Latin american production on solid waste management in Scopus, 2010 - 2020

Madona Tito-Betancur¹, Oscar Mamani-Benito², Ronald M. Hernandez³, Josué Edison Turpo Chaparro⁴, Renzo Felipe Carranza Esteban⁵, Miguel A. Saavedra-López⁶, Osmer Campos-Ugaz⁷

¹Universidad Tecnológica del Perú, Arequipa, Perú
²Universidad Señor de Sipán, Chiclayo, Perú
³Unidad de Virtualización Académica, Universidad de San Martín de Porres, Lima, Perú
⁴Universidad Peruana Unión, Lima, Perú
⁵Universidad San Ignacio de Loyola, Lima, Perú
⁶Universidad Continental, Cusco, Perú
⁷Universidad Católica Santo Toribio de Mogrovejo, Chiclayo, Perú

ABSTRACT

Solid waste management has become a critical problem in developing countries, therefore, with the aim of analyzing the Latin American scientific production on solid waste management in Scopus, a retrospective descriptive study was conducted considering as the unit of analysis the publications on solid waste management in journals indexed in Scopus, during the period 2010 to 2020. The search included all published and indexed articles, using the fields Article Title, Abstracts, Keywords, having as search term the word "Solid waste management". As result, 494 articles were found, of which 420 are original, 58 are reviews, and the rest are letters, editorials, conference papers, and notes. Brazil stands out as the largest producer of solid waste management knowledge (62.5% of Latin American production), followed by Mexico, Colombia, Chile, and Argentina. On the other hand, 158 international institutions have participated in the Latin American production and only 10 have produced more than 10 articles, with universities in Brazil and Mexico standing out. Among the most productive journals, Waste Management and Waste Management And Research stand out; and the researchers with the most publications are Liséte Lange and Sandro Donnini Mancini. It is concluded that research on solid waste management in Latin America in the period 2010 - 2020 is still deficient compared to other areas of the environmental field. The Latin American countries with the highest production in this area are Brazil, with more than 50%, followed by Mexico, Colombia, Chile, and Argentina.

Keywords: Solid Waste, Solid Waste, Scientific Production, Latin America, Latin America, Scopus

Corresponding Author:
Madona Tito-Betancur
Universidad Tecnológica del Perú, Arequipa, Perú
madonabetancur@gmail.com

1. Introduction

Throughout history, human activity has been generating waste, precisely, the denomination that refers to what no longer serves and ceased to have utility. Therefore, solid waste is those materials resulting from daily activities that are discarded because they are no longer useful [1]. Solid waste management is a problem for large cities, especially in developing countries, where factors such as population growth, population concentration in urban areas, inefficient development of the industrial and/or business sector, changes in consumption patterns and improvements in living standards, among others, have increased the generation of solid waste [2]. Currently, all issues related to environmental impact are of social concern [3], therefore, solid waste management is considered a public problem [1], on which a large number of investigations seek to determine the factors that influence its management in developing countries [4]. As revealed by research in Mexico, where, regarding environmental pollution caused by solid waste, it is reported that in databases such as Redalyc, Scielo, Dialnet, EBSCO, and CONRICYT it is evident that this has been a problem that has been
increasing globally [2]. This reality differs in developed countries, where public health is no longer an objective of integrated waste management, but rather the concern is focused on the optimization of waste management practices with a view to resource conservation. Whereas in developing countries solid waste management is considered one of the three most recurrent problems for any municipal management [4]. Scientific literature reports research on the topic, especially initiatives reporting how municipal solid waste should be managed [5], frequent problems related to recycling and recovery [6], sustainability of smart waste management plans [7], the direction of research on waste recycling modeling [8], technologies for solid waste management [9], especially those applied in developing countries [10] and the odd case study with some encouraging results such as the one reported in Egypt [11]. It is also important a general and systematic description of the scientific literature related to solid waste; in this regard, the literature reports studies such as the one conducted by C. Rodrigues-Vaz, D. Oliveira-Inomata, and J. Cesar-Stiirmer who after doing bibliometric research in Higher Education institutions, resorted to databases such as Web of Science, Scopus and Science direct, finding that out of a total of 118 articles only 14 were related to the topic [12]. Another bibliometric study on the evolution and state of research in environmental accounting found that the terms most related to this topic are sustainability, sustainable development, environmental impact, and climate change [3]. Similarly, a study that aimed to identify global trends related to solid waste between 1997 to 2014, resorted to databases such as Science Citation Index Expanded, Social Science Citation Index, and Conference Proceedings Citation Index, realizing that research was increasing in topics such as energy fuels, chemical engineering and biotechnology applied to microbiology, noting also the predominance of Chinese institutions and industrialized countries that generate scientific knowledge do the subject [13]. Scientific activity in the world is linked to the search for solutions to improve municipal solid waste management [14]. This reality contrasts with what is happening in Latin America, where a few initiatives have attempted to systematize the available information that conducted a bibliometric study on scientific production in environmental education; however, it is still pending to analyze the scientific activity on solid waste management [15]. Since in this continent, there is evidence of a large percentage of generation and very few initiatives for proper management [16], this despite having regulations for the comprehensive management of solid waste [17-27]. Therefore, the objective of this research was to analyze the Latin American scientific production on solid waste management in Scopus, period 2010 - 2020.

