Solid waste management performance: a case study in a research institution

Desempenho da gestão de resíduos sólidos: um estudo de caso em uma instituição de pesquisa

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ABSTRACT
Waste is a environmental problem. Waste generation increases exponentially, and the management to minimize environmental impacts. The launch of the 17 (SDGs), by the U. N., aimed to mobilize to implement public policies based on the pillars of sustainability. At (studied company) routines of research laboratorial activities, farms and administrative areas generate waste. We evaluated the waste management at the (studied company) research institution. We applied methodologies for a comprehensive view. Gravimetric method for characterization of waste in each category. Monitoring of waste generator points resulted in the diagnosis of waste separation. The methodology of the Discourse of the Collective Subject was used to understand the perception of employees. We development the SWOT matrix, to identify the factors that affect the waste management. We understand and rank the strengths, weaknesses, opportunities and threats, and they can be used for the development of management.

Keywords: environmental management, social representation, stakeholders, SWOT matrix.

RESUMO
O lixo é um problema ambiental. A geração de resíduos aumenta exponencialmente, e a gestão minimiza os impactos ambientais. O lançamento dos 17 (ODS), pela ONU, teve como objetivo mobilizar para a implementação de políticas públicas baseadas nos pilares da sustentabilidade. Nas rotinas de atividades laboratoriais de pesquisa, fazendas e áreas administrativas geram resíduos (empresa estudada). Avaliou-se a gestão de resíduos em uma instituição de pesquisa. Aplicou-se metodologias para uma visão abrangente. Método gravimétrico para caracterização de resíduos em cada categoria. O monitoramento dos pontos geradores de resíduos resultou no diagnóstico da separação de resíduos. A metodologia do Discurso do Sujeito Coletivo (DSC) foi utilizada para compreender a percepção dos funcionários. Desenvolveu-se uma matriz SWOT, para identificar os fatores que afetam a gestão de resíduos. Foram entendidos e classificados os pontos fortes, fracos, oportunidades e ameaças, e eles podem ser usados para o desenvolvimento da gestão.

Palavras-chave: gestão ambiental, representação social, partes interessadas, matriz SWOT.

1 INTRODUCTION

Waste generation and disposal are inherent in human activities. Currently, waste management is the focus of public policies worldwide. For example, through the 17 Sustainable Development Goals (SDGs) proposed by the United Nations (UN), the commitments of the global agenda based on economic, social and environmental pillars were stated (Salvia et al., 2018). In corporate management, environmental responsibility has been implemented as a strategy (Chen et al., 2018).

(Studied company) is aware of its environmental responsibility has aligned its activities with a commitment to contribute to the country in the service of SDG. The eleventh SDG is about Sustainable Cities and Communities and to achieve its goals, (studied company) works to contribute to the integrated management of its waste (Da Costa et al., 2018).

The research activities carried out in the institution generate a variety of solid waste in their laboratories, offices and experimental farms. This waste requires management and involves the participation of employees and collaborators, from the generation and separation to the final destination. Waste management is a challenge for the whole society (Xiao et al., 2017).

This research presents the tools used in waste management at the institution, to monitor the generation and disposal, the verification of the separation process and the commitment and awareness of those involved in the process, as well as a strategic analysis tool used to direct the improvement actions. According to Moreira et al. (2018), waste management needs support tools for diagnosis and evaluation of the process.

The gravimetric method is used for quantitative and qualitative evaluation of waste and contributes to decision-making and management changes (Rocha et.al., 2018). Additionally, waste management establishes appropriate disposal and treatment and considers generation and minimization through reuse and recycling (Fagnani and Guimarães, 2017).

To understand the perception of those involved in the selective collection process, the Discourse of the Collective Subject (DCS) methodology was applied, which is based on the collection of data through interviews and analysis of its content, selecting what is

representative and repeated as an idea to build speeches (Ribeiro et al., 2016). Knowledge produced by a collective group enables the representation of a shared reality (Nóbrega et al., 2016).

The SWOT matrix is a tool that analyzes the management system, considering its strengths and weaknesses, its opportunities and threats, seeking to evaluate the main factors that impact on these points of interest. This model, when used in strategic management allows the planning of the organization, optimizing the strengths to minimize its weaknesses and considering the opportunities and external threats (Paschalidou et al., 2018). The SWOT matrix was designed to be used both in the early stages of decision-making and in strategic management planning (Zorpas et al., 2018).

