

Solid waste management in urban areas of Latin America

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Abstract

Currently, the generation of solid waste is observed as a problem that is escalating to higher levels in all countries of the world and also in Latin America. Thus, this literature review article aims to understand and describe the various waste management procedures used in different countries in the region. A search was carried out in different databases and bibliographic sources, using the Scielo, Dialnet and Scopus platforms. In this way and applying inclusion and exclusion criteria, 30 articles were selected, which were considered to provide the reality of policies, action plans, innovation in management techniques and infrastructure. Finally, the administrative deficiency in waste disposal processes is pointed out, which occurs widely in Latin America, with Brazil being the country that presents the greatest number of studies highlighting the deficiencies of its constituent cities. Furthermore, the impact of the joint work of participatory agents (population, state, private sector) is highlighted, which conditions both the good and bad results of solid waste management.

Keywords: Solid waste, Urban, Driving, Management, Latin America.

INTRODUCTION

Society is concerned with continuously producing materials with the aim of creating a comfortable social environment. However, this leads to environmental degradation because the participating agents (people, institutions, private sector), do not place sufficient emphasis on waste management, which prevents waste from being used for the benefit of other industries (Bedoya and Trespalacio, 2022). Therefore, the policies of the nations involved in this manufacturing advance present opportunities to favorably impact waste collection. These initiatives are based on the nation's commitment to sustainable development, which is highlighted through international cooperation to improve management (Villagómez et al. 2020).

Countries such as Germany, Switzerland, Japan and Sweden, among others, have a successful recycling rate, due to the fact that solid waste management is composed of the interaction of several agents, in addition to the functional intervention of the State and the provision of the legal norm, technology and cultural aspect (Segura et al. 2020). In contrast, environmental management in Latin America shows a considerable distance from policies implemented in other continents. The deficiencies in this region are reduced to the scarcity of planning, in addition to the poor preparation of those in charge of providing these public services, among other factors such as the lack of alternatives (Lozano and Barbarán, 2021).

The political implication of waste management in some Latin American nations makes it necessary to create guidelines to achieve a social transformation and balance the impact of the ecosystem (Sánchez-Muñoz et al. 2019). This is so since, on average, one kilogram of waste is generated per inhabitant; overall the amount of waste is proportional to 10% of waste in the entire planet (Vargas et al. 2022). In addition, megacities generate waste of diverse origin and different categories, which makes their management difficult; therefore, it is the States that have the main role of executing action plans in response to excessive waste. In the same way, it is important to incorporate effective technology and infrastructure, encourage community participation and the appropriate transportation of waste (Mendoza, 2020).

The consequences of waste exposure and handling have a negative impact on people's health; this is due to the decomposition of waste, and also affects the community, since public transportation causes additional physical effort to move waste to the dumps (Severiche et al., 2021). The contamination of public spaces makes evident the poor control of waste, which generates a detrimental impact that affects people's wellbeing (Zambrano et al. 2022).

Municipal solid waste is characterized by organic matter, which is distinguished as biodegradable waste; this denomination is given due to the composition of food leftovers that can be found in kitchens, restaurants and markets (González-Jiménez and Villalobos-Morales, 2021). The management of organic waste is necessary due to the emission of toxic gasses that cause diseases directly and indirectly, and are transmitted by various vectors (insects and stray animals). These diseases can range from typhoid fever to dengue fever and chikungunya, something that is of crucial consideration for Latin American nations (Novais and Márquez, 2020). In addition to avoiding the spread of diseases, solid waste management is indispensable to ensure effective care in the atmosphere, since large amounts of decomposing garbage produce methane, which damages the soil and water, something that happens a lot in Latin America (Sánchez-Muñoz et al. 2019).

In terms of waste, inorganic or non-biodegradable wastes are composed according to their potential for generating fuel (paper, plastic, textiles) and non-combustible (glass and metals); additionally, both stand out for being recyclable (Villa-Cáceres, 2022). Any waste is easy to find, since it appears all over the world; thus, plastics derived from petroleum are a relatively easy waste to recover and use in a sustainable way (Meza de Luna et al. 2022). The handling of inorganic waste and materials that can be recovered and recycled is reflected in the separation of inorganic waste for use (Bernache, 2019).

