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SOLID WASTE MANAGEMENT THROUGH MULTI-CRITERIA ANALYSIS; CASE STUDY IN ABC DO PAULISTA – BRAZIL

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ABSTRACT

This article presents a case study of three municipalities located in the state of the State of São Paulo: Santo André, São Bernardo do Campo and São Caetano do Sul. These municipalities have similar challenges in terms of waste management, in accordance with the National Solid Waste Policy - Law[No]. 12.305/2010. The guidelines required by the PNRS, the objective was to apply the multiskewanalysis (Multitribution Value Theory) to evaluate solutions for the management of municipal solid waste (MSW) in each municipality, considering the incorporation of treatment with energy recovery. To perform the evaluation of each solution, a three-day workshop was held in each municipality, with the objective of collecting information about the problems, objectives and solutions. The result showed that, in the phase of treatment and disposal of waste, the best solution for the municipality of Santo André is to perform composting and biod indigestion. In São Bernardo do Campo, the solution chosen was to diversify waste treatment and think of routes such as composting and biod indigestion of organic waste. Finally, in São Caetano do Sul, due to the needs of the municipality, a more in-depth study of tailings was proposed, mainly due to the determination of gravimetric composition.

INTRODUCTION

In the last 12 years, after the framework of the National Solid Waste Policy (PNRS) - Law No. 12,305/2010, Brazilian municipalities began to face greater challenges related to the issue of waste management. These challenges are intertwined with the improvements to be made, especially in the areas of education, technology, management and governance of the municipality. In the case of the municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul, there is a selective collection service in place and most of the waste has adequate disposal, but there are still significant challenges to be overcome, such as: insertion of new alternatives for waste treatment, implementation of more effective actions with regard to environmental education for citizens, reduction of the high costs of operational services and the guarantee of an environmentally suitable destination for all waste. Given the diversity of challenges to be overcome by municipal managers to meet the PNRS, the definition of an order of priorities in waste management is a complex task. In this sense, the application of multiparlide analysis (MDA) and decision-making tools can help in the proposal of solutions for municipal managers. These tools have already been applied in other studies on waste management.

Cardoso *et al.,* (2009) applied the THOR multi-criteria tool in the decision on the destination of post-consumer plastics and the consequences of changing the packaging material used. In the study by Baasch (1995) the multi-criteria tool was used in the waste management of the municipalities of Santa Catarina through the AHP method. Bohnenberger *et al.* (2018) used the GIS (geographic information system) in the implementation of a waste recycling plant. In the study by Silva *et al.* (2018), a hybrid analysis was used with the AHP and PROMETHEE methods in the evaluation of municipal solid waste management in municipalities in northern Rio de Janeiro. Cetrulo (2020) used ELECTRE II in the choice of indicators in waste management. Therefore, the objective of this work was, from the application of the multicriteria analysis of the MAVT (*Multi Attribute Value Theory*), to evaluate solutions for the management of municipal solid waste (MSW) in the municipalities of the ABC region, considering the incorporation of treatment systems with energy recovery.

STRATEGIC METHODOLOGY

The methodological strategies applied were divided into stages (Figure 1). From the presentation of the methodological structure, the

strategies were organized in two phases the divergent phase and the convergent phase. According to Abuabara *et al.* 2019, with the main elements shown in Figure 1, is based on systemic thinking about current problems and what you want to achieve in the future (CHECK LAND 1999; MCNALL *et al.* 2015; BOND and MIDGLEY, 2001).
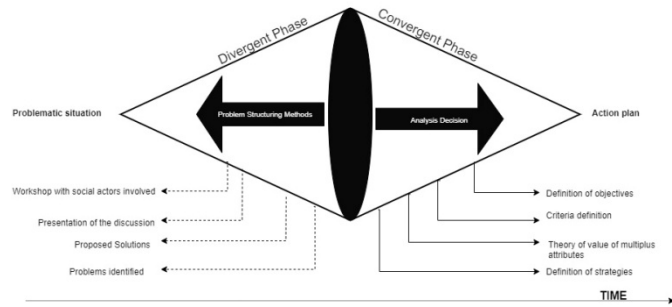
Source: ADAPTED ABUABARA *et al.,* (2019)

