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PROPOSAL FOR THE IMPLEMENTATION OF POST-CONSUMER REVERSE LOGISTICS PRACTICES IN THE TREATMENT OF SOLID WASTE: A MULTI-CASE STUDY IN THE TEXTILE AND CLOTHING SECTOR OF SANTA CRUZ DO CAPIBARIBE

PROPOSTA DE IMPLEMENTAÇÃO DE PRÁTICAS DE LOGÍSTICA REVERSA DE PÓS-CONSUMO NO TRATAMENTO DE RESÍDUOS SÓLIDOS: UM ESTUDO MULTICASO NO SETOR TÊXTIL E DE CONFECÇÃO DE SANTA CRUZ DO CAPIBARIBE

PROPUESTA PARA LA IMPLEMENTACIÓN DE PRÁCTICAS DE LOGÍSTICA INVERSA POSCONSUMO EN EL TRATAMIENTO DE RESIDUOS SÓLIDOS: UN ESTUDIO DE CASO MÚLTIPLE EN EL SECTOR TEXTIL Y DE CONFECCIONES DE SANTA CRUZ DO CAPIBARIBE

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ABSTRACT

The study aims to propose the implementation of post-consumer reverse logistics practices in the treatment of solid waste from microenterprises in the textile and clothing sector in Santa Cruz do Capibaribe. For that, it was necessary to know the productive process of the companies; identify the solid residues that are generated in the production process; raise the actions that are currently adopted by companies regarding the treatment of their solid waste; and, finally, propose new actions for the treatment of solid waste generated in the production process. This is an applied, qualitative, exploratory and descriptive research, in the format of a multicase study, which used a semi-structured interview script and non-participant observation as a data collection instrument. After knowing the reality of the two companies, it was concluded that there is a long way to go in the search for the implementation of Post-Consumer Reverse Logistics practices. It was noticed that their efforts, aiming at the correct disposal of solid waste generated in the production process, are insufficient, since they adopt few treatment actions, giving rise to the incorrect disposal of a high volume of materials. Thus, actions were proposed for the treatment of this solid waste, involving resale, recycling, reuse and a more appropriate final destination.

RESUMO

O estudo tem como objetivo propor a implementação de práticas de logística reversa de pós-consumo no tratamento de resíduos sólidos de microempresas do setor têxtil e de confecção de Santa Cruz do Capibaribe. Para tanto, foi necessário conhecer o processo produtivo das empresas; identificar os resíduos sólidos que são gerados no processo produtivo; levantar as ações que são atualmente adotadas pelas empresas quanto ao tratamento dos seus resíduos sólidos, e, por fim, propor novas ações de tratamento desses resíduos gerados no processo produtivo. Trata-se de uma pesquisa aplicada, qualitativa, exploratória e descritiva, sob o formato de estudo multicaso, que utilizou como instrumento de coleta de dados um roteiro de entrevista semiestruturada e a observação não participante. Após conhecer a realidade das duas empresas, concluiu-se que há um longo caminho a ser percorrido na busca pela implementação de práticas de Logística Reversa de Pós-consumo. Percebeu-se que os seus esforços, visando uma destinação correta dos resíduos sólidos gerados no processo produtivo, são insuficientes, já que adotam poucas ações de tratamento, dando margem para que ocorra o descarte incorreto de um alto volume de materiais. Assim, foram propostas ações de tratamento desses resíduos sólidos, envolvendo revenda, reciclagem, reutilização e uma destinação final mais adequada.

RESUMEN

El estudio tiene como objetivo proponer la implementación de prácticas de logística inversa posconsumo en el tratamiento de residuos sólidos de microempresas del sector textil y de confección en Santa Cruz do Capibaribe. Para eso, fue necesario conocer el proceso productivo de las empresas; identificar los residuos sólidos que se generan en el proceso productivo; plantear las acciones que actualmente adoptan las empresas en cuanto al tratamiento de sus residuos sólidos; y, finalmente, proponer nuevas acciones para el tratamiento de los residuos sólidos generados en el proceso productivo. Se trata de una investigación aplicada, cualitativa, exploratoria y descriptiva, en formato de estudio multicaso, que utilizó como instrumento de recolección de datos el guión de entrevista semiestructurada y la observación no participante. Luego de conocer la realidad de las dos empresas, se concluyó que hay un largo camino por recorrer en la búsqueda de la implementación de prácticas de Logística Inversa Post-Consumo. Se percibió que sus esfuerzos, encaminados a la disposición correcta de los residuos sólidos generados en el proceso productivo, son insuficientes, ya que adoptan pocas acciones de tratamiento, dando lugar a la disposición incorrecta de un gran volumen de materiales. Por lo tanto, se propusieron acciones para el tratamiento de estos residuos sólidos, que implican la reventa, el reciclaje, la reutilización y un destino final más adecuado.

1 INTRODUCTION

The textile and clothing industry are responsible for causing great impact on the environment; its various processes and the speed with which its products are produced, consumed and discarded has generated great concern due to the high level of degradation it causes in the environment (Salcedo, 2014). The process of creating clothing involves several steps that end up generating leftover fabric, which is discarded in landfills or incinerated in any way. It is also common to discard pieces at the end of their useful life, which is usually brief, thanks to new trends that emerge with each turn of the season or season (Salcedo, 2014; Gwilt, 2015).

Short life cycle of clothing items, known as fast fashion*,* aligned with the appeal aimed at consumerism, even for the sake of survival of the industry, end up becoming a major challenge for the production of sustainable fashion, and, unfortunately, the number of textile companies that seek to adapt to environmental principles is small (Delgado, 2008; Schulte, & Lopes, 2008).

Although the residues from spinning, weaving and clothing production, such as the remains of fabrics and trimmings, are apparently not as dangerous, when gathered in a quantity they have a high pollutant load, due to their high flammability. Therefore, the incorrect disposal of this waste can lead, for example, to a large fire, which can quickly consume the surrounding environment and contaminate the soil (Salcedo, 2014).

One of the viable alternatives to solve the problem of waste in the textile and clothing industry is the implementation of Reverse Logistics, a sub-area of Logistics that is responsible for bringing products, after the end of their useful life, back to the production chain, whether for reuse, reuse, recycling or even for correct disposal (Motta et al., 2011).