2. Materials and methods

2.1. Design

A retrospective descriptive study.

2.2. Unit of analysis

The unit of analysis was considered to be the publications on solid waste management, in journals indexed in Scopus, during the period 2010 to 2020 and whose authorship mentions affiliations of Latin American institutions. Scopus includes more than 40804 journals of science, technology, social sciences, arts, humanities, and medicine, so it was decided to use this database due to a large number of journals included, and its rigorous selection process of journals, which allows collecting the most relevant studies on the subject.

2.3. Procedure

The search included all published and indexed articles, using the fields Article Title, Abstracts, Keywords, using in the search terms the words: "Solid waste management". With the extracted documents, a database was organized in Microsoft Excel that included the following data: name of the signing authors, the title of the publication, type of publication, affiliation institutions of the signing authors, journal of publication, and country of publication.

2.4. Data analysis

The data obtained were analyzed through the statistical software SPSS version 26.0, obtaining the frequency tables and with the support of the VOSviewer software, a network was elaborated with the main thematic axes associated with the keywords of the publications.
3. Results

A total of 494 articles published and indexed in Scopus were found, with authorship to affiliations of Latin American institutions. Six types of publishable documents were included in the analysis (Table 1).

Table 1. Types of documents in solid waste management publications

| Type of document | N  |
|------------------|----|
| Article          | 420|
| Review           | 58 |
| Editorial        | 7  |
| Conference paper | 5  |
| Letter           | 2  |
| Note             | 2  |

Brazil is the Latin American country that contributes with the highest scientific production on solid waste, representing 62.55% of the Latin American production, followed by Mexico, Colombia, Chile, and Argentina, countries that have 15 or more publications. There are 03 Latin American countries (Paraguay, Jamaica, and Venezuela) that have at least 01 publications on the variables studied (see Table 2).

Table 2. Latin American countries with scientific production in the area of solid waste management

| Country          | N    | %    |
|------------------|------|------|
| Brazil           | 309  | 62.55|
| Mexico           | 67   | 13.56|
| Colombia         | 45   | 9.11 |
| Chile            | 20   | 4.05 |
| Argentina        | 15   | 3.04 |
| Bolivia          | 9    | 1.82 |
| Ecuador          | 8    | 1.62 |
| Peru             | 7    | 1.42 |
| Cuba             | 5    | 1.01 |
| Honduras         | 2    | 0.40 |
| Uruguay          | 2    | 0.40 |
| Dominican Republic| 2   | 0.40 |
| Paraguay         | 1    | 0.20 |
| Jamaica          | 1    | 0.20 |
| Venezuela        | 1    | 0.20 |

In terms of productivity by institution, 158 international institutions have participated in the Latin American production on solid waste management; however, only 10 have produced more than ten articles. Table 3 presents the results of the institutions with a frequency of publication of ten or more documents, among which the institutions of Brazil and Mexico stand out.