Figure 1. Decision-making process for the chosen case study

The divergent phase of the methodological stage corresponds to the workshop held with representatives of solid waste management of the studied municipalities, during which a problematic situation was presented and the five stages of msw management were discussed, namely: generation, collection, screening, treatment and final destination. The workshop was held with waste management actors from the municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul. The objective of this workshop was to map the problems, objectives and possible solutions for the management of municipal solid waste. In the convergent phase, the data resulting from the workshop were worked. For this, the actors involved in the workshop and specialists in the area were invited to answer an online questionnaire *(google forms)* composed of two stages: the first - evaluation of the interest and power of decision makers on the influence of social actors in waste management and, in the second stage - judgment of the solutions that were obtained in the workshop provided by decision makers for each municipality.

In the first stage, based on the form, decision makers were asked to evaluate topics related to waste management through the following questions:

1. How much do you consider yourself involved with waste management problems in the municipality? Where: 0 "is not at all involved" and 10 is "very involved"
2. How much do you think you have the power to intervene in the problem of waste management in your municipality? Where: 0 "have no power" and 10 is "total power"

For each question, decision makers were asked to choose their answer on a range of answers ranging from 0 (zero) to 10 (ten). From the answers, three notes were used that comprised the note of decision makers: the first and the second were attributed from the questions that portray the self-assessment of decision makers (research participants), the third being given by the analysis researcher, with the objective of mediating the information provided.[12] Each participant performed a self-assessment, assigning a score from 0 to 10, where 0 meant "has no power or interest in the issue" and 10, "has full power or interest in the issue". This self-assessment was complemented with the evaluation of the analysis researcher to form an average. Subsequently, the final score of power *and interest of* each participant (decision-taker) was calculated from an average between the self-assessment and the judgment of the researcher of this study (researcher). The final weight of each one was calculated by multiplying the final score (power *x interest*) for a participant,

[1]Decision makers are all actors who were part of the study (Scientists, Public Managers, Teachers, Specialists and Citizens).
[2]The researcher is the person who performs the evaluation, in this case the researcher of the study;

divided by the sum of the other scores for that municipality, as shown in equation 1:

$$\gamma_{ij} = \frac{\frac{1}{4}(x_{ij}+X_{ij})(y_{ij}+Y_{ij})}{\sum_{i=1}^{n}\frac{1}{4}(x_{ij}+X_{ij})(y_{ij}+Y_{ij})} \qquad (1)$$

About what:

γij : is the weight of decision-taker *i in* municipality *j*
x_i : is the score assigned by the *municipality's stakeholder ij* to its power in the matter
X_i : is the score assigned by the facilitator to the *power of stakeholders i of* the municipality *j in* the question
y_i : is the score assigned by the *stakeholder i* of municipality *j* for your interest in the issue
Y_i : is the score assigned by the facilitator to the *interest of the interested parties i of* the municipality *j in* the question
n_j : is the total number of decision makers in municipality *j*

This data provided an array of power and interest. This matrix is a tool applied by Ferretti and Grosso (2019) in their study, which consisted of evaluating the level of power and interest of each actor involved, with the judgment ranging from zero to ten. Thus, it was possible to identify the decision-making power of each social actor involved in the study. In the second stage of the questionnaire, the solutions proposed in the workshop were judged, using the Likert scale (LIKERT, 1932) (CLASON and DORMODY, 1994) (CUMMINS and GULLONE, 2000) (DALMORO and VIERA, 2014) as a judgment. This scale ranges from "useless, not very useful, neither useful nor useless, useful to very useful". This scale was chosen because it was considered easy for the evaluators to understand. In addition, the *Likert scale* is also one of the most accepted among researchers and market professionals (SANCHES *et al*., 2011). Subsequently, the *Likert scale score was* converted to quantitative data, as shown in table 1:

Table 1. Conversion of the Likert scale to a qualitative evaluation

Qualitativo	Likert scale
Very useful	5
Useful	4
Neither useful nor useless.	3
Not very useful	2
Useful	1

Source: THE AUTHOR

The answers were converted into notes and treated in the MAVT formula (equation 2). These answers presented the best solution proposed by the social actors, according to the judgment at each stage of the waste management process, including: generation, collection, sorting, treatment and final disposal of waste.

