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Typology and Trends in Links between Solid Waste Management and Public Policy: A Systematic Literature Review

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ABSTRACT
Objective – to propose, through a systematic literature review, a typology and discuss trends about the relation between solid waste management and public policies, since there was no work found with such a scope. Methodology – The research is exploratory, with a quantitative approach for bibliometric analyses, and a qualitative approach with content analysis, for adherence of the articles to the finished corpus and discussion on typology results. Results – Corpus production index analysis showed that interest on the theme keeps growing. Bibliographic coupling put into evidence an interactive connection network, in which the main works have satisfactory *links* with each other, both in numbers and total strength, demonstrating cooperation between theory and methodology. The theme map displayed emergent themes on "municipal solid waste management", basic themes on "pickers" and "circular economy", niche themes such as "environmental management" and "public policies" and motor themes, especially "waste management", in which the relationship between the Keywords, organized by betweenness centrality, spawned the typography. Theory and methodology contributions – typology building happened with no biases, representing advancements on the knowledge basis. Social and environmental contributions – discussion on typology results evidenced trends for participation and collaboration from all social actors (pickers, cooperatives, companies, government) on solid waste management, thus embracing environmental responsibility.

KEY WORDS: Typology; Solid waste management; Public policies.

1. INTRODUCTION

The world produces 2,01 billion tons of solid waste annually, expected to rise to 2,2 billion until 2025, and it is projected to be double that amount by 2050. Absence or precarity on waste management causes pollution on water, soil and air, compromises basic sanitation, puts health at risk, allows the spread of diseases, among other implications (NIMITA JEBARANJITHAM et al., 2022; BORGES et al., 2022; ÁSPET et al., 2022; LUDLOW et al., 2021).

In this context, in addition of other actors, the role of the State is important on the adoption of measures seeking to reduce or end the consequences of this process (LIHUA et al., 2020), by proposing actions toward treatment and appropriate disposal of solid waste, a process bound to be realized via public policies, originated in the United States, based on the production of the institutions, and afterwards in Europe. Since it applied state theories, they do not have a single concept given the multidisciplinarity, among other factors, and it is certain that after being formulated they can be implemented, monitored and evaluated (SOUZA, 2006). In Brazil, public policies are analyzed since 1930, funded on diversifying the analysis locus, the actors involved, the methodologies used, the audience and the kind of mobilized knowledge (FARAH, 2016).

In order to understand the links between solid waste and public policies, a search in the scientific paper database Scopus has been conducted, yielding 1,717 documents. After applying inclusion and exclusion criteria, and checking relevance to the themes, a final corpus of 70 papers has been formed, in which it has been observed the articles did not have a link typology, which motivated the current research.

Thus, the main research question arose: Which typology can be realized from the a systematic literature review on the links between public policies and solid waste management? Thus, the aim of this review is to propose a typology of the studies on the link between solid waste management and public policies, as well as to analyze and discuss the main trends on the themes that arise from the typology.

The systemic mapping was elaborated according to Tranfield et al. (2003), with rigid

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stages of planning, conduction and knowledge dissemination. For the last stage, in addition to the recommended descriptive analyzes, it is presumed that the articles are bibliographically coupled, and the corpus may put into evidence words that reveal research central themes, as long as it is possible to elaborate a theme map, based on bibliometrical calculi of betweenness centrality, aiming to propose an obliqueness-less typology, reducing research biases.

In that way, we aim to contribute to studies on social sciences, environmental sciences and multidisciplinary fields, intermingling public administration on the perspective of public policies, given that once the categories of a typology, the categorized studies and trends from the research are known, contributions to governmental decision making are possible, as well as permitting the fostering of scientific debates about the subject.

2. METHODOLOGICA PROCEDURES

Methodological procedures follow recommendations from Tranfield *et al.* (2003), which splits it in three stages: planning, systematic review and knowledge spreading.

The planning stage is comprised of choosing the database and defining the search string, and the review proper is where the inclusion and exclusion criteria in the analyzed papers and reviews are applied, forming the final corpus, from which in turn the results and discussion are made known.

Thus, the choice for the database used in this research was founded in the Search for a comprehensive and reliable source. The article database Scopus was chosen due to its wide coverage of academic literature (THELWALL; SUD, 2022; KHOURY et al., 2022).

