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Implementation of cleaner production: A ten-year retrospective on benefits and difficulties found

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ABSTRACT

Cleaner production is a fast-growing area with numerous important developments seen over the years, which have led to substantial improvements, both in technological, process and organization terms. Yet there is a paucity of literature organizing the body of knowledge on the benefits and difficulties seen in this field. Thus, following a systematic literature review protocol, this paper provides a ten-year state-of-the-art analysis on the benefits and difficulties faced in the implementation of cleaner production strategies, and outlines some means via which they may be addressed. Main results point out that companies and governments have been able to successfully reap both tangible and intangible benefits after Cleaner Production implementation as its appeal to attract customers and reap reputation gain increases, for example. However, the results also show a series of difficulties that remain and hinders the widespread advancement of this methodology.

1. Introduction

The challenge posed by sustainability in its broader spectrum (dynamic balance between the economic, environmental and social dimensions) has been known as sustainable development and has currently became a notorious and observable fact on several fronts (Fore and Mbohwa, 2010). Despite constant gains of productivity and efficiency in industrial production over time, global consumption levels continue to increase rapidly and to exert increasing pressures on the planet's natural resource base, generating an unsustainable situation for society at present and in the future (Sangwan and Mittal, 2015; Virakul, 2015). In addition, in general terms the industrial production still makes poor use of renewable resources and is responsible for the generation of pollutants and wastes of difficult disposal, which negatively impacts the environment, the community and often the workers' health (Armenti et al., 2011; Ashton et al., 2016; Gutberlet, 2000; Virakul, 2015).

In the last decades, the aggravation of problems and environmental pressures, coupled with growing consumer awareness (Joung et al., 2013) and legislative pressures, has generated a series of propositions aimed at addressing the issue of sustainability in industrial production. However, as observed by Glavič and Lukman (2007), the multiplicity of methodologies, terms and tools related to sustainability generates disagreements as to the best alternatives to be adopted, being subject of debates in the academic and business circles, as well as in the formulation of public policies.

Among the alternatives proposed to assist in leading the industry to a more sustainable future, Cleaner Production is an approach that has been demonstrating positive results in mitigating environmental damages and creating economic and social benefits in its application since its origin (Glavič and Lukman, 2007;

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Kjaerheim, 2005; Lopes Silva et al., 2013; Peng and Liu, 2016).

We believe this ten-year review to be relevant for the following reasons. With the advancement of environmental sustainability and the sustainable development concept, Cleaner Production, as a specific methodology, is constantly suffering external influences and needing to adapt its goals and methods to maintain an holistic organizational view and its continuous improvement character (Glavič and Lukman, 2007; Lopes Silva et al., 2013).

Although Cleaner Production has already been applied in a number of industries and its popularity has been increasing since its inception, several branches of the industry have not yet been reached and there are still gaps in the understanding and identification of the difficulties that can be encountered in its implementation, as well as its potentially obtainable benefits (Luken et al., 2016; Vieira and Amaral, 2016; Zeng et al., 2010). For this reason, we decided to target the benefits and difficulties topic as core of our literature review, aiming to bring up the current state of the methodology regarding present implementation possibilities and likely trade-offs.

Our main objective is then trying to contribute to the advancement of Cleaner Production by bringing up a clear picture of the current possible implementation benefits and the difficulties still faced in the process. We hope this clearer reading of both into a single paper contributes twofold. To the academy, by showing current results of recent research and by providing insights and references for the study of specific benefits or difficulties to academics in their specific fields of study. To managers and organizations that are looking to implement Cleaner Production, a clear and objective overview of what they can expect because of the process, so they can delineate more effective strategies.

This study may offer suggestions for future works and promote the advancement of Cleaner Production; in addition to facilitating the mapping of risks and rewards for production managers. It should be noted, however, that the issues related to what specific tools and the ways by which companies and other institutions are pursuing to achieve the mentioned benefits are outside the scope of this research. Likewise, we do not advance with suggestions for the solution and mitigation of the difficulties encountered. Planning means and tools for attaining benefits and solving difficulties, therefore, require further research to be carried out.

To the extend of the authors knowledge, no single review brings this broad picture of the positive effects and hindrances regarding Cleaner Production implementation and this is the research gap we aim to explore.

The research questions that guide this literature review are then:

Q1. By exploring the literature, what can be observed about the current implementation possibilities of the Cleaner Production methodology?

Q2. Which specific benefits and difficulties associated with Cleaner Production implementation have been reported by the recent literature?

In addition to this introduction, this article presents three more sections. Section 2 presents the background in Cleaner Production, while Section 3 discusses the methodological procedures employed to make the research reliable. Then, in Section 4, the results of the survey are presented and discussed. Two tables containing the results were developed, one associated to the presentation of the benefits and another associated to the presentation of the difficulties in the implementation of Cleaner Production, according to the literature. The article ends by presenting the main conclusions and suggestions of future research derived from the analysis in Section 5.

2. Background

As briefly mentioned in the prior introduction, the relevance of Cleaner Production increases as worsening levels of industrial pollution, scarcity of global natural resources, and tightening of the requirements of standardization of corporate environmental performance are observable. Companies and related stakeholders still find difficulties in achieving a healthy balance between the economic and environmental aspects of their activities (Sambasivan et al., 2013). That occurs as a result of the sum of market pressures arising from these factors and also from new consumers' demands (Luken et al., 2016).

The theory and methodology underlying the research presented in this paper comes then from the Cleaner Production methodology. It originated from the conference of the United Nations Environment Program (UNEP) in 1989 and its proposed definition at the time was: "The continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment" (UNEP, 1990, p.).

Initially, the perception that led to the creation of Cleaner Production was that the traditional methods of pollution prevention known as "end-of-pipe", i.e. those that treated the pollutants after their generation in the production processes and before disposal in the environment, had high costs and reduced effectiveness. To address this problem, later a new perspective was introduced as a pollution prevention strategy, which addressed the emission of pollutants in the production process as an inherent form of inefficiency and waste of resources and which could therefore be eliminated at its source. This would be done at a reduced cost and would also increase the efficiency of the processes as a consequence. For this reason, Cleaner Production became known as an eco-efficiency strategy (Malinauskienė et al., 2016; UNEP, 1990).

With the advancement of sustainable development and industrial sustainability proposals, the initial scope of Cleaner Production was expanded and gradually became a strategy that also encompassed the design and evaluation of products, processes, and services, incorporating all dimensions of sustainable development in the most holistic way possible (Fore and Mbohwa, 2010; Glavič and Lukman, 2007; Wang et al., 2015).

