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"Gheorghe Asachi" Technical University of Iasi, Romania

RELATIONSHIP BETWEEN CLEANER PRODUCTION PRACTICES AND COMPANY SIZE IN THE BRAZILIAN TEXTILE INDUSTRY

Geraldo Cardoso de Oliveira Neto*, José Manuel Ferreira Correia[1], Henrricco Nieves Pujol Tucci[1], Paulo Cesar da Silva[1], Dirceu da Silva[2]

[1]Industrial Engineering Post-Graduation Program, Universidade Nove de Julho (UNINOVE), Vergueiro Street, 235/249 - 12nd Floor, zip code: 01504-001, Liberdade, São Paulo, Brazil
[2]Department of Cultural Practices, Universidade Estadual de Campinas (UNICAMP), Bertrand Russell Avenue, 801 - Zip code: 13083-865, Campinas, São Paulo, Brazil

Abstract

The application of Cleaner Production (CP) practices is a preventive strategy guided by economic and environmental benefits to companies. The textile industry is a major generator of pollutants, yet it is a crucial sector in Brazil that generates annual revenues of USD 51.58 billion and millions of jobs, even though it is constituted mostly of small and medium companies. This study aims to identify the CP practices adopted by different sizes of companies in the textile sector located in Brazil. A survey was conducted, and answers were analyzed using the Kruskal-Wallis test to assess the relevance of each CP practice according to company size. The results showed that small companies apply CP practices exclusively for economic benefit because they have financial difficulties and lack of credit, medium-sized companies are challenged by large supply chains to achieve an environmental management system to provide products and services, and large companies seek green certifications to export their products to the European market. The results contribute to business practices by facilitating identification of the most relevant CP practices for each company size.

Key words: company size, CP practices, textile industry

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1. Introduction

The World Commission on Environment and Development (WCED) emphasized the need for present and future generations to operationalize sustainable development through cleaner technologies and products. The term Cleaner Production was first defined as a conceptual and procedural approach to production that considers all phases of a product's life cycle with the aim of preventing or minimizing risks to humans and the environment (Baas, 1995). Since then, the term Cleaner Production (CP) has received more definitions, such as preventive actions to reduce and offset pollutant emissions and depletion of resources, economic and environmental benefits, efficient use of raw materials, efficient use of water, efficient use of energy, recycling, waste reuse and occupational health benefits (Glavič and Lukman, 2007; van Berkel et al., 1997).

The World Bank estimates that nearly 20% of all freshwater pollution in the world is caused by the textile industry (Periyasamy et al., 2017) as a result of improper disposal of chemicals and toxic metals used in its production processes (Zivkovic et al., 2018). Therefore, one of the main ecological concerns is to achieve sustainability in the textile chain (Bamonti et al., 2016; Monteiro et al., 2018) and the application of CP practices collaborates as a mitigator of environmental impacts (Gavrilescu, 2004), causing changes in the environmental quality. Thus, the

* Author to whom all correspondence should be addressed: e-mail: geraldo.prod@gmail.com; Phone: +55 11976127859

adoption of CP by the textile industry is essential to reduce the environmental impacts generated, regardless of the size of the company. There are several criteria that can be considered to classify a company as small, medium and large, there is evidence in the literature of scientific studies that used the sales volume, revenues, investments, however, is the fact that most of the work using the number of employees. The most countries consider small companies those with up to 50 employees, medium-sized companies with up to 250 employees and the company is categorized as large with more than 250 employees (Ayyagari et al., 2003; Lepoutre and Heene, 2006).

In this context, a systematic literature review was conducted to identify implemented CP practices, size of the company and country researched, as shown in Table 1.

Our research identified nineteen studies that addressed CP practices in Small and Medium Enterprises (SMEs). Our research identified the CP application in a small French metal finishing company despite the implementation difficulties (Laforest et al., 2013), and the difficulties of implementing investment-requiring CP practices in Vietnam (Luken et al., 2016). Literature reviews were conducted and indicated that when SMEs are engaged in applying CP practices, company size is no longer a relevant factor (Klewitz and Hansen, 2014; Muchie, 2000;), corroborated by a documentary analysis performed in an Indian company (Adapa, 2018). Another study in India concluded that the compliance with laws and regulations, participation in a supply chain and voluntary engagement encourage large companies and SMEs to apply CP practices (Hens et al., 2018).

In Asia, a multiple case study in five SMEs (Indonesia, Philippines and Vietnam) was performed (Burritt et al., 2019). In Australia, a study established that government incentive programs for CP practices in SMEs have failed because they did not consider continuing training and self-assessment routines (van Berkel, 2000; 2007). In China, a research identified that the lack of government incentive, negligent environmental surveillance and high initial cost prevent SMEs from applying CP practices (Shi et al., 2008). In Malaysia, one research related the application of CP practices to compliance and certifications (Bai et al., 2015), and another studied the implementation of cleaner production practices from Malaysian manufacturers' perspectives (Yusup et al., 2015). In the Americas, a documentary analysis collected information from 972 Mexican SMEs on the application of CP encouraged by the government, the results obtained by this large group of SMEs were the neutralization of environmental impacts equivalent to a city of 40,000 inhabitants (van Hoof and Lyon, 2013). Another research in Mexico identified that the main benefit was the proximity of companies, where it was possible to change the design of products in order to improve the use of natural resources and raw material, thus reducing costs (van Hoof and Thiell, 2015). Literature review concluded that SMEs have difficulties in implementing CP practices due to lack of financial resources and skilled human resources (Vieira and Amaral, 2016). There are applications of CP practices in small companies in the furniture sector in Brazil (Silva et al., 2013), in the food sector in Canada (Aikenhead et al., 2015) and in metallurgy sector in Brazil (Nunes et al., 2019), where all the cases achieved economic benefits and reduction of the environmental impact (Oliveira Neto et al., 2017).