Afterwards, for the string making, a search in titles, summaries and keywords in the articles was conducted, and were chosen keywords from the research questions shown in the introduction, while using the connector AND for linking terms, and OR to widen the research between words with similar literature meanings, both in English. The initial inquiry, with no inclusion criteria, returned 1,717 documents, according to Table 1.

Table 1 – Search string and number of articles.

Database	String	Results
Scopus	TITLE-ABS-KEY (("*public policies*" OR "*public policy*" OR "public politics" OR "*government policies*" OR "*government program*") AND ("*waste management*"))	1.717

Source: Authors (2023).

In this study, the inclusion criteria used were: scientific papers and review articles, with open access, within the Multidisciplinary, Social and Environmental Sciences fields, with 259 remaining papers. As for the exclusion criteria, articles which did not match the research object, which is solid waste management, were removed, thus the articles to be read have been reduced to 70, forming the final corpus, as per Picture 1.

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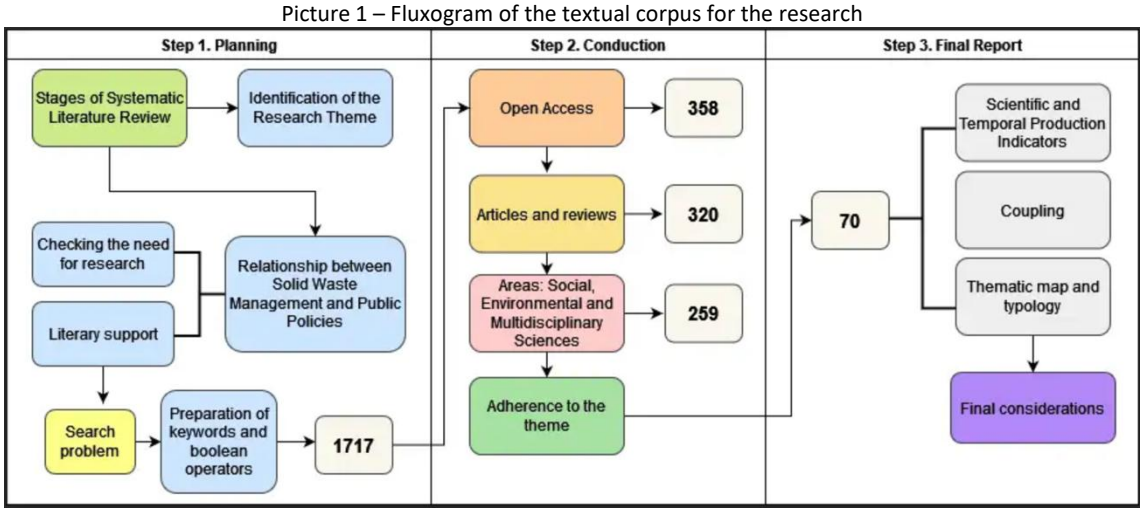
Picture 1 – Fluxogram of the textual corpus for the research



Source: Authors (2023). Adapted from Tranfield *et al*, 2003.

Therefore, the fluxogram presented in Picture 1 encompasses all relevant stages to comprehend the studied phenomenon and can be replicated by any other researchers or people with interest, so the study can advance to the knowledge spreading stage.

3. RESULTS AND DISCUSSION

This section shows the analyses of both scientific and temporal production from the textual corpus, through the analysis of word clouds made from abstracts, investigating bibliographic coupling among scientific papers, and theme map studying based on betweenness centrality, which allowed categorizing in the proposed typology.

3.1 Scientific and temporal production from the textual corpus

This analysis aims to contextualize papers related to the studied theme, in order to show the main descriptive statistics of such articles.

Picture 2 – Scientific production indexes from the corpus.

Source: Authors (2023).