In addition, Cleaner Production has become a potential methodology for supporting the decisions of the organization as a whole and, in its implementation, can include both improved and new management techniques, such as Life Cycle Analysis (LCA). These tools can be used to support the assessment and mapping of opportunities for improvement, viability, and sources of inefficiencies to be addressed by Cleaner Production (Glavič and Lukman, 2007; Malinauskiene et al., 2016). The widespread use of this methodology should not rely on subsidies and government programms alone and, as shown by (Maroušek, 2014) in the case of biochar production, a Cleaner production approach has the potential of generating innovations and competitiveness gains that make it financially attractive, a prerequisite for its scale gains.

As highlighted in the introduction, the implementation of Cleaner Production can provide many benefits, but their achievement requires persistence and dedication.

3. Method

With the objective of carrying out a bibliographical survey to provide a synthesis of the benefits and difficulties associated with the implementation of Cleaner Production. We performed a systematic literature review following a strict protocol and a rigorous approach, minimizing the risk of bias, also providing a transparent study enable for replication.

To do so, we followed the systematic literature review

methodological procedures of (Xavier et al., 2017) that follow (Denyer and Tranfield, 2009) approach and are presented in Fig. 1. Scientific papers were searched on top international databases - only one being a national Brazilian database that comprises international literature, the official Superior level government agency (CAPES) Journal database, was consulted - that are: Science Direct, Emerald Insight, Scopus, Springer, Wiley, EBSCO, CAPES Journal database, Web of Science, Taylor & Francis, and ResearchGate. The articles were searched for using the following terms: "Cleaner Production", "Sustainable Manufacturing", "Sustainable Production" and "Green Manufacturing". These strings derive from a previous bibliometric analysis of similarity of terms carried out by (Sangwan and Mittal, 2015) to comprise all frameworks of Cleaner Production. By affinity of theme and keywords, most of the references were found in the Journal of Cleaner production, as can be observed in Table 1. Initially, we combined the strings with "Benefits" and "Difficulties" to narrow the results of our research. However, we reached the conclusion that many benefits and difficulties could be implicitly mentioned and decided to expand the selection by using the initial strings alone and selecting further literature by title and research scope.

Following this strategy, 111 articles that dealt with and contained conceptual evidence, bibliographic surveys, or case studies related to Cleaner Production were selected by title, abstract and keywords. The articles selected were not discriminated by the type of research proposed. A time horizon of ten years was proposed, with 2016 as the base year, for the article submission at the "6th International Workshop Advances in Cleaner Production: Ten years working together for a sustainable future", that took place in São Paulo, Brazil. This delimitation comprised 92 of the 111 articles initially analyzed. Thus, the tables only present articles published between 2006 and 2016.

After analysis and conduction of a full and thorough reading of all the selected references, only those that contained explicit mention of the benefits and difficulties found in the implementation of Cleaner Production were utilized. Only peer reviewed articles from international journals in indexed databases were maintained. Journals from conference procedia, book chapters, thesis and dissertations were all taken out of the final selection. From this sample, 56 articles were selected to integrate Tables 2–4 which contain the main results of the research. With the term "Benefits" we mean: every positive, tangible, or intangible, performance increase, without discriminating any area of implementation, attributed to Cleaner Production implementation. On the other hand, any barriers found before the implementation or problems faced during or after a Cleaner Production initiative, as well as perceptions of any kind that could hinder the process in any area of implementation, were considered difficulties. The specific benefits and difficulties were grouped by similarity of their nature into broader categories. Those were created according to the authors experience in operations management to facilitate the reading of the tables, propose a framework to answer the research questions and attend our objective of providing a clear picture of current Cleaner Production implementation possibilities in a concise and objective way. Each category is then further discussed in detail in session 4. Fig. 2 presents the chronological distribution of the articles used to obtain the information.

Table 1
Accessed Journals and number of references found. (Source: developed by the authors).

Journal	Number of references
Journal of Cleaner Production	41
Resources, Conservation and Recycling	4
Journal of Engineering, Design and Technology	2
Chemical Industry and Chemical Engineering	1
Clean Technologies and Environmental Policy	1
Environmental Engineering Science	1
Environmental Progress & Sustainable Energy	1
International Journal of Occupational Safety and Ergonomics	1
Management of Environmental Quality: An Int. Journal	1
Renewable and sustainable Energy Reviews	1
Production	1

4. Results and discussion

After the review of 56 scientific articles, many implementation possibilities of the Cleaner Production methodology can be observed, the different areas explored in the literature review are shown in Table 2.

4.1. Benefits arising from the implementation of cleaner production

Although Cleaner Production is initially defined by UNEP (1990)

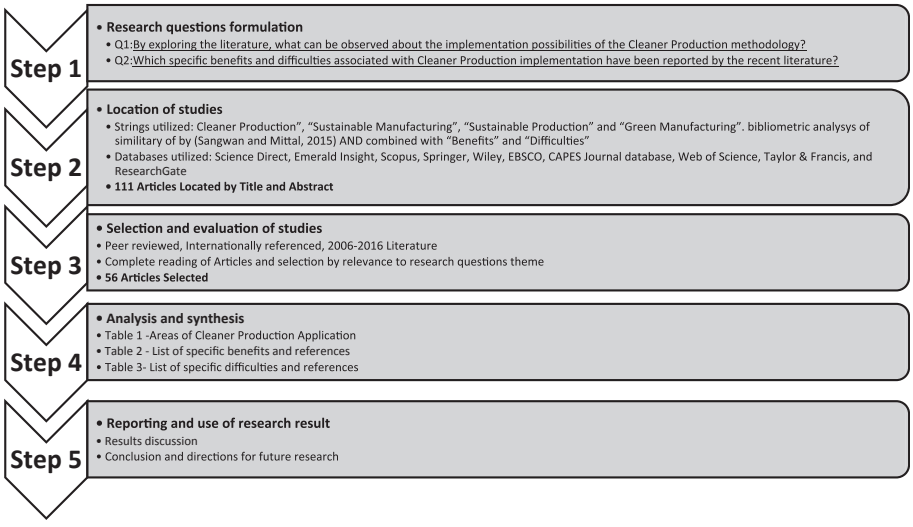

Fig. 1. Methodological procedures flowchart (References (Denyer and Tranfield, 2009; Xavier et al., 2017).

Table 2
Areas explored in the research literature. (Source: developed by the authors).