Table 3. Latin American institutions involved in solid waste management research

| Institution                                           | Country | Documents |
|------------------------------------------------------|---------|-----------|
| University of Sao Paulo - USP                         | Brazil  | 61        |
| Federal University of Rio de Janeiro                 | Brazil  | 33        |
| UNESP-Universidade Estadual Paulista                  | Brazil  | 26        |
| Federal University of Minas Gerais                   | Brazil  | 25        |
| State University of Campinas                          | Brazil  | 18        |
Table 4 presents the list of the most productive journals, among which Waste Management and Waste Management and Research stand out (publications greater than 40 documents). These journals are located in quartile 1 and quartile 2 of the SJR respectively and are classified in the environmental science category. The scientific production is concentrated in journals in quartiles 1 and 2, which demonstrates not only the high visibility of the contributions but also their potential quality.

Table 4. Most productive journals in the field of solid waste management

| Magazine                                      | Documents | Quartile | SJR           | Categories                                      |
|-----------------------------------------------|-----------|----------|---------------|-------------------------------------------------|
| Waste Management                             | 65        | United Kingdom | Q1 | Environmental Science | 1.63                                      |
| Waste Management And Research                 | 44        | United Kingdom | Q2 | Environmental Science | Business, Management, and Accounting; Engineering; Environmental Science | 0.65                                      |
| Journal Of Cleaner Production                | 29        | Netherlands | Q1 | Environmental Science | Economics, Econometrics, and Finance; Environmental Science | 1.89                                      |
| Resources Conservation And Recycling         | 26        | Netherlands | Q1 | Environmental Science |                                             | 2.22                                      |
| Sanitary and Environmental Engineering       | 23        | Brazil     | Q3 | Environmental Science |                                             | 0.19                                      |
| International Journal Of Environmental Pollution | 13        | Mexico     | Q4 | Environmental Science |                                             | 0.19                                      |
| Journal Of Environmental Management          | 12        | United States | Q1 | Environmental Science | Business, Management and Accounting; Decision Sciences | 1.32                                      |
| Spaces                                       | 10        | Venezuela | Q3 | Energy; Environmental Science |                                             | 0.22                                      |
| Sustainability Switzerland                   | 9         | Switzerland | Q2 | Environmental Science |                                             | 0.58                                      |
| Journal Of Solid Waste Technology And        | 8         | United States | Q4 | Environmental Science |                                             | 0.16                                      |

Table 5 shows the authors who to date have contributed the largest number of studies on solid waste management. Of the 138 authors of the 494 documents analysed, those who have contributed more than five documents to date include researchers such as Lange, Lisète and Mancini, Sandro, among others.
Table 5. Latin american authors with the highest production of documents on solid waste management

| Authors                  | Institution                                                      | Country    | Number of documents | h index |
|--------------------------|------------------------------------------------------------------|------------|---------------------|---------|
| Lange, Liséte C.         | Federal University of Minas Gerais                               | Brazil     | 7                   | 16      |
| Mancini, Sandro Donnini  | UNESP-Universidade Estadual Paulista                             | Brazil     | 7                   | 10      |
| Battistelle, Rosane Aparecida Gomes | UNESP-Universidade Estadual Paulista                             | Brazil     | 5                   | 12      |
| Colvero, Diogo Appel     | Brazilian National Council for Scientific and Technological Development | Brazil     | 5                   | 3       |
| Fehr, Manfred            | Uberlândia Federal University                                   | Brazil     | 5                   | 9       |
| Feitosa, Anny Kariny     | University of Vale do Taquari - Univates                        | Brazil     | 5                   | 1       |
| Gorritty Portillo, Marcelo Antonio | Universidad Mayor de San Andres Bolivia                         | Bolivia    | 5                   | 4       |
| Guisbert Lizarazu, Edith Gabriela | Universidad Mayor de San Andres Bolivia                         | Bolivia    | 5                   | 3       |
| Ponce-Ortega, José María | Michoacán University of San Nicolás de Hidalgo,                 | Mexico     | 5                   | 35      |
| Santibañez-Aguilar, José Ezequiel | Tecnologico de Monterrey                                      | Mexico     | 5                   | 12      |