Picture 2 presents the total corpus, made from 70 papers out of 43 journals, dated 1978 to 2023, written by 260 authors and coauthors, and average age of 5.51 years. Papers have

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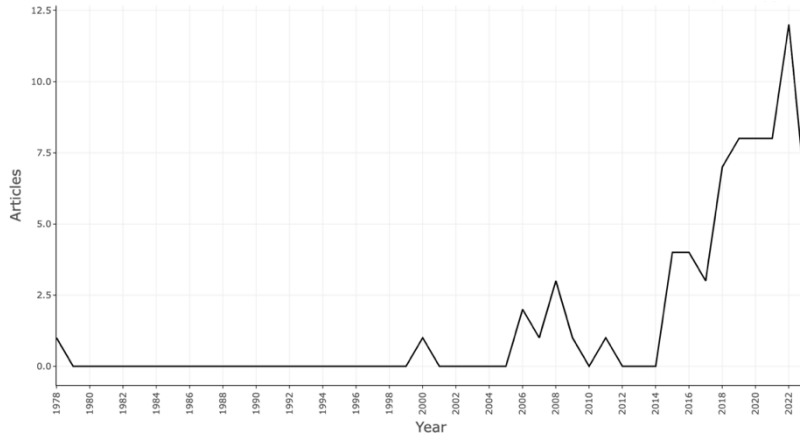
an annual growth of 4.06%, with 8 documents from a single author, meanwhile the coauthorship index reached 3.8, showing a focus on cooperation, with 30% of international coauthors, and an average of 17.33 citations per document.

Also, the research shows 3,952 references and 262 author keywords, which is considered a good amount by bibliometric studies, which justifies posterior analyzes in this paper, consistent in bibliographic coupling between references and theme mapping by author keywords, shown in sections 3.3 and 3.4 of this work.

Despite the 4.06% annual growth rate, temporal distribution analysis in Picture 3 shows that, from 1978 to 2018, there was a total amount of 28 works, 40% of the corpus.

Picture 3 – Annual scientific production from the corpus



Source: Authors (2023).

The remaining 60% were published between 2019 and 2023, comprising 42 papers. Even though distribution is concentrated in the last five years, which shows recency and matches the 5.51 years found in average age, it is possible to pinpoint a rising trend in studies.

3.2. 3.2 **Bibliographic coupling among scientific papers**

The coupling analysis investigates links between two or more papers. The thicker they are, the stronger they are, quantified by the total link strength index, meaning the articles have a greater intensity of methodological and/or theoretical cooperation in terms of coupling. The nodes represent each work and are calculated via density and degree of correlation among the remaining articles, which intensity is also measured by total link strength, which shows which papers have greater intensities in their respective clusters. Thus, in this analysis, the greater the nodes, the bigger the intensity of cooperation in the paper (VAN ECK; WALTMAN, 2020).

In this way, the corpus text was imported into the software VOSviewer. An analysis was carried out by document, via the total counting method and with a minimum of 5 citations per article, yielding a result of 38 documents, among which those with at least 3 links were chosen, reducing the corpus to 19 documents. Afterwards, an analysis based by intensity was made, via the association by force method as well as node scaling, which resulted in the plotting shown in Picture 4, with 55 links and total link strength of 82, forming four clusters, labeled red, green, blue and yellow. Afterwards, the main works in each cluster were highlighted in order to

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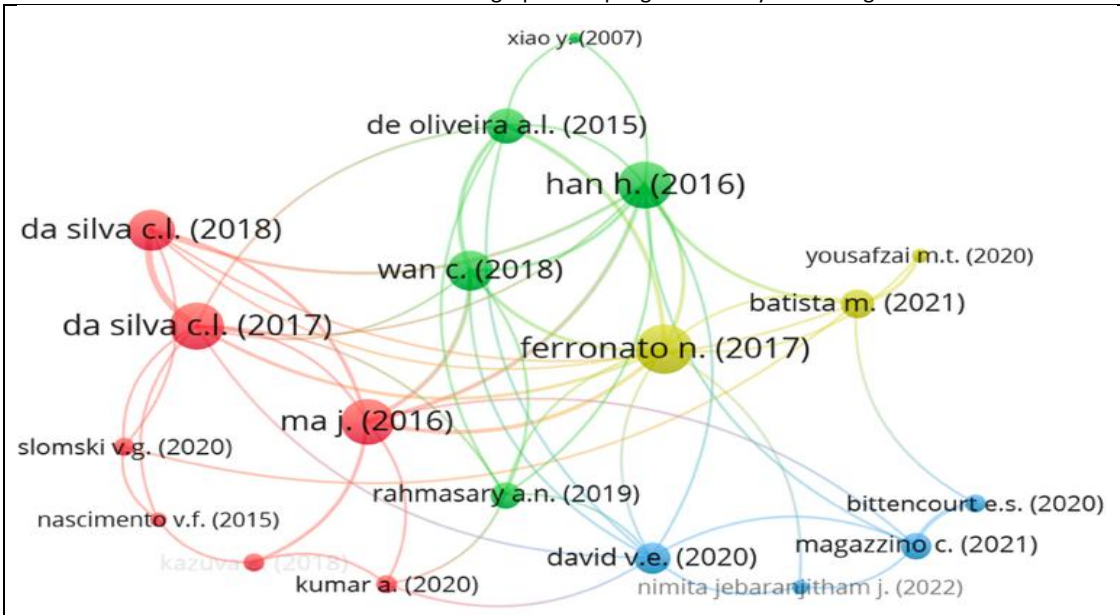
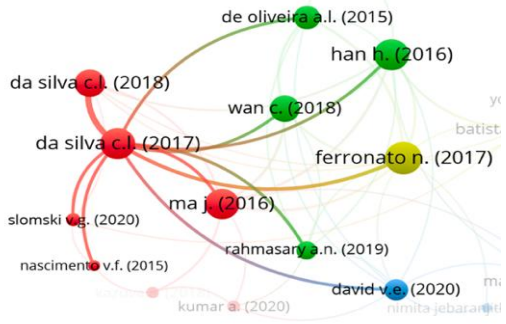
demonstrate links among other articles in the network, shown in Pictures 4a, 4b, 4c and 4d.