Reverse Logistics is defined by the Council of Supply Chain Management Professionals (CSCMP, 2023) as "a specialized segment of Logistics focused on the movement and management of products and resources after sale and after delivery to the customer. Includes product returns for repair and/or credit."

Predicted in the National Solid Waste Policy - PNRS, as an instrument of economic and social development, post-consumption Reverse Logistics is a set of actions focused on returning products to the production chain, whether for reuse in its own cycle or in other cycles, or when this possibility no longer exists, receive the correct final destination (Gausmann, & Cyrne, 2020).

Therefore, for the development of this study, the Municipality of Santa Cruz do Capibaribe was chosen. It is located in the Northern Agreste of Pernambuco, belonging to the Alto Capibaribe microregion, and is 187.8 km away from the State capital. The municipality is one of the main exponents of the clothing hub in rural Pernambuco, a region that has been standing out with considerable growth rates in its economy due to the activities of local businesses related to the textile and clothing industry (Souza, 2012; Araújo, 2015; Santos & Nascimento, 2017).

Observing the various enterprises in the textile and clothing industry currently installed in Santa Cruz do Capibaribe, the question arises: What Post-Consumer Reverse Logistics practices can be implemented in the treatment of solid waste from micro-enterprises in the textile and clothing sector production of Santa Cruz do Capibaribe? Therefore, the objective of this study is to propose the implementation of Post-Consumer Reverse Logistics practices in the treatment of solid waste from micro-enterprises in the textile and clothing sector in Santa Cruz do Capibaribe. To this end, the following specific objectives were established: to understand the companies' production process; identify the solid waste that is generated; raise the actions that are currently adopted by companies regarding the treatment of their solid waste; and propose new solid waste treatment actions.

The present study chose the textile and clothing sector due to its strong contribution to the Brazilian economy. According to the Brazilian Association of the Textile and Clothing Industry (ABIT, 2023), in 2021, the sector had a turnover of R$ 190 billion; R$ 4.9 billion were invested; the clothing production was 8.1 billion pieces (clothing, socks and accessories, home line and technical articles), while the volume of textile production was 2.16 million tons. Furthermore, there are 22.5 thousand formal production units across the country, 1.34 million formal employees, and 8 million if indirect employees are added.

The Municipality of Santa Cruz do Capibaribe was selected as an object of study because it is recognized nationally and internationally for its fashion production industry. According to Palomino (2010), fashion is not just limited to the use of clothes in everyday life, but also needs to be inserted in a much larger context, political, social, sociological and sustainable. Production waste, including that from fashion production, when well directed can contribute to increased profitability (Couto & Lange, 2017).

In a survey carried out in periodicals in the area of Management, Operations and Logistics, no recent works that are dedicated to the study of Reverse Logistics in the textile and clothing industry were identified. Thus, the present study may contribute to discussions on the topic, awakening interest for future work.

According to Dias (2005), when a company adopts the Reverse Logistics process efficiently in its operation, it communicates to its customers that it is committed to growing in a sustainable way. Therefore, this study seeks to present to entrepreneurs in the clothing hub of rural Pernambuco the implementation of possible Reverse Logistics practices in the textile and clothing industry.

Studies on solid waste management are generally carried out in large companies, making it necessary to awaken waste management in small industries, the focus of this study, as their combined waste is equivalent to or exceeds the impact of a large industry (Araújo, 2015).

2 THEORETICAL FOUNDATION
2.1 THE TEXTILE AND CLOTHING INDUSTRY AND ITS ENVIRONMENTAL IMPACT

The negative impacts caused by the textile and clothing industry can be felt since the acquisition of its raw materials, in which it is estimated that 25 million people are poisoned per year, due to the incorrect or excessive use of pesticides in the plantations from which the fibers are extracted (Martins et al., 2011). In addition to natural fibers, synthetic fibers are also used in the fashion industry; many are derived from hydrocarbons found in petroleum, which are not biodegradable.

Waste is generated throughout the entire production chain of the textile and clothing industry. The Brazilian Association of Technical Standards (ABNT, 2004), in accordance with the Brazilian Standard - BR 10004, categorizes solid textile waste in Class II A – non-inert, which may have properties such as: biodegradability, combustibility or solubility in water. However, if there is contamination during the production process, they are considered Class I solid waste – Hazardous, posing a risk to public health when handled inappropriately.

One of the processes with the greatest potential for generating waste is processing, in which the fabric receives chemical substances to improve its appearance and structure or modify its tone. This production stage demands the excessive use of water, it is estimated that each kilo of dyed fabric generates 50 to 100 liters of contaminated effluents, which, if discarded incorrectly, can deplete oxygen from aquatic environments, unbalancing an entire ecosystem (Arslan -Alaton et al., 2008; Araújo, 2015; Lalnunhlimi & Krishnaswamy, 2016). Furthermore, the printing and dyeing processes require the use of several toxins, and a wide variety of elements that hinder the possibility of recycling (McDonough & Braungart, 2002; Araújo, 2015).

In most clothing industries, poor planning, the production stages of modeling and cutting, among other factors, generate leftovers, or waste, the vast majority of which are scraps of fabric. It is important to highlight that waste is not equivalent to garbage (reject), since it is undesirable and worthless (Araújo, 2015). Inadequate disposal of this waste ends up harming the environment, bringing numerous risks, such as contamination of soil and groundwater.

Production planning that uses correct materials, shapes, color and systems can minimize social and environmental impacts by up to 80%, for example, developing products and collections using organic cotton, with natural dyeing, or using synthetic fabrics made with pet bottles. However, many manufacturers are afraid that the use of these materials will negatively influence sales (Schulte & Lopes, 2008; Lima et al., 2018).

Therefore, the phases of creating a piece, from assembly to disposal, need to follow sustainable methodologies. Therefore, companies need, in addition to producing, to define the destination of the waste left over from this production (Lima et al., 2018). However, the majority of professionals working in the development of these products are unaware of or ignore their impacts, creating a deficit in waste management. The investment made by most

companies in the textile sector in Brazil is often limited to the minimum so as not to result in a fine, when in fact the motivation should be the concern to have a socially and environmentally responsible process (Abreu et al.*,* 2008; Martins et al., 2011).