For this separation, it is important to classify waste as inorganic, organic and non-recoverable materials; based on this, the actions of the participating agents are focused on maneuvering the machinery for collection,

storage and transfer to their final destination, which generates a considerable cost (Alcocer et al. 2020). The latter is an aspect that is not prioritized in Latin America, where only 2.2% of waste is recycled; the problem that generates this deficiency encompasses both the administrative structure of waste and the lack of infrastructure necessary for these processes (López-Yamunaqué and Lannacone, 2021).

The application of standards in Latin American countries tends to be variable and, therefore, shows little effectiveness in the results; that is why it is necessary to know the current panorama of waste management, in order to define the points to improve and with the purpose of guaranteeing a functional waste control. In this context, the question that arose in this research is: "What is the current reality of solid waste management in urban areas of Latin America? Based on this, the main objective of the article is to learn about and describe the various policies on municipal solid waste management, as well as the processes for waste treatment and disposal in the countries examined.

DEVELOPMENT

Theoretical framework

Legal framework and development plans

When considering the implementation of different regulations, which encompass both the legal aspect and development plans, various applications carried out by different countries and their functionality in resource management are presented. In the case of Bogotá and Mexico City, Rodríguez-Díaz et al. (2022) point out that a new implementation of waste cleanup management ("zero trash") is efficiently applied; this has the objective of recycling through a company that intervenes with the elimination of stored waste. It is noted that for the two cities the obstacles are inadequate waste transportation operations and the costs involved, which leads to poor organization.

In relation to the shortcomings that a government presents in management, Leal and Sampaio (2021) state that the absence of the legislative factor impairs the different actions that make up the process. They state that, in the different cities of Brazil, the legislation presents an article that presents an organic law specifically to deal with environmental issues; however, no sanctions are evidenced. Carmen-Niño et al. (2019) mention that in Article 115° of the legislation of the United Mexican States, it grants municipalities the power and duty of waste management, this in conjunction with localities and organizations. From this, it is realized that in the province of Xaltianguis, by not presenting an adequate municipal regulation, it does not show the minimum conditions for proper management.

For Gutiérrez and Stevanato (2021), policy innovations in waste management indicate that the budget is not a relevant condition for the improvement of the process, since it depends on various factors. These factors are represented by the intervention of the private sector in the process. In the Colombian context, Ortega-Ramirez et al. (2021) point out that the policy promoting environmental education has changed the population's perspective and has had a positive impact. This policy is implemented through the joint work of public and private institutions such as UTCH, CODECHOCÓ, among others. This improvement can be seen in contrast to the 1990s, when the recycling rate was only 0.32%, which is far from what is happening today. Thus, it is pertinent to be able to efficiently organize the distribution of expenses, materials and machinery for a functional management.

Evaluation of procedure and infrastructure

Regarding the waste disposal process, Mathias (2021) points out that the process varies from one facility to another in southern Brazil. He points out that internal transportation causes problems in 60% of the supply

sites, since only 20% adequately separate materials for selective collection. It is stated from this that the administration of waste management in Brazil suffers from an imbalance in the effectiveness of each part of the process separately. Thus, the legal norm is insufficient to channel fruitful procedures and does not tend to make performance reports to evaluate future improvements.

In the case of Argentina, López et al. (2021) point out the position of the Autonomous City of Buenos Aires, where the city government entered into a leasing contract with six companies for the collection and cleaning of public spaces. On the contrary, the results of the implementation of this process manifest an inefficient operation, since in 2019, 1% of 388.6 kt was recovered as recyclable material. Regarding the final disposal of waste, in the city of Buenos Aires there are no landfills located within the city territory; however, these landfills are located outside the city space.

Regarding recycling possibilities, García et al. (2019), in their research on the Puerto Bolívar Municipal Market in Ecuador, point out that the Municipal Company (EMAM) concluded that there is no waste control where municipalities apply the various State regulations. In addition to this, the amount of organic and inorganic waste represents a recycling potential that is not used in the right way.