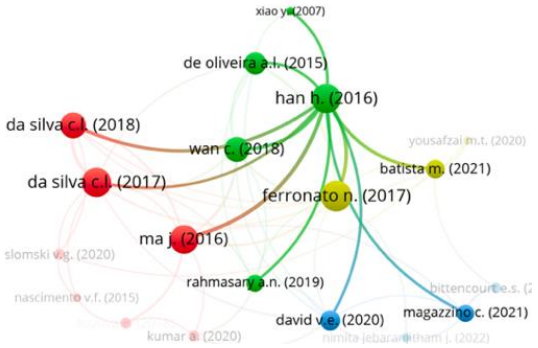
Picture 4 – General bibliographic coupling network by link strength



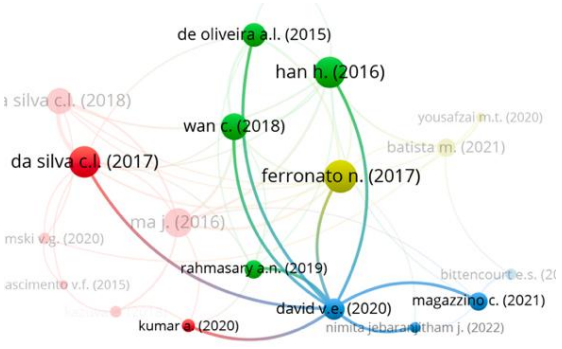
Picture 4a – Coupling network with main paper in the red cluster



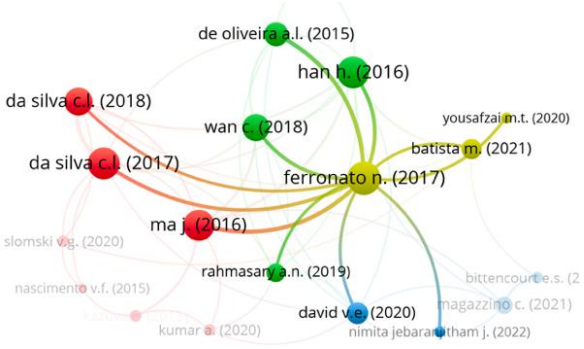
Picture 4b – Coupling network with main paper in the green cluster



Picture 4c – Coupling network with main paper in the blue cluster



Picture 4d – Coupling network with main paper in the yellow cluster



Source: Authors (2023).

The red cluster (red, via Picture 4) has 7 works and is represented by one written by

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Silva *et al.* (2017), entitled "Proposal for an evaluation model for municipal urban solid waste management in Brazil: a study conducted in the city of Curitiba", published in the journal "urbe. Revista Brasileira de Gestão Urbana", which aimed to propose an evaluation model of the actions in the municipal public sector in face of urban solid waste management within the Brazilian context.