There were 10 researches that considered companies of all sizes and addressed CP practices. A multi-case study was conducted in Portugal with four large companies and six SMEs reducing the generation of waste and toxic pollutants (Duarte et al., 2005). In addition, it was determined that implementing CP practices in large companies results in noticeable changes, in medium-sized companies, there are many options for CP application, and in small companies, CP applications are usually temporary (Dieleman, 2007). Other research was conducted in Spain, concluding that the larger the company, the greater the engagement with pollution control through CP practices (Murillo-Luna et al., 2011). Another research determined that SMEs face significant obstacles to applying CP because they are limited by a shortage of skilled labor, poor record keeping, lack of performance indicators, unstable finances, and low investment capital (Khalili et al., 2015).

In Brazil, it was observed that it is more difficult to apply CP in small companies due to weak organizational structures, however, when combining CP practices with project management company size is no longer a relevant factor (De Guimarães et al., 2017). Another survey conducted in Brazil concluded that the size of the company is not a relevant factor for applying CP practices when the company has ISO14001 certification (Oliveira et al., 2016), corroborated by a research conducted in Australia across five companies of different sizes (Khan, 2008). In addition, it was identified that when the company is engaged in achieving sustainable performance, size is not a relevant factor for a Brazilian mining company (Silvestre, 2014), corroborated by a research conducted in Uganda (Musaazi et al., 2015), as the main interest of Brazilian metalworking companies is the economic benefit (Severo et al., 2015).

Six researches considered large companies and addressed CP practices. In South Africa, a research concluded that large companies have more financial resources to implement new technologies (Pandey and Brent, 2008), corroborating the study performed in Brazil (Wasserman et al., 2016), with focus in the economic benefits (Sousa-Zomer et al., 2017), as well as being an effective tool on improving the pollution prevention approach in China (Xie et al., 2013). However, in China, government incentives, strict laws and monitoring in companies are needed (Oliver and Ortolano, 2006). In addition, a research conducted in Turkey analyzed the application of CP practices in large companies (Yüksel, 2008).

Table 1. CP Practice, research country and company size

CP Practices	Companies size	Small and medium-sized companies (SME)																	
	Authors	*Muchie, 2000*	*van Berkel, 2000*	*van Berkel, 2007*	*Shi et al., 2008*	*Laforest et al., 2013*	*Silva et al., 2013*	*van Hoof and Lyon, 2013*	*Klewitz and Hansen, 2014*	*Aikenhead et al., 2015*	*Bai et al., 2015*	*van Hoof and Thiell, 2015*	*Yusup et al., 2015*	*Luken at el., 2016*	*Vieira and Amaral, 2016*	*Aikenhead et al., 2015*	*Bai et al., 2015*	*van Hoof and Thiell, 2015*
	Countries	*UK*	*Australia*	*Australia*	*China*	*France*	*Brazil*	*Mexico*	*Germany*	*Canada*	*China*	*Mexico*	*Malaysia*	*Austria*	*Brazil*	*Canada*	*China*	*Mexico*
No definition of CP Practices has been identified, only small indications		X	X	X	X		X	X	X	X	X			X		X	X	
P1	Environmental issues are considered during the selection of suppliers.											X	X					X
P2	Environmental issues play a role in factory layout.																	
P3	Technologies for minimizing energy consumption.					X									X			
P4	Environmental issues are considered in the selection of equipment for product manufacturing.																	
P5	Packaging recycling possibilities are evaluated.					X									X			
P6	The replacement of the material with non-toxic and non-polluting components is evaluated.												X					
P7	The possibilities of reducing the use of packages are considered.																	
P8	For increasing the recyclability of the products, the possibilities of the changes in the composition of the products are evaluated.												X					
P9	The ease of disassembly of products is evaluated in the design of products.																	
P10	Environmental issues are evaluated in the selection of manufacturing systems.																	
P11	Environmental issues are considered in materials handling.																	
P12	Possibilities for consumers and end-users to access the recycling centers are evaluated.																	
P13	Reducing the usage of natural resources is considered in the manufacturing processes.					X												
P14	Environmental issues are considered in the processes of production planning and control.					X							X					
P15	While evaluating the production schedules, environmental problems that may be created by the schedules are also considered.																	
P16	Possibilities of using energy, efficient and clean technologies are considered in capacity decisions.					X							X		X			
P17	The forward and reverse logistics are considered in stock planning.																	
P18	Increasing the durability of the products is considered.					X							X					
P19	The possibilities of disposal of products are evaluated in product designing.																	
P20	The environmental effects that may occur while usage of the products by the consumers are evaluated.																	
P21	Environmental issues are considered in logistic networks design.					X												
P22	The collection and distribution of products and components that will be recycled, remanufactured or reused are designed and planned.												X					
P23	The participation of customers in recycling programs through programs such as education and information sharing are encouraged.																	
P24	The possibilities of using renewable resources are considered.												X					
P25	Development of products to reduce the use of packaging and/or use of recyclable packaging.																	
P26	Reduce the volumes of emissions and waste in the production system.					X												

P27	Avoid waste of raw materials and inputs using them rationally.					X						X	X		X			X
P28	Consider the CP intrinsic to the Environmental Management System, with periodic audits, aiming at continuous improvements.																	
P29	Improve employee environmental awareness through capacity building.														X			
P30	Improve working conditions to reduce waste.																	
P31	Efficient use of water.					X							X		X			

Table 2. CP Practice, research country and company size (continuation)