This paper presents the use of the SWOT matrix as a strategic analysis and planning tool for the waste management within a research institution. For the matrix arrangement, the qualitative research methodology, DCS, was used to obtain knowledge regarding environmental awareness.

2 METHODOLOGY

2.1 THE RESEARCH

In a methodological perspective, this research is classified as exploratory, qualitative and descriptive. A literature review and a case study were used, based on survey data to obtain information that represents the local reality (Silva et al., 2018).

2.2 COMPANY CHARACTERIZATION

(Studied company) is a decentralized unit of (studied company) - State of Minas Gerais – Brazil. The research activities of the institution are based on the development of technological solutions that contribute to the strengthening of the milk production chain in Brazil and in the tropics. The unit has thirteen research laboratories, as well as a sector focused on the administrative area. It currently has a staff of 320 employees and approximately 200 trainees. In the constant search for modernization of its practices and processes, the restructuring of the infrastructure and the adaptation to more sustainable management took place. The concept of sustainability is necessary to consider the resources used and to evaluate the impact of carrying out the activities in environmental, economic and social terms (Arnold, 2017).

2.3 GENERATED WASTE MANAGEMENT

The Solid Waste Management Plan (SWMP) of the institution was analyzed, which describes the management of the waste generated in the unit, according to the following categories: non-recyclable waste, organic waste, recyclable waste, waste of healthcare (WHC), chemical waste, used linear fluorescent lamps, spent batteries and used tires. This waste varies according to volume and type of research carried out. Waste characterization should be considered as a starting point in an environmentally sustainable management policy (Oyekale, 2017, Pirani et al., 2014, Afroz et al., 2011). Waste management is gaining prominence due to the exponential increase and the potential risks of the waste generated, when mishandled (Moreira et al., 2018).

Specific technical aspects of waste, management models and the local context influence the waste management strategies (Ripa et al., 2017).

The gravimetric study, carried out in 2018, is described in this research to control and monitor the waste generated in the unit. Characterization is an essential step in waste management (Adeniram et al., 2017). A quantitative survey of recyclable and non-recyclable waste was carried out through the collection and packaging of the residues for one week to increase the significance of the sample. The residues were collected at generator points, packed in containers and at the end of this period they were categorized and weighed separately. The volume of accumulated waste during one week was adjusted to represent the estimated amount for the period of one year. Due to the periodicity of disposal waste described in Table 01, the samples were stored for one year (January to December 2018), weighed and quantified. Realistic diagnosis is the crucial point to adjust the dimension of management and its relation within the organization process (Fagnani and Guimarães, 2017).

Gravimetry is held annually during the review and updating of the SWMP, as required by National Policy on Solid Waste (NPSW) (Brazil, 2010).

Table 01. Amount of solid waste generated at (studied company) in 2018.

Waste	**Weight kg /year**
Recyclable	2030
Non-recyclable	2960
Organic	1960
Light bulbs	200
Used tires	320
Waste of healthcare	1260
Chemical waste	400

Beyond to gravimetric, the points of generation of recyclable and non-recyclable waste are monitored routinely to evaluate the separation process at the source. The investigation carried out in all generators points was characterized qualitatively. When separation is appropriately performed, it is assessed as correct; when it presents some errors, it is considered partially incorrect and incorrect when it is entirely wrong. This work has been carried out since the waste management implementation in the unit, in 2015. According to Wilson et al. (2015), evaluating the performance of waste management can be accomplished in several ways and with a strategic focus on the intended objectives.

The separation of waste is a challenge for the functioning of the system since this action depends directly on the generators. It requires individual effort, and participation of all (Stoeva e Alriksson, 2017).

2.4 QUALITATIVE RESEARCH: DISCOURSE OF THE COLLECTIVE SUBJECT (DCS)

Qualitative research was conducted to know the perception of employees and trainees about waste management. The methodology identifies the social representations from the construction of speeches written in the first person, based on the answers collected from the participants, through recorded interviews (Lefevre et al., 2014). The DCS was based on the theory of Social Representation (SR), a methodology that allows the construction of a single discourse from a set of similar fragments extracted from the answers provided by the interviewees (Markova, 2017).

DCS identifies how interviewees see their insertion into the waste separation process, the importance of awareness campaigns, and their changing habits. The answers to each question were recorded at the time of the interview, without interference, and they represented the knowledge of the sender about the specificity of each subject.The elaboration of the questions followed specific criteria to meet the objectives of the work or the approach.

