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Integrated Municipal Solid Waste Management: A Literature Review On The State Of The Art
La Gestión Integral De Residuos Sólidos Municipales: Una Revisión De Literatura Sobre El Estado Del Arte

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ABSTRACT

In accordance with bibliometrics and the analysis of relevant articles, a review of the state of the art of the phenomenon of integrated municipal solid waste management was carried out. In this study, a keyword search argument has been formulated in the Scopus database, with this information the statistics of publications in terms of time, by types of documents, by area of knowledge and by countries was elaborated, then proceeded to the analytical reading of the methodological, theoretical, strategic and critical contributions to the management of publications using ATLAS.ti and with the bibliographies manager Mendeley. Then, it is concluded that according to the Scopus database, research was observed since 1975, with greater interest by researchers in this phenomenon since 2006, in which books, articles and reviews stand out, mainly in the environmental sciences, engineering, social sciences and in recent years economics and medicine. In the illustration of the phenomenon it was determined that developing countries do not have the proper process of municipal solid waste management and that is the main function of a local government, for which solutions were given in the cities through research conducted through a diagnosis, then the solution to the problems that were found and generate products such as energy, fuel and others.

Finally, the management of this phenomenon is facing an epidemic such as Covid 19, which changed the lifestyle of human beings and therefore the generation of solid waste, a change was made in the processes where recycling activities decreased in the countries of Europe, so, they arranged the extreme care in the process of municipal solid waste management.

Key words: Management, municipal solid waste, recycling, landfills.

RESUMEN

Conforme a la bibliometría y al análisis de los artículos relevantes, se ha realizado una revisión del estado del arte del fenómeno de la gestión integral de residuos sólidos municipales. En este estudio se ha formulado un argumento de búsqueda de palabras claves en la base de datos Scopus, con esta información se elaboró las estadísticas de publicaciones en cuanto al tiempo, por tipos de documentos, por área de conocimiento y por países, después se procedió a la lectura analítica de los aportes metodológicos, teóricos, estratégicos y de críticas a la gestión de las publicaciones mediante el ATLAS.ti y con el gestor de bibliografías Mendeley. Luego, se concluye que de acuerdo con la base de datos de Scopus se observó investigaciones a partir del año 1975, con mayor interés por los investigadores en este fenómeno desde el año 2006, en que destacan libros, artículos, revisiones, principalmente en las ciencias ambientales, de ingeniería, ciencias sociales y en estos últimos años economía y medicina. En la ilustración del fenómeno se determinó que los países en desarrollo no tienen el adecuado proceso de gestión de los residuos sólidos municipales y que es la principal función de un gobierno local, para lo que se dieron soluciones en las ciudades a través de las investigaciones realizadas mediante un diagnóstico, luego la solución a los problemas que fueron encontrados y generar productos como energía, combustible y otros.

Finalmente, la gestión de este fenómeno se enfrenta a una epidemia como es la Covid 19, que cambio el estilo de vida de los seres humanos y por ende la generación de los residuos sólidos, se realizó un cambio en los procesos donde disminuyeron las actividades de reciclaje en los países de Europa, por lo que, dispusieron los extremos cuidados en el proceso de la gestión de residuos sólidos municipales.

Palabras clave: Gestión, residuos sólidos municipales, reciclaje, vertederos.

INTRODUCTION

Municipal solid waste management in developing countries faces numerous challenges that can be assessed in terms of inadequate and operationally inefficient service coverage, limited utilization of recycling activities, inadequate disposal and management in hazardous and sanitary landfills. They add, that the government and the competent authority should focus more on awareness programs on waste sorting through the composting process, which will help improve crop productivity, the waste management approach is geared towards a process and then followed by recycling(Paron & Bharti, 2019,pp.201,204).