CP Practices	***Continuation of SME***								***All sizes of companies***										***Large companies***						***No mention of company size***							
	Yusup et al., 2015	***Luken et el. 2016***	***Vieira and Amaral 2016***	***Oliveira Neto et al., 2017***	***Adapa 2018***	***Hens et al., 2018***	***Burritt et al., 2019***	***Nunes et al., 2019***	***Duarte et al., 2005***	***Dieleman 2007***	***Khan 2008***	***Murillo-Luna et al., 2011***	***Silvestre and Silva Neto 2014***	***Khalili et al., 2015***	***Musaazi et al., 2015***	***Severo et al., 2015***	***Oliveira et al., 2016***	***de Guimarães et al., 2017***	***Oliver and Ortolano 2006***	***Pandey and Brent 2008***	***Yuksel 2008***	***Zhang et al., 2015***	***Wasserman et al., 2016***	***Sousa-Zomer et al., 2017***	***Baas 1995***	***van Berkel et al., 1997***	***Zeng et al., 2010***	***Oliveira Neto et al., 2015***	***Silva et al., 2017***	***Matos et al., 2018***	***Severo et al., 2018***	***Sousa-Zomer et al., 2018***
	Malaysia	***Austria***	***Brazil***	***Brazil***	***India***	***Belgium***	***Indonesia***	***Brazil***	***Portugal***	***Mexico***	***Australia, Pakistan***	***Spain***	***Brazil***	***USA***	***Uganda***	***Brazil***	***Brazil***	***Brazil***	***China***	***South Africa***	***Turkey***	***China***	***Brazil***	***Brazil***	***Nederland***	***Nederland***	***China***	***Brazil***	***Brazil***	***Brazil, Germany, Canada***	***Brazil***	***Brazil***
No		X		X			X	X	X	X	X	X	X	X	X		X			X			X									
P1	X																				X							X				X
P2																					X								X			
P3			X		X	X										X		X			X		X		X	X			X	X	X	
P4																					X					X						
P5			X																		X		X					X	X	X		
P6	X					X															X		X			X						X
P7																					X					X	X	X				
P8	X																				X						X					X
P9																					X					X						
P10																					X								X			
P11																					X											
P12																					X											
P13						X															X										X	X
P14	X															X					X						X	X	X			
P15																					X											
P16	X		X			X												X			X		X			X	X				X	X
P17																					X							X				
P18	X					X															X					X	X		X			X
P19																					X							X			X	
P20						X															X											
P21																					X											X
P22	X																				X							X				X
P23																					X											X
P24	X																				X						X	X				
P25																					X						X					X
P26						X										X		X			X		X		X	X			X	X	X	X
P27	X		X			X										X		X			X		X		X	X			X	X	X	X
P28																					X		X				X					
P29			X		X																X				X		X	X				
P30						X										X		X			X				X		X			X		
P31	X		X		X	X										X		X			X		X					X		X	X	X

However, 8 researches that defined CP practices, but did not address the size of the company were also identified.

Some researches presented literature review about: CP concepts and practices (Baas, 1995); linked project and product redesign with CP practices (van Berkel et al., 1997); model combining CP practices with the Deming cycle and tested in a beverage industry (Silva et al., 2017) and analyzed CP implementation (Matos et al., 2018). Other research, it was relationship CP practices with company performance in China (Zeng et al., 2010). In addition, three researches were developed in Brazil; evaluated which CP practices are most used by Brazilian companies (De Oliveira Neto et al., 2015a; 2015b); analyzed the relationship of CP practices with circular

economy (Sousa-Zomer et al., 2018) and analyzed the relationship between CP practices, social responsibility and eco-innovation (Severo et al., 2018). However, no research was found on the evaluation of CP practices that considered the size of companies in the textile sector. This study intends to contribute as a manual highlighting the most relevant CP practices for each company size, thus resulting for small and medium companies in improving financial and environmental performance and, additionally for large companies, improving the image for the market consumer.

In Brazil, the textile industry is very important and directly employs 1.5 million workers in its production chain, with over 8 million indirect jobs. Its revenues are USD 51.58 billion per year for an average textile production of 1.3 million tons and 8.9 billion garments; Worldwide, it is the fourth largest manufacturer of blue jeans, and fourth in the production of knitwear and the fifth largest industrial park, as well as a reference in swimwear and home wear manufacturing (ABIT, 2018). Thus, the following research question is suggested: What are the CP practices adopted in the Brazilian textile sector according to the company size? Therefore, this paper aims to identify the CP practices adopted by different-sized companies in the textile sector located in Brazil.

2. Material and methods

2.1. Procedure for data collection

First a systematic literature review (Fig. 1) was developed by combining the following keywords: (i) "cleaner production" AND "practices"; (ii) "cleaner production" AND "principles"; (iii) "cleaner production" AND "program"; (iv) "cleaner production" AND "scheme"; (v) "cleaner production" AND "activities"; (vi) "cleaner production" AND "tools"; (vii) "cleaner production" AND "techniques".

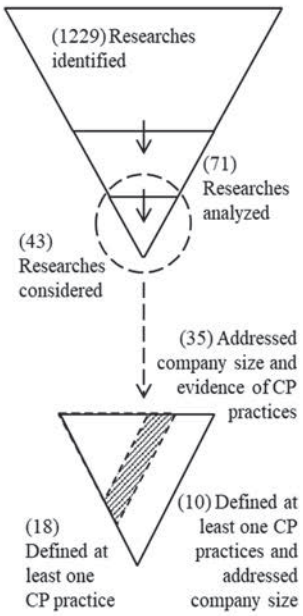
These keyword groups were searched in six databases: Scopus, Science Direct, Emerald, Wiley, Taylor & Francis and Scielo, which presented 1.229 studies. At this stage, 1.158 articles were disregarded because the keywords were found in the introduction, literature review and references, leaving 71 studies, and those that developed the concepts of CP practices underwent a systematic content analysis.