The interview script presented in Table 2 was based on three questions. Question 01 refers to participation in waste separation; Question 02 focuses on understanding the campaigns and their importance; and Question 03 is about how the knowledge gained in the company influences the routine outside the work environment.

Table 2. Structured interview script using DCS methodology.

	Question goal	Questions asked to interviewees
Question 01	To check the views of interviewees on proper waste separation.	(studied company) performs the separation and proper disposal of recyclable waste. What do you do in your daily life in the company that can contribute to this action?
Question 02	To check the recognition of the importance of the campaigns as a way of raising awareness.	(studied company) carries out waste separation campaigns. What is your opinion about the campaigns? What is your perception on them?
Question 03	To understand if the actions performed within the unit, aimed at the correct separation of waste, induces changes in interviewees' habits.	We are all involved and practicing the concepts of waste separation. How do the environmental actions carried out at (studied company) influence your behavior outside the company?

Twenty-two people among researchers, analysts, assistants,and collaborators were interviewed. The selection of interviewees considered the representativeness of activities in the company, involving applied research, laboratory and administrative routines and field activities.This selection is a qualitative research step that determines the characteristics of a group in which it is desired to know the perception about a particular subject (Otenio et al., 2014).

The research was registered in the electronic system used to register research involving human beings in the Ethics Committees/Platform Brazil, through the CPEA protocol (Certificate of Presentation for Ethical Appreciation) number 03366012.2.00005147.

The interviewees signed a Free Informed Consent Form, which ensures the agreement of the interviewee with the participation in the research.

The interviews were recorded on a SONY® ICD-PX312 digital recorder and the audio files transcribed in their entirety to the text format, and then the meaning of the set of answers was analyzed. QQsoft® software was used to tabulate the responses, assisting in the organization, grouping,and identification of Central Ideas (CI) through categorization. Fragments with similar meanings for each CI were used to construct speech-synthesis (CSS) / result.

2.6 SWOT MATRIX

The SWOT matrix was used to identify strengths and weaknesses, opportunities and threats related to internal and external factors of solid waste management. The SWOT analysis is based on both quantitative and qualitative approaches for analysis and

diagnosis applied in indoor and outdoor environments and is useful to support decision strategies (Comino e Ferretti, 2016).Strengths are the skills inherent to the process, and weaknesses are the shortcomings that hinder the process. Opportunities are favorable points for achieving results, and threats are the challenges imposed externally that can affect the whole process (Jasiulewicz-kaczmarek, 2016).

Questions were prepared for determination of factors used in the SWOT matrix, as described in Table 3.

Table 3. Questions for SWOT analysis.

Factors	Questions
Strengths	What actions strengthen the selective collection? What factors support waste management? Are financial resources for waste management available?
Weaknesses	What can be improved? What is done incorrectly? What barriers hinder progress?
Opportunities	Where are the good chances of the plan? What alternatives does the NPSW indicate to the implementation of the plan? Can waste management influence the neighborhood?
Threats	What obstacles does the plan face? Are there support services for the implementation of the plan? Do employees show interest and willingness to support selective collection?

Adapted from Srivastava et al., 2005.

The answers to the questions in Table 3 were obtained from monitoring worksheets, checklists, evaluations of external organizations, interviews with specialists and managers of waste management institutions, as well as the qualitative research with the DCS methodology. The answers to these questions were used in the setting of the SWOT matrix.

The matrix was constituted through the listing of at most three factors corresponding to each point, maintaining the numerical equilibrium. To analyze the internal environment, the strengths and weaknesses of the routines implemented and established by the company were verified. For the analysis of the external environment, opportunities created in the implementation of the waste management process were considered, as well as threats that occur due to factors external to the institution.

In a study published by Raharjo et al. (2015) the SWOT matrix was used similarly, collecting qualitative data from questionnaires and interviews to identify the real situation and to indicate perspectives for improving the existing condition.

3 RESULTS AND DISCUSSION

The results of the gravimetric study showed that most of the generated waste is non-recyclable (33%), followed by recyclable (23%) and organic (21%). The composition of the waste is different from that found in solid urban waste studies in Brazil and other developed or non-developed countries, where the most significant portion is composed of organic and recycled waste (Deus et al., 2017; Massukado et al., 2013). It is due to the fact that it represents the research company waste, with its peculiarities, rather than domestic urban waste.

