

Textile Waste Management Practices In The Garment Industry: a Circular Economy Perspective

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Abstract

The global production of textile fibers, the consumption of textiles, and the amount of textile waste are generating problems at ever-higher levels. A way to reverse this situation is the reinsertion of clothing items already used in the production chain. Thus, in the light of the circular economy, this research aims to identify and characterize practices for the management of post-consumer textile waste involving the process of collection, sorting, and reinsertion of garment items in the production chain. The methodology applied to this study involved an in-depth semi-structured interview with 11 industry experts from micro and small-sized companies (SMEs) located in the Florianopolis city (Brazil). Our intention was to analyze their current textile waste management, considering the resources and the responsibilities necessary to carry out the circular textile waste management practices. It was concluded that although the business models may have emerged with sustainable principles in their foundation, waste management textiles are also strongly affected by the external environment, mainly by consumers.

Keywords

Circular Economy, Textile Waste Management, Garment Industry.

1. Introduction

The waste management literature has, accordingly, attached particular importance to disposal of clothing items in post-consumption due to the growth in the disposal of large quantities of textile waste to landfills and unsold stock through incineration (Hu et al., 2014, Hvass, 2014, Burton, 2018). In addition, although much of the textiles used in the manufactured items can be reused or recycled, it is estimated that 85% of global production has its final destination in landfills (Mckinsey Global Fashion Index, 2019; Burton, 2018).

This issue can be changed if the flow of garment materials throughout the production chain and consumption becomes circular using reuse and recycling practices (Pal, Gander, 2018). In addition to environmental advantages that can be caused by the reuse and recycling of textiles, there are benefits from a socioeconomic

perspective, since it can help not only the impacts caused by the industry, but also the companies inserted in it, in particular, Small and Medium Enterprises (SMEs) (BOCKEN et al., 2017; KOZLOWSKI et al., 2018).

According to Kozlowski et al. (2018), SMEs represent a significant portion of the garment industry and can significantly contribute to the transition to a circular model of production and consumption. Moreover, Bocken et al. (2017) demonstrated that the circularity experimentation process is not necessarily exclusive to SMEs. The responsibilities and resources needed in large garment brands from a circular economy perspective were analyzed and it was concluded that the diversity of other projects (between university or other companies) continues to be a promising path that can trigger new activities and practices, which are in the core of transitions to circularity (Bocken et al., 2017; Diddi et al., 2019).

However, it is still difficult to align market expectations with circular practices, since the introduction of sustainable measures for the capture and use of resources is still organized linearly, which may result in the loss of competitive capacity and incompatibility with proposals to create value for the customer (Franco, 2017; Pal, Gander, 2018). Furthermore, textile waste management process in which circular practices are inserted are still considered dispersed. Thus, from a circular economy point of view, this implies the design of solutions that take into account the responsibilities and interdependencies created between the agents related to the management of textile waste and the resources necessary to collect, sorting and reinsert materials into the garment production chain (Pal, Gander, 2018).

From a practical point of view, these practices can offer an overview of how they are chosen by garment brands and how this operation takes place (resources and responsibilities). In a theoretical way, the identification and mapping of these initiatives would provide new solutions that can be tested in other contexts (Bech et al., 2019).

1.1 Objectives

Therefore, through the analysis of eleven Garment SMEs brand located in metropolitan Florianopolis (Brazil), this study aims to:

- a) Identify the current practices of collection, sorting and reinsertion of post-consumer textile waste with focus on practices that reduced use of natural resources and promote circularity of textiles in the supply chain; and
- b) Characterize the current practices identified in relation to resources and practices' responsible, under the closed-loop perspective, from the reuse (preferably) and recycling of textile waste management.

2. Literature Review

2.1 Circular practices in the management of textile waste in post-consumption

The final disposal of garment items by consumers does not necessarily mean the loss of its structural integrity or physical utility (Fraser, 2011). In this case, a circular textile waste management can be taken into account, developing collection, sorting and recovery processes together to optimize organizational arrangements and maintain negative environmental impacts to a minimum (Dahlbo et al., 2017). Circular practices are understood as activities that aim to keep textile resources in closed-loop cycles within the production and consumption processes at their highest level, based on the capture of value after the consumption of clothing items by the consumer.