In the Latin American region there is a problem in the implementation of waste control, where the causes, according to Rodríguez and Baca (2022), are the absence of control and spaces to implement the waste disposal process, the maintenance of landfills in poor condition and the low valuation of the informal sector. That is why, according to Batista et al. (2021), the development of programs in Latin American countries (Argentina, Chile, Colombia, Ecuador and Brazil) would not be enough to make a significant change, since there are structural barriers and deficiencies. Thus, the current infrastructure processes, governmental application and also the availability of spaces and technology are ineffective; the problem of waste management lies both in the intervention of informal agents, so that the service tends to be ineffective, something that generates a bad image in the population, and in the insufficient maintenance of the infrastructure.

Evaluation of the results of the management process

Based on the research of Pimienta-Serrano and Pacheco-Bustos (2022), various wastes such as plastics, metals, paper, cardboard and glass were identified on the beaches of the Colombian Caribbean; however, the cleaning process was not very effective, giving detrimental results. He points out that this situation is due to bad practices in tourism and recreation on the beaches, which causes a high percentage of microplastics (55-60%), as opposed to poor disposal and control of waste (18% and 28%).

According to Torres and Lange (2022), in Brazil's policy there is a preference for reuse and recycling of waste, since this collection of materials tends to reduce costs, in addition to the urgency of establishing automatic operations in the process. Energy recovery is proposed as a complementary way to waste collection, since the use of sanitary landfills is an inadequate option. In Bolivia, specifically in the city of Viacha, according to Ferronato et al. (2021), waste management is very poorly developed; the deficient technical conditions and the low investment in infrastructure and services have negative repercussions on the population. Dissatisfaction and exposure to disease are the main consequences of this poor management.

Participation and transparency

Based on the research of Ortiz-Alvarez et al. (2022), in the district of San José, a survey was conducted in which it was concluded that the main problem, for 57% of people, was poorly managed collection. Meanwhile, for 40% it was the people who littered the street with waste and 11% represented the lack of containers in public spaces. For Cervantes and Castellanos (2022), the Integrated Waste Management Unit (IWMU) has a work environment that tends to boost motivation among workers. However, when six interviews were

conducted with employees, it was found that motivation is not a problem that conditions the development of their work; on the contrary, there is little regulation and organization, in addition to regulations that limit the capabilities of workers.

According to Arteaga et al. (2023), the participatory agents in the improvement of waste management are the population, governmental institutions and the private sector in Chiclayo. Together, they can improve the process; however, they do not show a reliable interest in consolidating a beneficial attitude for public health. This has a negative impact on management processes, as the city of Chiclayo uses informal dumps. In the case of Mexico, Bernache (2019) states that, in the four municipalities of Jalisco there is no integration between the waste management systems, which degenerates the processes by having different routes for each of the municipalities. This causes the incorporation of service providers to increase their profits despite having a negative impact on the environment.

The possibilities for action in waste management in Mexico, according to Rojas et al. (2022), are positive, which is linked to the municipal organization as a managing agent of spaces for waste collection and treatment. On the contrary, the negative features of the role of the municipality is the poor planning that limits the development of a circular economy model, as well as alternative processes. On the other hand, Khan et al. (2022a) conducted a diagnosis of waste in the Brazilian territory, where the provinces of Sao Paulo and Santo Andre stand out, where enormous amounts of waste were found. That is why the authors point out the participation of the government in 94%, while the private sector is restricted; however, the technology provided by the latter agent, provides improvements in waste treatment, being the integrated gasification the one that offers efficiency and power at the energy level.

Environmental and social impact assessment

In the case of Ocampo (2021), the reality of recycling in Peru, Colombia and Brazil is evaluated, where it is pointed out that of the three countries the regulation of recycling in the Peruvian context is deficient due to the fact that it has 90% informality; and the legal framework is observed as a restrictive obstacle to carry out its work. The opposite is true for Colombia and Brazil, where the former has a waste collection scenario with 56% formality due to the integration of state-owned companies. In the case of Brazil, there is a program called "Lixo" that has a positive impact on the environment, since it promotes a culture of recycling through the economic gain from the collection of this waste.