The processes used in fashion production need to be aligned with the new society, which is more conscious and is willing to give up small momentary privileges in favor of preserving the environment. In this sense, governments in several countries are developing and applying strict legislation that encourages industries to adapt to a new production standard, with more sustainable practices (Schulte & Lopes, 2008), as, for example, in Brazil with the institution PNRS, in 2010.

2.2 REVERSE LOGISTICS

Reverse Logistics is responsible for planning and operationalizing the entire return flow of materials to the production cycle, through reverse distribution channels, whether after-sales, when the material is not consumed, or post-consumption, which occurs when the material reaches the end of its useful life. The management of these materials has a direct link with the search for environmental efficiency (Leite, 2009; Motta et al.*,* 2011).

Pinheiro (2014) proposes that Reverse Logistics would be a process of planning, implementation and control, aimed at bringing value to the product that would previously be discarded. For the Brazilian Reverse Logistics Council (CLRB, 2023), the focus of this field of study is the efficiency in the return of products that have been consumed or that have not yet been consumed, that is, it equates the flow of part of the waste that would otherwise be discarded.

Reverse Logistics must be treated as an integrated and systemic supply chain discipline, which aims to: boost sustainable development, enable the efficient disposal of waste after its useful life, comply with current environmental legislation and promote financial gains (Xanthopoulos & Iakovou, 2009).

In the present study, it is understood that Reverse Logistics is the tool capable of enabling balance in the use of natural resources in production processes, as by returning and reintegrating part of the waste back into the production cycle, it ends up minimizing the direct extraction of raw materials, allowing time for the renewal of natural resources.

The first reference to the term Reverse Logistics in the literature occurred in the 70s, gaining strength in the following decade, but only in the 90s the discussion was intensified and the implementation process actually began, in which materials that would previously have been discarded began to have the opportunity to return to the production process, once again becoming a supply to be inserted into production and subsequently distributed (Donato, 2008; Couto & Lange, 2017).

Some of the contributions of Reverse Logistics can be seen in the strategic and operational strengthening of companies that adopt its practices, since economic value is recovered, value

is added in the provision of services, compliance with legislation is promoted, and improves the company's image in society (Leão et al., 2020).

In a world of uncertainty and limited resources, Reverse Logistics presents itself as a possible solution to the shortage of inputs, by extending the useful life of products, giving them more possibilities for use. This process of revaluing the product provides a reduction in the use of raw materials, as well as the consumption of energy, water and many other elements that would be part of the so-called primary production chain (Pinheiro, 2014).

Companies can obtain competitive advantages through the implementation of Reverse Logistics practices, which presents itself as a sustainable and profitable business strategy. Furthermore, they can increase their revenue and their service offering, and reduce their costs. Another benefit is the association of your brand with a "green" image, linking it to sustainable concepts (Rafael, 2013; Pinheiro, 2014; Couto & Lange, 2017).

Therefore, the implementation of a Reverse Logistics system can represent reliable proof of the company's commitment to sustainability (Salvi & Schulte, 2014), since consumers, increasingly aware, seek evidence of the veracity of the socio-environmental commitment assumed by companies, that is, people want to see their actions in practice.

For a long time, the management and disposal of solid waste was an activity seen only from an environmental perspective, without the ability to generate financial returns. Over time, it was realized that this view was erroneous and full of prejudices (Leão et al., 2020). Thus, from a financial perspective, through Reverse Logistics, many companies can benefit by reusing material resources that would previously end up directly in the trash, reinserting them into their own production chain, or selling their waste to other companies that can start, for example, a recycling process (Pinheiro, 2014; Couto & Lange, 2017).

However, there are major challenges for the implementation of Reverse Logistics in Brazil: the legislation needs to be revised to better clarify issues related to the management of hazardous waste; setting goals for the use of secondary raw materials; development of criteria for tax exemption for activities linked to Reverse Logistics; tax incentives for products that use recycled materials in their production or have an ecological design ; creation of lines of credit for investment that encourage regional recycling units; and promoting coordination between sectors to align objectives (Couto & Lange, 2017).

2.2.1 REVERSE DISTRIBUTION CHANNELS

Reverse Logistics can be divided into two reverse distribution channels: post-sales and post-consumer, which do not necessarily refer to materials that come from the end consumer. All planning and management of reverse distribution channels are designed aiming to adding value (Leite, 2009). According to Pinheiro (2014), industrial waste can be used as raw material by other industries, through reverse distribution channels, and its commercialization can occur directly with the recycling industry or through intermediaries.

The so-called After-Sales Reverse Logistics is responsible for the return of products with little or no use resulting from a defect shortly after acquisition, the need for repair, damage during transport or not having met the customer's expectations, with the objective of adding value to them (Motta et al., 2011; Pinheiro, 2014).

Post-Consumption Reverse Logistics, the focus of this study, according to Pinheiro (2014), is an area of activity that equates and operationalizes the physical flow and information corresponding to post-consumer goods, that is, goods in usable conditions, at the end of their useful life and industrial waste, which were discarded and returned to the business cycle or production cycle through reverse distribution channels.

Post-Consumer Reverse Logistics ensures that any product that reaches the end of its useful life acquires a new use through recycling, or if this is not possible, it is disposed of safely, minimizing the negative impacts generated. Therefore, it is necessary to develop reverse post-consumption channels that bring these materials back into the production cycle. The attention and care for the product after the end of its useful life demonstrates the responsibility that the company has towards society and the environment (Motta et al., 2011).

2.2.2 REUSE, RECYCLING AND REMANUFACTURING

A Post-Consumer Reverse Logistics can contribute to reducing the use of resources, through recycling product waste, transforming them into something new; reuse; and remanufacturing, making the necessary adjustments, preserving the essence of the products. Recycling and reuse have the power to offer the market a secondary raw material, which was not extracted directly from nature, representing energy savings, saving natural resources and replenishing the production cycle (Motta et al., 2011).

According to PNRS, reuse is the "process of using solid waste without its biological, physical or physical-chemical transformation". Recycling is defined as the "process of transforming solid waste that involves changing its physical, physical-chemical or biological properties, with a view to transforming it into inputs or new products" (Brasil, 2010). Therefore, recycling would be a reverse revaluation channel that transforms products that were discarded into secondary raw materials or recycled products (Monteiro, 2013).