Area of cleaner production studied	Number of articles
Conceptual Paper[a]	10
Public Policy Cleaner Production Application	8
Alcoholic Beverages Industry	3
Pharmaceutical Industry	2
Zinc Electroplating industry	2
Dry-cleaning Industry	1
Printed Wire Board	1
Stone Processing	1
Printed Circuit Board	1
Earthwork Industry	1
Air Compressors Remanufacturing	1
Lime Factory	1
Jewelry Industry	1
Milling Process	1
Ceramic Industry	1
Saponin Industry	1
Magnesia Refractory Material industry	1
Wooden Furniture Industry	1
Truck Industry	1
Textile Industry	1
Fruit Juice Production	1
Cement Industry	1
Foundry Industry	1
Mining Industry	1
Fish Processing Industry	1
Maquilladora Industry	1
Power Plant	1
Milk Industry	1
Zinc Electrolysis Industry	1
Overall Manufacturing	1
Pulp and Paper Industry	1
Sewage Treatment Process	1
Iron Industry	1
Coal Industry	1

[a] Conceptual papers regard articles that bring Cleaner Production conceptual evidence, literature reviews, theoretical studies and generally applied management tools.

as an environmental strategy, the literature shows that the environmental, economic, and social results obtained by this strategy in a series of industrial sectors are increasingly inseparable. Examples of this can be found in several articles. For Oliveira Neto et al. (2015), changes in the competitive environment of the automotive industry and the pressures of different stakeholders have led to the need for environmental improvements, from which a series of benefits for the business as a whole was identified. Severo and Guimaraes (2016) concluded that there is a strong correlation between Cleaner Production and product innovations that generate positive financial impacts for corporations. Bai et al. (2015) demonstrate how the implementation of compulsory audits of Cleaner Production for industrial companies has helped to improve the level of resource efficiency and pollution, as well as being a potential factor in changing the perception of production organizations regarding public goods and the environment. Cobra et al. (2015) propose the elaboration of a hybrid definition between Cleaner Production and Lean Manufacturing, since they observed significant parallels among the objectives of the two methodologies. Sengupta et al. outlined its relevance for teaching. Several authors, (Almeida et al., 2015; Li and Hamblin, 2016; Lopes Silva et al., 2013; Severo and Guimaraes, 2016; Yusup et al., 2015; Zeng et al., 2010), for example, highlight the importance of ISO14000 as an important tool to aid in Cleaner production development and assist in reaping benefits such as “New business opportunities” and “Improvement of the organizational image and strengthening of the relationship with stakeholders”.

Finally, a detailed discussion about benefits arising from the implementation of Cleaner Production is then presented after Table 3.

4.1.1. Reduction of pollution, waste, and GHG emissions

It can be seen from Table 3 that the reduction of pollution levels generated by a productive operation, as well as its level of residues and greenhouse gas emissions, are among the main and most generalized benefits of Cleaner Production found in the literature. Of the 56 articles researched that mentioned benefits associated with their implementation, about 96% reported this topic as one of them. This is consistent with the observation by Cobra et al. (2015) and Dodić et al. (2010) that the reduction of waste in the production process (which potentially becomes waste and pollution) is the central objective of the methodology.

About this point, significant results can be observed, to highlight a few significant reduction examples:

- (Ribeiro Massote and Moura Santi, 2013): 23% solid waste; 93% effluent generation
- (Rivera et al., 2009): 11% waste; 21% GHG emissions
- (Ozturk et al., 2016): 52% wastewater; 18% solid waste; 32% gas emissions
- (Giannetti et al., 2008): up to 47% solid waste

4.1.2. Process, productivity, and product efficiency improvements (energy, water, materials, and use and reuse of productive resources)

This topic presented the second largest number of citations among the literature, with 94.44% of the articles identifying it as one of the benefits of Cleaner Production implementation. In addition, it is possible to observe a strong correlation between productivity and efficiency gains and the reduction of the level of residues, pollutants, and emissions treated in the topic above, with 98% of the articles mentioning the two benefits together.

Here too, it is possible to observe full coherence between a benefit obtained in the literature and the initial objectives of the methodology, since in its approach, unwanted byproducts of production processes are born from all kinds of process inefficiencies, from the project to the production itself, a problem that the literature seeks to solve by identifying the source of the pollutant, residue, or emission and, consequently, of the respective inefficiency to be eliminated (Malinauskiene et al., 2016; Oliveira and de Alves, 2007; Ozturk et al., 2016). In addition to the obvious benefit of lower input utilization in a single production unit, this topic is of great relevance because, as noted by Malinauskienė et al. (2016), large-scale efficiency gains are a growing concern and increasingly necessary to avoid the depletion of sources of supply of raw materials and reliable inputs for the industry.

Examples of relevant productivity gains resulting from the implementation of Cleaner Production are observed mainly in energy savings (Giannetti et al., 2008; Ozturk et al., 2016; Rivera et al., 2009), water (Giannetti et al., 2008; Ozturk et al., 2016; Rivera et al., 2009; Willers et al., 2014) and materials and other inputs (Giannetti et al., 2008; Ozturk et al., 2016). The results in the above-mentioned cases reached maxes of 36% energy use reduction, 51% water use reduction and 86% reduction of a pollutant degreasing solution for jewelry production.

4.1.3. Reduction of risks (occupational, human, and environmental)

In this topic, articles that put the risk reduction incurred by an organization in its production as a benefit of Cleaner Production were selected. Of all the reviewed literature, 70,37% of the articles mentioned this topic. This risk reduction was observed mainly on three fronts. Occupational risks are related to the work itself as well as the internal risks of the organization. Human risks are those of

Table 3
Benefits of Cleaner Production (Source: see references for each benefit).