In the case of the participation of various agents, in the study by Barros and Silveira (2019), the administration of waste processing is complicated to evaluate, due to the low participatory motivation of both the population and political agents; added to this, the need to acquire different technological resources becomes crucial in this context. The aforementioned urgency refers to the low quality standards at the level of waste management observed in Belo Horizonte (69%), Betim (63%) and Contagem (56%). These percentages, indicating the level of sustainability of each city, show the need to plan an integration between various participatory agents that can find a long-term solution to the needs of the municipalities.

As a feasible option, Kumar et al. (2023) point out that Waste-to-Energy (WTE) techniques, which prioritize energy reuse, have a positive impact not only on waste treatment but also on the economy, since this technique involves the reduction of waste for conversion to biofuel. In turn, developed countries, having limited technology, are unable to implement these techniques based on the circular economy; this is a problem that transcends to the geographical, political, social and economic level. According to Barros and Steiner (2022), waste generation is expected to increase in relation to the number of people who are potential waste generators.

Methodology

This research presents a qualitative approach, since its objective is to know and describe the current reality of what the available literature shows in relation to solid waste management in Latin America (Sandoval, 2002). Likewise, it is considered descriptive, because it only measures "the presence, characteristics or distribution of a specific phenomenon" (Veiga de Cabo et al, 2008, p.2). The method used was a literature review; this consists of creating a systematic process in which it is possible to investigate, collect, organize, analyze and interpret the written documents. It also seeks to establish relationships, phases, differences, positions or the current status of what is known in relation to the object of study (Machi & McEvoy, 2012).

An exhaustive search was carried out in recognized databases in order to select the articles to be examined, which had to include studies related to the area of Social Responsibility and Sustainability. This search yielded the following databases: Scielo, Dialnet and Scopus. In order for the articles to be pre-selected, certain criteria were established: they had to be empirical studies; published between 2018 and 2023; concerning the area of Social Responsibility and Sustainability, the documents had to be open access and be studies conducted in Latin America. After the application of the inclusion criteria, titles, abstracts, keywords and results of one hundred and twenty (120) articles obtained in this search were reviewed. Of these, only thirty (30) articles were selected, representing 25% of the search. However, the documents not taken into account in the selection process were excluded for two reasons: they did not report results of empirical studies because they were books, book chapters and conferences; also, those that did not focus on the Latin American region and on the period of time indicated above were discriminated against.

The review of the 30 articles allowed the identification and systematization of the most significant elements related to the results, discussions and conclusions of each study. The patterns that allowed the construction of the categories of analysis were then highlighted. Some aspects that were observed repeatedly in the documents examined were the different conceptualizations of "solid waste" and the relationships between "solid waste", "management" and "Latin America", thus giving rise to two main categories: 1) conceptual approaches and 2) relationships between "solid waste", "management" and "Latin America". Next, the 30 scientific papers considered for this literature review are shown; they contain information concerning solid waste management in Latin America; the database consulted, the title, the year and language in which the paper is presented and the type of research are also shown. Those that specifically mention MSW management have been included in this list, so the first 30 scientific papers that met the requirements in the search carried out in the different databases were chosen (See Table 1).