Other authors emphasize that the problems in solid waste management is due to governance and culture taxonomy, the dominant policy is bureaucratic, which refers to the focus on government planning and regulation as an instrument of development; the academic policy culture is about the importance of knowledge in social and human life;civic culture designates an approach that attempts to mobilize society as a useful instrument for that purpose and to improve the quality of people's lives, social movements and dissident groups in society are typical phenomena of this culture. He adds that what is important is the culture of economic policy, which focus on wealth, economic growth and strategies to increase productivity using

market instruments and the culture of economic policy. Baark,2001 y Fox, 2016, como se citò en (Lee, 2020,p.1049).

It can be seen that the service of solid waste management is provided by the public sector, however, it does not show an efficiency to meet the demand, mainly in developing countries, according to this scenario the participation of the private sector is sought in order to reduce costs and achieve cover the existing gap, both sectors are determined their functions, if the public sector does not inspect and is not facilitator in this environment towards the private executor, it will achieve that this operator chooses to generate profits and neglect the service itself, considers that legislation is important as well as public awareness.(Olukanni & Nwafor, 2019,pp.1-2).

Also solid waste management is further constrained by inefficient management of funding and technical, technological and policy support, low public participation, lack of educational awareness through programs, deficiency in staff training, and lack of recognition of the informal recycling sector. The review of research on the subject provides information to planners, decision makers, and stakeholders in order to develop strategies, such as recycling for waste reduction, promotion of sustainable practices implemented by the community, small businesses, and all institutions.(David et al., 2020,p.1314).

In relation to the Covid-19 pandemic and waste management, it is shown that most of the recommendations analyzed are related to hygiene routines, the use of protective equipment, and adequate segregation, packaging and final destination. In general, they depend to a large extent on the awareness and commitment of citizens and on the planning and support of municipalities, which should invest in information campaigns and provide alternatives to infectious waste produced in households(Penteado & Castro, 2021,p.1).

Researchers consider biogas technology as one of the best technologies for organic waste treatment, in many emerging countries, more than 50% of municipal waste is organic waste, the amount of organic waste treated with biogas technology is still very limited. This study identified the key challenges faced by practitioners in maintaining biogas plants from the literature and interviewed biogas plant managers operating sustainably and, based on the findings, developed an implementation framework to assist in making manufacturing and professional decisions in planning a sustainable municipal organic waste biogas plant(Pandyaswargo et al., 2019).

The current economic model based on the linear principle of exploitation "extract, produce, consume and dispose" will not be able to continue for long and, therefore, it is essential to adopt a new production model based on the sustainable use of resources and the protection of the environment, which eliminates waste and transforms it into a resource.

In the context of the preceding paragraph, we consider the principle of the circular economy related to sustainability based on the principle of "closing the life cycle" of products, services, waste, materials, water and energy, and for this closure seven steps are proposed (the 7 Re's): Rethink the way in which we spend resources, redesign products so that they can be disassembled and thus make them last longer, reuse, repair, remanufacture, i.e., recover items that reach the end of their useful life to manufacture others from them, recycle and recover(Rodríguez-Martín et al., 2020).

The systematic analysis of the literature has shown the evolution of recycling treatment for municipal organic waste, as well as the main milestones and turning points. On the other hand,

the strategic diagrams show the interest of researchers in different key topics, which have progressed from simple treatments, recently applied to produce compost from the biodegradable fraction of municipal waste, to its use to produce biofuel; this last application is framed in policies oriented to promote the use of renewable energies that reduce greenhouse gas emissions(Fernández-González et al., 2020,p.13).

The counterfactual model to measure the effects of MSW unit pricing policies, the results were obtained from an empirical application of propensity score matching to estimate the effects of unit price treatment on household solid waste disposal, in this sense, when a community adopts user fees for municipal solid waste, there is a concern that households that choose to avoid the additional cost will resort to illegality in terms of final disposal by the citizen, as is the case for garbage disposal in garbage collection containers used by sites served by private waste haulers(Wright et al., 2019).

This bibliometric research addresses the topic of integrated management of municipal solid waste, understood as a central category, with the purpose of validating the epistemological approach to the topic in question for the development of the state of the art.