Benefits	Authors	% Authors
Reduction of pollution, waste, and GHG emissions	(Almeida et al., 2015; Altham, 2007; Armenti et al., 2011; Ashton et al., 2016; Bai et al., 2014, 2015; Boltic et al., 2016; Bonilla et al., 2010; Büyükbay et al., 2010; Cabello Eras et al., 2013; Castillo-Vergara et al., 2015; Daylan et al., 2013; Dodić et al., 2010; Dong et al., 2012; Esquer et al., 2016; Fore and Mbohwa, 2015, 2010; Geng et al., 2010; Giannetti et al., 2008; Glavič and Lukman, 2007; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2010, 2016; Li and Hamblin, 2016; Lopes Silva et al., 2013; Malinauskiene et al., 2016; Ochoa George et al., 2010; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Peng and Liu, 2016; Rahim and Raman, 2015; Ribeiro Massote and Moura Santi, 2013; Rivera et al., 2009; Severo and Guimaraes, 2016, 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Velazquez et al., 2014; Vieira and Amaral, 2016; Wang et al., 2015; Willers et al., 2014; Xu et al., 2016; Yüksel, 2008; Yusup et al., 2015; Žarković et al., 2011; Zeng et al., 2010; Zhang et al., 2015a,b; Zhou and Zhao, 2015)	96,30%
Process, productivity, and product efficiency improvements (energy, water, materials, and use and reuse of productive resources)	(Almeida et al., 2015; Altham, 2007; Ashton et al., 2016; Bai et al., 2014, 2015; Boltic et al., 2016; Bonilla et al., 2010; Büyükbay et al., 2010; Cabello Eras et al., 2013; Castillo-Vergara et al., 2015; Daylan et al., 2013; Dodić et al., 2010; Dong et al., 2012; Esquer et al., 2016; Fore and Mbohwa, 2015, 2010; Geng et al., 2010; Giannetti et al., 2008; Glavič and Lukman, 2007; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2010, 2016; Li and Hamblin, 2016; Lopes Silva et al., 2013; Malinauskiene et al., 2016; Ochoa George et al., 2010; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Peng and Liu, 2016; Rahim and Raman, 2015; Ribeiro Massote and Moura Santi, 2013; Rivera et al., 2009; Schaltegger et al., 2012; Severo and Guimaraes, 2016, 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Velazquez et al., 2014; Vieira and Amaral, 2016; Wang et al., 2015; Willers et al., 2014; Yüksel, 2008; Yusup et al., 2015; Žarković et al., 2011; Zeng et al., 2010; Zhang et al., 2015a,b; Zhou and Zhao, 2015)	94,44%
Reduction of risks (occupational, human, and environmental)	(Almeida et al., 2015; Armenti et al., 2011; Bai et al., 2014, 2015; Boltic et al., 2016; Büyükbay et al., 2010; Cabello Eras et al., 2013; Castillo-Vergara et al., 2015; Daylan et al., 2013; Dodić et al., 2010; Dong et al., 2012; Esquer et al., 2016; Fore and Mbohwa, 2015, 2010; Giannetti et al., 2008; Glavič and Lukman, 2007; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2016; Lopes Silva et al., 2013; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Peng and Liu, 2016; Ribeiro Massote and Moura Santi, 2013; Severo and Guimaraes, 2016, 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Velazquez et al., 2014; Vieira and Amaral, 2016; Wang et al., 2015; Willers et al., 2014; Xu et al., 2016; Yüksel, 2008; Yusup et al., 2015; Zhang et al., 2015a,b)	70,37%
New business opportunities (market access and innovation in sustainable products and processes)	(Almeida et al., 2015; Armenti et al., 2011; Boltic et al., 2016; Bonilla et al., 2010; Büyükbay et al., 2010; Castillo-Vergara et al., 2015; Dodić et al., 2010; Fore and Mbohwa, 2015, 2010; Giannetti et al., 2008; Hicks and Dietmar, 2007; Huang et al., 2013; Li and Hamblin, 2016; Malinauskiene et al., 2016; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Ribeiro Massote and Moura Santi, 2013; Severo and Guimaraes, 2016, 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Vieira and Amaral, 2016; Yusup et al., 2015; Zeng et al., 2010)	48,15%
Improvement of the organizational image and strengthening of the relationship with stakeholders	(Almeida et al., 2015; Altham, 2007; Büyükbay et al., 2010; Dodić et al., 2010; Fore and Mbohwa, 2010; Hicks and Dietmar, 2007; Li and Hamblin, 2016; Lopes Silva et al., 2013; Oliveira and de Alves, 2007; Ortas et al., 2013; Ozturk et al., 2016; Severo and Guimaraes, 2016, 2015; Thrane et al., 2009; Ulutas et al., 2012; Yüksel, 2008; Yusup et al., 2015; Zeng et al., 2010)	33,33%
Organizational competitiveness and profitability	(Almeida et al., 2015; Armenti et al., 2011; Bai et al., 2014, 2015; Boltic et al., 2016; Büyükbay et al., 2010; Cabello Eras et al., 2013; Castillo-Vergara et al., 2015; Daylan et al., 2013; Dodić et al., 2010; Dong et al., 2012; Esquer et al., 2016; Fore and Mbohwa, 2015, 2010; Giannetti et al., 2008; Glavič and Lukman, 2007; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2016; Lopes Silva et al., 2013; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ortas et al., 2013; Ozturk et al., 2016; Peng and Liu, 2016; Ribeiro Massote and Moura Santi, 2013; Severo et al., 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Velazquez et al., 2014; Vieira and Amaral, 2016; Wang et al., 2015; Willers et al., 2014; Xu et al., 2016; Yüksel, 2008; Yusup et al., 2015; Zhang et al., 2015a,b)	70,37%
Improvement of the work environment (environment, workers and managers qualification, motivation)	(Altham, 2007; Armenti et al., 2011; Büyükbay et al., 2010; Daylan et al., 2013; Dodić et al., 2010; Esquer et al., 2016; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2016; Li and Hamblin, 2016; Lopes Silva et al., 2013; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Ulutas et al., 2012; Willers et al., 2014; Yüksel, 2008; Zeng et al., 2010; Zhang et al., 2015a,b)	35,19%
Quality and improvement of product safety for consumers	Boltic et al., 2016; Büyükbay et al., 2010; Dodić et al., 2010; Esquer et al., 2016; Fore and Mbohwa, 2015; Ochoa George et al., 2010; Oliveira and de Alves, 2007; Severo et al., 2015; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Vieira and Amaral, 2016; Yusup et al., 2015)	22,22%
Technological update of productive processes	(Almeida et al., 2015; Altham, 2007; Bai et al., 2014; Boltic et al., 2016; Bonilla et al., 2010; Büyükbay et al., 2010; Castillo-Vergara et al., 2015; Daylan et al., 2013; Dodić et al., 2010; Esquer et al., 2016; Fore and Mbohwa, 2015; Geng et al., 2010; Giannetti et al., 2008; Hicks and Dietmar, 2007; Huang et al., 2013; Li et al., 2016; Li and Hamblin, 2016; Oliveira and de Alves, 2007; Oliveira Neto et al., 2015; Ozturk et al., 2016; Ribeiro Massote and Moura Santi, 2013; Rivera et al., 2009; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Vieira and Amaral, 2016; Wang et al., 2015; Willers et al., 2014; Yüksel, 2008; Yusup et al., 2015; Zhang et al., 2015a,b; Zhou and Zhao, 2015)	59,26%

Table 4
Difficulties in Cleaner Production (Source: see references for each benefit).