Remanufacturing through repair and/or reconditioning aims to extend the life cycle of products, prolonging their lifespan and minimizing waste generation. It consists of enabling the use of a discarded or broken product again, through an industrial process, which involves: disassembly, cleaning, inspection and sorting, replacement or repair of components, reassembly, testing, and, finally, return to the consumer. The order of these steps can be changed, depending on the product, its volume or on the industry segment to which it belongs. Components that are replaced through this process can be sent to the reverse recycling channel (Bouzon et al., 2011; Monteiro, 2013; Sehnem & Pereira, 2019).

3 METHODOLOGICAL PROCEDURES

Research is applied, in terms of nature, as it aims to solve real problems. The results obtained in the present study may support decision-making by managers of textile and clothing companies regarding the actions to be taken to treat solid waste generated in their production process (Vergara, 2003; Silva & Menezes, 2005; Pinheiro, 2014). This is a qualitative research approach, through which, according to Godoy (1995), we seek to obtain descriptive data about people, places and processes, through the researcher's direct contact with the situation studied. Therefore, the phenomena are seen from the perspective of the study participants.

As for the objectives, the study is exploratory and descriptive. According to Gil (2008), exploratory research lays the foundation for little-explored subjects, allowing the development of concepts and ideas, bringing more clarity to the subject. Finally, this is a multi-case study, as it involves the analysis of two organizations. For Yin (2005), the use of more than one case provides robustness and more convincing evidence for the study.

The research was carried out with two micro-companies located in the Municipality of Santa Cruz do Capibaribe, which were selected according to three criteria: operating in the textile and clothing sector, manufacturing 100% of their products within the limits of the municipality, and allowing visits of the researcher during data collection.

The first company has been operating in the sector for over eleven years. It has approximately 35 employees, a factory with its own headquarters and three stores (two in Santa Cruz do Capibaribe and one in Toritama). The brand is prestigious locally and nationally, and its main product is the cotton knit T- shirt. The second has been working in the sector for four years; its activities are focused on the women's fitness fashion segment; its main product is the polyamide top and pants or shorts set, intended for physical exercise. It has 10 employees; its factory is located on the same land as its owners' residence. It has no stores, just a box at Moda Center Santa Cruz; and its main sales channel is digital, responsible for 80% of the total sold.

A manager from each of the companies participated in the research. In order to preserve their identities and those of their respective companies, it was decided to code them as Manager A and Manager B throughout the presentation and analysis of the results. As a data collection instrument, a semi-structured interview script was used, which served as a guide, allowing an open space for speech between the research participant and the researcher (Flick, 2009). The script was composed of four blocks of questions, organized according to the specific objectives of this study (Chart 1).

Table 1. Interview script.

Specific objectives	Questions
Know the production process	1. Tell us a little about the company and the sector in which it operates.
	2. What products does the company manufacture?
	3. What materials (raw materials) are used in the company's production process?
Identify solid waste that is generated in the production process	4. What solid waste is generated in the company's production process?
	5. What is the company's production stage that generates the most solid waste?
	6. Does the company seek to maximize the use of raw materials used in the production process, in order to minimize waste and losses?
Survey the actions that are currently adopted regarding the treatment of solid waste	7. Does the company know the final destination of its solid waste?
	8. What are the reasons why the company does not adopt correct solid waste disposal practices?
	9. Is there any encouragement from local public bodies regarding correct solid waste disposal practices?
Propose new solid waste treatment actions	10. Does the company know or have heard about Reverse Logistics?
	11. Despite not practicing/knowing Reverse Logistics, would the company be open to discussing the subject and thinking about a proposal for future implementation?

Source: Authors (2022).

The interviews were carried out on pre-scheduled dates, depending on the managers' availability. One of the interviews was carried out in person, and the other via the Google Meet platform. Both were recorded: in person, a voice recorder was used, while online, the platform's own recording resources were used.

In addition, non-participant observation was used in order to understand the dynamics of the production process of the two companies. This data collection technique is a process in which the researcher places herself as an observer in a social situation, having a direct relationship with the individual in their social space, which ends up interfering in the context studied, in the same way that it is transformed by this experience (Minayo, 2007). To systematize non-participant observation, a checklist was used with the points that should be observed during the visits that were carried out in both companies. Table 2 presents the checklist used in non-participant observation during visits.

Table 2. Checklist used in non-participant observation.

| Activity	Goals
Visit to micro-enterprises in the textile and clothing sector	Observe how the productive sectors are divided; Observe the execution of the activities that make up the production process; Observe possible accumulations of production waste; Observe how solid waste is disposed of; Observe whether there are solid waste treatment actions.

Source: Authors (2022).

The treatment and analysis of the collected data began after applying the semi-structured interview script: the collected material was transcribed and read exhaustively, in search of a better understanding of what was answered by the interviewees. Then, the answers were organized according to the questions and their specific objectives. Some brief excerpts from

the managers' responses were included in the results, using the relevance criterion (Mattos, 2006). The technique of interpretative analysis was used, through which organizations are seen as socially constructed realities, with their own members as the main authors, who are creators and maintainers of organizational values and beliefs, in addition to being the main agents of change (Burrell & Morgan, 1979; Brito, 2000; Gobbi & Brito, 2009).

The data obtained during non-participant observation were fundamental to understanding the dynamics of the companies studied. The experience acquired through interaction with the environment allowed the researcher to understand terms and expressions typical of clothing manufacturers, as well as observe the behavior and work rhythm of the people involved. Aiming for a better understanding of how the present study was conducted, Figure 1 summarizes the research steps, demonstrating how it was operationalized.