Figure 1 shows the diagnosis of the selective collection since the implementation of waste management to the date of this study. It is possible to observe that the year of 2017 showed the best results with a low incorrect separation index.

Figure 1. Performance evaluation of selective collection.

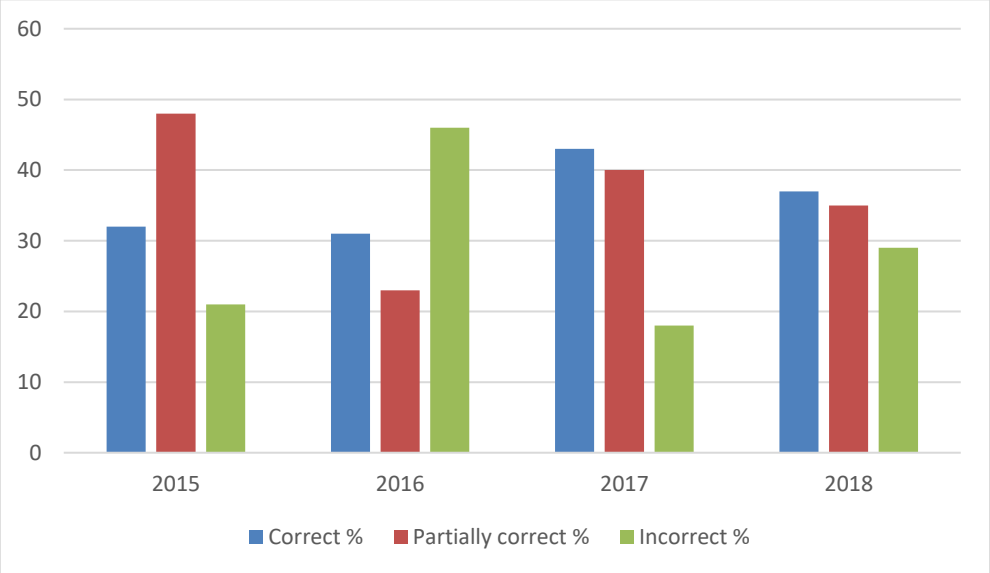

Figure 1 shows that there are errors in waste separation at the time of disposal. Although the waste separation process in the institution has rules not to induce the adhesion of employees, but to promote informative and awareness campaigns, the result of the internalization of the selective waste collection is similar to that found by Sorkun (2018). The author concluded that people consider the act of recycling as convenient only when supported by social norms, which encourage behavior change. In both studies the

difficulty of adherence to the selective collection process and the need to find new tools to improve the performance of waste separation are evident.

The qualitative research method (DCS) was used to understand the perception of employees and collaborators about waste management as well as their level of awareness and involvement.

The answers to the questions presented in Table 2 were analyzed following the DCS methodology, and as a result, five speeches were generated. Two statements were select as relevant for the social representation of solid waste separation.

Question 1 generated 3 CI, with respectively 3 CSSs. In the Central Idea/category 1: "Contributes to the process, separating correctly" produced from question 1. For this question, most respondents (87%) recognize their insertion in the process of selective collection, contributing and practicing:

3.1 CSS 01

"Because there are containers, I separate organic waste, recyclable waste, and everything. I direct the general waste to the non-recyclable trash. I always try to discard according to what is indicated on the bins. In my day-to-day life, there are two separate boxes, one for recyclable and another for non-recyclable.At the time of collecting the waste in the office rooms, we already have the boxes 'separated'. (studied company) *gives all support, gives directions because if we don't have guidance, it's difficult to proceed. Putting things in the right place, we have been able to keep up with this work by preventing soil contamination. There were some things I didn't know that were recyclable, other things I thought were recyclable, and they are not, then I learned here at* (studied company), *observing. We received directions from the staff that works with the trash recycling, so they ask, and we separate. I always separate the garbage, so it doesn't pollute the environment, that's why I try."*(Codification of the interviewees who contributed to this CSS: E03, E04, E05, E06, E07, E08, E09, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E21, E22).

Although the following stretch in the speech CSS 01 was identified: "*Because there are containers, I separate organic waste, recyclable waste, and everything... I direct the general waste to the non-recyclable trash.*" It was verified that the correct separation does not occur in reality, as shown in Figure 1.