Difficulties	Authors	% Authors
Lack of clear sustainability guidelines (organizational or governmental).	(Almeida et al., 2015; Altham, 2007; Bai et al., 2014, 2015; Dodić et al., 2010; Dong et al., 2012; Fore and Mbohwa, 2015; Geng et al., 2010; Hicks and Dietmar, 2007; Li and Hamblin, 2016; Lopes Silva et al., 2013; Peng and Liu, 2016; Schaltegger et al., 2012; Severo et al., 2015; Shi et al., 2008; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Velazquez et al., 2014; Vieira and Amaral, 2016; Yüksel, 2008; Žarković et al., 2011)	59,46%
Inappropriate record keeping – Negligence in knowledge management	(Büyükbay et al., 2010; Giannetti et al., 2008; Lopes Silva et al., 2013; Ribeiro Massote and Moura Santi, 2013; Shi et al., 2008; Velazquez et al., 2014)	16,22%
Unavailability of resources (financial, human, and managerial, technological, informational, and monitoring)	(Almeida et al., 2015; Armenti et al., 2011; Ashton et al., 2016; Bai et al., 2014, 2015; Brown and Stone, 2007; Daylan et al., 2013; Dodić et al., 2010; Dong et al., 2012; Fore and Mbohwa, 2015, 2010; Geng et al., 2010; Hicks and Dietmar, 2007; Li and Hamblin, 2016; Lopes Silva et al., 2013; Oliveira and de Alves, 2007; Peng and Liu, 2016; Rahim and Raman, 2015; Shi et al., 2008; Silvestre and Silva Neto, 2014; Thrane et al., 2009; Ulutas et al., 2012; Vieira and Amaral, 2016; Yüksel, 2008)	67,57%
Discontinuation of Cleaner Production implementation projects	(Bonilla et al., 2010; Brown and Stone, 2007; Fore and Mbohwa, 2010; Hicks and Dietmar, 2007; Lopes Silva et al., 2013; Severo et al., 2015; Vieira and Amaral, 2016)	18,92%
Potential absence of incentives beyond compliance and operational inertia	(Almeida et al., 2015; Ashton et al., 2016; Brown and Stone, 2007; Dodić et al., 2010; Dong et al., 2012; Fore and Mbohwa, 2015; Hicks and Dietmar, 2007; Li and Hamblin, 2016; Lopes Silva et al., 2013; Peng and Liu, 2016; Severo et al., 2015; Shi et al., 2008; Ulutas et al., 2012; Vieira and Amaral, 2016; Yüksel, 2008; Yusup et al., 2015)	37,84%
Short-term investment	(Altham, 2007; Büyükbay et al., 2010; Dodić et al., 2010; Dong et al., 2012; Fore and Mbohwa, 2015; Huang et al., 2013; Lopes Silva et al., 2013; Oliveira Neto et al., 2015; Peng and Liu, 2016; Shi et al., 2008; Ulutas et al., 2012; Vieira and Amaral, 2016; Yüksel, 2008; Yusup et al., 2015; Zeng et al., 2010)	40,54%
Absence or difficulty of participation of employees	(Armenti et al., 2011; Brown and Stone, 2007; Daylan et al., 2013; Lopes Silva et al., 2013; Ribeiro Massote and Moura Santi, 2013; Shi et al., 2008; Ulutas et al., 2012; Vieira and Amaral, 2016; Yüksel, 2008; Yusup et al., 2015)	27,03%
Inadequate planning	(Bai et al., 2014; Geng et al., 2010; Lopes Silva et al., 2013; Severo et al., 2015; Silvestre and Silva Neto, 2014; Ulutas et al., 2012; Vieira and Amaral, 2016)	18,92%
Conflicts between stakeholders	(Armenti et al., 2011; Bai et al., 2014, 2015; Geng et al., 2010; Hicks and Dietmar, 2007; Schaltegger et al., 2012; Shi et al., 2008; Silvestre and Silva Neto, 2014; Ulutas et al., 2012; Vieira and Amaral, 2016)	27,03%
Inadequate communication systems	(Altham, 2007; Fore and Mbohwa, 2015; Geng et al., 2010; Lopes Silva et al., 2013; Vieira and Amaral, 2016)	13,51%
Absence of specific structured methodology for analysis and implementation of Cleaner Production	(Lopes Silva et al., 2013; Schaltegger et al., 2012; Ulutas et al., 2012; Vieira and Amaral, 2016)	10,81%
Increased complexity of operation	(Dodić et al., 2010; Geng et al., 2010; Vieira and Amaral, 2016)	8,11%
Absence of an "Environmental-friendly" culture (business and social level, including difficulty in seeing the benefits of Cleaner Production)	(Altham, 2007; Dodić et al., 2010; Geng et al., 2010; Hicks and Dietmar, 2007; Li and Hamblin, 2016; Shi et al., 2008; Yüksel, 2008)	18,92%
Difficulty receiving market feedback	(Altham, 2007; Hicks and Dietmar, 2007; Thrane et al., 2009)	8,11%

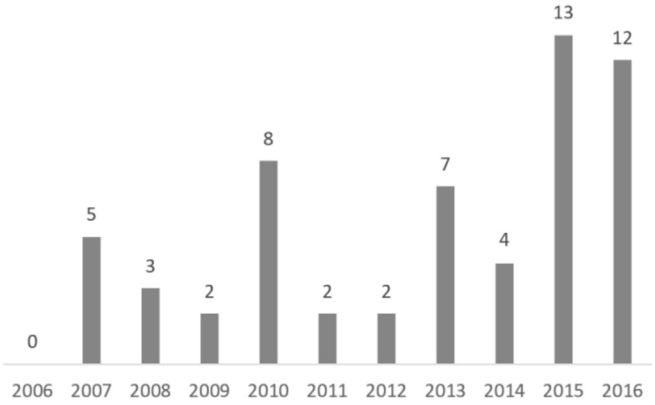

Fig. 2. Chronological distribution of the analyzed articles (Source: developed by the authors).

exposure to hazardous materials and internal and external contamination. Finally, environmental risks are faced by the organization when dumping waste into the environment or using hazardous materials of high environmental impact in their production.

The study by Armenti et al. (2011) highlights the advantage of Cleaner Production and pollution prevention methodologies over traditionally used end-of-pipe approaches. For the authors, in attempting to avoid environmental risk with end-of-pipe technologies, what is often observed is an external environmental risk transfer to internal occupational health risks when waste and pollutants are retained within the operation. The same occurs in the opposite direction when, trying to avoid workers' exposure to hazardous waste in the work environment, the organization installs technologies that release them into the environment and increase environmental risk. Within Cleaner Production's preventive approach, identifying and eliminating, or reducing, pollutants at source allows both types of risk to be mitigated. Through the case study analyzed, with three manufacturing operations of printed wire board, the authors also conclude that, even if the main objective of the implantation in most cases is the reduction of emission of pollutants, the improvement of the efficiency of processes and generation of competitive advantages, risk reduction benefits appear secondary through the elimination of wastes, pollutants, and amount of hazardous material used in the process.

4.1.4. New business opportunities (market access and innovation in sustainable products and processes)

The operational pro-activity provided by Cleaner Production can lead to a multiplication of innovations with benefits for both organizations and environment (Silvestre and Silva Neto, 2014). From

its inception, the organization takes a more critical look at how its products are produced and the wastes that can affect business sustainability both in the short and long term (Severo and Guimaraes, 2016). This more critical internal look, combined with external market pressures, gives rise to possibilities for innovation in products, using less absolute amounts of materials and higher percentage of renewable material, thus being less aggressive to the environment; or of processes, using renewable raw materials, achieving higher efficiency and generating lower waste and environmental impact (Li and Hamblin, 2016; Severo et al., 2016). In addition, we also observed that external market pressures have conditioned the access of low level environmental companies to consumer markets to disclose the concrete actions and results that they present. Also, in this case, the literature presents Cleaner Production as a valuable tool (Hicks and Dietmar, 2007).