Figure 1. Research Stages.
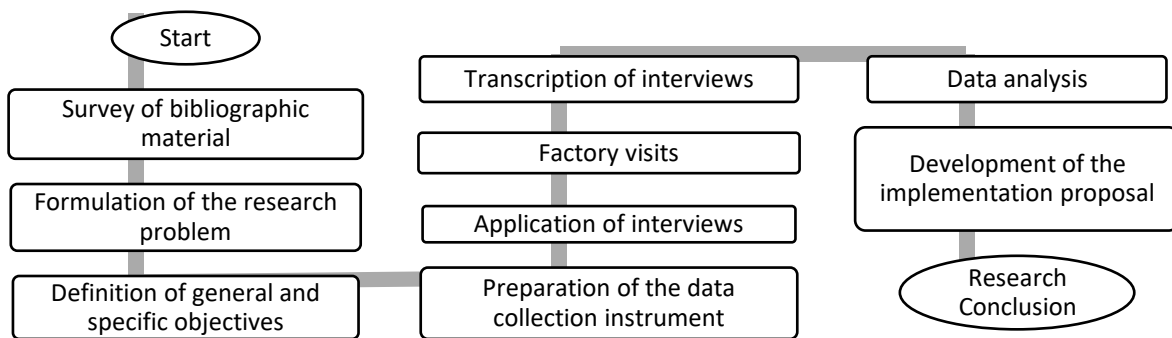
Source: Authors (2022).

4 PRESENTATION AND ANALYSIS OF RESULTS

This section is structured into three sections: 4.1 The production process and companies' solid waste; 4.2 The solid waste treatment actions currently adopted; and 4.3 Proposal of new solid waste treatment actions.

4.1 THE PRODUCTION PROCESS AND COMPANIES' SOLID WASTE

In Table 3 The main products manufactured by the two companies and the materials used by each of them in their production process are presented.

**Table 3.** Main products and raw materials.

	PRODUCTS	MAIN RAW MATERIALS
COMPANY A	T-shirts, Polo shirts, Sweatpants and Pants.	Cotton knit, Suede, Pique, Sweatshirt, Moletinho, Denim, Jeans, thread, buttons.
COMPANY B	Top, Leggings, Shorts and UV protection shirts.	Polyamide fabrics of various weights, lines, elastic, bulge, among others.

Source: Authors (2022).

Depending on the collection's proposal, these inputs and products may be supplemented with items related to current trends, such as: a new type of trim, stonework or metallic appliqués, or new fabrics launched for the season. Regarding the companies' production process, based on the interviewees' responses, a flowchart was created (Figure 2), in which the activities with the greatest potential for generating solid waste were marked in yellow, and the most critical activity in red.

Figure 2. Production flowchart.
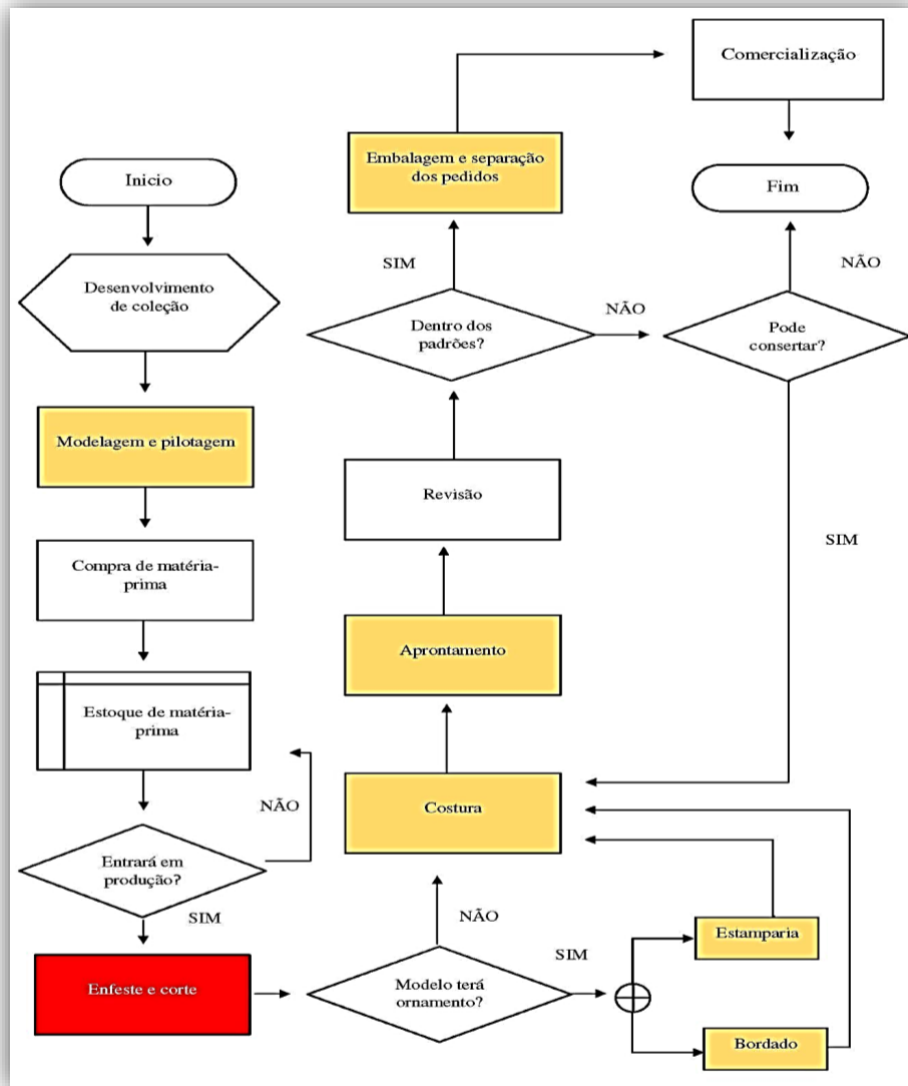
Source: Authors (2022).

4.1.1 COLLECTION DEVELOPMENT

Collection development is the activity in which clothing designers develop the entire creative process of the collections, defining models to be put into production, the raw material, the color palette and the accessories that will be used. At this stage, there is no significant generation of waste, but the decisions made directly affect the environmental impact that the

collection will bring, as solid collection planning, committed to socio-environmental values, results in cleaner and more responsible production.

Regarding the periodicity of collection development, Company A, as it is a men's shirt shop, ends up launching a new collection every new season or when requested by its main customers. Company B, which serves the female public, creates collections weekly, with new features, whether through fabrics with new colors and different textures, new models, or the replacement of pieces that were successful in past collections.