$$V = \sum_{i=0}^{n} \alpha_{ijk} \qquad (2)$$

About what:
V: it is vector with the final value of the judgment of the alternatives of decision-taker i in stage and municipality m.
α_{ijk} : is the judgment of decision-taker i for alternative j in goal k
n: is the total number of decision makers in the municipality

Regarding the Group score (G) for each alternative (j) for step (e) is given by:

$$G_{ej} = \sum_{i=0}^{n} \gamma_i x_{ij} \qquad (3)$$

where is the weight assigned to decision taker i and xij is the score of this decision taker for j and n alternative γ_i is the total number of

decision makers. Then, a normalization was performed so that the final value of the alternatives was in the range [0 to 1]. This normalization results in the final score (P) of each alternative (j) for each step (e) and is given by:

$$P_{ej} = \frac{G_{ej}}{[G_e]} \quad (4)$$

Where it represents the "ceiling" (highest value) of the evaluated alternatives for the step.$[G_e]$

Because vector V corresponds to the values of the decision-taker's judgments at each stage of the process, the vector with the final values (VF) of the decisions of this decision-taker is given by:

$$VF_i^{em} = \frac{V_i^{em}}{[V^{em}]} \quad (5)$$

The i position of the final vector VF in is the result of the sum of the alternative judgments that I divided by the "ceiling", that is, by the highest value of the sum of the judgments of all alternatives.

AGGREGATION OF RESULTS

The results of the trial were normalized as shown in equation 6.

$$V_j = \sum_{i=0}^{n} \alpha_{ijk} \times \gamma_i \quad (6)$$

About what:

aijk is the judgment scoreboard of decision taker i for j alternative step k and yi is the weight of this decision taker

$$DG_i = \frac{V_j}{|V|} \quad (7)$$

The group I decision is equal to the aggregate score divided by the highest score assigned to each solution.

RESULTS

The ABC Paulista is located in the southeast of the metropolitan region of São Paulo, had a very fast industrial growth, which enabled a high economic growth. The cities chosen for this case study are Santo André, São Bernardo do Campo and São Caetano do Sul, located in ABC Paulista (Figure 2).

Relationship of interest and power of waste management decision makers at ABC Paulista: The decision makers present in this analysis are the social actors who participated in a workshop on the management of the municipality. Municipal managers from different sectors of municipalities, residents and specialists in the area (who have master's and/or doctorate degrees) participated in the workshop. All of them, afterparticipating in the workshop, answered a questionnaire. The relationship of *interest and power*, from the analytical point of view of those involved in the evaluation, was calculated from a set of scores, referring to self-assessment itself. The third year of the groups was defined by the researcher based on deep knowledge of the situation (FERRETTI and GROSSO, 2019, p. 6). From the researcher's self-assessment and evaluation, an arithmetic mean was obtained, this choice was based on the weight of the alternatives of the solutions that will be judged later.
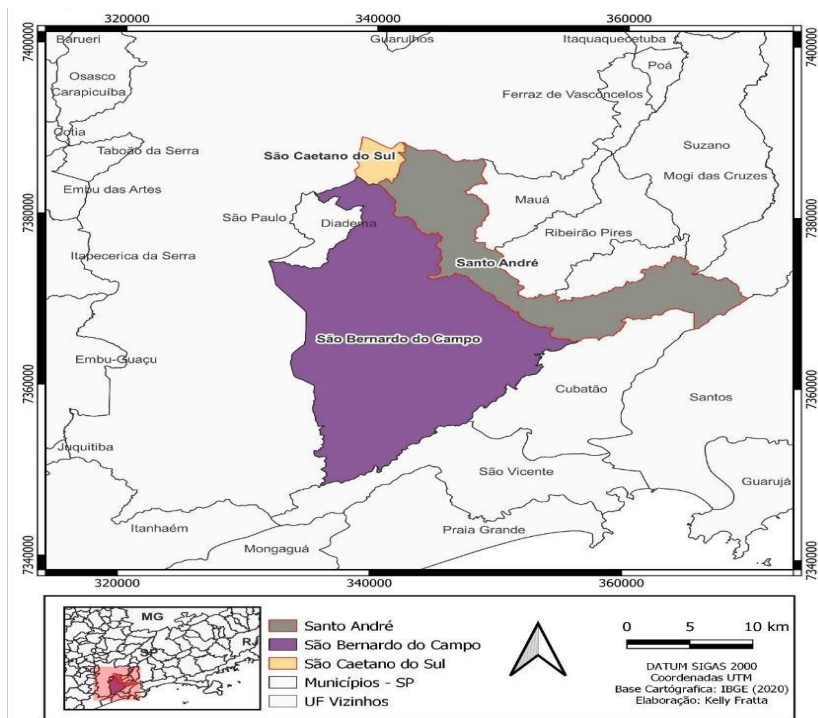