The review of the bibliography reveals the solutions proposed in some cities, so the question is, what is the theory or methodology according to the bibliographic review on the subject of municipal solid waste management, which lead to a series of proposals for each city.

The objective of this literature review is to determine the state of the art on the topic of integrated management of municipal solid waste. For this purpose, a search was carried out in the Scopus database and a bibliometric analysis was performed using the VOS Viewer for semantic analysis, free software for this analysis, delimiting the articles reviewed and obtaining a result of nine hundred and one documents, which are mainly found in the areas of knowledge of environmental science, energy, chemical engineering, social sciences and medicine.

METHODOLOGY

Unlike some years ago, when it was necessary to invest a lot of time and money to classify information, since the process was manual, today, with technological progress, computer systems improve data processing and more accurate and reliable information is obtained. Ding et al. 2014; Garfield, 1955 and Merigó et al. 2015b, as cited in(Cancino et al., 2017).

Bibliometrics is the application of mathematical and statistical fundamentals to written sources found in databases containing metadata and elements such as authors, title of publication, type of document, language, abstract and keywords or descriptors(López et al., 2009).

The research has been developed in two stages. The first consists of a bibliometric analysis on the topic of integrated management of municipal solid waste and the second is an analytical review of the most relevant literature on the phenomenon.

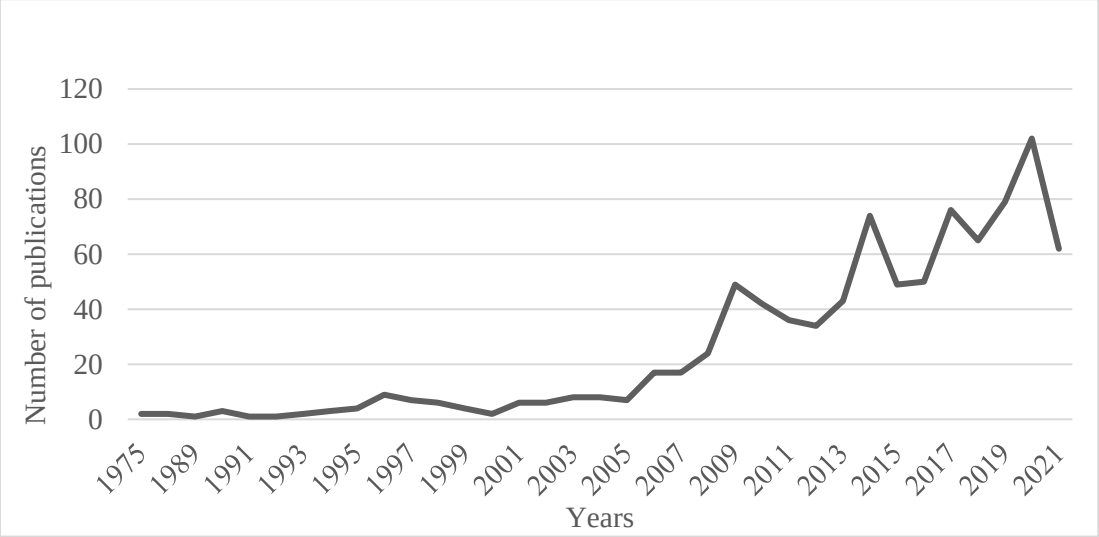
For the bibliographic exploration regarding the topic of integrated management of municipal solid waste, a search argument was carried out in the Scopus database. The search protocol was applied in May 2021 with the following structure:(TITLE (“Municipal solid waste management") OR TITLE ("Integral management of municipal solid waste")). Nine hundred and one records were identified and subjected to bibliometric analysis, considering the categories of evolution of publications by year, authors, areas of knowledge and countries.

The export of the data in comma-separated format, which has made it possible to integrate the information into the VOS Viewer program with which the analysis of co-occurrences of the key terms was carried out, as an exploration of the thematic associated with the topic of integrated management of municipal solid waste.
For the analytical review of the most relevant documents in the data, full-text readings were carried out using ATLAS.ti, which made it possible to identify categories such as theoretical approaches to the phenomenon, methodologies, public policies, techniques and management strategies to improve the service.

