen so soon. The reason for this can also be seen in Table 3. There is a lack of investment in practical actions to build a culture of conservation that avoids so much material waste.

Table 3 - Forms of manifestation of difficulties.

How they happen	**Frequency**
Lack of information	6
Disinterest	4
Lack of selective collection	4
Lack of disclosure	4
Lack of waste collection	3
Nonexistence	2
Lack of culture	2
Lack of investment	2
Lack of conservation	1
Lack of scheduling	1

Source: Data collected by the authors.

Table 4 details how the difficulties of contributing to selective collection happen. Unfortunately, the population's lack of interest has been intensifying due to the lack of interest of public agencies in supporting companies, cooperatives, and educational institutions that can carry out projects and be on the front line in each neighborhood of the city. They could help to reduce the lack of information about discards and the procedures for doing so. It is aggravated by the population's lack of interest, which does not seek information on how to dispose of it correctly in their daily lives. Finally, there is a lack of interest from companies producing large amounts of garbage to help collect materials from the streets.

The lack of information or disclosure was another difficulty in collecting selective garbage. There is a lack of structure and good places for disposal; the number of selective garbage bins in the city is minimal, without any type and form of publicizing these reduced collection points, as described in table 4. There are no actions or guidelines that will make the population create the habit of recycling, how to dispose of waste, and perform the separation correctly.

Table 4 - Detailing how difficulties occur.

Difficult focus	How they happen
Disinterest	The disinterest of the population Lack of interest from companies and politicians Lack of vision due to the rush of everyday life Works all day, knows nothing about recycling
Lack of information	They don't know the correct way to dispose of the garbage People throw garbage in forbidden places If you don't have information, there's no way to practice recycling There is no guidance on how to recycle, store, and where deliver
Nonexistence	There is no efficient and responsible collection in the city There is no awareness policy
Culture	There is no culture of selection; everything goes into a single garbage bag There is no massification of information on recycling Condominium without recycling culture
Selective collect	Few trash cans Don't pass the collection car Lack of selective collection Few collection points There is a lack of selective collection in the community There is no separate collection point
Lack of disclosure	There is misinformation There is misinformation and little disclosure There is no disclosure of collection points for recycling Accessibility and exposure would help a lot
Conservation	Knowing when to dispose of materials keep stuff clean
Scheduling	Low availability on the agenda
Investment	There is no political project for the practice of recycling Lack of investment and application of recycling methods
Waste collection	Mix all garbage and rain on collection day Collectors are selective. Want a specific type of material If you separate the waste, the collectors mix it again

Source: Data collected by the authors.

Another group of difficulties is the lack of investment and incentives for recycling. The government is still flawed in this area. Few laws encourage companies to invest in this area. The application of resources is minimal, with few recycling projects and methods that help the community collect materials. Society is still very dependent on autonomous waste pickers, primarily responsible for recycling, as seen from the research by Silvestrim et al. (2022) and Mendes et al. (2022). Initiatives are still very weak. As there are no investments in the right way of recycling, the population and companies end up disposing of waste in the places that suit them, which are almost always inadequate and hinder the correct collection of materials. There is also no awareness policy for the population to promote their environmental reeducation.

The culture of waste of these materials established in society has become challenging to recycle. The population does not know how to select materials; there is no habit of separating the waste into different bags, and there is no massification about recycling because it is not something of society's culture. The lack of awareness about the consumption and decomposition of materials and the impacts that waste causes not only causes problems for companies but also for the environment, which ends up being the most harmed by this lack of awareness of waste disposal.

The reasons for the nonexistence of selective waste collection can be explained by the difficulty encountered by respondents for it to be carried out effectively. It was reported that there are not enough bins to dispose of garbage, and there are not many garbage collectors. There are few collection points in the city, which makes the selection of materials impracticable and causes the waste to be disposed of incorrectly. Sometimes, there is selectivity about some materials at the time of collection. For example, self-employed waste pickers prefer cardboard and metal cans over other materials. It frustrates the population at the time of disposal because, almost always, collectors mix all the separated waste.

4.3 Examples of how difficulties happen

When asked about difficulties, the interviewees' examples could be organized into two groups based on their causes: materials and procedures. Table 5 shows the various obstacles and techniques mentioned by the respondents, considering the materials and processes simultaneously. The main one concerns the inexistence of a good and known place for storing the material, pointed out by 17 people. The second place appears the inexistence of any form of a selection of these materials, with 15 respondents. As can be seen, the lack of an appropriate place for storing the material and the inexistence of any form of selection are the two major obstacles due to the lack of collaboration of respondents with solid waste recycling in Manaus. The other types of barriers were interests, with 6 occurrences; transport, with 5; and time, with 4.

Table 5 - Obstacles and procedures.