Source: IBGE (2010)

Figure 2. Map of the location of the municipalities: Santo André, São Bernardo do Campo and São Caetano do Sul

**Table 2. Weight of each decision-taker involved**

Decision-making process	Santo Andre					Saint Bernard do Campo						Sao Caetano do Sul			
Decision makers	U	B	C	D	A	F	G	H	A	J	K	L	M	N	O
Percentage in (%)	17	19	9	30	25	29	22	13	11	12	13	37	8	19	36
Result	100					100						100			

Source: FERRETI and GROSSO adaptation (2019)

Finally, the last stage of the process focused on judging the best solution considering the decision group (equation 7), that is, the value 1 (or 100%) was attributed to the best alternative and the values of the others were proportionally corrected.

Thus, each decision-taker involved in this study was represented by a letter (which ranged from A - O). The study did not aim to compare them individually, but to analyze the management of municipalities in general.

From this, table 2 (equation 1) shows the means of the self-assessments of decision makers and facilitators, each actor and their respective weights are divided by the three municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul. From the analysis of Table 1, it is noted that the municipalities presented different numbers of decision makers, with São Bernardo do Campo having the highest number (six decision makers), followed by Santo André, with five and São Caetano do Sul, with four. Decision makers. After defining the individual weight of each one, the scale of *interest and the power of* each decision-taker involved in the present study was established. In graph 1, the results of expression 1 are presented, it is possible to observe the relationship *of interest and power* of decision makers, for each municipality: Santo André (red), São Bernardo do Campo (green) and São Caetano do Sul (blue).
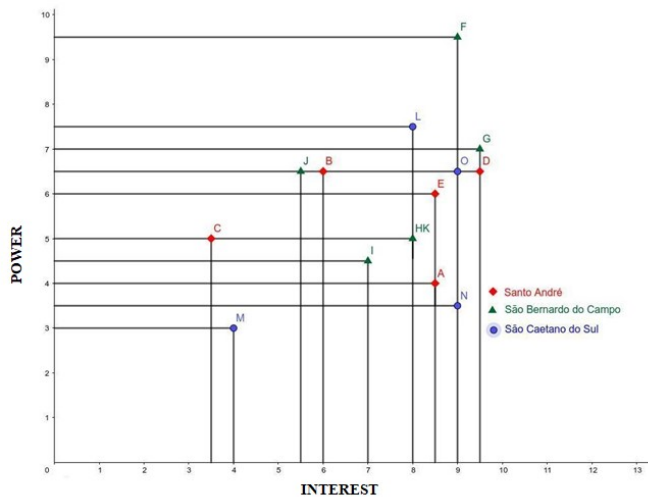
Graph 1. Power and interest relationship of social actors involved in waste management in the municipality of ABC Paulista

The three highest-weight decision makers are represented by the letters "D" (0.304), "L" (0.370) and "O" (0.361). The lowest weights of the actors involved were identified for decision makers "C" (0.086), "I" (0.105) and "M" (0.074). After determining the weights, the *relationship of interest* and power can be calculated from equation 1. The results showed that, for São Bernardo do Campo, in the relationship *between power and interest,* decision-taker 'F' had the greatest interest and greater power. In fact, this decision-taker was the one with the highest power and interest score among all municipalities. For São Bernardo do Campo, the decision-taker who obtained the *lowest power and* interest *score* was the decision-makers "I". In Santo André, the decision makers who had the *greatest power* were the "B" and "D", but the decision-taker "D" also showed *interest* in the subject. The lowest values of *power and* interest were associated with decision makers "C" and "A", respectively. Finally, in São Caetano do Sul, the decision-taker "L" had the *highest power value* and the decision-taker "N" and "O" had the *highest interest values* . The municipality also obtained the lowest values *of power and* interest of all decision makers, characterized by decision-taker "M".