4.1.5. Improvement of the organizational image and strengthening of the relationship with stakeholders

In addition to the exclusively operational benefits, it is possible to observe that the implementation of Cleaner Production also has the potential to generate benefits and intangible assets for the organizations. In 18 of the selected articles (33,33%), one of these benefits mentioned was this topic.

Yüksel (2008) exemplifies that companies' managers that implemented Cleaner Production identified an improvement in the image of their products and services by associating them with the environmental concern of the company, a potential link of improvement of organizational image and strengthening of the relationship with clients. In addition, they also noticed an improvement in the company's internal working conditions, which could be used to improve the relationship with internal stakeholders. When analyzing the impact, the DJSI-AP (Dow Jones Sustainability Index – Asia Pacific), Ortas et al. (2013) point out that Cleaner Production, and the environmental performance improvement it brings to organizations, have benefits that go beyond the reduction of operational costs, extending to intangible benefits that confirm the observations of this topic, such as: endorsement of the organizational image of commitment to the environment, its stakeholders, and sustainable development; and reductions in perceived risks of the medium- and long-term business associated with its engagement with environmental and social issues, which improves the perception of investors, customers, and employees. The study by Severo and Guimaraes (2016) further corroborates this observation by confirming the hypothesis that innovation in sustainable products, addressed in the topic above, goes beyond its intrinsic benefit, providing benefit to the organization's image, in addition, the use of Cleaner Production practices strengthens the company's intangible asset with its stakeholders.

4.1.6. Organizational competitiveness and profitability

Also with a significant percentage of observation in the researched literature (70,37%), this topic reaffirms Cleaner Production's vision and objective of being a strategy to generate simultaneous gains in both the environmental and financial areas of organizations. Since the absence of adequate resources is one of the main impediments to the implementation of this methodology, as can be seen in Table 3, it is vital for the success of programs and projects that have both environmental appeal and economic justification (Cabello Eras et al., 2013).

The profitability of Cleaner Production is strongly associated with the elimination of waste in processes and products and productivity improvements from its implementation – only one article from this topic is not related to achieving this result, and 37 out of 38 mention reduction of pollution, waste and GHG emissions, while 35 mention processes, productivity, and product efficiency improvements (energy, water, materials and utilization and reuse of productive resources). It is precisely these gains in the use and reuse of materials, productivity and cost reduction in processes and pollution treatment that have greater potential for cost reduction and, consequently, to improve the profitability of an operation (Cabello Eras et al., 2013; Glavič and Lukman, 2007; Oliveira Neto et al., 2015; Ribeiro Massote and Moura Santi, 2013).

Organizational Competitiveness has been treated separately since, although it is naturally associated with profitability gain, it is a more comprehensive term that can incorporate both the aforementioned intangible and tangible aspects (Oliveira and de Alves, 2007) detailed in the other benefit topics.

4.1.7. Improvement of the work environment (environment, workers and managers qualification, motivation)

Although this benefit has a tangible component, which is the improvement of observable working conditions and qualification of workers to make Cleaner Production viable, their economic and environmental benefits are difficult to quantify and, therefore, it can also be considered as an intangible benefit (Li et al., 2016). As an example, it is possible to observe that some measures from the implementation of Cleaner Production directly improve the quality of the work environment by exposing the workers to less insalubrious factors, also considering their suggestions in the improvement programs, guaranteeing simultaneous benefits to the process and to the quality of working conditions (Büyükbay et al., 2010; Huang et al., 2013; Yusup et al., 2015). In addition, another benefit that is difficult to quantify is the increase in staff qualifications, which needs to be achieved through training and seminars for those involved in the project, as observed by Daylan et al. (2013) and Huang et al. (2013). However, the increased awareness of critical processes and the environment provided to workers may make it easier to spot opportunities for productivity improvement, which in some cases require no additional investment (Zeng et al., 2010).

4.1.8. Quality and improvement of product safety for consumers

Safety and quality improvement should also be incentives for manufacturing managers to implement Cleaner Production. According to the authors, it encourages practices of technical and procedural improvements that, in addition to gains in efficiency and process efficiency, are broken down into product quality and safety improvements such as: optimization of the life cycle, ease of recycling, less use of hazardous materials, and ease of repair and reprocessing. This observation dialogues with the view of (Silvestre and Silva Neto, 2014), which identifies the adoption of a proactive management methodology such as Cleaner Production as the origin of the organizational stimulus for these improvements, in which there is room for greater participation of different stakeholders in the management and development process.

4.1.9. Technological update of productive processes

A significant number of authors mention this topic as one of the results of applying Cleaner Production programs (59,26%). Although the investment in technology is not necessarily a benefit in itself, as it implies additional investments, it has been chosen to classify it as one, since in several cases it is mentioned as such in the literature on the subject and there is association of this particular methodology as a technology diffuser in the industry (Zhou and Zhao, 2015). Moreover, it is often the absence of a critical eye on the waste of a process that allows obsolete technologies to continue to be used. With Cleaner Production, studies of the technologies available on the market (Zhou and Zhao, 2015), or even benchmarking (Altham, 2007), can expose the weaknesses and inefficiencies of a process in terms of the technologies used. In

addition, once the origin of the waste is studied (Giannetti et al., 2008) and it goes back to obsolete or dirty technology, its replacement by a cleaner and more efficient technology can generate competitive economic and environmental benefits for the organization (Bai et al., 2014; Oliveira Neto et al., 2015). It is in this sense that the technological update is also a benefit of this methodology.

4.2. Difficulties in the implementation of cleaner production

In addition to the identification of benefits, this study also aimed to identify the difficulties that hinder, prevent, or discourage the implementation of Cleaner Production. Among the literature reviewed, a total of 39 articles reported some difficulty that could be found regarding this methodology. Difficulties were categorized as they appeared in the literature review and the results are presented in Table 4.

4.2.1. Lack of clear sustainability guidelines (organizational or governmental)

Despite the reported benefits, the success of Cleaner Production programs has as one of its main difficulties (mentioned by 59,46% of the researched literature) the lack of clarity in the policies and guidelines responsible for establishing the resource needs and internal synergies in the case of an organization or the broader competitive environment and the need to adopt sustainability tools when it comes to a national policy.

As an example of this problem in manufacturing organizations, Shi et al. (2008) note that without a clear policy for the implementation of this type of methodology, the priorities of managers and decision makers tend to focus much more on traditional aspects of operations of daily life, such as market share and increased production. In addition, many managers are not familiar with the benefits of Cleaner Production, and without clear objectives, benefits, and methodology they will resist change and fear making changes to their traditional manufacturing operations. This finding is consistent with the study by Silvestre and Silva Neto (2014), which states that only a consistent change of mindset in companies and internal and external environmental policies are capable of creating the kind of synergy necessary for the successful implementation of sustainability tools, fully reaping its benefits.