4.1.2 MODELING AND PILOTING

In the modeling and production of pilot pieces, there is the first warning sign for industries regarding the generation of solid waste, as this is where the fabric cutting patterns are determined. Pieces with asymmetrical modeling use more fabric and end up generating a greater volume of waste during the cutting activity, as the shape of their parts makes it difficult to fit perfectly onto the face of the fabric.

In both companies researched, the main waste produced are: kraft paper, which is a 100% recyclable material, whose average deterioration time in a natural environment is 60 days, but its use is less aggressive than other types of paper, as it does not go through the bleaching process; and finished and semi-finished pieces, which do not receive an appropriate final destination (Aparas Macedo, 2023).

Regarding the stage, Manager B commented that:

> We do not put any piece into production before testing the pattern [...] I am the pattern maker of my own production, so I create, cut, invent and test [...] But along the way, sometimes we imagine a model, and sometimes it doesn't work out, the modeling, or the fabric [...] then we test it until perfection [...] Many of these pilot pieces come into my own wardrobe [...] but at the factory there is a huge bag of pilot pieces that didn't work out or need to be finished.

In an attempt to satisfy customers, the same piece can be remade countless times before continuing through the production process; some models are never produced and remain piled up in the factory itself. A portion of these piloted pieces, after approval, goes to Manager B's personal consumption, which despite being a good alternative, does not contain all the material generated.

4.1.3 BALING AND CUTTING

The dressing and cutting activities, according to Managers A and B, are the largest generator of solid waste in the production process of their companies. The activity begins with the arrival of the rolls of fabric that come out of stock and need to be unpacked and unrolled so that they spend around 8h to 12h resting. This step generates a large amount of plastic from the packaging of the fabric rolls, as well as plastic or cardboard straws, in which the fabric is wrapped.

Next, the fabric is laid out on the cutting table. As the fabric generally exceeds the dimensions of the table, the excess part is cut off. During the visit to Company A, we observed an accumulation of bags with these leftover fabrics under the cutting table and on shelves around it.

When questioned, Manager A said that the company currently does not have a plan for reusing these fabric scraps, which can exceed 1 meter in length. Manager B, on the other hand, stated that she uses these pieces of fabric to make pilot pieces and test new models.

After the wrapping is complete, the molds are fitted and the fabric is marked, before the cutting actually takes place. The delimitation of the parts that form the piece on the face of the fabric, which was previously carried out manually, currently occurs through the use of a computer program that, given the width and length of the flat base of the fabric, finds the best possible fit, as commented by Manager A:

> We try to make the most of everything, especially because to maintain a competitive price without losing the quality of the merchandise, the solution is to appeal to reduce costs and waste. One of the investments that helped us the most in this quest to reduce and better use raw materials was the purchase of a system that automates shaping and cutting.

Company A wraps and cuts 80 to 120 rolls of fabric every fortnight, each with an average of 20kg, that is, 1600 kg to 2400 kg, on 4 different benches or sheets. The bench refers to the maximum capacity that can be placed on the cutting table, while the sheet refers to the amount of fabric arranged on the cutting table to meet a production plan with a specific number of models and sizes, pre -determined, with the aim of satisfying a demand. The program used by the company facilitates the fitting of patterns and promotes better use of the fabric, but much of it becomes waste and ends up in the trash.

Figure 3 shows the screen of the program used by the two companies to assemble the computerized trace. It demonstrates what the trace of a basic t-shirt would be like, in which each color refers to a different size of the piece, and the blank parts would be leftover fabric at the end of the operation. After defining the trace, the generated file is printed to be pasted onto the face of the fabric to serve as a guide in the cutting stage.

Figure 3. Computerized trace.
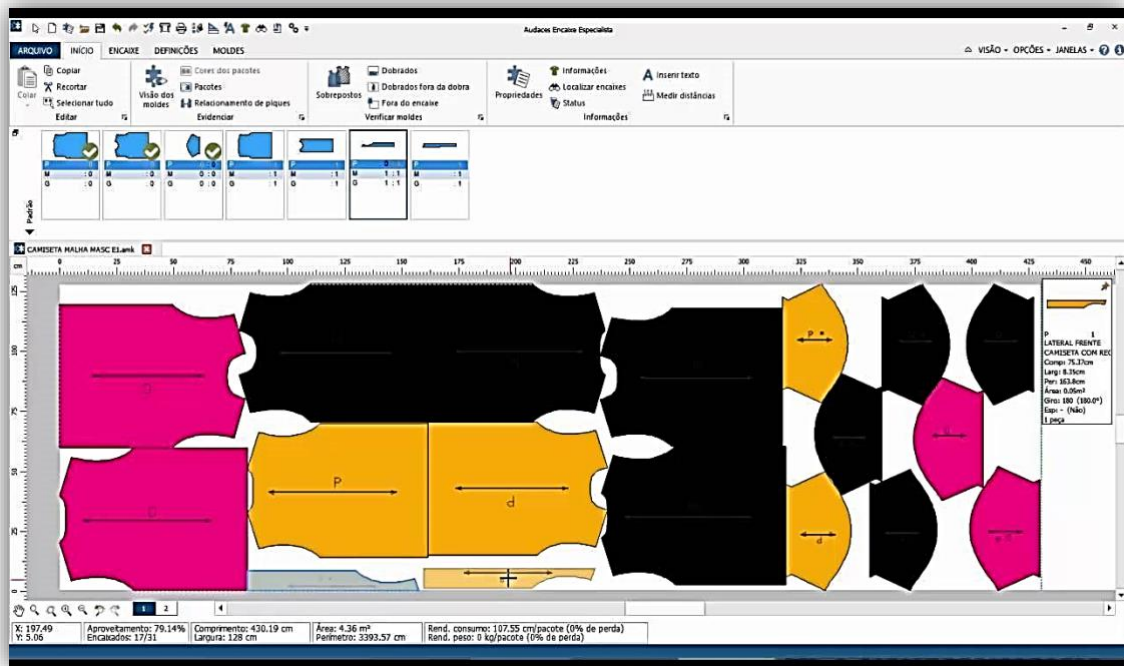
Source: Audaces (2023).