It has been discovered that Curitiba made this service universal and carries out the basic picking and final disposal, with little waste reuse and repurposing, similarly to other Brazilian state capitals. On the other side, planning is more programmatic and less strategic, with a link to the chain's integrated management. There is no mention of prioritizing the discussion or the actions about conscious consuming, product lifecycle, reverse logistics and energy reuse which could reduce waste management. The paper also does not deepen the integrated discussion on transshipping stations to organize reuse and reutilization at the end of the waste chain, and neither explores alternative treatments nor composting. Variables like cost per inhabitant and public service finance sources are not deemed significant in the current model, but the cost is expected to rise, which may turn out to be an issue. The landfill situation is transitory and polemic after the closure of the Caximba landfill (SILVA et al., 2017).

The paper in question has a total link strength of 17, out of a total of 82 across the entire network, that is, approximately 20.7%, and directly links to 10 other works (Picture 4a), with which the greater strength (7) is made with another paper from the same main author and coauthored with another researcher (SILVA; BOLSON, 2018) in the same cluster, intitled "*Public Policy for Solid Waste and the Organization of Waste Pickers: Potentials and Limitations to Promote Social Inclusion in Brazil",* showing intense linking between the two papers, the latter related to studying social inclusion promotion by organizations in solid waste management.

Cluster 2 (green, via Picture 4), made of 5 papers, singles out Han *et al.* (2017), titled "*The Crowding-Out Effects of Garbage Fees and Voluntary Source Separation Programs on Waste Reduction: Evidence from China",* published in the journal Sustainability. The study, directly related to 11 other Papers (Picture 4b) and total link strength of 17 (20.7% of the entire network), examines how and in what way governmental policies of waste picking taxation and volunteer programs of waste sorting at the source, with internal containers and free trash bags, may affect the efficacy of urban solid waste (USW) management, hoping to reach a desirable reduction of USR creation per person.

In this perspective, the authors conclude that USW per capita increase as available income is also elevated, and that selective collecting at the source contributed for reducing waste creation per capita. However, those policies working together caused an increase in waste generation per capita, raising the need for proper tax collection systems, higher subsidies and well-made campaigns of public education and information, to promote selection and reduction of sources of domestic residue. Besides, the paper has a stronger link with Ma and Hipel (2016), from the red cluster, intitled "*Exploring social dimensions of municipal solid waste management around the globe – A systematic literature review*", a paper which uses secondary data in order to carry out that exploring.

Cluster 3 (blue, via Picture 4), with 4 works, is represented by David *et al.* (2020), which has lower connections (9) and weaker link strength (9), 11% of the entire network. Its name is

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"*Rethinking sustainability: a review of Liberia's municipal solid waste management systems, status, and challenges*", published in the *Journal of Material Cycles and Waste Management*, and aimed to highlight waste management in Liberia, and to provide information about the challenges faced by waste managers and what stops them from developing a sustainable system, concluding that waste management worsens everyday due to, among other reasons, the lack of guidelines on what waste creators should do, and managers' unwillingness to plan and implement a sustainable and integrated management system. This study uniformly links itself to the others via a single connection (Picture 4c).

The highlight in cluster 4 (yellow, via Picture 4) belongs to Ferronato *et al.* (2017), with a total link strength of 18, roughly 22% of the whole network. Named "*Social Surveys about Solid Waste Management within Higher Education Institutes: A Comparison"*, aimed to evaluate which approach should be used for social research in higher education, comparing developing (La Paz/Bolívia) to developed (Italy) countries. Research in La Paz revealed that, despite the low recycling rates (circa 8%), most students (56,96%) sort up to half of domestic residue. At the same time, circa 53% of interviewees do not know of any recycling practices from the informal sector, which plays a crucial role in improving recycling rates in the city. In rich countries, on the contrary, there is low technology acceptance, with 49% of people against landfills and incinerators near residential areas. The paper also compares methodologies used in two case studies, showing that 96% sort up to half of home residue (FERRONATO et al., 2017).

The aforementioned work couples the most with two other articles (Picture 4d), one from Ma and Hipel (2016) from the red cluster and already mentioned in the green cluster, and the other from this cluster intitled "*Solid waste management in coastal cities: where are the gaps? Case study of the North Coast of São Paulo, Brazil*", from Oliveira and Turra (2015),which analyzes solid waste management public policies in the coast of northern São Paulo, with great seasonal variations in population and in waste production.