RESULTS AND DISCUSSION

This study shows that there have been documents on municipal or urban solid waste management since 1975, and it is since 2006 that there has been a greater production, see Figure 1.

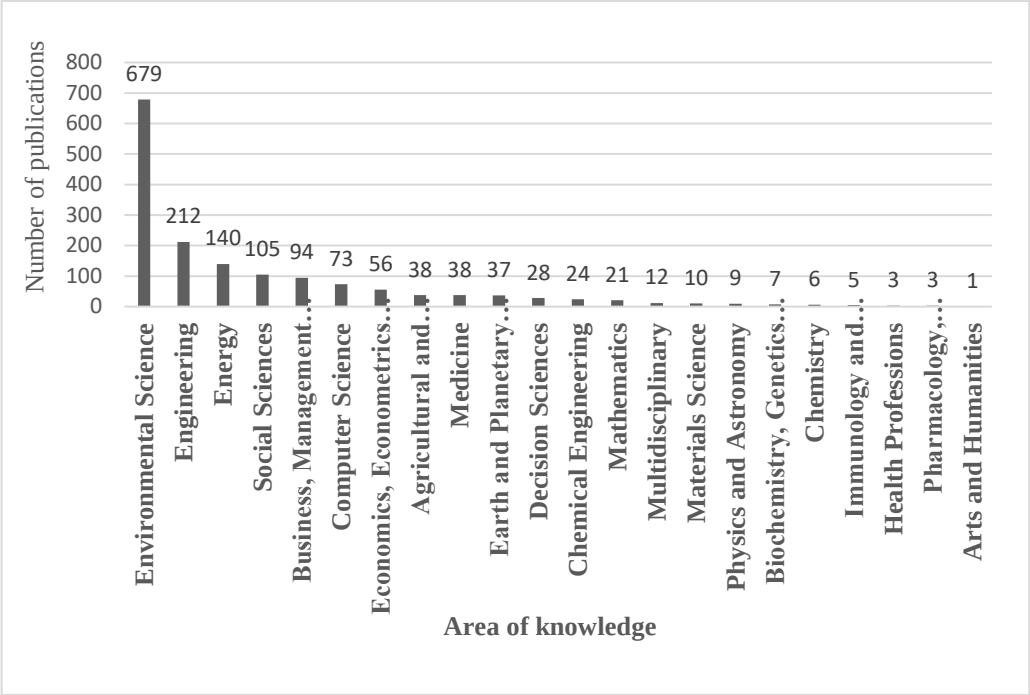
Figure 1 Annual publications in Scopus 1975-July2021.



Source: Scopus database

In relation to the areas of knowledge, the greatest production is in environmental sciences, as shown in Figure 2, which continues to the present, with respect to the social sciences, the interest of researchers in this subject is increasing.

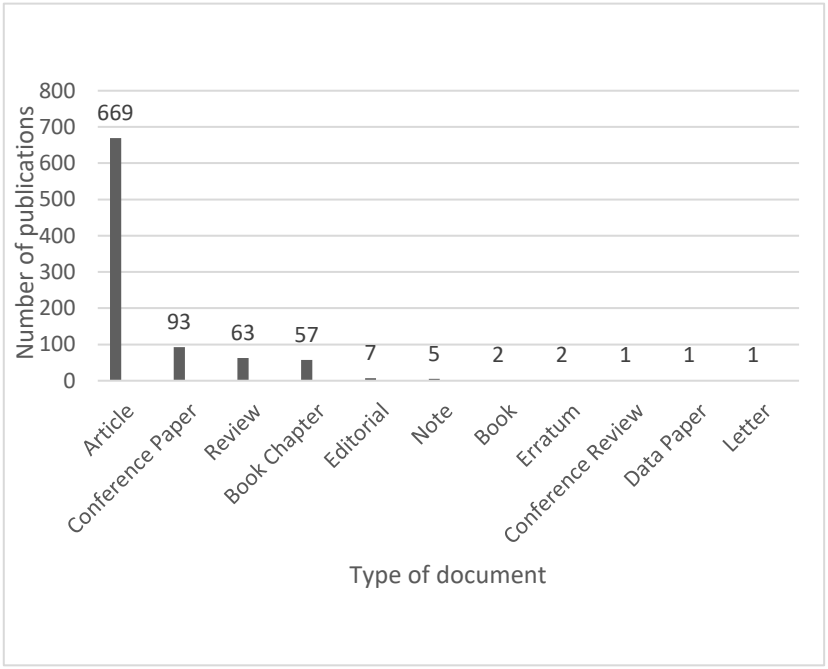
Figure 2 Publications by areas of knowledge 1975-July 2021.