Table 1
Articles examined in the review

Title/Author(s)	Database	Language	Methodology	Conclusions
Application of activity-based costing in solid waste management: a case study. Rocha-dos-Santos, W.; Leite, W. and Schalch, V. (2022).	Scielo	Portuguese	Applied	The ABC activity-based costing method in waste management brings benefits by determining the costs of each service. Thus, it is possible to plan the use of each resource and manage its costs.
Comparative analysis of the solid waste management plans of Bogota D.C. and Mexico City. Rodríguez-Díaz, A., Díaz-Mendoza, C., Pasqualino, J. and Bahamón-Restrepo, A. (2022).	Scielo	Spanish	Bibliographic review	In the cities of Bogota and Mexico City, there are shortcomings in the solid waste management systems due to a lack of investment capacity and organization in logistics.
Problems of the Generation, Disposal and Treatment of Solid Waste in the Municipality of Quibdó, Colombia. Ortega-Ramírez, A., et al. (2021).	Scielo	Spanish	Bibliographic review	Although there is support for the management of urban solid waste (USW) in the areas examined, the aim is to provide a sustainable economic model, which implies providing incentives with subsidies and tax exemptions to companies that transform urban solid waste into a sustainable product.
Entrepreneurship, social mobilization and innovation: waste management in Argentinean municipalities. Gutiérrez, R. and Stevanato, A. (2021).	Scielo	Spanish	Study comparative	plastic and other materials. The authors propose the ISWM management model (reduce, reuse, recycle and treat waste) that allows the development of municipalities due to the optimization of the process and the social incorporation of waste collectors.
Gestão dos resíduos sólidos: o caso do consórcio de desenvolvimento sustentável do alto sertão na Bahia - urbe. Leal, T. and Sampaio, R. (2021).	Scielo	Portuguese	Mixed	In this study, 11 municipalities were analyzed, none of which complies adequately with current Brazilian legislation on resource management policy.
Improvement of the integrated management of urban solid waste in the canton of Quevedo, Ecuador. Alcocer, P., Cevallos, O. and Knudsen, J. (2019).	Scielo	Spanish	Quantitative	A multi-objective mathematical model was presented with the purpose of mathematically processing waste management; this description allows the analysis of waste management in the canton of Quevedo (Ecuador) to project an improvement in waste logistics.
The importance of participation and co-responsibility in the management of municipal solid waste (MSW). Carmen-Niño, V. et al. (2019).	Scielo	Spanish	Quantitative	This research presents the legal framework of the Political Constitution of the United Mexican States, which grants municipalities the responsibility to manage their waste together with social organizations and localities.
Barriers and opportunities for waste pickers within solid waste management policy in Colombia. Gómez-Maldonado, et al. (2022).	Scopus	English	Mixed	Integrated waste management in Colombia does not fully comply with formalization requirements, which include financing processes and organizational management.
Solid waste assessment in a coastal fishing community in Peru. Ortiz-Alvarez, et al. (2022).	Scopus	English	Quantitative	The authors state that in Peru there is little understanding of the consequences of waste contamination; nevertheless, there are contributions to the Integral Solid Waste Management Law that contribute to proper waste management.
Material flow analysis of solid waste in the district of Guápiles. Solís-Blandón, A. and Abarca-Guerrero, L. (2021).	Scielo	Spanish	Quantitative	Through the AFM method, which allows us to effectively observe how materials and waste are managed in a specific place, we determined the dissatisfaction of the inhabitants of Guapilés regarding waste collection.
Management of solid waste from health services according to the National Solid Waste Policy: a study conducted in the South of the Brazil. Mathias, R. (2021).	Scielo	English	Mixed	In southern Brazil, waste management has shortcomings due to the inadequacy of legal regulations. The management policy is not enough to detect performance in the process.
Management and environmental management of solid waste, case study. Garcia, et al. (2019).	Scielo	Spanish	Quantitative	Waste management at the Puerto Bolivar Municipal Market in Ecuador is limited to waste separation. On the contrary, it has adequate infrastructure to implement an action plan effectively.
Social metabolism and material flow analysis applied to waste management: A study case of Autonomous City of Buenos Aires, Argentina. López, et al. (2021).	Scopus	English	Mixed	CABA's urban solid waste management in Argentina has a negative environmental impact outside its jurisdictional boundaries.
Closing the gap in the management of solid waste...	Scopus	English	Quantitative	It is concluded that within Chile there is a need to improve waste management

Note. Own elaboration

From these results, specific quantities were obtained in relation to the studies carried out in the Latin American region and those that presented the current reality of the territory. In this case, it stands out that in Brazil (20%) and Mexico (16.6%) the studies on urban waste management are those with the greatest presence; followed by Colombia (13.3%) and Peru (10%) with studies analyzing the shortcomings of the processes, which allows us to observe the points to be improved in this region of the continent. The scarcest studies are provided by Ecuador (10%), Bolivia (3.3%) and Chile (3.3%). Finally, those studies where the region is not specified (20%) are those that provide information about technological and procedural innovations, which are mentioned in the Latin American region in general (see Figure 1).



Figure 1

Scientific production in Latin America

Note. The figure shows the percentage of articles produced in Latin American countries. Own elaboration.