Thus, observing the coupling shows great links among works, and the main articles in each cluster are successfully linked between each other in theory and methodology, and the highlights in clusters 1, 2 and 4 have total link strength of 17, 17 and 18 respectively, even though the main result pose challenges in action research, so the need to plan and implement public policies for solid waste management in the shown situations is evident.

3.3 Theme map analysis and typology via betweenness centrality

Theme maps are based on centrality (horizontal axis), density (vertical axis), measured by the chosen theme's relevancy and development, respectively. Splitting the map into four quadrants allows studying the link between the variables and the central themes in play at the literature along the observed period.

Thus, Picture 5 was made out of 246 author keywords, with a minimum word count of 250 and minimal frequency of 5, with 2 tags showing the two main keywords related to the theme in each cluster, totaling 8 clusters, each identified by the first keyword in each quadrant, due to greater betweenness centrality.

Each cluster represents a keyword chain, related to each other by node-forming links where such words lie. The software Bibliometrix® creates and places those clusters in each

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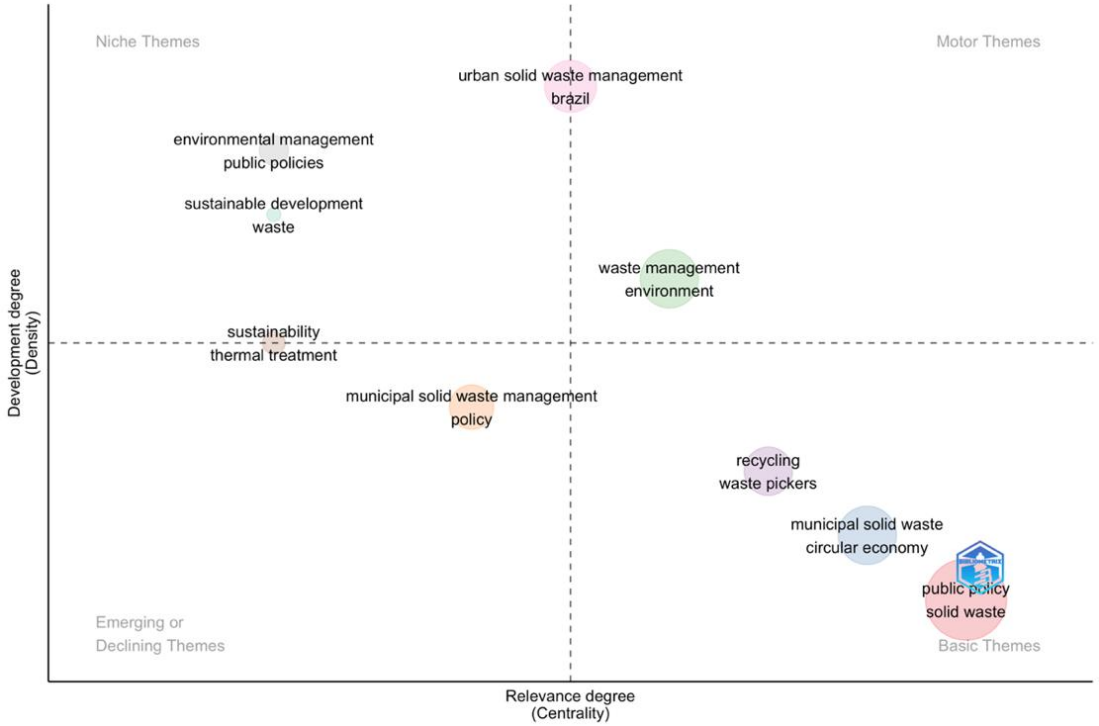
quadrant, and organize them in this paper via betweenness centrality.

Betweenness centrality is represented by the amount of contributions from a given author made to establish links between their peers (NEWMAN, 2005) and, according to Zhang and Luo (2017), each node probably has high betweenness centrality and it is through each node that peers are linked throughout the network.

This paper may interpret by authors, but betweenness centrality (btw) was calculated by author keywords and, as such, refers to how often each act as inbetweeners among the others. Thus, the more often the keyword appear in the links, the bigger btw is, suggesting a bigger significance, insomuch as it acts as a link among other keywords and can possibly predict observed themes.

Picture 5 – Theme map



Source: Authors (2023).