Content analysis is an important method to select the theoretical constructs that underlie the research through coding and categorization (Bryman, 2003). Thus, 43 papers were selected, as the excluded articles did not present CP practices in their results, discussions and conclusions. As for company size, 19 considered SMEs, 6 considered large companies, 10 considered companies of all sizes and 8 did not address the size of companies. Thus, 31 CP practices were identified to compose the questionnaire (Appendix 1) for six expert analyses from the Brazilian textile industry.

2.2. Procedure for data analysis

This study was developed in the textile sector of companies located in Brazil and used the survey method to identify which CP practices were relevant for each company size. For this purpose, the pilot test was applied to validate the research instrument. This allowed testing the research instrument, checking the data quality and making the necessary adjustments before the application of the instrument in other companies (Forza, 2002).

Studies identified by keywords	Qty
CP + Practices	258
CP + Tools	210
CP + Activities	178
CP + Program	177
CP + Techniques	171
CP + Actions	124
CP + Principles	77
CP + Scheme	34
TOTAL	1229



Relationship between CP Practices and Company Size	Qty
Studies that addressed the issue of CP Practices	71
Studies that addressed the issue of CP Practices AND related to the Size of the company	35
Studies that added to the definition of CP Practices	18
Studies that added to the definition of CP Practices AND related to the Size of the company	10
Studies that added to the definition of CP Practices OR related to the Size of the company	43
Small and medium-sized companies	19
All sizes of companies	10
Large companies	6
No mention of company size	8

Fig. 1. Systematic literature review

The validation of the research instrument was performed through a specialist analysis and the variables were subjected to experts of the textile sector in Brazil, all with more than 20 years of experience in the segment. Thus, the 31 CP practices identified and adapted in the literature (Oliveira Neto et al., 2020) were evaluated for their understanding, relevance and applicability in the Brazilian textile sector.

The analysis indicated that 20 CP practices were relevant to companies, so 11 practices should be disregarded:

- It has been established that changing the composition of the product to increase recyclability (P8) is not applicable because the products are made of yarn, fabric or knitwear, often composed of a single component, and for the same reason the ease of disassembly (P9) was disregarded.
- The integration of consumers with recycling centers (P12 and P23), action planning considering reverse logistics (P17) and collection of products for recycling or reuse in production (P22) were not considered because textile products are reused in production or used in nonwoven and recycle waste fabric industries.
- Without standardized machines or packaging used by different suppliers, in addition to regional differences and necessary changes to the already established textile centers, product design considering the use of recyclable packaging or packaging reuse (P25), product design considering improvements in product flow (P19) and environmental issues considered in the logistics network design (P21) were not considered.
- Use of textile products by consumers does not cause effects that may lead to environmental problems (P20) and increasing the durability of products is of little significance because the textile sector depends on fashion trends (P18).

When adopting the survey research method, it is necessary to apply structured questionnaires to analyze patterns and relationships between variables, enabling statistical analyses (Bryman, 2003). The survey application followed three phases: delimiting the research universe and sample size, performing pre-tests to check the research instrument for data validity and reliability, and applying the survey to the delimited universe and sample (Forza, 2002). The questionnaires, available in the appendix, used the 5-point Likert scale to determine the relevance of each CP practice to companies of three different sizes: small, medium and large.

The analysis of the collected data was performed in stages, where initially the quality of the data, the relationship between variables and treatments were observed (Hair et al., 2010). Next, a statistical test was applied to check the normality of the data set and each cluster. This study adopted the Shapiro-Wilk test because it provides the test value parameter (p-value), the analysis of agreement between the data and the null hypothesis based on the confirmation of whether the distribution is normal. The lower the test values, the lower the consistency between the data and the null hypothesis. Therefore, as this study considered the significance level of 5%, when the test values are greater than 0.05, it can be concluded that the distribution is normal, otherwise data do not follow a normal distribution (Triola, 2008).

Thus, it was found that the data in this study did not follow a normal distribution, as can be seen in the normality analysis presented in the appendix. It is important mentioning that the Kruskal-Wallis test was adopted because it is an alternative nonparametric test, in other words, it does not require the data to follow a normal distribution and homogeneity of variance (Pagano, 2012). The interpretation of the Kruskal-Wallis test results (Fig. 2) must be done directly, i.e., the higher the value relative to the midpoint, the more relevant the information will be (Kruskal and Wallis, 1952). Therefore, this study considered the values greater than 30 calculated by the Kruskal-Wallis test as high levels of relevance between CP practices and company size.

3. Results and discussion

The results obtained with the Kruskal-Wallis test (Table 2) were summarized allowing an overview of the relevance of each CP practice on each company size. All CP practices had some level of relevance to company sizes. The results indicate that both small and medium-sized textile companies located in Brazil aim to reduce waste in the production system to primarily achieve economic benefits, due to financial difficulties to make investments. The most used practices in the textile sector aim to reduce the consumption of: energy (P3), packaging (P7), raw materials (P27), contributing to the reduction of waste (P30) and reduction of waste generation and emissions in the production system (P26).