Figure 1 shows that the most frequent descriptor is solid waste management with 257 occurrences, followed by waste management and solid waste with 254 and 186 occurrences, respectively. In this case, the number of co-occurrences of two words indicates the number of publications in which both words appear in the list of keywords of the selected papers. The colors indicate clusters of keywords relatively related to each other according to the strength of association obtained by the VOSviewer program, in addition to the visual difference of clusters. Using the 89 descriptors out of a total of 5187 recorded in the 494 retrieved documents and the five clusters, the thematic focus of each grouping was analyzed. Cluster 1 (red) includes the words solid waste management and its relation to biodegradation and garbage disposal. The green cluster analyses the themes of municipal solid waste, its economic and environmental impact. The yellow cluster describes recycling logistics and environmental planning. Finally, the purple cluster indicates the relationship between waste pickers as conservation agents and the informality of their sector.
Figure 1. Visualization of a keyword occurrence network

4. Discussion

The Millennium Development Goals [28] and the 17 Sustainable Development Goals. Emphasize a healthy and safe environment and responsible production and consumption [29]. In this sense, solid waste acts as one of the most important sources of pollution, and its analysis and research have become major topics of study [30]. Therefore, the objective of this research was to analyze the Latin American scientific production on solid waste management in Scopus, period 2010 - 2020. Solid waste management aims to achieve greater waste prevention and better resource management which shows that for Latin America collection procedures, transfer stations, treatment strategies, energy recovery, and waste treatment techniques are fundamental to their environmental goals [31, 32]. For Latin America, it is important to have control of this process as it is for another country like China, in which they constantly develop studies and knowledge maps [33]. The results found show that Latin American production is significant with 494 articles. Globally Europe has the highest number of publications in the field of solid waste, followed by Asia, Oceania, and Latin America, and the Caribbean; incredibly Africa and North America have fewer studies [32]. At the Latin American level, the results show that Brazil contributes 62.55% and is followed by Mexico, Colombia, Chile, and Argentina. This result is consistent with other research that found Brazil and Mexico as the most prolific Latin American countries in the fields of environmental science [15]. Brazil ranks third with the most publications and as one of the countries that are implementing recycling policies [34], where 62% of municipalities implement selective collection programs for urban solid waste [16, 17]. And where environmental education is one of the pillars of such change [35]. Another important result shows that more than 46% of all scientific production on solid waste belongs to higher education institutions (228 articles). The results were found to show 158 institutions with at least 10 articles and three of them, all from Brazil, with more than 25 articles. This positioning of Brazil in its scientific production is also due to the result of undergraduate and graduate work promoted by universities [36] and that several of them, occupy prominent places in the world ranking [37]. Also, this result highlights authors linked to public universities which publish more compared to private universities [36]. It is important to analyze the relationship of private universities with public universities, so that transfer and joint work experiences are generated [38]. Of the 138 authors analyzed, 10 authors publish
more than 5 papers, which is congruent with the law of scientific productivity where only six percent of the authors in a given field produce more articles [39]. Another important aspect is that researchers publish in Q1 and Q2 journals respectively, which shows their high visibility and quality, taking into account that the COVID-19 pandemic has generated a significant increase in publications from the area of environmental sciences [40]. It is also observed that co-authorship networks of universities or institutions have little collaboration between them [41] and that even for Brazilian universities there are numerous obstacles to incorporate the environmental dimension in the training of human resources [12]. It is therefore important that Latin American researchers from countries with emerging research increase the level of collaboration with academics from countries such as Brazil and Mexico and with universities such as the University of Sao Paulo and the Federal University of Rio de Janeiro that have experience in the field of solid waste management, but without losing opportunities for collaboration with countries such as the United States, the United Kingdom, and Italy, which are also countries with more resources to invest [42]. Both international and regional cooperation can stimulate insightful and innovative ideas while keeping abreast of the latest research published in influential journals that can explore the possibility of using solid waste as a renewable energy source and improve public acceptance in Latin American countries. Therefore, it is important to pinpoint the preferences of researchers which in the case of Brazil are related to recycling, sustainability, and life cycle assessment [43]. Among the most productive journals chosen by Latin American researchers is Waste Management. Likewise, [44] Reported the Waste Management journal as the most productive journal in the environmental area. Similar studies report that Waste Management journal was most frequently cited with an impact factor of 5.431, indicating that its papers are most read, discussed, and referenced [42, 45], similar data in the case of India and Arab countries [46, 47]. In studies in the field of engineering and environmental sciences, Waste Management published the most articles [30]. The clusters found are identified by the research activity by the institutes [38]. Clustering methods have a long tradition in bibliometrics as a tool for grouping bibliometric units based on similarity properties that measure the distance between them [48]. Cluster analysis (1), Red, shows words kind of coexistence namely: waste disposal, landfill, water pollutants, biofuel, leachate treatment, solid waste management, biodegradation, and garbage disposal. It is the largest cluster. Waste management is mainly considered in the context of sustainable development as one of the key services that every city government should provide [7, 49]. As well as waste management evaluation methods [50]. The blue cluster (2), shows the coexistence words: solid waste, sustainable development, environmental policies. This cluster represents problems related to sustainability and which are a line of research that occurs in the governance framework [4]. As well as interventions on issues related to urban solid waste and waste collectors [51]. The green cluster (3) shows the coexistence words: municipal solid waste, environmental impact, circular economy, waste incineration, greenhouse gases, developing countries. This is a group of problems related to the economic and environmental impact of municipal solid waste. These components were presented in different studies ) [36, 37]. And in the case of Brazil, which has regulatory policies that can stimulate the circular economy that today is one of the most recurrent themes in the environment [52, 53]. The yellow cluster (4) shows the coexistence words: logistics, recycling, environmental planning, optimization, e-waste. Here we can find some relatively novel terms such as e-waste that have been causing a series of problems in the region and that can support a proposal for continuous monitoring and analysis to better manage this type of waste [54, 55]. This study has some limitations, although Scopus has a wide scope in relation to publications, however, it is limited in terms of inclusion of low impact sources and updating of the latest articles. On the other hand, the study did not include journals indexed by SCI of WoS so it is likely that some documents have been lost.