Waste management encompasses three processes, namely: (a) collection that indicates the accumulation of clothing items in post-consumption, (b) sorting which means deciding what to do with each product and, finally, (c) reinsertion that indicates re-integrate the item in the production chain (Beh et al., 2016). According to Leal-Filho et al. (2019) the positive impact of collection process begins with habits (and possible re-education) in consumer behavior. The correct disposal of clothing items for donation or resale in second-hand stores involves the user's knowledge and understanding of recycling, reuse and sustainability (Hu et al., 2014).

Generally, such collection practices are carried out through different channels, with the collectors being responsible for defining and organizing the way in which they will communicate, search for and remove clothing items to transport these products independently to the sorting centers (Palm et al., 2014; Franco, 2017). In general, collection initiatives are usually chosen with a view to those responsible for the activity and available resources (e.g. Franco, 2017; Méjias et al., 2019).

Once collected, textiles are systematically separated and classified, depending on certain criteria that will define the destination of the material and the processes by which the textiles will be reprocessed (Hu et al., 2014;

Bukhari et al., 2018). The sorting process flows after collection, and it can be directed according to the channels chosen by the consumer after using the clothing item (resale or donation). After the separation process, the item of clothing can be reinserted into the production chain through reuse or recycling.

The recycling process involves the sorting and classifying of textiles based on their conditions and the types of fibers used. Usable post-consumer items are sold or donated, the rest are crushed and made into fiber or textile using mechanical procedures (for example, the separation of textile items by color is important to avoid the generation of pollutants and allow savings energy), crushing and extraction (depending on the final use, it is necessary to incorporate virgin fibers), carding (cleaning and mixing yarns) and spinning (Lela-Filho et al., 2019; Noman et al., 2013).

Conforming to Ellen MacArthur Foundation (2017), recycling initiatives that process waste into by-products of lower added value should be used in situations where other reuse initiatives cannot be applied or when its application has a high environmental impact. If compared to reuse practices, recycling practices are less important in terms of ensuring the circularity of resources in the production chain. This is because in the processes of reuse and restoration, the basic functionality of the material is maintained, conserving it at its highest value within the resource cycles (Pal, Paras, 2018).

The reuse practices deal with the collection and separation of post-consumer clothing items that usually do not have any type of defect and can be used after basic sorting, washing, basic finishing or restoration. In this way, the clothes can be converted into a usable form through direct resale, upcycling practices (functions of the item maintained and improved) or downcycling (functions inferior to the item, e.g. carpet) (Pal, Paras, 2018; Han et al., 2017).

2.2 Resources and responsible for circular practices in the management of textile waste in post-consumption

The emergence of circular economy is becoming widely addressed by companies, society, governments, media and researchers, in order to achieve sustainable growth (Govidan, Hasanagic, 2018). As stated by Patora-Wysock and Sulkowski (2019), any environmental practice will include several activities developed collectively, focusing on the use of resources and interactions holistically, in the search for innovation and responses to society's demands. In this idea, stakeholders - consumers and companies - play a central role in closing resource cycles, requiring the understanding of stakeholders in the circular economy ecosystem, mainly in terms of responsibilities and actions within the activities developed (Staicu, Pop, 2018).

Although no literature was found that specifically addressed the stakeholders in the stages of collection, sorting and reintegration into the garment production chain, it is possible to observe that, in the majority, the activities involve the direct relationship between the company that will reuse or recycle clothing items (Keith, Silies, 2015; Han et al., 2017), the designers (Yasin, 2017) consumer and user (Mcqueen et al., 2017, Vehmas et al., 2018; Kim, 2019), NGOs (Brace-Govan, Binay, 2010; Hu et al., 2014) and Public Administration (Larney, Van Aardt, 2010; Burton, 2018).