4.1.4 PRODUCTION

The production activity comprises four stages: sewing, printing, embroidery and preparation. In sewing, waste is generated through cuts made by sewing machines, consisting of leftover threads, threads and trimmings, which are deposited in boxes. Typically, these residues are mixed with common trash and food waste. Other common waste generated in this activity are straws, and thread and elastic spools, cardboard or plastic, which, as they have a market value, can be resold. The waste generated in printing and embroidery generally consists of leftover paints and chemical products, interfacing, embroidery threads and needles and stencil bases used in the production of screen-printing screens.

The preparation or finishing activity consists of completing the production of the part. Manager B reports the difficulty of finding accessories, such as buttons, ribbons, cups and laces, with the color corresponding to the fabric, leading to excessive purchases, as there is a fear of not finding certain colors of that item if it is missing during production. Therefore, it is assumed that the waste generated during finishing is the surplus of accessories that make up the piece, which may vary according to the collection proposal.

It is important to highlight the importance of the company developing a collection plan, which is capable of predicting the need to purchase items, such as: labels, buttons, zippers, thermo-adhesive stickers, tags, appliqués, etc., preventing it from occurring too much due to scarcity. Knowing precisely the type and quantity of material that will be used will help the raw material purchasing process, reducing costs, as well as minimizing the risk of waste (Pinheiro, 2014).

4.1.5 PACKAGING AND SEPARATION OF ORDERS

The parts that go through the previous activities and are considered within the standard go to packaging, separation and orders, so that they are then sent to customers. When assembling orders, the following are used: nylon bags, polyethylene bags, string, adhesive tapes (polypropylene and acrylic), cardboard boxes, identification labels, among others.

In the companies under study, there is no standardization of packaging measurements, with the person in charge of the operation being able to make the packages, commonly called bales. This lack of standardization can result in the use of more materials than necessary to package customer orders. Waste from this activity is discarded together with common trash.

After orders are properly separated and packaged, they go to distribution points and are taken to end consumers. Table 4 presents the waste generated in each of the activities that make up the production process of the two companies studied.

Table 4. Waste generated in the production process.

Activity	Solid waste
Modeling and piloting	Leftover kraft paper, finished and semi-finished pieces.
Dressing and cutting	Plastic bags, cardboard and plastic straws, paper scraps, glue residue, piece ends (larger scraps), smaller scraps and strips of cloth.
Embroidery	Threads, needles and interfacing.
Press Shop	Remains of paint, chemicals, stencils and wood from canvas.
Sewing	Bushings (remains of thread and thread), fabric shavings, thread straws, elastic spools, lubricating oil and metal parts that were replaced from the machines.
Preparation	Buttons, zippers, applications, ribbons, thermo-adhesive stickers, labels, non-standard parts.
Packaging	Plastic bags, pieces of nylon, leftover tape and string, paper and cardboard.

Source: Authors (2022).

4.2 SOLID WASTE TREATMENT ACTIONS CURRENTLY ADOPTED

After presenting the production process and the solid waste that is generated, we sought to identify the solid waste treatment actions that have been adopted by the companies under study to minimize the negative effects of their production on the environment.

The waste treatment process must begin preventively, involving the choice of raw materials with sustainable values, as well as the development of patterns that eliminate or minimize leftover fabric. According to Salvi and Schulte (2014), Anicet and Ruthschilling (2013) and Albuquerque (2019), an efficient strategy in the search for more ecological and sustainable fashion production is to use zero waste design, which has its bases coming from the Japanese idea of total quality.

In this context, Manager A demonstrates her environmental concern by including sustainable cotton fabric in his production. She reported that the mesh is in the testing phase, and that the permanence of the input will depend on customer validation. However, this can already be considered a big step towards more efficient management, which starts with the good choice of materials that satisfy current needs without compromising future generations. Thus,

Company A's concern with delivering value to its customers was evident, while maintaining a commitment to the environment (Brundtland, 1991; Kotler & Armstrong, 2015).

Company A's initiative to include sustainable cotton fabric in the production of its collection is aligned with sustainable design, in which some elements are exchanged with a view to maintaining and preserving the environment (Donaire, 1999; Rafael, 2013).

Manager A also stated that one of her strategies to maintain the competitive price is to minimize losses and waste in the production process, in addition to trying to reuse as much as possible the leftovers of past collections in the production of future collections. According to Leite (2009), one of the biggest motivational factors for companies to choose to reuse or reduce their losses in the production process is still financial motivation.

In short, the actions currently carried out by Company A regarding the treatment of solid waste generated in its production process are: weekly sending of fabric scraps from cutting activities to a company that manufactures bushings, which are used in automotive cleaning; separation of plastic and cardboard, which are subsequently sold; and pieces that do not meet quality standards are sold at 40% of their original value.

Company B, on the other hand, had the pandemic as its starting point for developing actions related to reuse, as Manager B comments:

> [..] mid-2020 until a little bit of 2021, we made a lot of masks to send as gifts to our customers. These masks were placed between the mold inserts, in that part of the fabric that would go to waste. This was very positive for us, our customers loved the treats, and the cost was very low. We liked this idea and whenever we can fit in, we add some treats, such as: pompoms for the hair, little bags, those things that you can make with scraps of cloth.

Furthermore, Manager B stated that whenever possible, she sends leftover fabrics to nearby rural areas. Family members of the manager, who live in this location, use the leftover fabric to make rugs and some handicrafts that are sold, and the value serves as a supplement to the family income.

Although these actions adopted by companies are a beginning, they still do not cover the entire universe of solid waste generated by their production processes, which requires greater structuring.

4.3 PROPOSITION OF NEW SOLID WASTE TREATMENT ACTIONS

After identifying the actions that are currently adopted by the companies under study aimed at treating solid waste generated by their production processes, possible actions were proposed with the objective of the future implementation of a Reverse Logistics system. According to Monteiro (2013), there are five basic questions that guide the entire process of implementing a Reverse Logistics system: why implement it? why return? how? where? who?

The large volume of waste generated weekly, aligned with the desire to link the brand to environmental issues in order to promote consumer reliability regarding the company's

commitment to the environment, are some of the reasons that lead to the implementation of a Logistics system Reverse in a company (Rafael, 2013).