5. Conclusions

We conclude that, through this study, significant points have been obtained on the Latin American production of solid waste management throughout the period from 2010 to 2020. The number of articles on solid waste was 494 articles, most of these articles were published in 10 scientific journals in the Environmental Science categories of Scopus. The Latin American countries with the highest production are at the same time those with the highest production in science, being Brazil with more than 50% of production followed by Mexico, Colombia, Chile, and Argentina those who published a large number of articles. The journal Waste Management published the largest number of articles. Among the most representative topics are solid waste management and its relationship with biodegradation. Urban solid waste, recycling logistics, environmental planning, and the relationship of waste pickers as agents of conservation.
References

[1] N. M. Jiménez, "Waste: urban product, a matter of public intervention and object of integrated management," Cultura y Representaciones Sociales, vol. 11, no. 22, March, pp.158-192, 2017.

[2] M. A. Ruiz, "Current status of environmental pollution present in the Mixteca Oaxaqueña," Journal of Negative and No Positive Results, vol. 5, no. 5, May, pp. 535-553, 2020.

[3] N. Araújo, J. A. Fraiz and L. Cardoso, "Evolution and status of research in environmental accounting," Contabilidad y Negocios, vol. 14, no. 28, October, pp. 36-53, 2019.

[4] L. Abarca-Guerrero, G. Maas and W. Hogland, "Solid waste management challenges for cities in developing countries," Rev. Tech. Mar. Vol. 28, no. 2, April - June, pp. 141-168, 2015.

[5] A. Soni, D. Patil, and K. Argade, "Municipal solid waste management," Procedia Environmental Sciences, vol. 35, no. August, pp. 119-126, 2016.

[6] H. I. Abdel-Shafy and M. S. M. Mansour, "Solid waste issue: Sources, composition, disposal, recycling, and valorization," Egyip. Journ. Petrol, vol. 27 no. 4, December, pp. 1275-1290, 2018.

[7] S. Das, S. H. Lee, P. Kumar, K. H. Kim, S. S. Lee and S.S. Bhattacharya, "Solid waste management: Scope and the challenge of sustainability," Journal of Cleaner Production, vol. 228, no. August, pp. 658-678, 2019.

[8] X. Bing, J. M. Bloemhof, T. R. P. Ramos, A. P. Barbosa-Povoa, C. Y. Wong and J. G. A. J. Van der Vorst, "Research challenges in municipal solid waste logistics management," Waste Management, vol. 48, no. February, pp. 584-592, 2016.

[9] K. Moustakas and M. Loizidou, "Advances and prospects in the field of waste management," Environmental Pollution Research, vol. 26, no. 35, October, pp. 35283-35287, 2019.