CP Practices	*Kruskal-Wallis*		
	Mean Rank		
	S	*M*	*L*
An example of Cleaner Production Practice	11.55	17.90	50.30

CP Practices and Size of Companies:

Parameters considered for the Kruskal-Wallis test:

- High level of relevance < 30.00
- Medium level of relevance < 20.00
- Low level of relevance < 10.00

Fig. 2. Kruskal-Wallis parameters

Table 2. Kruskal-Wallis test

Code	*CP Practices*	*Shapiro-Wilk*	*P-values*	*Kruskal-Wallis*		
		Chi-square	*Asymp. Sig*	*Mean Rank*		
				S	*M*	*L*
P1	Environmental issues are considered during the selection of suppliers	0.8996	0.0001	11.55	17.90	**50.30**
P2	Environmental issues play a role in factory layout	0.8576	0.0000	18.50	22.00	**46.25**
P3	Energy efficient and energy saving technologies are used	0.8535	0.0000	**34.48**	**41.40**	**50.35**
P4	Environmental issues are considered in the selection of equipment for producing the products	0.8246	0.0000	12.48	22.50	**50.30**
P5	Possibilities of recyclability of packages are evaluated	0.8426	0.0000	18.50	19.50	**50.30**
P6	The replacement of toxic substances with non-toxic and non-polluting material is evaluated	0.8549	0.0000	17.90	22.00	**50.30**
P7	The possibilities of reducing the use of packages are considered	0.8491	0.0000	**31.70**	**37.10**	**50.35**
P10	Environmental issues are evaluated in the selection of manufacturing systems	0.8587	0.0000	10.50	15.55	**46.25**
P11	Environmental issues are considered in materials handling	0.8592	0.0000	11.55	19.50	**50.30**
P13	Reducing the usage of natural resources is considered in the manufacturing processes	0.8379	0.0000	12.48	21.50	**46.25**
P14	Environmental issues are considered in the processes of production planning and control	0.8677	0.0000	10.68	19.35	**46.25**
P15	Environmental problems that may be created by the production schedules are considered	0.8845	0.0000	10.95	**32.35**	**48.20**
P16	Possibilities of using energy efficient and clean technologies are considered in capacity decisions	0.8419	0.0000	17.90	**31.70**	**48.20**
P24	The possibilities of using renewable resources are considered	0.8499	0.0000	11.55	29.50	**50.30**
P26	Reduce the volumes of emissions and waste in the production system.	0.8340	0.0000	**31.70**	**39.60**	**50.30**
P27	Avoid waste of raw materials and inputs using them rationally.	0.7965	0.0000	**32.50**	**39.60**	**50.30**
P28	Considers the CP intrinsic to the Environmental Management System, with periodic audits, aiming at continuous improvements	0.8910	0.0001	10.68	**30.00**	**50.50**
P29	Improve employee environmental awareness through capacity building support	0.8535	0.0000	10.50	28.00	**46.25**
P30	Improve working conditions to reduce waste	0.8401	0.0000	**30.00**	**37.10**	**50.30**
P31	Efficient use of water	0.8577	0.0000	21.85	**34.58**	**50.30**

In this context, the adoption of CP practices by small companies aims to reduce waste to achieve cost reduction through minimization of energy consumption by turning off equipment not in use and replacement of technologies, and to reduce packaging acquisition costs and help companies reduce their consumption of materials and inputs to increase reuse and avoid material disposal, contributing to a reduction in waste generation and emissions in the production system. Medium-sized companies adopt the efficient use of water (P31) with greater significance because the traditional production process of the textile industries uses large quantities of chemicals and toxic substances in the finishing process. Minimizing the use of toxic products requires investment and incremental changes in the production system and product design. Also, medium-sized companies are under pressure to implement CP practices, and thus have difficulties meeting the environmental requirements required by large companies to provide products and services. The main requirement is to comply with the environmental management system using CP (P28), once external supplier audits identify nonconformities that need to be addressed for the company to meet the requirements. As a result, medium-sized companies have to solve environmental problems in the production schedule (P15) by developing action plans to address identified nonconformities, which require adjustments in production processes and should not impact productivity. Consequently, capacity decisions consider the use of clean and efficient energy technologies (P16) in action plans that require changes that are only possible in the long run.

Regarding large companies, it was established that large textile companies located in Brazil also aim to meet the environmental management system through cleaner production (P28), but in this case, large companies primarily aim to present an image of a social and environment conscious company to supply goods to the international market, mainly the European market. Consequently, large companies request their suppliers to comply with environmental requirements in order to provide products and services. Therefore, environmental issues are considered during supplier selection (P1), equipment and machinery selection (P4) and material handling (P11), additionally considering the possibility of using renewable resources to select raw materials and energy (P24).

Another relevant finding is that large companies have active planning and development projects, aiming at product design development considering environmental issues, studying the possibilities of reuse and recycling of materials (P5), reduced use of packaging (P7) and replacement of toxic with non-toxic material (P6). Large companies generate economic benefits through the application of CP practices, behavior similar to that indicated by small and medium companies through the reduction of waste generation and emissions in the production system (P26), efficient use of raw materials and inputs (P27), efficient use of energy (P3), efficient use of water (P31) and improved working conditions (P30).

It was also observed that large companies have implemented CP practices at the heart of production planning and control (P14), as environmental issues can be observed in manufacturing system selection (P10) and factory layout (P2), as well as reducing the use of natural resources (P13) Furthermore, problem solving is considered in the production schedule (P15) and capacity decisions consider the use of clean and efficient energy technologies (P16). As a consequence of the environmental maturity of large companies, employees are trained and improve their environmental awareness (P29).

According to this method we observe that small textile companies located in Brazil have financial difficulties due to the lack of capital to invest in training and technology while the country undergoes economic crisis generating high interest rates and market shrinkage, reducing consumption. As a result, they adopt CP practices, contributing to the reduction of costs by reducing waste generation, minimization of energy consumption, reducing the consumption of materials and efforts to increase reuse and avoid the disposal of materials, contributing to the reduction of waste generation and emissions in the production system, according to Fig. 3.

This finding can be corroborated by van Hoof and Lyon (2013), who carried out a research in SMEs and concluded that economic and environmental benefits of applying CP practices are positively related to company size, however, the results consider few CP practices.