The first quadrant, on the lower left, links fringe keywords with low centrality and density, that is, happen the least in the corpus. However, one should be careful, since those can be emergent or deprecated keywords. In this quadrant, the cluster named "municipal solid waste management" puts the word "politics" into evidence, which is an emergent theme, as can be stated in the temporal evolution of papers analyzed here (MA; HIPEL, 2016; FERRONATO et al., 2017; KUMAR; AGRAWAL, 2020; MOLINOS-SENANTE et al., 2023), the first two of those having been analyzed in the coupling section. On the border between this and the third quadrant (niche themes), it is noted the "sustainability" cluster as related to "thermal treatment", also emergent, as the works Paul (2021) and Torres and Lange (2022) can attest.

The second quadrant, on the lower right, displays high centrality, low density keywords, labeled as basic themes which, according to Martínez et al. (2015), are relevant for

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developing a research theme but have not yet been developed enough. This quadrant highlights the clusters: "public policy" with centrality linked to "solid waste"; "municipal solid waste", heavily linked to "circular economy"; and "recycling" also strongly linked to "waste pickers", perhaps referring to social inclusion fostered by solid waste management (ESPINOSA-AQUINO et al., 2023).

The third quadrant, on the upper left, houses low centrality, high density keywords, understood as niche themes, developed but in isolation. The "environmental management" cluster is linked to "public policies", and "sustainable development" to "waste". On the border between the third and the next quadrant, the cluster "urban solid waste management" is heavily linked to Brazil as a country.

Finally, the fourth quadrant, on the upper right, shows keyword with both high centrality and density, that is, those with enough development and relevant to the themes, thus named motor themes. In this sense, the "waste management" cluster denotes heavy links with "environment".

Guided by the btw, from the connection between cluster-forming keywords and links made with each secondary keyword, the final corpus reached the following typology, as shown in Table 2.

Table 2 – Typology derived of betweenness centrality between cluster and secondary keywords

Cluster	Keyword	Btw	Author	Year	DOI
Municipal solid waste management	Policy	1250	Ma J.	2016	10.1016/j.wasman.2016.06.041
Sustentainability	thermal treatment	573	Paul	2021	10.46754/jssm.2021.12.007
Public policy	Solid waste	2483	Jerin	2022	10.1016/j.heliyon.2022.e08918
			Chalhoub	2018	10.1080/23311843.2018.1529853
			Godoy	2016	10.25091/s0101-3300201600020004
			Souza	2021	10.19092/REED.V8I.502
			Castro	2015	10.1590/S1413-41522015020000109837
			Costa	2018	10.1590/s1413-41522018132985
			Ribas	2019	10.7213/rev.dir.econ.soc.v10i2.23915
			Polaz	2009	10.1590/s1413-41522009000300015
Municipal solid waste	Circular economy	7064	Saeedi	2023	10.3390/su15086776
			Wiprächtiger	2022	10.1111/jiec.13275
			Ulloa	2022	10.3390/ijerph19106041
			Deineko	2019	10.21511/ee.10(1).2019.06
			Fiksel	2021	10.1007/s10098-020-01982-0

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Recycling	Waste pickers	1700	Espinosa	2023	10.3390/su15031826
			Santana	2022	10.1590/s1413-415220210258
			Silva	2018	10.3390/recycling3030040
			Jacobi	2011	10.1590/S0103-40142011000100010
Environmental management	Public policy	74	Souza	2023	10.21511/ee.10(1).2019.06
Sustainable development	Waste	1943	Batista	2021	10.1016/j.jclepro.2021.127516
			Fiksel	2021	10.1007/s10098-020-01982-0
			Aldieri	2019	10.1016/j.wasman.2019.06.045
Urban solid waste managment	Brazil	1462	Silva	2018	10.3390/recycling3030040
			Slomski	2020	10.3390/su12135249
Waste managment	Environment	1128	Molinos	2023	10.1177/0734242X221122514
			Rashid	2020	10.21511/ee.10(1).2019.06

Source: Authors (2023).

That way, the typology in question was made by categorizing the Papers with no obliquity, since the btw index which guided this process allowed to build a knowledge base with potential of predictions and scientific understanding (MCKELVEY, 1975; COLLIER et al., 2012), which main trends will be shortly discussed.