Suggested solution proposals: Regarding the solutions suggested by decision makers, it can be mentioned that the municipalities presented different proposals, classified according to each stage inspired by the hierarchy of the National Solid Waste Policy. In *the generation stage, the* municipalities presented as a common objective the issue of dissemination of information to the population, this issue is still difficult to access for the entire population of the ABC. Therefore, the municipality of São Bernardo do Campo has as pedagogical proposal the program "garbage that is not garbage" to root this theme for the entire population and, thus, disseminate communication about municipal solid waste. The municipality of São Caetano do Sul has another need, which is the partnership with local cooperatives and the expansion of voluntary delivery points. Regarding the collection, the municipalities analyzed the need to integrate the actors involved with

the theme, that is, merchants, manufacturers, citizens. This integration could be possible through partnerships to perform selective collection. In Santo André, the need to increase the frequency of selective collection was presented, since, for decision makers, the collection is still inefficient, as it is performed only once a week. Santo André presented the need to dispose of glass individually, as it is a delicate material that ends up harming many cooperative members and waste pickers. The municipalities of São Bernardo do Campo and São Caetano do Sul have similar solutions. In São Bernardo do Campo, one of the proposed solutions was the study and publication of books to be carried out by Coopcent and the Ministry of Labor, this partnership aims to expand knowledge about the importance of cooperatives, in addition to value them for society as a whole. In addition, São Bernardo do Campo also brings as a solution the need to value cooperatives through financial incentives. In the same municipality, one of the points presented as a screening solution was the need for studies on waste gravimetry (create annual periodicity) in cooperatives and conventional collections, in addition to providing a solution for the flooding points in the municipality.

In relation to waste treatment, Santo André proposed to present solutions involving biodigestion and composting of waste. São Bernardo do Campo presents as a solution the need to diversify the destination of waste instead of sending it entirely to the landfill. Another suggestion was the creation of a "recycling plant" so that local industries can use the recycled material collected in the municipality. The municipality of São Caetano do Sul proposed as a solution the use of treatments with energy recovery of tailings and also the use of composting. Regarding the *final disposal of* waste, two possibilities were suggested by Santo André: insertion of tailings as raw material for civil construction in the municipality and transformation of controlled dumps and landfills located around the municipality in landfills. In São Bernardo do Campo and São Caetano do Sul, the proposed solution in *relation to the final destination was the study of the rejects* by the Universities to be aware of the type of material discarded and, thus, to be able to mitigate the amount of tailings destined to landfills without prior treatment.

Order of priority in the solutions suggested by the municipalities: Based on the solutions proposed by each municipality, an evaluation of the best solution was performed for each stage of management, based on the application of equation 5 (MAVT). The results are shown in Figure 3. In this number, the x-axis scale represents the solutions offered at each management stage, while the y-scale represents the judgment of decision makers. The results presented are at different scales, since different amounts of solutions were offered at each stage.

Generation: Regarding the *generation stage*, the best result in joint decision-making for the municipality of Santo André was "Improving knowledge about separation" (option 1). Those involved reported that, currently, the municipalities have many difficulties in relation to the information provided by the municipality about the separation of waste for selective collection and conventional collection, besides the campaigns being infrequent, which makes it difficult to establish this information. In São Bernardo do Campo, the solution "Implementing a pedagogical project "garbage that is not garbage" in the city (option 1) was the option that obtained the highest score. The project suggested by decision makers was the one that has the greatest involvement of the actors, because it deals with the recovery of waste, in addition, this project could be widely applied in private and municipal schools, in neighborhood associations, NGOs, industries and even in local commerce. In São Caetano do Sul, two questions received the best score: "Increase in the volume of recyclables that the city collects" and "Responsibility of generators". Social actors have identified that the amount of waste collected in the municipality is still insufficient, so it is necessary to create measures to increase the collection of recyclables, and it is necessary to create environmental awareness projects that can improve the amount of waste collected. waste (large, medium, small generator) is effectively held accountable if it does not comply with its obligations, i.e. if it