Source: Scopus database.

Regarding publications by type of document, there is a greater number of published articles and a smaller proportion of reviewed articles, see Figure 3.

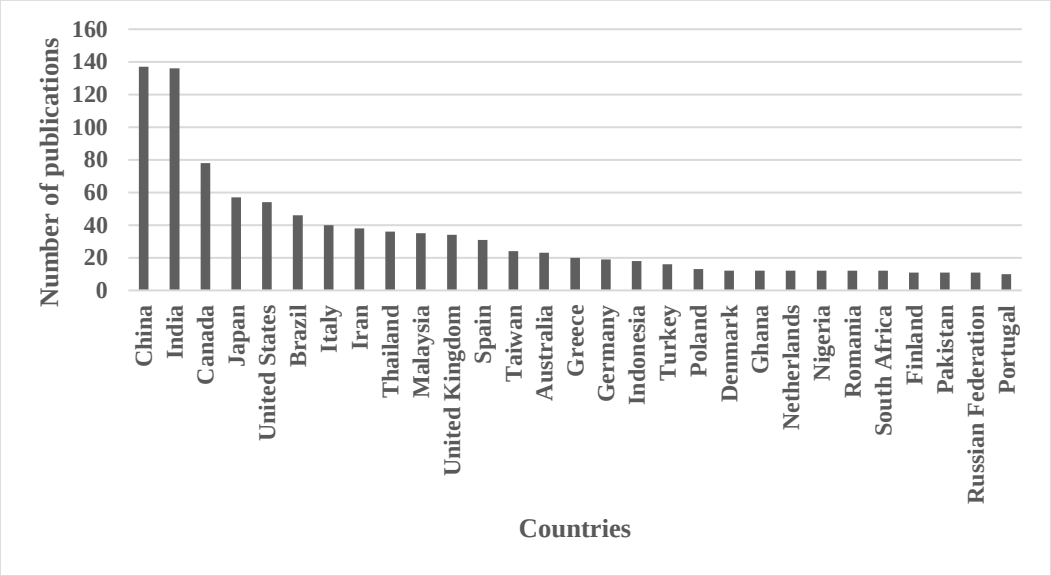
Figure 3 Publications by type of document 1975-July 2021.



Source: Scopus database.

In Figure 4, with respect to publications in the countries on the topic under study, the countries that stand out are China, India, Canada, the United States, Brazil and Italy.

Figure 4 Publications by country 1975-July 2021.