The various databases used provided a considerable amount of information; however, the one that provided the greatest number of sources was the Scielo platform. The greater variety of articles related to the topic of waste management in Latin America allowed access to topics that could not be found in platforms such as Scopus or Dialnet. Thus, the number of articles selected in each platform is shown in Table 2:

Table 2

Scientific articles by database

DATABASE	PUBLICATION DATE					TOTAL
	2019	2020	2021	2022	2023	
Scopus	1		4	4	2	11
Dialnet			1	2		3
Scielo	4	1	5	6		16
Total						30

Note. Own elaboration.

Based on these findings, it is concluded that, in Latin America, the intervention of the private sector and the financial capacity they can offer are a great help to optimize waste management, as well as the application of procedural innovations by the State that contribute to an improvement at the economic level. On the other hand, the lack of concern for developing efficient regulations, in addition to the weak enforcement of the regulations already in place, and the lack of economic resources, are institutional obstacles that hinder the optimization of the process.

Among the initiatives or plans implemented in Latin America for solid waste management, the one implemented in Bogotá and Mexico City stands out, which is called zero waste, recycling, and where

sanitation service providers must cover these needs (Rodríguez-Díaz, et al. 2022). Likewise, Rocha-dos-Santos et al. (2022) point out that the application of the ABC method in the Brazilian urban population allows government agencies to evaluate their economic stability; in this way, the information acquired is used to propose various options for service provision.

In a different case, for Alcocer et al. (2019), the establishment of a multi-objective mathematical model to identify management productivity had positive results in the optimization of each part of the process. In the canton of Quevedo in Ecuador, the main company in providing the management service is EPMAGAQ, which, by means of Gams software, evaluates production cost, environmental impact and customer satisfaction. It results in a mathematical model capable of showing alternatives for action, and takes into account types of waste, the number of collection sites, treatment areas and final disposal.

Furthermore, in the area of financing, according to Gómez-Maldonado et al. (2022), the so-called incentive for the use and Transformation of Solid Waste (TSW) represents an important economic contribution that the Colombian government cannot acquire because the Territorial Regulation Plans (in Spanish, POT) are a barrier that complicates the acquisition of good equipment, transportation and quality of life. Similarly, Solís-Bladón and Abarca-Guerrero (2021) express that in Costa Rica the AFM tool shows the various negative aspects of waste management in the district of Guápiles, as it has poor management due to the use of informal waste managers; this creates discontent in the community that causes ignorance of urban sanitation practices. With respect to waste management in rural areas, Khan et al. (2022a) points out that composting is the most appropriate option for waste treatment, due to the fact that the large amount of waste in these areas is organic in nature.

In the case of Peru, Huamaní et al. (2020) state that the techniques used in the city of Juliaca are segregation, shredding, compression and packaging as a product; however, the acquisition of the necessary infrastructure for this purpose, in addition to a large economic investment, requires land, machinery and human capital. In this research, it is concluded that in the city of Juliaca the reality of waste is reduced in the use of inorganic waste, which covers 29.78% of collected waste, where only 20% was adequately reused. To this end, we evaluated the different types of waste that appear most frequently in the district of Juliaca, which are: paper/cardboard (7.20%), plastic (12.44%), glass (7.10%) and metals (14%).

CONCLUSIONS

In this review article, several studies on the management of solid waste in some Latin American countries were presented, and significant contributions were made. Since 20% of the articles were directed to the analysis of Brazil, this country is considered as the one that presents the highest indexes of technical contributions, as well as showing the existing weaknesses in the administrative processes.

It is established that both the public and private sectors may show deficiencies in the execution of plans and services for public cleaning. However, private companies are involved because of the State's need for material resources. The lack of motivation of government agents and the convenience of the private sector impede the proper management of waste, since it is the population that originates this waste in public spaces; therefore, the collaboration of the state apparatus is indispensable to promote a culture of cleanliness.

It is concluded that the deficiencies in waste management are linked to the poor organization of participatory agents (population, State, private sector), in addition to the lack of seriousness in the implementation of norms that regulate waste management, which gives way to the incursion of the informal sector and companies that exploit resources with a negative impact on the environment. In this way, it is projected to promote innovative techniques that are functional and sustainable alternatives for countries that do not have the means to emulate the processes of neighboring countries.

REFERENCES

Please refer to the articles in Spanish Bibliography.

BIBLIOGRAPHICAL ABSTRACT

Please refer to articles Spanish Biographical abstract.



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