improperly disposes of waste and does not meet the requirements of PNRS 12.305/2010.
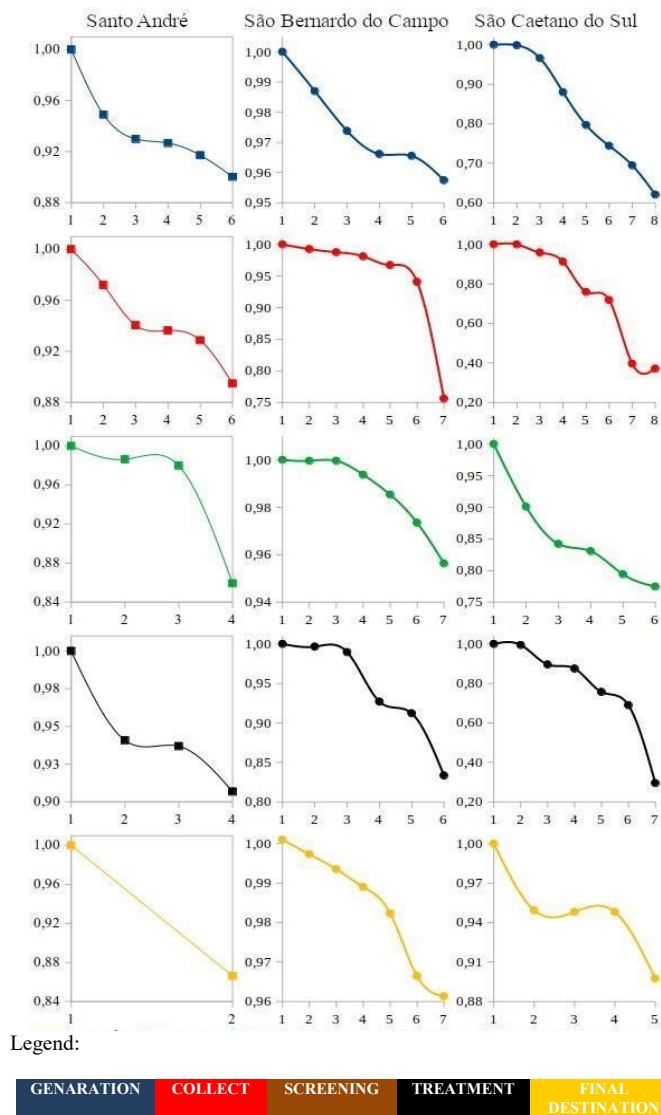

Figure 3. Evaluation of the best solutions according to MAVT

Collect: Regarding *the collection*, in the municipality of Santo André, the best choice given by the interviewees was "Fix the amount of payment for waste pickers of recyclable materials", since, currently, this payment is made only for cooperatives in the region. This payment can regularize this profession, thus gaining a better organization of the collection of recyclable waste in the municipality, in addition this regulated activity could offer a better quality and quantity of materials collected by the city, since the municipalities could improve and expand the collection, in addition to formalizing the service. In São Bernardo do Campo, the issue that stood out the most was "Integrating the problem into all organs" since the issue of waste management is not integrated in the municipality, consequently, it is not consolidated among the departments of health, economy and health. safety and construction (among other departments), which are directly or indirectly involved with the subject.

The integration of the problem could provide discussions and solutions to problems related to waste, for example: if there is a problem related to the collection of recyclables in peripheral neighborhoods, the environment and works departments could analyze joint solutions. Such partnerships would be beneficial to society, as the same problem can be seen from different points of view. In São Caetano do Sul, two alternatives gained prominence: "Bringing together the actors involved in selective collection" and "Educating the population about recyclable material". the municipality of São Bernardo do Campo. The social actors of the

municipality can be public and private and the integration of these actors could establish projects in society. citizens need to raise awareness of the issue and overcome the barrier of resistance in not separating recyclable waste.

Screening: In relation to screening, in Santo André, the solution "Improving or implementing environmental education actions" was chosen. This solution was highlighted by the need to improve the educational and pedagogical approach of the current environmental education actions applied in schools and society in general. In São Bernardo do Campo, three proposals resulted in the same score (1.00): the first, "Adequate training for cooperatives", corresponds to the current needs of the cooperative members, which involves the economic and legal management of cooperatives; the second solution, "Carry out actions on the financial and cooperative valuation", refers to a coordinated activity, carried out by the city with society in general, which aims to value the cooperatives of the municipality so that the population itself can cooperate effectively, bringing recyclable materials to the points where waste sorting is carried out; and the last solution, "Improving household classification to contribute to the collection and the cooperative", is a necessary measure to help work in cooperatives. In São Caetano do Sul, the best solution proposed was the "Support to Cooperatives", which is fundamental, since the municipality does not yet carry out many activities to support cooperatives.