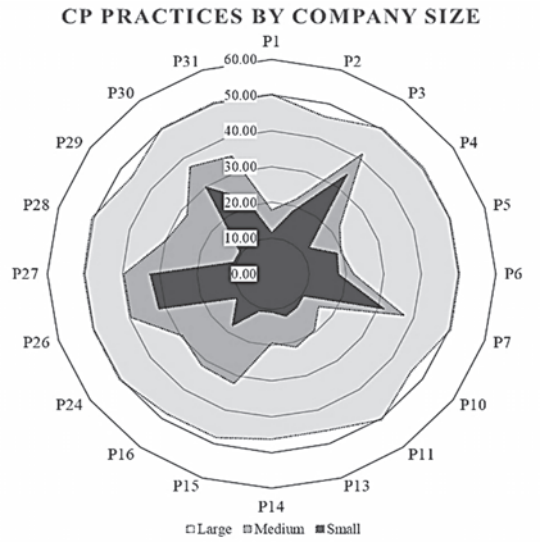


Fig. 3. Radar chart of CP Practices by company size

The research by Yusup et al. (2015) conducted in SMEs using Spearman correlation test, Kruskal-Wallis test and Mann-Whitney test to analyze several relationships with CP practices. But it is important to note that only 6 CP practices were considered, in addition, the relationships between these CP practices and the size of the companies were not analyzed in detail. The research by Vieira and Amaral (2016) concluded that regulation needs to stimulate more CP practices, especially small companies, with support and incentives. The research by Hens et al. (2018) came to the conclusion that, in the near future, the application of CP practices will be driven by SMEs, but not in developing countries. Therefore, the studies superficially address the identification of CP practices for small companies.

Meanwhile, the results of the present study demonstrate that small companies in the textile sector choose to apply CP practices that result in economic benefits and these results enable small business managers to strive to reduce waste from production (P30) and generation of waste and emissions (P26), while minimizing energy (P3), packaging (P7) and raw material (P27) consumption.

Medium-sized textile companies located in Brazil are able to reduce costs through the implementation of CP practices, all the more so because medium-sized companies have the capacity to make small and specific investments. In addition, medium-sized companies are under pressure to adopt CP practices and meet environmental requirements to provide products and services. Thus, the main requirement is compliance with the environmental management system, with regular external audits and identification of environmental non-conformities, preparation of action plans considering quick wins and long-term decisions involving the use of technologies.

This finding can be corroborated by the research of Laforest et al. (2013), who concluded that 16 CP practices are applicable to the studied company with efficient water use being the most relevant, however, an identified limitation of the research disregarded performance gains. The research by van Hoof and Thiell (2015) concluded that SMEs have difficulties in complying with environmental regulations. The research by de Guimarães et al. (2017) concluded that SMEs have difficulties in adopting CP practices and that these effects are minimized through the application of project management techniques.

In other words, these studies found that SMEs have difficulties in implementing CP practices, however, it was not identified which CP practices were neglected by medium-sized companies, in other words, which CP practices drive relevant results for this type of company. This study shows that medium-sized companies textile sector consider CP practices not only for cost reduction, but also as an order-winning factor, contributing to medium-sized companies to dedicate themselves to the application of CP practices related to both waste reduction and compliance with the environmental management system.

The large textile companies in Brazil are dedicated to presenting an image of a company that cares about social and environmental values so that they can supply products to the international market, especially the European market. Thus, large companies need their supply chain to also comply with environmental requirements, creating pressure for other companies to comply with an environmental

management system. In this sense, large companies invest in research and development so that the product design considers environmental issues and, consequently, reduce waste and generate more profit.

This finding can be corroborated by Yüksel (2008) research that using the Kruskal-Wallis test and concluded that cost reduction is a motivating factor for the implementation of CP practices, and large companies are very proactive in environmental management and emphasize the application of CP practices in product development considering environmental and profit-making issues. The research by Murillo-Luna et al. (2011) and De Oliveira Santos et al. (2020) concluded that companies of all sizes are proactive in implementing techniques to reduce pollutants, but identified that the larger the company, the more advanced will be the environmental protection measures. The research by Khalili et al. (2015) concluded that large companies overcome the obstacles of implementing the concepts of sustainable development and CP practices with less difficulty than SMEs.

The research by Wasserman et al. (2016) concluded that the projects involved all the levels of the organization, the implementation has led to increased productivity and served as a catalyst for solving long-standing problems including the adoption of cleaner technologies. In Brazil, Oliveira et al. (2016) concluded that having ISO14001 certification brings environmental maturity to the company and establishes a culture of continuous application of CP practices. Therefore, the analyzed studies addressed the application of CP practices, evaluated their relevance and presented the benefits for large companies, however, the results of the present research show that large companies in the textile sector apply all CP practices considered in this research. There is a big difference in how large companies regard the relevance of each CP practice compared to the assessment of SMEs, and large companies continually invest to develop environmentally friendly products and conditions that allow exportation, inasmuch as the most relevant CP practice for large companies was the environmental management system, according to Fig. 4.

Therefore, it was determined that the size of the company is related to the implementation of CP practices. Small companies are only motivated to obtain economic benefits, medium-sized companies are pressured to meet quality requirements and large companies need to widely implement CP practices to obtain international certifications. Additionally, there is a huge gap between small and medium-sized companies compared to large companies.

4. Conclusions

This research concludes that CP practices were identified as relevant to small, medium and large textile companies located in Brazil. With this, there are contributions to theory and practice. As for knowledge about CP practices in small companies, this study has been able to demonstrate that applications that result in economic benefits are the only relevant ones because of the financial difficulties small companies have.