Table 1 summarizes the relevant stakeholders' characteristics identified in the literature:

Table 1. Relevant stakeholders' characteristics identified in the literature

Stakeholders	Description
Consumer	Consumers using and participating in the disposal process and/or reuse of clothing items
NGOs	NGOs that donate, resell or transform donated or discarded products through collection, selection and reinsertion processes in the production chain
Designer	Freelance professionals who perform upcycling processes on items of post-consumer clothing
Public Administration	Public authorities and universities engaged in new solutions for waste management
Companies	Companies that reuse or recycle post-consumer items, preferably SMEs

In relation to resources, the analysis of the literature made it possible to infer that technological aspects, qualified labor and transportation of textiles are commonly mentioned, mainly, in studies that address the management of textile waste related to pre-consumption and post-consumption (Noman et al., 2013; Larney, Van Aardt, 2010; Bukhari et al., 2018). Thus, the resources were discussed with a focus on the technologies adopted to operate the activities (low, medium or high automation), qualified labor (high, medium or low specialization) and transport chain between and through the links of textile waste management (distance between different collection, sorting and final destination of garment items and its characteristics).

3. Methods

Regarding approaches applied in this exploratory study, they were divided into 4 stages, being: (1) Construction and validation of the data collection instrument, (2) Application of the data collection instrument; (3) Definition of data analysis's approach, and (4) Analysis of data and results achieved. The first stage defined the instrument for data collection. It was chosen for an in-depth, semi-structured interview, as it aims to understand the current circular practices of textile waste management adopted by SMEs.

The in-depth interview was conducted with 11 professionals working in the garment industry, with majority working in SMEs, as they represent a significant portion of the clothing industry and can contribute significantly for the transition to a more circular economy (Testa et al., 2017). The content of the interviews were analyzed based on the content analysis, adapted from Charmaz (2009), Bardin (2010) and Miltra and Buzzanell (2016).

Initially, it was performed the open coding, where the main themes occur on the basis of recurrence, salience, forcefulness and repetition during the pre-analysis (MILTRA, BUZZANEL, 2016). Charmaz (2009) points out that this code are the expectations of answers arising from the interview questions, linked to the theory that supports the study, focused on the object of analysis and coded in an axial way, thus, as the same term (category) can be approached in different ways (subcategories).

The codes were grouped into thematic axes, according to Bardin (2010). The thematic axes were divided into: (1) Description of circular aspects in the management of textile waste in the operation; (2) feasibility of the business, (2) Description of resources and textile waste management practices' responsible. After that, it was executed the exploration of the material, where it could emerge new codes or thematic saturation (MILTRA, BUZZANEL, 2016).

From exploration of the material, the excerpts of the interviews were allocated to the defined categories that encompassed two thematic axes. The treatment of results deals with interpretation of the material identified and grouped by each thematic axes (using the defined codes). The textile waste management practices were organized in: (a) circular economy aspects were treated and discussed with literature review, (b) table with its characteristics by the links of collection, sorting and reinsertion of garments items. The issues related to resources and stakeholders were organized with a table where it is defined as the main resources and responsible quoted in interviews.

4. Data Collection

The data collection was carried out from May to June 2020, and a pre-test was previously carried out to validate the data collection instrument. Initially, industry experts were contacted by direct message on the social network Instagram. 48 experts from the clothing industry were contacted and, among them, 11 accepted to participate in the study. In-depth interviews were conducted using video calls and lasted an average of 45 minutes.

The interview protocol started with more general questions, which take into account the respondents' profile (education, position in company, work experience). This part aimed to encourage greater proximity and free participation of the interviewee. Subsequently, the participants were asked about broader issues in relation to the circular economy and their understanding of the topic and finally, questions were asked about their daily work experiences, direction to collection, separation, reuse or recycling process of post-consumer textile waste.

After data collection, a content analysis was carried out where the data were pre-analyzed, coded and explored based on the categorization of the data and treated based on the research objectives. The results achieved will be exposed in the following session.