On the government side, research suggests that the participation of the public sector in environmental awareness is fundamental, as is the promotion of collaborative and taxing public policies. These policies shape the competitive environment of companies and encourage them to adopt proactive methods of improving environmental performance while at the same time gaining competitiveness (Peng and Liu, 2016; Yüksel, 2008). As noted by Peng and Liu (2016) and Shi et al. (2008), the absence of such incentives can become a barrier to the implementation of Cleaner Production for a number of reasons, including: difficulty of company management in understanding the real importance and potential of the methodology, weak incentives for the adoption of efficiency gains and improvement of environmental performance, absence of a sense of urgency in the elaboration of proactive prevention plans, low demand for products with an intangible environmental component, and difficulty of forming a more environmentally correct consumer and producer market, among others.

4.2.2. Inappropriate record keeping – Negligence in operations knowledge management

A more operational aspect of companies that can also compromise the quality and success of Cleaner Production programs is the lack of reliable data and record keeping of the inputs and wastes inherent to the organization's processes (Büyükbay et al., 2010; Shi et al., 2008). For programs to continue, it is necessary to overcome this barrier and introduce detailed reports and records on which possible improvement actions shall be taken (Shi et al., 2008).

4.2.3. Unavailability of resources (financial, human, and managerial, technological, informational, and monitoring)

In the researched literature, the lack of necessary resources allocated to Cleaner Production projects was the main mentioned difficulty, with 67,57% of the articles surveyed falling into this category. The lack of adequate resources is a rather generic categorization and can occur on several fronts. In the financial question, Peng and Liu (2016) identify that the promotion of Cleaner Production can turn out to be a process that demands quantities of capital often unavailable in companies with less access to resources. Silvestre and Silva Neto (2014) corroborate this argument, since they argue that there are cases in which the economic factor overlaps with the others and prevents the adoption of technologies and suggested solutions. Especially in small and medium companies, the aspect of economic viability needs great attention so that the programs are not depleted due to economic difficulties, since these companies have less access to financial resources (Rahim and Raman, 2015).

From the perspective of the lack of human, managerial, technological, and monitoring resources, Shi et al. (2008) exemplify in their study, in a very concise way, some of the difficulties that can be found, such as: lack of knowledge and technical limitations of workers who could be involved in projects and insufficient training for operational level employees to maintain the effectiveness of the potential measures taken; lack of internal or external knowledge sources, hindering access to information on how to map and act on processes using Cleaner Production; lack of knowledge and ability of managers to assess and reap the potential economic and environmental benefits offered by this strategy, corroborated by Ashton et al. (2016), who state that, despite recent progress, there is still a very large knowledge gap regarding the methodology and its effectiveness. Also, Vieira and Amaral (2016) identified that inadequate information tools, problems in the organization's knowledge management structure, and lack of skilled human resources hinder the identification of possible improvements and opportunities.

4.2.4. Discontinuation of Cleaner Production implementation projects

According to Vieira and Amaral (2016), it is fundamental that Cleaner Production is treated as a tool for continuous improvement and, therefore, its implementation has a cyclical character and monitoring and constant gains. Therefore, seven authors in the researched literature precisely identified the discontinuity of these programs as a barrier to obtaining their best results. Bonilla et al. (2010) and Severo et al. (2015) claimed that, alone, Cleaner Production projects do not guarantee continuous improvement in the operational and environmental results of an operation. In addition, Brown and Stone (2007) point out that companies often resort to government incentives or even promote internal support programs for this type of project and, once the incentives are withdrawn or the initial team is modified, the processes return to the initial state and the program ceases to exist.

For this type of discontinuity not to occur, it is fundamental that these projects are integrated to management methodologies and continuous improvement in a systemic way within the organization, creating synergies between different departments within an organization (Bonilla et al., 2010; Lopes Silva et al., 2013; Severo et al., 2015).

4.2.5. Potential absence of incentives beyond compliance and operational inertia

Despite growing market signals about the benefit to companies of taking proactive measures to improve environmental performance, many productive organizations are not yet responsible for bearing all the costs imposed on society and the environment by their products and processes and,therefore, neglect their management (Fore and Mbohwa, 2015). Therefore, in the absence of an appropriate regulatory and market environment, in which efforts with proactive measures such as Cleaner Production are rewarded by different economic agents (Hicks and Dietmar, 2007; Yüksel, 2008), these organizations are often unable to see reasons and benefits to undertake beyond the minimum necessary to not suffer punitive sanctions due to their environmental performance. In addition, the lack of such an environment of favorable incentives makes it difficult to break the resistance to change in the part of managers, which is even worsened by the additional investments (Hicks and Dietmar, 2007; Shi et al., 2008; Vieira and Amaral, 2016).

4.2.6. Short-term investment

While the description of the benefits of Cleaner Production allows for the generation of very positive operating results and profitability after its implementation, the process may in some cases consume a significant amount of company capital and not generate immediate results. Therefore, many companies that do not have abundant capital availability may not have sufficient incentives to adopt this methodology (Peng and Liu, 2016). Moreover, in these cases, the immediate expenditure affects the financial result of the company negatively during implementation and companies with a shorter-term focus may see this as a very negative point (Oliveira Neto et al., 2015), especially when considering the fact that economic issues overlap with the others among the perceptions of different stakeholders (Dong et al., 2012).

Finally, Zeng et al. (2010) note that this is a relevant difficulty that stands out from a certain level of implementation of Cleaner Production. This is because, despite opportunities for improvement at low or no cost, initiatives aimed at achieving higher levels of environmental performance and sustainability include reformulation aspects of products and processes and replacement of raw materials and energy sources, which require significant amounts of initial investment.

4.2.7. Absence or difficulty of participation of employees

According to Daylan et al. (2013), the implementation of Cleaner Production does not only include technical and procedural changes, but also changes in the attitude of workers and in the management system. Armenti et al. (2011) and Vieira and Amaral (2016) stress that the benefits of this methodology are only perceived when both management and the other employees are engaged in improving the company's environmental performance. For this reason, we identified in the researched literature that the lack of participation of the workers involved or affected directly by the process of the implementation of Cleaner Production is a strong barrier to its success (Lopes Silva et al., 2013; Shi et al., 2008). This is especially noticeable when considering the continuous character of improvement of this methodology, since it requires constant commitment and a flow of suggestions for improvement over time (Yusup et al., 2015).

4.2.8. Inadequate planning

As with the implementation of any project or organizational change, good planning is a key aspect to the success of Cleaner Production (Lopes Silva et al., 2013). However, when done improperly, it can also become a barrier. According to Bai et al. (2014), it is common for companies to adopt technologies related to Cleaner Production in a timely manner and without any type of planning to structure methodologies integrated with the rest of the organization, which makes the results of the program mediocre. Lopes Silva et al. (2013) point out in their study another aspect related to the planning of this methodology and its maturity, which is the lack of use of quality tools. These tools could improve the quality of planning and add to the management maturity of this tool. Vieira and Amaral (2016) also exemplifying the importance of planning, since, to generate good results, it is fundamental that organizations create an environment where adequate resources and information are available for Cleaner Production realization, in line with Topic 4 of the session results, the result of prior planning.