The results of the selective collection monitoring are not compatible with this speech, since the percentage of incorrect disposal is high, presenting its worst result in

2016 (Figure 1). The results show a gap between the intentions to separate the waste from the action itself, once most respondents claim to contribute the process correctly. The results are similar to those found by Stoeva and Alriksson (2017), who demonstrated that even under favorable conditions for waste separation, individual behavior is tied to personal attitudes toward separation.

Question 2 generated 2 CI, with respectively 2 CSSs. In the Central Idea/category 2: "Campaigns are good, important and necessary for awareness," was an extract from Question 2. Most respondents (77%) said that campaigns are useful, essential and necessary for awareness.

3.2 CSS 02

"These campaigns are useful and necessary because there is always something new to learn or improve. Campaigns and lectures are essential to bring more information to us. We have received several emails regarding the correct disposal of materials. These emails bring a lot of information; this can make a person aware, show what is happening, show why waste separation is important. Everything that's in communiqués serves for our personal lives, in other circumstances, it could get unnoticed. Campaigns are important because often we also don't know how to dispose of waste correctly. Lack of knowledge disturbs people. Educate people, so they understand how to put things in the right places. When we receive information about waste separation and what to do with certain types of products, we try to apply them here whenever possible. Educational work is critical! I think it's related to the aim of the campaign, whether to recycle as many materials as possible or to separate them according to their composition. It's a good initiative because at least we have a specific place to store recyclable waste and the proper place to dispose of non-recyclable waste. It's good because sorting out the garbage makes it easier for people to collect the garbage. Avoid sending this to landfill: bags, bottles, those things that are difficult to degrade. I consider it extremely important that we generate less waste and reduce the impact on the environment, due to environmental sustainability.At home, I do it! I can't do everything because I need several containers to store the trash. I transmit the information. I informed my parents, and they are already practicing. But I know we could get better, including me." (Codification of the interviewees who contributed to the CCS: E01, E02, E03, E04, E05, E06, E07, E09, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E22)

The following stretches of CSS 02 speech, …"*These campaigns are useful and necessary because there is always something new to learn or improve*"…; …*"Educational work is critical! I think it's related to the aim of the campaign, whether to recycle as many materials as possible"...,* show that campaigns are holistic. They are recognized as necessary for the dissemination of information for correct waste separation, enough to generate a change of attitude. People's awareness is challenging. Marques et al. (2017) found that commitment and knowledge are challenges to the success of the selective collection. For Musella et al. (2018) campaigns should be carried out in conjunction with public policies to have greater impact. The recognition of the reality presented in the discourse as opposed to verifying the correct separation highlights the need to seek alternatives and strategies to encourage the institutional internalization of waste separation.

The results obtained contribute to the elaboration of the SWOT matrix. The answers to the questions in Table 3 correspond to the factors described in the SWOT matrix (Table 4).

Table 4. SWOT matrix for waste management in (studied company).

Internal factors	External factors
Strengths (S) Carrying out campaigns; Resources for waste management operation; Waste Disposal Infrastructure.	Opportunities (O) Socio-environmental action; Solidary selective collection.
Weaknesses (W) Understanding of actions; Internal logistics of waste; Separation at the source.	Threats (T) The hiring of a specialized company; Disposal of recyclable waste / legal framework.

Regarding strengths, it highlights the performance of periodic campaigns to reinforce the importance of waste separation for the recycling process and correct disposal. Awareness campaigns are part of waste management activities aimed at improving the selective collection. Such actions are essential to spread more accurate and timely information for the implementation of sustainable projects (Pham et al., 2019). However, the results obtained by the campaigns are not successfully achieved, once 87% of people claim to separate waste, while the effects of diagnosis show that the correct disposal corresponds to less than 50%.

Another strong point is the availability of financial resources necessary to enable the management of waste as well as the hiring of adequate disposal services and

acquisition of material. It has been found in the literature that an insufficient budget hinders the proper management of waste and the implementation of improvement projects (Leal Filho, et al., 2016). The support and direct involvement of managers in environmental management actions are crucial to the establishment of sustainability practices (Hoque, et al., 2017). In our results the maintenance budget for contracting services and purchasing supplies has not been enough to boost the process of separation.

However, the presence of adequate infrastructure for the private collection of waste generated, according to its specificities and needs, was also considered a sharp point. Providing specific containers for each type of waste is favorable to the success of the results (Saladié and Santos-Lacueva, 2016). For Stoewa et al. (2017) the installation of collectors and the frequency of collection are measures that serve as motivation. In this case, neither the campaigns nor the availability of an organized and accessible infrastructure has been enough to encourage the correct disposal.