Sources of obstacles	**Frequency**
Storage	17
Selection	15
Interest	6
Transport	5
Time	4
Total	**47**

Source: Data collected by the authors.

The materials group shows that the lack of garbage cans harms the disposal system. Natural waste plays a significant role in supplementation cycles, sending them to clean landfills, which means that the primary tailings are sent for conclusive removal. Among the main difficulties for reuse to become a more everyday practice are a) lack of information on the number of inhabitants on how reuse is carried out, b) restricted proposal of a particular assortment, c) difficulty in realizing more notable monetary viability, d) deficit of the actual assortment project and organization, e) decrease in the number of qualified specialists, and f) non-receipt of reverse planned operations and so on.

Despite the absence of monetary and financial drivers for effective selection and organization, there are also a small number of specialized and qualified professionals working here, which considerably hinders the growth of reuse in enterprises and on a day-to-day basis. The population and organizations end up not understanding how reuse works and how to adjust it to their daily lives. It is depicted in Table 6.

Table 6 - How difficulties occur.

Types	How they happen
Material	Few trash cans Non-specific dumps There is no market for using the discarded material There is no collection point in all neighborhoods Mix with garbage Rain on collection day It ends up being all mixed up in the garbage car Some want paper, plastic, Others prefer copper, battery, aluminum, iron, and others Mix dry garbage with wet garbage The disposal site is not signposted or organized Lack of specific collection for recyclable materials
Procedure	Throws garbage in the trash and does not separate recyclable material Transport is difficult to the places that recycle Lack of planning, policies, and public interest Lack of interest of the population in separating the material for disposal Lack of government support There's no one to collect There is no transport Batteries and batteries are discarded in the standard waste It is not known whether there is a specific collection There are people interested in the sustainable collection Misinformation and little benefit to volunteer recyclers There is an idea that there is no difference between garbage and recyclable material It is not worth separating recyclable waste: they will all have the same fate House with no storage space, there's nowhere to leave it

Source: Data collected by the authors.

The second group concerns procedures. The lack of knowledge causes waste to be disposed of incorrectly, in which people throw their garbage without the necessary separation to be recycled. Another cause was the lack of planning and government investment in recycling. The lack of support makes the incentive for selective collection even less, which makes the amount of collector transport available to the population. In addition, the places that receive these materials are still minimal, and there are not enough selective trash cans in the city, making it more difficult to dispose of garbage.

These results align with the difficulties of practicing reverse logistics, especially in large cities. The findings of the study by Franz and Silva (2022), for example, point to physical and infrastructural difficulties. Trossaert et al. (2022) showed that the lack of infrastructure is crucial for the success of the selective collection, while the study by Santos and Proença (2022) found that the lack of server experience, lack of information system, lack of infrastructure, and lack of technology prevents waste from being collected efficiently. The material causes correspond to the lack of infrastructure and materials and equipment necessary for the practice of reverse logistics; procedural causes concern the procedures of the population to do their part and share information and knowledge so that this practice becomes effective.

4.4 Actors that could help reduce difficulties

We tried to find out the actors that could help reduce the difficulties of the practice of selective collection in the city. The results are contained in table 7. The government was considered one of the main pillars for reducing these difficulties. Through orientation campaigns for residents and entrepreneurs, information can be intensified and help obtain sponsorship for projects with this purpose. In addition, it can create a body in communities and educational institutions to establish partnerships with neighborhoods. This initiative could bring together entities that work with scrap collectors and cooperatives of small entrepreneurs who work with handicrafts, starting a new production chain.

Table 7 - Who could help lessen the difficulties.

Agents	**Frequency**
Government	21
Companies	10
Citizens	6
Community/Associations	4
Total	**41**

Source: Data collected by the authors.

Community help and philanthropic associations contribute positively to the transmission and propagation of knowledge. These entities can implement projects that seek to reduce, reuse and recycle materials as much as possible, reducing the environmental impacts caused by tailings. Just as important, it also helps generate income opportunities for its participants. Through churches, community leaders, and waste pickers associations, it is possible to give voice to the cause and influence the population to develop a social culture focused on an environmentally sustainable mentality.

Citizens must seek to absorb and practice knowledge about environmental projects and government actions. With environmental awareness and the option of correctly disposing of tailings, citizens contribute to preventing, for example, the garbage from being carried into the drainage system during the rains, reaching the rivers and seas. It prevents it from causing various types of damage to the environment and prevents flooding during heavy rains. It also helps to reduce the garbage in landfills and leachate production in these places.