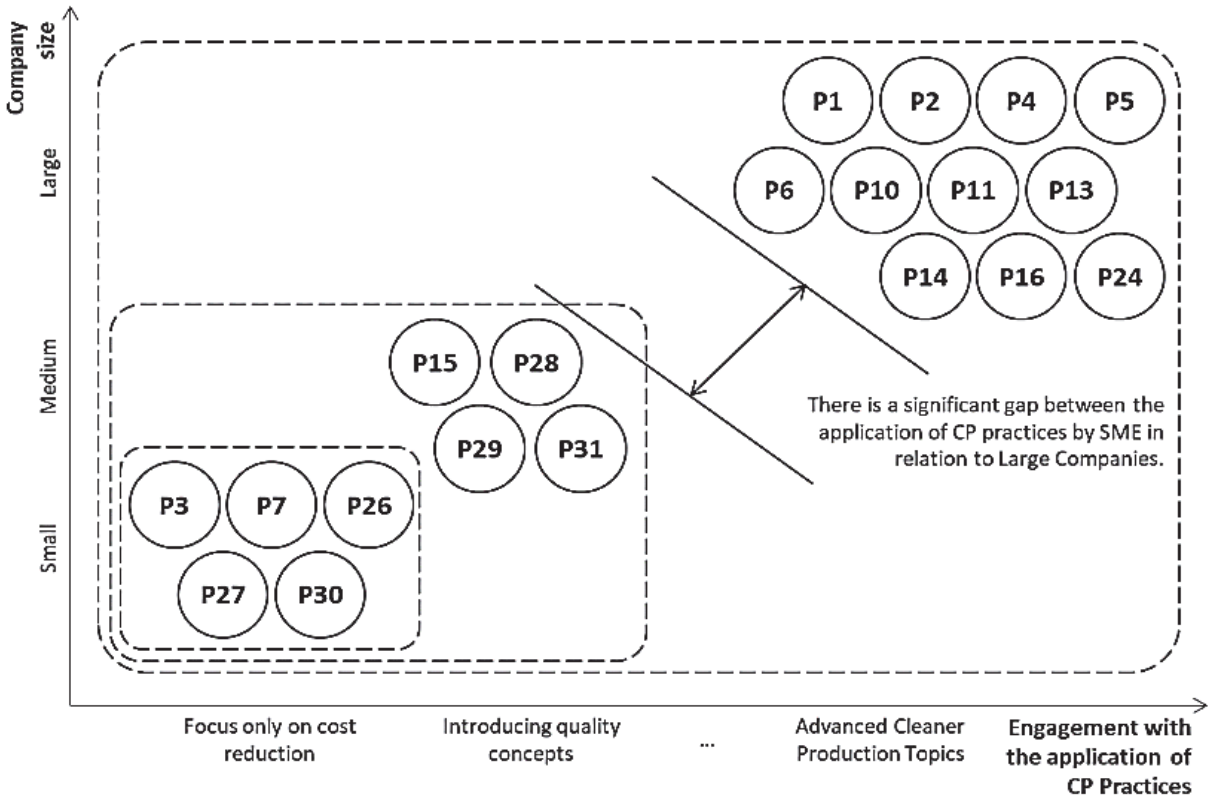


Fig. 4. Engagement with the application of CP practices by company size

However, in medium enterprises, the economic benefits are as relevant as meeting the environmental management system and resolution of environmental problems because medium-sized companies are under pressure to meet environmental requirements for the supply of products and services. In contrast, large companies consider all CP practices relevant, with emphasis on compliance with the environmental management system because obtaining environmental certifications is a requirement for exporting products to many countries. As for the practical application, this study was able to demonstrate which are each of the CP practices that companies of different sizes consider relevant, thus, the managers of small companies can find that minimizing the consumption of energy (P3), packaging (P7) and raw material (P27), in addition to reducing production waste (P30) and generation of waste and emissions (P26), are the most relevant CP practices that result in economic benefits.

Moreover, medium-sized company managers are able to find that efficient water use (P31) is an important CP practice for the textile industry due to the use in large quantities of chemical and toxic materials, which results in economic benefits and requires investments. It is also relevant for medium companies to comply with the environmental management system (P28), solving environmental problems within the production schedule (P15) and considering the use of clean technologies in capacity decisions (P16) because meeting environmental requirements is an order-winning factor, and finally managers of large companies are able to find that applying CP practices supports obtaining green labels so that their products can be exported to developed countries and that investing since product development considering environmental issues reduces costs and contributes to the maintenance of environmental certifications, so all CP practices were considered relevant for large companies in the textile sector.

Additionally, it is worth emphasizing that a huge gap was identified on how textile SMEs consider CP practices relevant compared to large companies, partly due to the need for investments and lack of incentives to adopt CP practices. On the other hand, this study has limitations, primarily that it considered only the textile companies located in Brazil, therefore, issues associated to generalization cannot be ignored. But this paper has other limitations, such as not considering CP practices related to the use of new technologies in Industry 4.0. Number of employees was determined a more appropriate approach to classify company size in the textile sector, but future research may utilize revenue to classify enterprise size. Future studies may expand research to a larger number of sectors and countries through the methods used herein, as well as considering different statistical analyses for the validation of results.

Appendix 1. Questionnaire used in research

Size of the company		**Adoption of Cleaner Production (CP) Practices**				
	Less than 50 employees					
	Less than 250 employees	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	250+ employees					
CP Practices		**-2**	**-1**	**0**	**+1**	**+2**
P1	Environmental issues are considered during the selection of suppliers					
P2	Environmental issues play a role in factory layout					
P3	Energy efficient technologies and technologies for minimizing energy consumption					
P4	Environmental issues are considered in the selection of equipment for producing the products					
P5	Possibilities of recyclability of packages are evaluated					
P6	The replacement of the materials with the materials that are non-toxic and non-polluting is evaluated					
P7	The possibilities of reducing the use of packages are considered					
P8	For increasing the recyclability of the products, the possibilities of the changes in the composition of the products are evaluated					
P9	The ease of disassembly of products is evaluated in the design of products					
P10	Environmental issues are evaluated in the selection of manufacturing systems					
P11	Environmental issues are considered in materials handling					