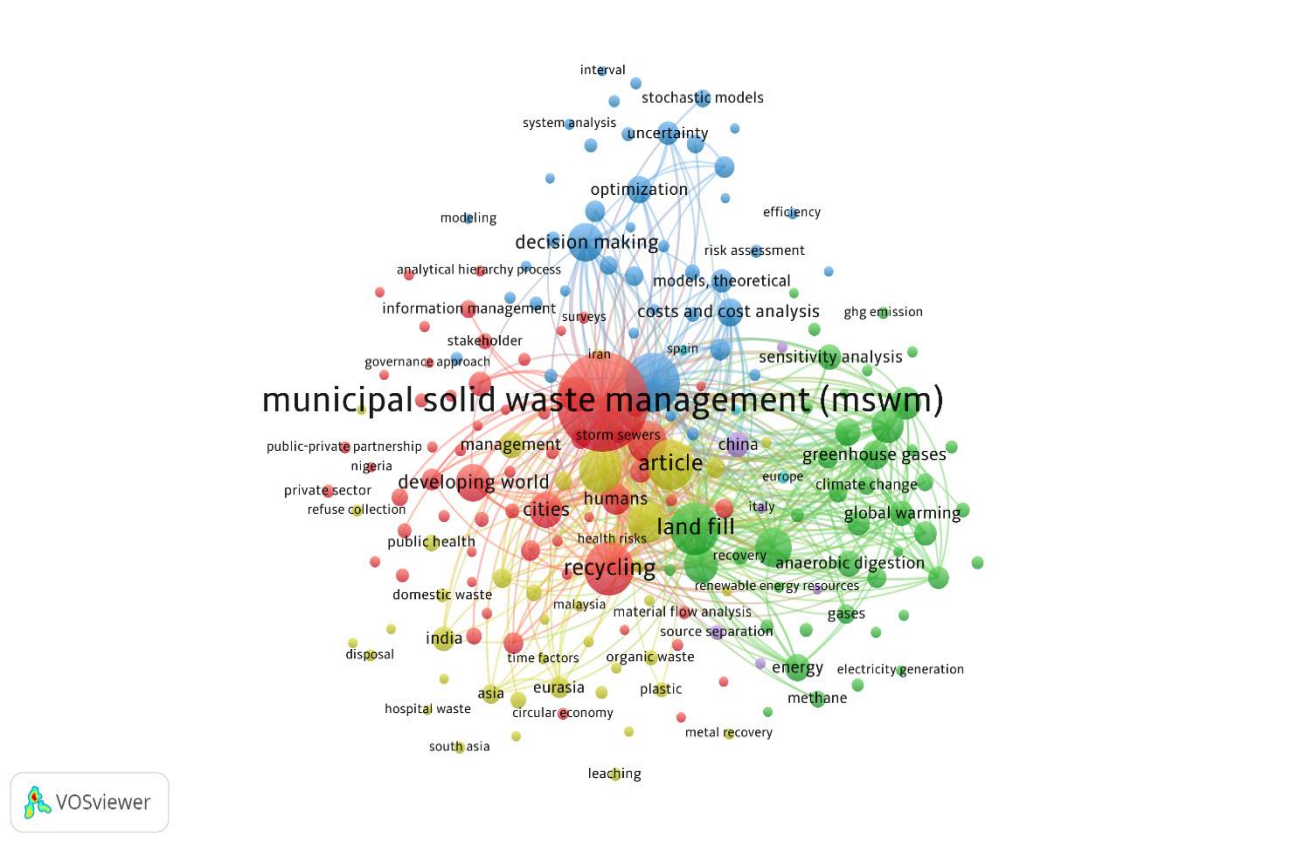


Source: Scopus database.

With regard to semantics in the conceptual theoretical approach to solid waste management, there are marked tendencies towards the themes of recycling, gas emissions, efficiency, effectiveness, governmental decisions, global development, circular economy, human and municipal management.

Figure 5 shows that the information from Scopus processed through the VOS Viewer program reflects a visual scheme based on the key terms found in the various publications, in addition to the scientists' research on recycling, landfills, composting, plastics, energy, management decisions, optimization, stochastic models, governance, private sector, global development, circular economy, change, management information, electricity generation, life cycle, gas emissions, geographic systems, greenhouse gas, public-private partnership, cities, countries, among others.

Figure 5 Semantic map on the study of municipal solid waste management.



Source: Scopus database.