Expectations of participation or collaboration between actors involved in waste management may positively influence in public policy development. As an example, one can cite studies linking the importance of social inclusion by involving pickers in the processes of solid waste management, since they promote the reinsertion of materials into the productive chain (ESPINOSA-AQUINO et al. 2023), deemed a fundamental strategy in selective waste collection to foster social and environmental sustainability in urban areas (JACOBI; BESEN, 2011). There are reports of payment of stipends for glass pickers in the Brazilian state of Minas Gerais, bringing them social and financial benefits (SANTANA et al., 2022), even though evidence shows that cooperatives depend on a deeper interaction between educational institutions and authorities, as the absence of technological innovations and limited production weakens such entities, compromising integration with other pickers networks (SILVA; BOLSON, 2018).

In this context, private sector involvement is mentioned, in the sense that collaboration plays a positive and significative role in fostering environmental innovation in waste recycling and earth fertilizers (ALDIERI et al., 2019). Also, by the amount of waste generated, there is an economic potential to be exploited by the companies through building plants for waste sorting, thus generating jobs and reducing public costs, contributing towards urban sustainability and a lesser impact in the environment (SLOMSKI et al., 2020).

One can bring up actions by state-owned companies, like using waste taxes to finance environmental management, despite underutilized in Brazil except in the South and Southeast regions (RIBAS; PINHEIRO, 2019), as well as adapting methodology for distributing resources

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from local trade taxes linked to solid waste, which can be beneficial to cities with better environment indicators, in order to strengthen state policies like in Pernambuco, Brazil (DE SOUZA et al., 2023), since training is a bottleneck in those municipalities and in creating plans for an integrated management of solid waste to plead for federal investment, since local gestors have difficulties in coming up with such plans (COSTA; PUGLIESI, 2018).

In the realm of public policies for solid waste management, studies show as advantageous to prioritize prevention rather than correction, especially in developing countries (SOTO CHALHOUB; FOO, 2018), and those policies need to be made clear in showing local and regional innovations in order to be successful (FIKSEL et al., 2021). Scientific production on implementing urban solid waste management, organic waste in particular, in Brazil, Mexico and Colombia, has been influenced by Circular Economy and Bioeconomy, since they give governments insights in different stages of public policies (ULLOA-MURILLO et al., 2022). An example comes from a research in São Carlos, in the Brazilian state of São Paulo (POLAZ; TEIXEIRA, 2009). While monitoring public policies, it used sustainability indexes for urban solid waste management, underscoring the relevance of environment, economy, social, political and cultural dimensions, with different social actors involved to make the indexes legit. A far posterior study showed unequal distribution in global scale in reaction to the social aspect of solid waste management, investigating issues like vulnerability, public involvement, attitudes and behaviors of said public, having pointed out the need of a bigger interest on the theme by researchers (MA; HIPEL, 2016).

Despite studies and advancements, researches show gaps and challenges on implementing public policies on solid waste management, like in Bangladesh where practices like sorting and recycling are not widely adopted, as well as the lack of effective monitoring and coordination among responsible agents (JERIN et al., 2022), and in the Federal District of Brazil, environmental issues like contamination of soil, air and water have been spotted, impacting people's health, even after the closing of the "Lixão da Estrutural" landfill (DE OLIVEIRA; GARCIA, 2021).

4. CONCLUSIONS

This article aimed to propose a typology and discuss trends of studies on solid waste management and public policies, through which it was possible to conclude that, from analyzing scientific and temporal production indexes, the theme in question is recent and rising in interest.

Coupling investigation shows intense links between works, the main ones have relevant links between themselves in theory and/or methodology, its results in action research reveal challenges confirming the need of creating and implementing public policies for solid waste management in the studied contexts.

Keyword theme mapping showed emergent themes about "municipal solid waste management" and "sustainability" associated to "thermal treatment", basic themes on "pickers" and "circular economy", niche themes like "environmental management", "public policies" and "sustainable development", and motor themes, especially "waste management" and "environment", forming the origin of the typology.

The typology, derived from text corpus and betweenness centrality, evidenced trends

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of participation and collaboration from actors involved in waste management, like social inclusion of waste pickers, and that recycling cooperatives need to foster this process. Participation of private companies in solid waste management was shown to be relevant, both to promote innovation and to possibly develop businesses to exploit this corner of the market.

The need of government action on monitoring and distributing environment taxes on what was studied became evident, as well as public policies, prevention and clarification to the society at large about the benefits, innovation among these, that may arise from making, implementing and evaluating public policies, in a participative way, consecrating environmental responsibility.

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