5. Results and Discussion

5.1 Description of current circular practices by regional brands in the stages of collection, sorting and reinsertion of clothing items

Although there are studies that address circular models of waste management in the garment sector (Jung, Jing, 2017; Vehmas et al., 2018), there is a lack of studies to investigate these theoretical concepts applied in real context and discuss the impact of adopting a given initiative, since decisions can be influenced by factors external to the business model (Bukhari et al., 2018).

In this study, when analyzed in a practical context, the circular economy was also defined within an environmental context. Usually, the understanding of the literature by circular business models is to improve environmental performance, when compared to conventional business models. In total, of the 11 interviewees, 7 claimed to know the term Circular Economy.

Even those respondents who did not know the term (4 respondents) understood that the circular economy could improve environmental performance at the expense of economic performance. In addition to this, although only 6 respondents started their business with sustainable values in the company's values, all respondents indicated that currently sustainability is currently integrated into the company's strategy and thought about its application in the context of collection, sorting, reuse or recycling of post-consumer garment items.

It is observed that 10 respondents had some initiative for reuse in their business model (among these, 8 microentrepreneurs) while only 1 interviewee worked directly with textile recycling (medium company). On average, the experts had 5 years of experience in the sector, while the companies that they worked were 2 years old.

Regarding the conceptualization of the term, most respondents understand the circular economy as being a movement of materials in a closed-loop cycle. In this sense, they have an understanding of their full use after reuse, to avoid disposal and the consequent accumulation of waste generated, thus promoting the sufficiency of natural resources in the future. In relation to the description of practices in textile waste management, Table 2 summarizes the information per interviewee.

Table 2. Description of SMEs analyzed practices in textile waste management

Interviewee	Collect	Sorting	Reintegration
Interviewee 01	Small volume collection of poorly maintained garment items at thrift stores and transport to studio	Manual sorting of items for donation or reuse. Process of washing the garment item and transfer to reuse process	Activity that makes jeans in backpacks and bags
Interviewee 02	High-volume collection of textile waste pre and post-consumer through suppliers and transport to sorting center	Manual sorting of items for donation or recycling. Process of manual cut and transport to conveyor belts	Activity in which polyester-based textiles are compressed into small pieces, and then crushed to be transformed into new fibers for rewiring
Interviewee 03	Small volume collection of garment items by bin disposal or donation items	Manual sorting of items for resale. Process of washing the garment item and transport to the customer	Activity that transforms umbrella on bags and purses
Interviewee 04	High-volume collection of textile waste through customer donations, NGOs and partnership with large-size garment brands	Manual sorting of items for re-use and transportation to studio	Activity transforming high-quality garment and textiles in new products or by-products with same function

Interviewee 05	Small volume collection of garment items through mining in personal collection and other users	Manual sorting of items for donation or reuse. Process of washing the garment item	Virtual resale activity garment items in good condition
Interviewee 06	Small volume collection of garment items in good condition at thrift stores and transport to studio	Manual sorting of items for donation or reuse. Process of washing the garment item	Virtual resale activity garment items in good condition
Interviewee 07	Small volume collection of garment items in good condition at thrift stores or NGOs and transport to studio	Manual sorting of items for donation or reuse. Process of washing the garment item	Resale activity garment items in good condition in physical and virtual store
Interviewee 08	Collection point for medium-volume disposal of garment items in good condition	Manual sorting of items for donation or reuse. Process of washing the garment item.	Activity that turns jeans textile waste into accessories
Interviewee 09	Small volume collection of garment items in good condition at NGOs	Manual sorting of items for donation or reuse. Process of washing the garment item	Virtual resale activity garment items in good condition
Interviewee 10	Small volume collection of garment items in good condition at NGOs	Manual sorting of items for donation or reuse. Process of washing the garment item	Resale activity garment items in good condition in physical and virtual store
Interviewee 11	Small volume collection of garment items in good condition at thrift stores	Manual sorting of items for donation or reuse. Process of washing the garment item	Activity that turns jeans textile waste into accessories

Regarding answers about how informants perceived their role in the textile waste management, it was observed that the collection and separation still mostly occur in small volume and manually. Usually, choosing a waste management practice was defined due to the treatment capacity of these items of garment or due to the maturity of the business, considering that the average time of analyzed companies were 2 years.