Private companies are essential to ensure the correct waste disposal since only 0.27% of the waste generated in Manaus is recycled (Silvestrim et al., 2022). Much of this material will cause problems and damage the streams that run through the city. Encouraging recycling companies makes it possible to generate employment and income opportunities for residents, reduce the impacts of waste and contribute to keeping the city cleaner since much of this material can be recycled. Among the primary materials found are pet bottles and disposable and household waste, which take years to decompose.

4.5 Roles of actors to help lessen difficulties

We tried to find out what the different actors can do so that the difficulties of selective garbage collection can be reduced. The results in table 8 show that the government can develop instructive awareness campaigns and create programs to show how indispensable selective collections are. These actions aim to transmit knowledge and education to the population, clarify the laws, disclose the measures taken and carry out a continuous inspection to maintain the collection practice's implementation and continuity. The joint work between the public power, the private sector, and the population are essential to standardize an environmentally sustainable collection process. For this to be possible, it is necessary to disclose and explain the ways of recycling, increase the collection points and make the collection schedules rigid. Investing in companies that are socially committed to recycling their waste is also necessary.

Table 8 - What agents must do.

Agents	What must they do
Governments	Conduct awareness campaigns Create programs focused on the issue. Disclosure of measures Working together with companies and the population Invest in companies Expose ways of recycling Introduce laws Carry out inspection Increase collection points Maintain collection continuity Strict hours for collection Make more bins available Provide flagged baskets
Private companies	Make the service available Create distribution center Generate employment Institute sustainable model Generate job opportunity Realistic planning Place collection points close to neighborhoods Collect directly from homes
Communities / Associations	Create programs Recycling incentives Give lectures, seminars, lives, projects, incentives Give examples Training
Population	Separate the waste Act Do not buy products with a high degree of waste generation

Source: Data collected by the authors.

On the other hand, private collecting companies must then study each actor's reality to provide a quality service that meets the city's and its inhabitants' needs. It can be possible with the implementation of collection points close to the neighborhoods and directly in the residences of the residents. Currently, it is necessary to have a sustainable management model that harmonizes social, environmental, and economic aspects (Molina et al., 2022; Akbari et al., 2022; Zheng et al., 2022; Coşkun & Akgül, 2022), focusing on the sustainability of society and responsibility for the impacts of human actions to guarantee the present and the future. It is essential to have a realistic plan that generates employment and job opportunities for citizens. It can be done through partnerships with the most diverse cooperatives and associations of collectors, composed of men and women who live in social vulnerability in the city.

The availability of adequate equipment, the increase in the number of bins, and the correct signage in the wastebaskets help to facilitate the disposal of materials. People can properly dispose of the material by viewing or reading the signs. But it is necessary to increase the number of garbage cans in the city to supply the population's demand and avoid incorrect disposal due to a lack of a good place. Once the correct disposal is made, it is necessary to speed up the waste preparation stage, separated by category, to be pressed and sent to the factories for the proper purposes.

Among the top ways and resources that can be used to transmit knowledge and information to the population is the creation of social programs and projects that encourage recycling. It can be operationalized through workshops and mini-courses for low-income people and artisans. If it provides financial incentives to private companies, the government can contribute so that they promote social projects inside and outside their environments through training their employees. Finally, the population can help with the separation of waste. This separation must be done by category, and it is always necessary to clean the material. In addition, it is essential to avoid buying products with a high degree of hazardous waste generation and rethink consumption practices.

5. Conclusion

This study showed that the main challenges for carrying out selective garbage collection in the city of Manaus are the lack of a) knowledge and action by the population, b) treatment of the material, c) selective collection, d) collection points, e) government actions and f) equipment. The selective collection is the starting point for all other stages of the reverse logistics process. When it does not function properly, all different stages are compromised, which results in a series of negative externalities that culminate in compromising the quality of life of the entire population. Added to this is the vast amount of wasted financial resources without transforming solid waste into raw materials to feed new cycles and production processes.

The leading cause of all these difficulties in carrying out an adequate selective collection of waste is the lack of knowledge of its most different shades and agents. There is a lack of knowledge about which materials can be recycled and how to prepare them, where to deposit them or who will come to collect them, configuring the lack of understanding of a procedural order. There is also institutional ignorance, in which the actors who should be involved and committed to the reverse logistics process do not know what roles they must play for selective collection to work. The result could not be different: there are no instruments, equipment, procedures, involvement, or commitment to this fundamental stage of reverse logistics.

Three essential technology-based studies are recommended for the production of knowledge and progress towards the planning, execution and monitoring of selective collection in the city of Manaus. The first is creating a website or platform specialized in selective waste collection, preferably under the joint and solidary responsibility of public and private institutions and communities. The second is developing an application in the style of urban transport, such as Uber and InDriver, for scheduling selective collection in the city. And the third is creating a reward system for companies and citizens who collaborate most with the selective collection, reducing part of the tax expenditures in the three spheres of government.

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