[10] S. Zheng, W. Liu and Q. Zhi, "Cleaner Waste Management: A Review Based on the Aspects of Technology, Market and Policy," Energy Procedia, vol. 104, no. December, pp. 492-497, 2016.

[11] S. ElSaïd and E.H. Aghezzaf, "Alternative strategies towards a sustainable municipal solid waste management system: A case study in Cairo," Waste Management & Research, vol. 38, no. 9, May, pp. 995-1006, 2020.

[12] C. Rodriguez-Váz, D. Oliveira-Inomata and J. Cesar-Stiirmer, "State of the Art on solid waste management in Higher Education institutions: a literature review," Rev. Cub. Chem, vol. 27, no. 3, pp. 228-242, 2015.

[13] H. Chen, W. Jiang, Y. Yang, Y. Yang, and X. Man, "Global trends of municipal solid waste research from 1997 to 2014 using bibliometric," Journal of the Air & Waste Management Association, vol. 65, no. 10, October, pp. 1161-1170, 2015.

[14] D. M. C. Chen, B. L. Bodirsky, T. Krueger, A. H. Mishra, and A. Popp, "The world's growing municipal solid waste: trends and impacts," Environmental Research Letters, vol. 15, no. 7, June, pp. 1-15, 2020.

[15] I. F. Medina and P. Páramo, "Environmental education research in Latin America: a bibliometric analysis," Rev. Colom. Educ., vol. 1, no. 6, June, pp. 55-72, 2014.

[16] "Status of SOLID WASTE management in Latin America and the Caribbean," Inter-American Development Bank, [online]. Available: https://publications.iadb.org/es/situacion-de-la-gestion-de-residuos-solidos-en-america-latina-y-el-caribe [Accessed: 18-August-2021]

[17] M. P. Sánchez-Muñoz, J. G. Cruz-Cerón and P.C. Maldonado-Espinel, "Urban solid waste management in Latin America: an analysis from the generation perspective," Rev. Finan. Polít. Econ., vol. 11, no. 2, mJuly - December, pp. 321-336, 2020.

[18] L. F. Jawad, B. Majeed, H. S. Alrikabi, "Tactical Thinking and its Relationship with Solving Mathematical Problems Among Mathematics Department Students," International Journal of Emerging Technologies in Learning (iJET), vol. 16, no. 9, pp. 247-262, 2021.

[19] A. Ghazi, S. Aljunid, A. Fareed, S. Z. S. Idrus, C. M. Rashidi, A. Al-dawoodi, and A. M. Fakhirudeen, "Performance Analysis of ZCC-Optical-CDMA over SMF for Fiber-To-The-Home Access Network," in Journal of Physics: Conference Series, 2020, vol. 1529, no. 2, p. 022013: IOP Publishing.

[20] L. Fouad, B. Hassan, H. Salim, "The impact of teaching by using STEM approach in the Development of Creative Thinking and Mathematical Achievement Among the Students of the Fourth Sci-entific Class," International Journal of Interactive Mobile Technologies (iJIM), vol. 15, no. 13, pp. 172-188, 2021.

[21] A. Fareed, A. Ghazi, A. Al-Dawoodi, S. Aljunid, S. Z. S. Idrus, C. Rashidi, A. Amphawan, A. M.
Fakhrudeen, and I. E. I. Fadhel, "Comparison of Laguerre-Gaussian, Hermite–Gaussian and linearly polarized modes in SDM over FMF with electrical nonlinear equalizer," in AIP Conference Proceedings, 2020, vol. 2203, no. 1, p. 020045: AIP Publishing LLC.

[22] H. Alrikabi, and H. Tauma, "Enhanced Data Security of Communication System using Combined Encryption and Steganography," International Journal of Interactive Mobile Technologies, vol. 15, no. 16, pp. 144-157, 2021.

[23] H. Salim, N. A. Jasim, "Design and Implementation of Smart City Applications Based on the Internet of Things," International Journal of Interactive Mobile Technologies (iJIM), vol. 15, no. 13, pp. 4-15, 2021.