About the sorting process, all respondents indicated to use manual sorting. It was noted that the collection volume itself (small volume) interferes with the preference for manual sorting. This manual separation is more accurate because, according to the interviewees, it guarantees a better quality in the collected materials. In fact, the separation in some cases (3) occurs at collection stage. Related to automation in the sorting process, it was only mentioned on recycling processes. The activity consists of transferring the sorting garments items (disassembled) to extruders by conveyor belts.

In relation to reinsertion, the cycling of the materials' composition was based precisely on the quality of this textile for reuse and abundance of the material at disposal points, especially jeans. The respondents understood that it is necessary to align customer expectations with the garment item collected to achieve, simultaneously, economically advantageous performance and company's values (companies that operate with a sustainable mindset).

The findings from the recycling process show that the items collected are categorically prevented from being reused (e.g. industrial uniforms). In addition, the collected and reusable clothes are separated during the manual process and donated to NGOs in the company's region. According to the Interviewee 02, this amount is small and does not make the business unfeasible.

Finally, it can be noted that the collection initiatives are strongly driven by the final proposal for garment items, while manual separation remains the most widespread initiative by all respondents, usually related to

consumer acceptance. Additionally, closed-loop business models need to guarantee resources in an increasingly competitive market and focus on brand growth (Norris et al., 2019). Thus, the analysis of a circular (singular) business model is not assertive, as circular economy solutions depend on the contributions of various stakeholders to the business models (PEDERSEN, HVASS, 2019). The following section discusses the stakeholders involved in the textile management process and the resources allocated for the practices applied between the SMEs analyzed.

5.2 Description available resources and stakeholders involved on brand's textile waste management

The description of the resources aims to address the understanding and dissemination of technologies, qualified labor and transportation between the textile waste management process of collection, sorting, reuse and recycling. On the other hand, the description of those practices responsible seeks to identify the interviewees' perception of how many agents actively participate in this process. In general, it was observed that the use and understanding of technologies is low, also justified by the volume of collection and production is still small, and the automation process costs do not fit in the current company's budget. Table 3 summarizes the interviewees' information.

Table 3. Main resources and Stakeholders cited by respondents

Interviewee	Resources	Stakeholders
Interviewee 01	Transportation network, Sewing Machine	Company and Consumer
Interviewee 02	Technologies for cutting and melting textiles, technology for cleaning the fibers, transportation network	Major retailers, manufacturers and NGOs
Interviewee 03	Transportation network, qualified labor	Company and Consumer
Interviewee 04	Transportation network, qualified labor	Company and Consumer
Interviewee 05	Transportation network	Company and Consumer
Interviewee 06	Transportation network, qualified labor	Company and Consumer
Interviewee 07	Transportation network, qualified labor	Company and Consumer
Interviewee 08	Collection points in public areas, transportation network, sorting center, qualified labor	NGOs, Company and Consumer
Interviewee 09	Transportation network, labeling systems	Company and Consumer
Interviewee 10	Transportation network, qualified labor	NGOs, Company and Consumer
Interviewee 11	Collection points in public areas, transportation network, sorting center, qualified labor	Company and Consumer

According to the interviewees, the resources are also important to choosing the garment items and vary according to the organization's business model. Among the technologies that the experts mentioned are interested in the future, it is highlight the cutting technologies that make it possible to use the collected textile waste in the best possible way. Regarding qualified labor, the majority linked high specialization with the success of textile waste management practices.

It is also clear that the characteristics of the cargo and the distance between the different collection centers directly affect the initiatives discussed. In addition, there is a strong environmental sense to carry out the logistics taking into account the distance between the collection points (e.g. if it is a greater distance, it will be a greater fuel consumption, which consequently increases the emission of polluting gases).