In relation to the analysis of the state of the art based on the reading of the most important articles on the subject of the phenomenon of integrated municipal solid waste management (ISWM), in relation to the various approaches such as the life cycle and the dynamics of the systems that these contributions consist of the treatment and disposal of municipal solid waste (MSW), to produce energy based on the processes of collection, incineration, composting and landfill; evaluating the sustainability of the practices of ISWM.(Richard et al., 2021;Lu et al., 2021; Pujara et al., 2019). Also highlighting life cycle modeling, life cycle timing and system dynamics, this study provides new insights for policy makers regarding optimal management of MSW, analyzing the impact of global warming, acidification, eutrophication and human health on life cycle assessment.(Lu et al., 2021;Nhubu & Muzenda, 2019).

The strategy of synergies unfolds in four aspects: Challengers within the public sector; potentials through the private sector; synergies with an association and with other associations; and also society with diverse interests, in that synergy means joining together to work together on this phenomenon (Jotaworn et al., 2021,pp.1,3). The "best-worst" method is proposed in the integral aspect to evaluate and filter the optimal scenario in the weight of

each criterion in the scenario of the elimination of RSMs.(Panepinto & Zanetti, 2021;Li et al., 2019).

Other contributions we have the economic environmental tools, which are mass and energy balance in the environmental aspects; in the economic aspects they are conventional instruments, using indexes for the evaluations. (Panepinto & Zanetti, 2021, p.1).
In technical methods involving technologies; and anaerobic digestion, which in this process generates fuel for industrial and residential use(Habib et al., 2021;Ayvaz-Cavdaroglu et al., 2019).Fukoka's method in existing landfills to capture leachate without great expense, contributing to avoid global warming(Doaemo et al., 2021, p.1).

The mixed approach is the one most emphasized, which uses field observations, semi-structured interviews and secondary data for data collection(Saja et al., 2021;Habib et al., 2021;Z. Li et al., 2021;Nhubu & Muzenda, 2019). In the quantitative routes we have the mathematical analysis, indicators(Panepinto & Zanetti, 2021;Ayvaz-Cavdaroglu et al., 2019); qualitative studies of the covid 19 epidemic and the management of RSM are shown(Torkashvand et al., 2021;Yousefi et al., 2021).

In their criticisms of ISWM, scientists address the current management processes in developing countries, these problems lie in the lack of knowledge, lack of funding, inadequate infrastructure in cities, and the lack of a proper management system(Camarillo & Bellotindos, 2021;Saja et al., 2021;Habib et al., 2021;Torkashvand et al., 2021).It also analyzes the strategies under various scenarios to solve the problems generated by the processes carried out so far by the cities and as alternative solutions in each reality and that currently have to deal with the epidemic covid 19 and the change that is in force in the management of RSM(Abis et al., 2020;Camarillo & Bellotindos, 2021;Y. P. Li et al., 2019;Vaverková et al., 2021).
Among other management strategies, it is closely related to the economic development in which developed countries base their MSW management on recycling and energy generating plants. On the contrary, in developing countries, the phenomenon under study is based on collection and landfilling of waste.(Abis et al., 2020,p.3).

It is required that the implementation of separate collection to obtain a better service and meet all the requirements of recycling, entities must be prepared for this implementation due to the high investment costs for the treatment of solid waste. It adds that under economic instruments presented in three solutions deposit or infrastructure, schemes for plastic containers, product pricing and flexible tariffs per waste, the important contribution is on research on the methods applied for the collection and treatment of an organic fraction of municipal solid waste with anaerobic digestion (AD), including the effects of the introduction of a system of separate collection of waste.(Seruga, 2021, pp.1-7).

In the approach to governance in the service, the commitment of personnel in the positions of supervisors and waste collectors is valued, it is important in the success of management, training and workshop training should be organized to learn about waste collection, composting and waste disposal; stresses that the health conditions of personnel working in this area should be monitored by regular medical clinics, also, they should be provided with all

the safety tools and uniforms that are mandatory to use them during these tasks. The most delayed aspects are the inclusion of service providers and the consistency of the legal framework; current regulations and policies do not provide for the incorporation of private and informal services in the ISWM service, which constitutes a great challenge to change the attitudes of public policies regarding informality(Saja et al., 2021;Galicia et al., 2019).