4.2.9. Conflicts between stakeholders

To be successful in projects and especially in preventive approaches to the application of environmental management, it is fundamental that all the different stakeholders involved have their interests and priorities established in the process (Armenti et al., 2011; Geng et al., 2010) – from the micro level, in which the different departments of a company do not synergistically act (Schaltegger et al., 2012), to the macro, in which environmental and sustainability policies are considered in a region and other major social factors (Lopes Silva et al., 2013; Vieira and Amaral, 2016). Therefore, when there is a decision to implement Cleaner Production, the perspectives of different stakeholders may diverge and become a barrier to the continuation of the process (Bai et al., 2014). In addition, programs run a much greater risk of failure in cases in which isolated initiatives fail to adequately manage this conflict and neglect the real needs of the interested participants (Silvestre and Silva Neto, 2014).

4.2.10. Inadequate communication systems

Another difficulty identified by the authors of the literature consulted is deficiencies in communication processes, both internal and external to the organizations. Although both types of communication are mentioned, there is a greater emphasis on the internal aspect. Vieira and Amaral (2016) identify that the possibilities of Cleaner Production are limited by the absence of adequate communication systems that interconnect those responsible for production and those responsible for the residue of the productive processes. Fore and Mbohwa (2015) and Lopes Silva et al. (2013) state that the lack of adequate information and communication systems are among the main difficulties to the success of these projects.

Focusing the external communication (Geng et al., 2010), point out the need for systems that enable the interaction between enterprises professionals nd public agents. This point of view dialogues with the above topic, creating synergies between different stakeholders with clear communication.

4.2.11. Absence of specific structured methodology for analysis and implementation of Cleaner Production

Despite the evolution in depth and scope of objectives of Cleaner Production, authors note that the difficulty reported in this topic, which was already observed decades ago, remains a major barrier (Lopes Silva et al., 2013). As identified by Vieira and Amaral (2016), despite the increasing number of methodologies and procedures for implementation, there is no specific formula applicable in all cases. In addition, existing methodologies in the literature fail to consider all the necessary information, the procedures that should be adopted in each phase, and the techniques and objectives that must be considered for the programs to be effective (Lopes Silva et al., 2013).

4.2.12. Increased complexity of operation

An additional risk observed is that, beyond the financial commitment often required, the implementation of Cleaner Production may require constant revisions in production processes and technologies used in it, as well as in the management control methods. As a consequence, a static and stability element is eliminated and constant changes turns the process management into a temporarily more complex operation for the organization (Dodić et al., 2010; Vieira and Amaral, 2016). In addition, as the methodology progresses, modifications may be required in related areas, such as product development, marketing, and inputs used. If this possibility is not well planned and viewed from the beginning of the process, there is a risk that the increase in complexity and challenges that arise during the process will become disincentive to the continuity of Cleaner Production (Vieira and Amaral, 2016).

4.2.13. Absence of an "Environmental-friendly" culture (business and social level, including difficulty in seeing the benefits of Cleaner Production)

As stated by Yüksel (2008), for Cleaner Production to spread, it is necessary that the issue of sustainability and the environment is incorporated into the culture of organizations at all levels. The paths that lead to the construction of this perception that impels companies to pursue solutions and provide resources to improve their environmental performance are, in turn, built from a series of internal, organizational, external, and social pressures (Hicks and Dietmar, 2007). Thus, the researched literature identifies the inexistence of these different pressures, and of a culture that considers the problems of sustainability and the environment, as an important barrier to Cleaner Production.

4.2.14. Difficulty receiving market feedback

When companies invest in environmental management programs, they aim to improve their financial results, whether through operating gains, market recognition, or gains in intangible assets. For all these benefits to be harvested, Altham (2007), Hicks and Dietmar (2007), and Thrane et al. (2009) point out that there needs to be a market for Cleaner Production in which business efforts are recognized and reflected, for example, in consumer preferences, improvements in the organization's image, and input price signals (water, energy, pollution-generation costs) that encourage them to adopt sustainability practices. For this reason, one of the topics identified is that often the current market conditions and the difficulty in receiving external signals of positive feedback from the market about the outcome of their actions may be obstacles to the promotion of such programs, which do not happen or are left aside after performing the necessary minimum (Altham, 2007; Hicks and Dietmar, 2007; Thrane et al., 2009).

5. Conclusions and future research

With the research and analysis of recent literature, we conclude our initial objectives were met and that the literature review conducted provided satisfactory answers to our research questions.

Answering research question one, the literature review conducted allows us to observe that, although still hindered by some present difficulties, Cleaner Production shows itself viable in a series of industries that can be explored within the listed references. The current picture of Cleaner Production indicates that the methodology can be a correct path to be followed by organizations in the search for improved sustainability performance, as Bai et al. (2014) and Kjaerheim (2005) point out. However, once more it is important to bring up the observation by (Luken et al., 2016; Vieira and Amaral, 2016; Zeng et al., 2010) that Cleaner Production has not yet reached many industries because of observed difficulties and that the correct management of these becomes essential.

Regarding research question 2, by reviewing of the selected literature we sorted a full list of the specific benefits and difficulties observed in Cleaner Production implementation. They have been categorized and all the references associated with each were exhibited in the tables to facilitate further exploration. We believe that the results presented by this article will contribute to the advancement of Cleaner Production, providing to academics and enterprise managers a clear picture of the benefits generated by the implementantaion and the difficulties faced in the process. Academics may be use the results as a start point to develop new researches and enterprise managers as guidelines to facilitate implementation of Cleaner Production projects.

Regarding future steps and limitations, it can be said that the main limitation of this research resides in the fact that it does not consider in detail the specific paths and steps taken by different productive organizations and governments to reap the benefits listed. Furthermore, it does not provide structured solutions to the difficulties encountered. This was not within the research purposes, and for that, further research is needed. It should also be noted that these points were raised from different experiences at the most diverse levels. Therefore, sectoral and conjunctural analyses and prospects should consider their specific contexts when using them as a reference, considering the existence of additional benefits and difficulties that escape the literature reviewed in this article.

To further contribute to the Cleaner Production knowledge body, we provide suggestions for further research about the theme approached in this review. More detailed research about the path and steps that can be taken to reap each or a set of benefits and avoid the observed difficulties, the proposal of management models and indicators that assist in achieving cleaner production goals; further study of the synergies and correlations of each benefit and difficulty; assessment of the applicability of the observations of this review in different industry branches and specific contexts and conditions.

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