P12	Possibilities for consumers and end-users to access the recycling centers are evaluated					
P13	Reducing the usage of natural resources is considered in the manufacturing processes					
P14	Environmental issues are considered in the processes of production planning and control					
P15	While evaluating the production schedules, environmental problems, that may be created by the schedules, are also considered					
P16	Possibilities of using energy efficient and clean technologies are considered in capacity decisions					
P17	The forward logistics and reverse logistics are considered in stock planning					
P18	Increasing the durability of the products is considered					
P19	The possibilities of the disposal of the products are evaluated in the design of products					
P20	The environmental effects, that may occur while usage of the products by the consumers, are evaluated					
P21	Environmental issues are considered in the design of logistic networks					
P22	The collection and distribution of the products and components that will be recycled, remanufactured or reused are designed and planned					
P23	The participation of customers and end-users in recycling programs through programs such as education and information sharing are encouraged					
P24	The possibilities of using renewable resources are considered					
P25	Projects the products for the opportunity to reduce the use of packaging and / or use of recyclable packaging					
P26	Minimizes waste generation and emissions in the production system					
P27	Efficient use of raw materials and inputs, avoiding waste					
P28	Considers the CP intrinsic to the Environmental Management System, with periodic audits, aiming at continuous improvements					
P29	Improve employee environmental awareness through capacity building					
P30	Improve working conditions to reduce waste					
P31	Efficient use of water					

Appendix 2. Normality analysis

This work used a robust statistical analysis to verify that the data distribution did not follow a normality. The table below presents these data and justifies the choice for the Kruskal-Wallis test.

Code	***Company Size***	***Skewness***	***Kurtosis***	***Shapiro-Wilk***	***p-value***	***Normality Analysis***
P1	Small	2.1231	2.7759	0.8996	0.0001	N-Norm
	Medium	1.2505	-0.4967			N-Norm
	Large	-1.0032	0.1886			N-Norm
P2	Small	2.8879	7.0370	0.8576	0.0000	N-Norm
	Medium	0.9453	-1.2418			N-Norm
	Large	-1.0043	0.1776			N-Norm
P3	Small	-1.6245	0.6985	0.8535	0.0000	N-Norm
	Medium	-0.9453	-1.2418			N-Norm
	Large	-0.9012	-1.7195			N-Norm
P4	Small	1.6245	0.6985	0.8246	0.0000	N-Norm
	Medium	0.4421	2.0180			N-Norm
	Large	0.0040	2.2353			N-Norm
P5	Small	1.2505	-0.4967	0.8426	0.0000	N-Norm

	Medium	0.9453	-1.2418			N-Norm
	Large	-2.1231	2.7759			N-Norm
P6	Small	2.8879	7.0370	0.8549	0.0000	N-Norm
	Medium	1.2505	-0.4967			N-Norm
	Large	-0.9812	-1.7195			N-Norm
P7	Small	-1.8116	-1.7195	0.8491	0.0000	N-Norm
	Medium	-2.4421	-2.0180			N-Norm
	Large	-1.5211	1.6364			N-Norm
P10	Small	2.1231	2.7759	0.8587	0.0000	N-Norm
	Medium	-1.2525	-0.4388			N-Norm
	Large	-2.1231	2.7759			N-Norm
P11	Small	0.9453	-1.2418	0.8592	0.0000	N-Norm
	Medium	1.6245	0.6985			N-Norm
	Large	-2.1231	2.7759			N-Norm
P13	Small	1.6245	0.6985	0.8379	0.0000	N-Norm
	Medium	0.9453	-1.2418			N-Norm
	Large	0.0056	1.9072			N-Norm
P14	Small	1.0032	0.1886	0.8677	0.0000	N-Norm
	Medium	0.9453	-1.2418			N-Norm
	Large	1.0960	-0.5474			N-Norm
P15	Small	2.1231	2.7759	0.8845	0.0000	N-Norm
	Medium	1.1203	-1.2070			N-Norm
	Large	-0.9832	1.9664			N-Norm
P16	Small	1.6245	0.6985	0.8419	0.0000	N-Norm
	Medium	0.9145	-0.2129			N-Norm
	Large	-0.9317	-0.7761			N-Norm
P24	Small	2.1231	2.7759	0.8499	0.0000	N-Norm
	Medium	0.9453	-1.2418			N-Norm
	Large	-0.9845	-0.4129			N-Norm
P26	Small	-2.4421	-2.0180	0.8340	0.0000	N-Norm
	Medium	-1.2455	0.7831			N-Norm
	Large	1.2177	-2.1826			N-Norm
P27	Small	-1.2505	-0.4967	0.7965	0.0000	N-Norm
	Medium	-0.9453	-1.2418			N-Norm
	Large	-1.4421	-2.0180			N-Norm
P28	Small	0.9812	-1.7195	0.8910	0.0001	N-Norm
	Medium	-1.1477	3.6670			N-Norm
	Large	-1.2505	-0.4967			N-Norm
P29	Small	0.9812	-1.7195	0.8535	0.0000	N-Norm
	Medium	-0.5492	2.6625			N-Norm
	Large	0.0009	2.9804			N-Norm
P30	Small	0.0980	2.2353	0.8401	0.0000	N-Norm
	Medium	-1.0421	-2.0180			N-Norm
	Large	-1.2505	-0.4967			N-Norm
P31	Small	1.2505	-0.4967	0.8577	0.0000	N-Norm
	Medium	0.9812	1.9195			N-Norm
	Large	0.8116	2.1946			N-Norm

The finding of non-normality used the Skewness criterion less than -1 or greater than +1, in addition to the Kurtosis criterion greater than +2. The Shapiro-Wilk test for the data sets was also developed and it was identified that all the calculated p-values were lower than the alpha considered of 0.05.

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