Treatment: Regarding the treatment, Santo André presented the best solution "Composting and biodigestion of organic materials". Although the municipality has, in the past, a composting plant and has not continued with this treatment, the current need is to resume this type of treatment due to the increase in waste generation, in addition to the lack of space in the landfill and the distance to be covered to take the waste to the final destination. Thus, decision makers have verified the need to create measures to reduce the amount of waste destined for landfill, which compromises the life of these landfills. In São Bernardo do Campo, the solutions indicated were: "Research and diversify waste treatment", since it is necessary to comply with PNRS 12.3050/2010, and "Improve the disposal of waste", which today is fully sent to lara landfill without previous treatments. It is noteworthy that the municipality has already submitted a proposal for energy use (presented in Article 1) for waste in general. Decision makers also mentioned the need to create measures to take advantage of tailings from cooperatives only. In São Caetano do Sul, the proposal "Bringing companies closer to universities and research institutes to provide solutions for waste" was an extremely important measure, since municipalities need these solutions and do not have municipal research institutes, so if collection companies worked together with universities, they could propose practical and efficient solutions.

Final destination of waste: For the *final disposal of waste*, in Santo André, the solution "Study the feasibility for the use of tailings in civil construction" was classified as the best among social actors, because it aims to use tailings destined to landfills. Another factor also considered important was the impact of the development of this type of technology for the region and for the municipality. In São Bernardo do Campo, the proposal "Studies that deal with the best recycling of materials to reduce waste" was considered a fundamental solution, because in this way cooperatives could have greater profitability with the sale of materials destined to the landfill. The other best solution established among the actors was the "Improvement of environmental education on dumps and landfills in the municipality", which was considered very important, since the impact that people feel when they see landfills and dumps around the municipality can generate greater awareness. environmental. It is noteworthy that the municipality of Santo André carries out such actions. And finally, in São Caetano do Sul, the best solution was to "charge the material manufacturers the correct disposal of waste", since it is an action provided for in PNRS 12.305/2010 and the municipality reports the difficulty in performing reverse logistics. manufacturers of materials. In this way, the collection solution with

the government can improve the articulation with the collection of manufacturers and merchants.

DISCUSSION

The results observed in each dimension of the waste management stage (Figure 3) identified the needs for improvements destined by the municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul. Therefore, the solutions chosen for each step were presented as follows:

In *the generation stage*, it was identified that the municipalities seek effective environmental awareness actions, a practice that directly reflects on the increase in the quantity and quality of waste that is classified in the cooperatives of the municipality and, consequently, in the reduction of waste destined to landfills.

Improvements in the stages of waste management should be based on participatory methodologies (CETRULO (2020); ALMEIDA AND TANAKA (2012); ARRUDA *et al.,* (2012)) in which the actors identify problems, solutions and objectives of the municipality. Studies and research need to involve all the minimum stages of the different phases of MSW management (generation, collection, sorting, treatment and disposal of waste), as they aim to meet the objectives of PNRS 12.305/2010, that is, " *non-generation, reduction, reuse, recycling, treatment of solid waste and final disposal of waste.* Another determining factor for the implementation of improvements is to apply all the guidelines established in PNRS 12.305/2010 in the management of municipal waste, because the current models revolve around conventional and selective collection, classification and final destination, that is, do not meet the minimum requirements (BESEN *et al.,* 2017). Subsequently, the simple separation between organic and dry waste will help the other stages of the management process to function properly, so that the combined result is, in fact, the

Table 3. Best solution chosen for each management stage in the municipalities studied

MUNICIPALITIES	SWASTE MANAGEMENT STEP
GENERATION	
Sa	Improve knowledge about separation
Sbc	Implement pedagogical project in the city "garbage that is not garbage"
Scs	Increase the volume of recyclables that the city collects
COLLECT	
Sa	Set payment amount for recyclable material collectors
Sbc	Integrate the problem into all agencies
Scs	Bring together the actors involved in selective collection
SCS [1]	Educate the population about recyclable material
SCREENING	
Sa	Improve or implement environmental education actions
Sbc	Appropriate training for members
Sbc[1]	Take actions on the appreciation (financial and appreciation) of the cooperative members
Sbc[2]	Improve home screening to contribute to the collection and cooperation
Scs	support cooperatives
WASTE TREATMENT	
Sa	Composting and biodigestion of organic materials
Sbc	Seeks to diversify waste treatment
Scs	Bringing companies closer to universities and research institutes to provide solutions to waste
FINAL DESTINATION OF GARBAGE	
Sa	Feasibility study for the use of tailings in civil construction
Sbc	Improve environmental education in the municipality on dumps and landfills
Scs	Charge material manufacturers for the correct disposal of waste