CONCLUSIONS

The integrated management of municipal solid waste is a topic that has been taken into consideration since 1975, with greater emphasis on the part of the researchers, who began to address it in 2006, specifically in conferences, books, editorials, reviews and, to a greater extent, articles. We also have it in the study areas of environmental sciences, energy, engineering, social sciences, computer sciences, economics and medicine, among others; the countries that lead these publications are: China, India, Canada, Japan, United States, Brazil and Italy.

In relation to the phenomenon in question, it is observed that some make a diagnosis in which problems are detected that highlight the deficiencies of the service in terms of the process and in these articles highlight the best results that should be obtained in terms of reducing the effects of negative externalities on the environment and to prevent global warming.

In the preceding we have several models and methodological and technical approaches that generate fuel for use in homes and industries; and indeed, for electricity generation; in addition, MSW management strategies are related to economic development, i.e., States that have the highest gross domestic product prefer processes based on recycling and power plants; which unlike developing countries opt for waste disposal in landfills.

Since 2020, there has been a change in the phenomenon under study due to the waste generated by the epidemic of covid 19 and the modification of the living situation in families, one of the reasons for the change in behavior is to avoid the spread of contagion, the most affected was the recycling of waste.

In spite of all these problems, we emphasize the strategies that municipal management should consider in terms of synergies and the important role of society, the private sector and the public sector. These synergies are important to improve the service and solve the problems of financing, infrastructure and work together to find the best alternative solutions.

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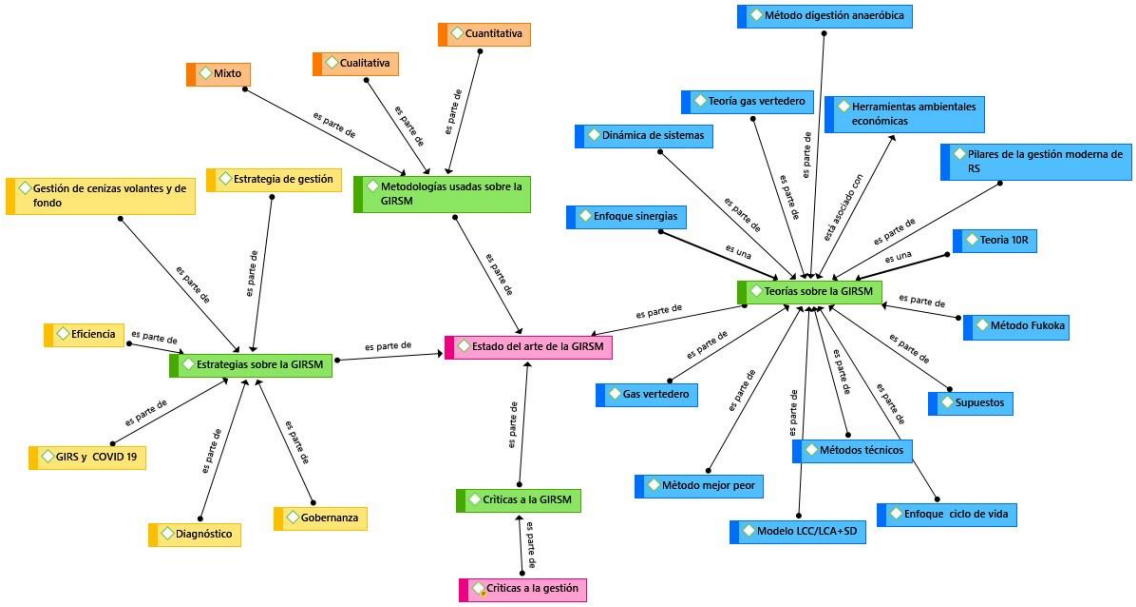
Annex 1

Reading analysis of articles



Note: Concept network elaborated with ATLAS.ti based on the analytical review of relevant documents.