Furthermore, returning materials to production lines can reduce energy and water consumption. According to the Brazilian Agency for Industrial Development (ABDI, 2019), every ton of recycled material saves 75% of energy and 450 liters of water. Furthermore, Reverse Logistics is an ally for maintaining sustainable and profitable businesses (Couto & Lange, 2017).

Therefore, the following actions were proposed for the treatment of solid waste from the two companies:

● Separation of waste generated in the production process - Xavier and Corrêa (2013) point out that the implementation of Reverse Logistics must begin with the separation of elements that can be inserted into a new production cycle and those that must go to an appropriate final destination;

● Sale of industrial waste - waste from the production sector under study has added value, and after being classified by size, can follow different paths: pieces of fabric longer than 1 meter can be sold to smaller clothing manufacturers that use scraps in their production, directly or through intermediaries, since the Municipality of Santa Cruz do Capibaribe has several stores specializing in retail sales; pieces smaller than 1 meter can be sent to companies who defibrate fabric or for cooperatives that produce handicrafts; plastic from input packaging can be sold to recycling industries, as can trimmings and accessories that can no longer be reinserted into the companies' production process (Pinheiro, 2014);

● Return of materials to suppliers - a solution for materials such as straws and thread cones would be to seek agreements with suppliers so that these items can return to their point of origin, which could further strengthen partnership bonds, generating benefits for both parties (Motta et al., 2011; Pinheiro, 2014);

● Reuse of packaging: considering the waste of materials in making bales with orders, based on Lacerda (2002), it is suggested that companies reuse cardboard boxes of different sizes that routinely arrive with inputs productive, to be used as packaging for products that will be sent to customers;

● Partnerships with cooperatives and associations of collectors - all waste not covered in previous proposals can be sent to these institutions, where they will have the possibility of being reused or recycled, since the municipality has the Association of Recyclable Collectors of Santa Cruz do Capibaribe - ACRESCC, which has sought to support solid waste management.

Thus, Table 5 summarizes the proposed solid waste treatment actions.

Table 5. Proposed solid waste treatment actions.

Solid waste		Action
Leftover fabrics	Pieces measuring 1 m or more	Sell to clothing manufacturers that use scraps in their production.
	Pieces less than 1 m	Send to companies that defibrate the fabric or to artisan cooperatives.
	Strips or claws	Provide appropriate disposal.
Input packaging	Plastic packaging	Sell to recycling industries or send to the collectors association.
	Cardboard boxes	Reuse in order packaging activity.
	Plastic and cardboard straws, cones and spools	Seek agreements with suppliers in order to enable their return, reversing the value as a discount on the next purchase
Leftovers from collections	Buttons, threads, collars, zippers and other fittings	Send to artisan cooperatives or collectors' associations

Source: Authors (2022).

In addition to the actions aimed at treating solid waste generated in the production process of Company A, some actions aimed at the return of post-consumer parts are also proposed. The idea consists of, initially, making the company's customers aware of the importance of caring for the environment, and informing them that the company is doing its part by dealing with waste from its production.

Taking advantage of the launch of its shirts produced with sustainable cotton, Company A could simultaneously launch a project aimed at returning post-consumer pieces. Thus, the company could promote, through social networks and direct communication channels with its customers, an awareness campaign about the importance of sustainable consumption that highlights the actions that the company has been adopting in the search for environmental preservation, calling on its customers to participate, whether by purchasing sustainable parts or enabling the return of parts that have reached the end of their useful life.

The company could, initially, offer a percentage of discounts to customers who, when purchasing shirts from the sustainable cotton line, return shirts that they no longer use. This action, in addition to strengthening the company's ties with its consumers, could effectively initiate a process of returning parts after the end of their useful life (Leite, 2009; Schulte et al., 2014). Returning spaces for these parts could be made available in the company's stores, and it could also be possible to create a credit or a voucher for the customer's next purchase.

The collected pieces, after going through a sorting process, if they were in good condition, could be donated to needy families or sent to bazaars of social institutions (Schulte et al., 2014; Albuquerque, 2019). And the parts that have effectively reached the end of their useful life should have the correct final destination monitored by the company, preventing them from being sent to open dumps.

5 FINAL CONSIDERATIONS

The general objective of this study was to propose the implementation of Post-Consumer Reverse Logistics practices in the treatment of solid waste from micro-enterprises in the textile

and clothing sector in Santa Cruz do Capibaribe. To this end, the production process of the two companies that participated in the research was known, the solid waste that is generated and the actions that are currently adopted regarding the treatment of solid waste were identified, and, finally, proposals were made. New actions that can be taken, aiming at a future implementation of Post-Consumer Reverse Logistics.

After getting to know the reality of the two companies in the textile and clothing sector in Santa Cruz do Capibaribe, it was concluded that there is a long way to go in the search for the implementation of Post-Consumer Reverse Logistics practices in these industries. Currently, it is clear that companies' efforts to correctly dispose of solid waste arising from their production are insufficient, as they adopt few treatment actions, which occur without effective planning, leaving room for incorrect disposal of a high volume of materials, which could be reinserted into some production chain. Therefore, actions to treat this solid waste were proposed, involving resale, recycling, reuse or the most appropriate final destination.

Regarding the limitations of the research, it is worth highlighting that companies located in the studied municipality still show some resistance in providing information regarding their production. Several managers were invited to participate in this study; however, knowing the content of the interviews, they ended up declining the idea. There is still a certain fear, on the part of some managers, that their information will be exposed unduly, even with the researcher's vehement affirmation of this study's commitment to ethics and confidentiality.

Nevertheless, this study achieved its objectives and could contribute to expanding the discussion on the treatment of solid waste through the implementation of Post-Consumer Reverse Logistics practices. It can also assist in decision-making for micro and small business managers of the textile and clothing sector. Furthermore, it may encourage more researchers to decide to delve deeper into this topic.

For future work, it is suggested to focus on topics that did not have space in this study, such as: consumer perception of companies that adopt solid waste treatment actions; the impacts of the COVID-19 pandemic on the generation of solid waste; studies on the generation of solid waste in rural Pernambuco; paths towards cleaner fashion production; replacement of traditional raw materials with items with sustainable motivations, among others.

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