The weaknesses, on the other hand, can be perceived in the adherence of practices, because although understood, they are not made true in the internal logistics itself and in the generating source, according to the answers (Table 3) obtained for the following questions "*What can be improved?*"; "*What is done incorrectly?*" Although campaigns and briefings are carried out routinely, there is no full adhesion of employees and trainees. In the face of this, it can be considered that campaigns can improve awareness for waste separation, as demonstrated in CSS 01. However, they are not sufficient to improve the process. This result is similar to that found by Salidié; Santos-Lacueva (2015), in a survey conducted with university students where there was an improvement of 17.9% in the selective collection, attributed to the realization of awareness campaigns.

It is possible that a change in organizational culture causes some discomfort among employees since they need to develop new habits (Pham et al., 2019). Taking into account the considerations of the authors, it will result in non-compliance of these practices, which interferes in the internal logistics process.

Social-environmental partnerships were considered as opportunities for expanding waste management concepts in the community where the company is located. In Taiwan public policies have encouraged companies to form alliances, and standards associated with environmental treaties international have become increasingly important, with their implementation becoming more rigorous, generating returns and producing a massive impact on business (Chuang et al., 2018). The partnership with non-

governmental institutions (NOGs), the third sector, shows the company's commitment to society (Chen, et al., 2019).

Besides complying with the legislation (Brazil, 2006), the selective solidary collection promotes the sustainable integrated management of solid waste and the improvement of working conditions for informal waste collectors, integrating them into formal cooperatives (Ibáñez-Forés et al., 2019). The government's regulatory strategy has a direct impact on the organization of the recycling chain (Long, et al., 2019).

Ultimately, the hiring of a specialized company for the disposal of hazardous waste was considered a threat. It is a demanding action for management, representing a threat in times of restriction of financial resources. Waste management costs are high, especially in developing countries, due to the increasing generation of waste and the development of technologies to meet the environmentally appropriate final disposal requirement. (Leal et al., 2016).

According to the Normative Decree No. 5.960 of 2006, public companies must send recyclable waste to the associations of collectors. This requirement can be considered a threat. However, current legislation makes it challenging to legalize cooperatives. This legislation has made more complicate the dispose of recyclable waste in accordance with the legal framework. In Brazil, most municipalities do not have formalized collection programs according to Gutberlet (2015), an impeding factor to comply with the legislation of selective collection supported by public institutions, mainly.

The SWOT matrix results showed that the Strengths outweigh the Weaknesses. However, weaknesses require new approaches to achieve higher employee and collaborator commitment. Considering the factors that impact management, it is possible to deal effectively with problems and to seek strategies to explore possibilities. Thus, there is a reduction on the impact of threats and improvement of weaknesses, taking advantage of opportunities (Souli et al., 2017).

Also with regard to sustainability, positive social impacts are achieved when using recycling systems, as they use more labor and generate income, seeking to minimize the negative impacts that are a consequence of: lack of remuneration, adequate working and health conditions; devaluation, by society, of people who work in the collection of recyclables (Mattos et al., 2022).

The combination of the factors analyzed in the SWOT matrix allows a strategic view of the waste management situation. The results can reveal the existence of barriers

to communication for the adoption of practices that promote the proper disposal of waste (Pasukphun et al., 2018).

Those responsible for environmental management should consider the matrix in the elaboration of public policies and in the reconstruction of strategic models for the adequate process of execution of selective collection and the success of solid waste management.

4 CONCLUSIONS

The combination of methodologies for evaluation of waste management performance, is a strategic approach widely used. However, the use of the DSC methodology and the application of the results obtained for the construction of the SWOT matrix showed how much those involved in the process impact the performance of waste management. Conducting interviews, listening to employees and trainees proved to be a valuable tool, because it allows researchers to know the perceptions of the interviewees and suggests a more participatory management model.

In addition to identify and classify strengths, weaknesses, opportunities and threats, the SWOT matrix also enabled the identification of obstacles and challenges involving the key point of management, people. Identifying the weakness faced by waste management, which is directly linked to employee awareness in waste separation, has shown how innovative and meaningful it is to use social representation to understand how campaigns are recognized and assimilated to guide actions to encourage adherence in waste management.

The results demonstrated in this study serve as basis for replication of this approach in other institutions, governmental or non-governmental, using as guiding strategies for advancing the waste management.

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