[24] A. Ghazi, S. Aljunid, S. Z. S. Idrus, A. Fareed, A. Al-dawoodi, Z. Hasan, R. Endut, N. Ali, A. H. Mohsin, and S. S. Abdullah, "Hybrid Dy-NFIS & RLS equalization for ZCC code in optical-CDMA over multi-mode optical fiber," Periodicals of Engineering Natural Sciences, vol. 9, no. 1, pp. 253-276, 2021.

[25] O. H. Yahya, H. T. ALRikabi, R. a. M. Al_airaji, and M. Faezipour, "Using Internet of Things Application for Disposing of Solid Waste," International Journal of Interactive Mobile Technologies, vol. 14, no. 13, pp. 4-18, 2020.

[26] A. Alaidi, I. Aljazaery, H. Alrikabi, I. Mahmood, and F. Abed, "Design and Implementation of a Smart Traffic Light Management System Controlled Wirelessly by Arduino," international Journal of Interactive Mobile Technologies, vol. 14, no. 7, pp. 32-40, 2020.

[27] A. G. M. Al-dawoodi, and M. Mahmuddin, "An empirical study of double-bridge search move on subset feature selection search of bees algorithm," Journal of Telecommunication, Electronic Computer Engineering, vol. 9, no. 2-2, pp. 11-15, 2017.

[28] "United Nations Millennium Development Goals," World Trade Organization, [online]. Available: https://www.wto.org/english/thewto_e/coher_e/mdg_e/mdgs_e.htm [Accessed: 28-August-2021]

[29] "17 Goals to Transform Our World," United Nations, [online]. Available: https://www.un.org/sustainabledevelopment/ [Accessed: 30-August-2021]

[30] L. Yang, Z. Chen, T. Liu, Z. Gong, Y. Yu, and J. Wang, "Global trends of solid waste research from 1997 to 2011 by using bibliometric analysis," Scientometrics, vol. 96, no. 1, November, pp. 133-146, 2013.

[31] A. T. Tenorio, F. T. Ferreira, G. Lima and J. Palma, "Urban solid waste challenges in the BRICS countries: a systematic literature review," Rev. Ambient. Água, vol. 13, no. 2, e2157, 2018.

[32] F. M. Tsai, T. D. Bui, , M. L.Tseng, M. K. Lim and J. Hu, "Municipal solid waste management in a circular economy: A data-driven bibliometric analysis," Journal of Cleaner Production, vol. 275, no. September, ISSN 0959-6526, 2020.

[33] C. Jiang, "Research on Environmental Management and Monitoring Technology of Solid Waste in China Based on Knowledge Map," Journal of Physics: Conference Series, vol. 1345, no. October, pp. 1-6, 2019.

[34] J. F. Gaviria-Cuevas, J. Soto-Paz, P. C. Manyoma-Velasquez and P. Torres-Lozada, "Trends in Research on the Supply Chain Management of Municipal Solid Waste," Información Tecnológica, vol. 30, no. 4, August, pp. 147-154, 2019.

[35] E. Chierrito-Arruda, A. L. Martins, E. A. De Souza, R. Da Silva and R. Grossi-Milani, "Pro-Environmental behavior and recycling: Literature review and policy considerations," Amb. Soc., vol. 21, no. pp. 1-18, 2018.

[36] E. C. Bonjardim, , R. Da Silva and E. V. Guardabassio, "Análise bibliométrica das publicações em quatro eventos científicos sobre gestão de resíduos sólidos urbanos a partir da Política Nacional de resíduos Sólidos - Ley No 12.305/2010," Desenv. Mei. Amb, vol. 46, no. August, pp. 313-333, 2018.

[37] R .M. Deus, R. A. Gomes and G. H. Ribeiro, "Solid waste in Brazil: context, gaps and trends," Eng. Sanit. Ambient, vol. 20, no. 4, pp. 685-698, 2015.

[38] A. Mesdaghiinia, A. H. Mahvi, S. Nasser, R. N. Nodehi and M. Hadi, "A bibliometric analysis on the solid waste-related research from 1982 to 2013 in Iran," Int. J. Recycl. Org. Waste Agricult, vol. 4, no. 3, May, pp. 185-195, 2015.

[39] A. J. Lotka, "The frequency distribution of scientific productivity," Journal of the Washington Academy of Sciences, vol. 16 no. 12, June, pp. 317-323, 1926.