Source: THE AUTOR

The stages *of collection and* screening showed how much the municipalities are concerned with valuing cooperatives through actions aimed at social inclusion. In addition, another unanimous solution among the municipalities was the discussion of the integration of actors (public and private) and agencies involved with the theme of waste management, which will allow the proximity of specific actions involving the current problems of waste in the municipalities. As for the *stages of treatment and destination* Finally, it was observed that municipalities are treating the issue as a need for change, that is, they are aware that municipalities need to carry out activities that mainly involve areas that meet the minimum content required by PNRS 12.305/2010 .[3] The solutions proposed for these themes are related to the increase in research for waste treatment, these researches have made it possible to diversify the current model, that is, to reduce the amount of waste that is mainly destined to the landfill. For this model to change its format, it is necessary to invest more in research, besides thinking about solutions such as biod indigestion and composting of organic waste. Finally, the implementation of reverse logistics adequately and the use of construction waste were also solutions pointed to the issue of waste disposal. Based on the results found, it is understood that the municipalities surveyed have challenges to meet the proposals of the listed solutions, in addition, a set of actions is needed to make continuous improvements in the coming years.

implementation of sustainable waste management (ZAGO, PALMEIRAS and BARROS, 2019). With regard to the *treatment and disposal of* waste, the study showed that there is not only a technological solution for all municipalities, because each one needs better management. The study was directed to the broad discussion on waste management to understand what could be the best treatment for tailings, currently in the municipalities surveyed. It was verified that, currently, after selective collection, there are no waste treatment systems, considered as tailings and destined directly to landfills. Thus, both biodegradable and non-biodegradable fractions are discarded in landfills without any prior treatment. With regard to the biodegradable fraction, decomposition occurs without taking advantage of its energy or fertilization potential. With regard to non-biodegradable fractions, there are those that are not recyclable but have high energy recovery potential, such as plastics, paper, textiles and sanitary products. The disposal of this waste in landfills means that this energy, which could contribute to the diversification of the national energy matrix, is wasted. (FERREIRA) *et al.,* 2020). In this study, it was found that, in order to have an effective implementation or improvement of the processes of treatment of these tailings, it is necessary that there is a great effort in the solutions presented at each stage of the waste management process.

CONCLUSION

The multi-criteria analysis of the MVAT was fundamental to define and understand the best solution for each stage of solid waste management in each municipality. Once the decision was made with

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[3]Art. 19 of Law No. 12,305/2010 has 19 items related to the minimum content of the Integrated Municipal Solid Waste Management Plans (PMGIRS); of these, 10 are articulated with the planning of actions aimed at selective collection and recycling (OLIVEIRA and GALVÃO, 2016)

the participation of all social actors involved in the study, all questions had the same weight in the evaluation. In relation to the decision makers who evaluated the solutions offered, it was observed that all of them had the same importance in the study (e.g., cooperatives, municipalities and prosecutors), that is, from the *power and interest graph* it is possible to understand which actor is more active in management as a whole. When it comes to decision-making, the best solutions were different for each municipality, representing that each has different needs with regard to the management of its waste, so that the chosen solution is not replicable. It is noteworthy that this study was based on the opinion of decision makers who were invited to the workshops, however, there are other actors involved, whose opinions and evaluations would be fundamental. It is suggested that, in future studies, the participation of the actors involved be broader, involving: private companies, energy companies, municipal health departments. All the solutions presented were scored as actions that can be worked together with the government, in addition, these contributions can be used in the renewal of municipal plans for the integrated management of solid waste in the municipalities surveyed. Finally, this study can contribute to the proposal to understand what are the needs for improvement in all stages of the management of the municipality and, thus, municipalities can make an environmental agenda in order to apply the continuous improvement of waste management.

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