As for those responsible for the initiatives, such agents represent those who perform direct function in the activities and necessarily participate actively in the initiative, thus restricting the power of decision between the focus company, NGOs (usually in the collection process) and customers. The latter constitutes one of the actors with the greatest influence on the definition of choice for a given initiative. The respondents understand the social role of the NGO and also saw not only better economic performance (due to more affordable prices), but also better environmental performance, given that such NGOs are benefited by large fast fashion retailers with non-sale stock items that if not resold, would simply be incinerated.

The theoretical framework also pointed out that external pressures, in particular, customer demands, directly influenced the way companies seek and reinsert garment items to the production chain (Diddi et al., 2019; Leal-Filho et al., 2019). Therefore, the search for garment items that meet the current business model and, consequently, the expectations of customers, mainly influence how respondents collect this material, depending on a qualified workforce and aligned with the final objective. of reuse of this textile residue (Franco et al., 2017).

In summary, the respondents are seeking to collect garment items that align customer expectations with social or environmental aspects. Another integration action also takes place when considering transportation between stages of waste management, since it also interferes with business costs and sustainable values defended by the organization. Qualified labor was even approached by all respondents due to being an activity that allows a better use of the collected textile waste. On several occasions, the collection and sorting practices were carried out together, given that in some practices the collection by quality and usable garment dominates (LEAL-FILHO et al., 2019).

In this way, a qualified workforce, based on the choice of collection points, defined the analyzed practices. In addition, waste management practices are affected by consumer expectations. Thus, the interviewees seek practices that align the sustainable values of the business with market expectations.

6. Conclusion

The purpose of this study was to explore the post-consumer textile waste management from a circular economy perspective. The study shed light on subjects that deal with responsible and resources that are taken into account during the collection, sorting and reinsertion of garment items in the production chain. Currently, in the SMEs analyzed, the resources focused are transportation networks (related to distance and type of material collected), highly qualified labor and composition of collected textile. The main agents involved in the processes are the SMEs that develop the initiatives, customers and NGOs. In addition, although in the theoretical context, technological resources emerge as the main item for assertiveness in the implementation of initiatives, in praxis, the most cited resources were transportation and qualified labor.

According to respondents, more than designing technologies for reuse and recycling, it is necessary to map the resources that compose the garment item. Therefore, disposal, return and disassembly practices become more efficient in the re-insertion of resources into the production chain. This statement corroborates with the theoretical findings indicative of the complexity of textiles (composition) in creating new technologies.

However, the analysis of the initiatives is still carried out by industry experts with a micro vision, aiming to very well align customer expectations with the types of materials needed for the production process. Therefore, not only are the company's values met (thinking of companies that operate with environmental principles), but also waste management enables economically advantageous performance.

Among the limitations of the work, the number of respondents is reiterated. In subsequent surveys, an approach that encompasses a larger number of respondents would be interesting. With regard to recommendations for future studies, it is observed that the replication of the same study in another region would allow the analysis of clusters and, thus, compares the findings of this study with new research. In addition, mapping economic, social and environmental criteria can provide inputs to analyze practices in a more comprehensive circular perspective.

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Acknowledgements

The authors would like to thank CNPq (The National Council for Scientific and Technological Development) and CAPES (Higher Education Improvement Coordination) for the financial support of this research.

Biographies

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Lucila Maria de Souza Campos is Associate Professor and currently head of department at Department of Production Engineering and Systems (EPS), at Universidade Federal de Santa Catarina (UFSC). She is also accredited as a teacher and supervisor in the Professional Master in Management Systems of the Universidade Federal Fluminense (UFF). She was visiting professor at Royal Holloway University of London (2015-2016) in the area of Sustainability. She holds the titles of Doctor (2001) and Master (1996) in Production Engineering by Universidade Federal de Santa Catarina and Bachelor in Production Engineer (1993) by Universidade Federal de São Carlos. She is also Permanent Professor of the Graduate Program in Production Engineering (PPGEP/UFSC) since 2010 and coordinator in the mandates 2013-2015 and 2017-2019. She teaches and researches in Production Engineering, with emphasis on operations management, environmental management and sustainability. Her research interests include EMS, sustainability indicators, lean manufacturing, green manufacturing, and circular economy, among others.