[40] M. Usman and Y. S. Ho, "COVID-19 and the emerging research trends in environmental studies: a bibliometric evaluation," Environmental Science and Pollution Research, vol. 28, no. Frebruary, pp.
[41] R. Medina-Mijangos and L. Seguí-Amórtegui, "Research Trends in the Economic Analysis of Municipal Solid Waste Management Systems: A Bibliometric Analysis from 1980 to 2019," Sustainability, vol. 12, no. 20, October, pp. 8509, 2020.

[42] C. Wang, D. Liu, Y. Li, L. Wang and W. Gu, "A multidisciplinary perspective on the evolution of municipal waste management through text-mining: A mini-review," Waste Management Research, vol. 39, no. 1, October, pp. 32-42, 2020.

[43] C. Wang, D. Liu, Y. Li, L. Wang and W. Gu, "A multidisciplinary perspective on the evolution of municipal waste management through text-mining: A mini-review," Waste Management & Research, vol. 39, no. 1, pp. 32-42, 2021.

[44] N. Li, R. Han and X. Lu, "Bibliometric analysis of research trends on solid waste reuse and recycling during 1992-2016," Resources, Conservation and Recycling, vol. 130, no. 4, March, pp. 109-117, 2018.

[45] S. Wong, A. X. Y. Mah, A. H. Nordin, B. B. Nyakuma, N. Ngadi, R. Mat, N. A. S. Amin, W. S. Ho and T. H. Lee, "Emerging trends in municipal solid waste incineration ashes research: a bibliometric analysis from 1994 to 2018," Environmental Science and Pollution Research, vol. 27, no. 8, pp. 7757-7784, 2020.

[46] P. Vijayakumar, S. Rao, and G. Sivasubraminiyan, "Solid waste research in India during 2008-2017: A bibliometric analysis," Library Philosophy and Practice, vol. 25, no. 2, May, pp. 1-14, 2019.

[47] S. H. Zyoud, S. W. Al-Jabi, W. M. Sweileh, S. Al-Khalil, S. H. Zyoud, A. F. Sawalha and R. Awang, "The Arab world's contribution to solid waste literature: a bibliometric analysis," Journal of Occupational Medicine and Toxicology, vol. 10, no. 1, pp. 1-14, 2015.

[48] M. Callon, J. P. Courtial, W. A. Turner and S. Bauin, "From translations to problematic networks: An introduction to co-word analysis," Social Science Information, vol. 22, no. 2, pp. 191-235, 1983.

[49] I. Gorzeń-Mitka, B. Bilska, M. Tomaszewska and D. Kołożyn-Krajewska, "Mapping the Structure of Food Waste Management Research: A Co-Keyword Analysis," International Journal of Environmental Research and Public Health, vol. 17, no. 13, July, pp. 4798, 2020.

[50] A. Allesch and P. H. Brunner, "Assessment methods for solid waste management: A literature review," Waste Management & Research, vol. 32, no. 6, June, pp. 461-473, 2014.

[51] F. J. Emmatty and V. V. Panicker, "Ergonomic interventions among waste collection workers: A systematic review," International Journal of Industrial Ergonomics, vol. 72, no. 1, July, pp. 158-172, 2019.

[52] L. Oranges, L. Bartocci, N. Oliveira, B. Garcia and L. Conde, "Diving into emerging economies bottleneck: Industry 4.0 and implications for circular economy," Management Decision, vol. 59, no. 8, August, ISSN 0025-1747, 2021.

[53] J. M. Fernández-González, C. Díaz-López, J. Martín-Pascual and M. Zamorano, "Recycling Organic Fraction of Municipal Solid Waste: Systematic Literature Review and Bibliometric Analysis of Research Trends," Sustainability, vol. 12, no. 11, June, pp. 1-15, 2020.

[54] J. D. De Oliveira, J. F. De Oliveira, M. Mendonça and S. Machado, "E-Waste Mistakenly Disposed of as Recyclable Waste: A Case Study from Brazil," Clean - Soil, Air, Water, vol. 48, no. 11, September, pp. 1-10, 2020.

[55] S. E. Vergara and G. Tchobanoglous, "Municipal solid waste and the environment: A global perspective," Annual Review of Environment and Resources, vol. 37, no. 2, November, pp. 277-309, 2012.