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ORIGINAL ARTICLE

Solid waste research in Scopus (2002-2023): A study based on the Peru scientific production

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ABSTRACT

Objective. In this study, we performed a bibliometric analysis of the Peruvian scientific production of solid waste.

Methodology. A bibliometric analysis was conducted based on records indexed in the Scopus database from 2003 to 2023. The bibliometric indicators examined were productivity by journals, productivity by institutions, productivity by authors, most cited articles, and co-occurrence of terms.

Results. Many journals and international conferences oriented from marine biology to ecological engineering stood out among the sources with the highest productivity. Three institutions stood out: Universidad Privada del Norte, Pontificia Universidad Católica del Perú, and Universidad San Ignacio de Loyola. There is a group of public universities that stood out, such as Universidad Nacional de Ingeniería, Universidad Nacional Mayor de San Marcos, Universidad Nacional Agraria La Molina, Peru, and Universidad Nacional del Centro del Perú. A small group of leading authors was observed: De-la-Torre, G. E., Vázquez-Rowe, I.; Marin, M. V., and Ziegler-Rodriguez, K. The most cited articles were related to the energetic use of agricultural waste, contamination by personal protective equipment waste during the COVID-19 pandemic, solid waste management in Latin America, environmental impact and public health of plastic waste related to COVID-19, and waste management evaluation and optimization. The co-occurrence map of terms revealed eight thematic clusters: (1) intersection between agriculture and waste management, (2) chemical processes in waste reduction, (3) waste management in aquatic environments, (4) intersection between agriculture and waste management with emphasis on approaches, practices and strategies, (5) agro-industrial waste, (6) impact of solid waste on air and water pollution, (7) social perspectives on environmental issues, and (8) eco-efficiency in the construction sector.

Conclusions. Peruvian research on solid waste strongly focuses on agriculture, given that these issues were highlighted in three of the eight thematic clusters identified.

Keywords: solid waste; scientific production; bibliometrics; Peru; environmental pollution; waste management.

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1. INTRODUCTION

The issue of solid waste management is of global concern. Kaza *et al.* (2018) posit that 2.01 billion tons of municipal solid waste are generated worldwide on an annual basis. This figure is projected to reach 3.40 billion tons by 2050. Many factors contribute to this phenomenon, including population growth, consumerism, waste production, urbanization, limited resources, and inadequate government policies (Awino & Apitz, 2024). This sector is frequently underestimated; nevertheless, solid waste has been demonstrated to have an increased global warming potential (Budihardjo *et al.,* 2023). Najafi *et al.* (2024) state that *"sudden changes in the quantity and composition of MSW can affect the main goals of waste management including environmental protection and material and energy recovery, or prioritize health goals"* (p. 2).

The composition of solid waste is significantly influenced by many factors, including socioeconomic, cultural, geographic, and even seasonal variables (Ibarra-Esparza *et al.,* 2023). In Peru, the country that constitutes our research context, the Ministry of Environment (2024) has reported that the annual average generation of organic and inorganic solid waste is 8,450,715 tons. This presents significant environmental and urban policy challenges, which must address these figures and contribute to a more substantial reduction and improved management of solid waste.

This article aims to conduct a bibliometric analysis of the Peruvian scientific production of solid waste. The results will facilitate the identification of national research trends on the subject. In this regard, several bibliometric studies have been conducted on the subject. Kaur *et al.* (2021) identified trends in municipal solid waste for producing bioproducts by analyzing citations, the co-occurrence of terms, and the productivity of authors and countries. Notable findings from their study include that most literature on this subject originates from North America, with municipal solid waste representing the most frequently cited topic.

Meanwhile, Fernandez-Gonzalez *et al.* (2020) focused their study on recycling the organic fraction of municipal solid waste. They concluded that the scientific field is still evolving in implementing a circular economy model. With a particular focus on recycling, Li, Han, and Lu (2019) have demonstrated that e-waste and biodiesel production from waste oil were emerging research areas. In a recent study, Zhang *et al.* (2022) examined the topic of solid waste recycling in the context of concrete construction engineering. The results demonstrated that China needs to catch up with other countries that are in progress on this topic, with fly ash studies being the most prevalent and frequently cited.

The subject of solid waste management was also explored by Rahaman *et al.* (2021). Following the mapping of literature indexed in Web of Science, the authors identified significant contributions from China and its collaborative efforts with Canada. The authors advised that future bibliometric studies should concentrate on subjects such as waste management, particularly liquid and gaseous waste management. Other studies of interest that provide comprehensive coverage include those by Wong *et al.* (2020), Yang *et al.* (2013), Bhattacharjee *et al.* (2023), and Ravichandran and Vivekanandhan (2020).

2. METHODOLOGY

The Scopus database was used to retrieve the literature. Among the parameters to execute the search strategy were considered:

- indexed publications with at least one author affiliated with a Peruvian institution,
- temporal coverage between 2003-2023,
- typology of relevant documents such as articles, congress articles, book chapters, and review articles, and
- presence of the term "solid waste" in the most pertinent sections of the document, such as the title, abstract, and keywords.

The resulting search equation was as follows:

TITLE-ABS-KEY ("Solid waste") AND PUBYEAR > 2002 AND PUBYEAR < 2024 AND (LIMIT-TO (AFFILCOUNTRY , "Peru")) AND (LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar"))

We used the following indicators to examine the Peruvian literature on solid waste:

- Productivity by journals
- Productivity by institutions
- Productivity by authors
- Most cited articles
- Co-occurrence of terms

Following extracting the Scopus records, normalization was conducted within a local database. In the case of the analysis of co-occurrence of terms, a map was constructed to identify the principal topics reflected in the literature. A cluster analysis was conducted using the Girvan-Newman algorithm (Kumar & Singh, 2024) to identify community structures within complex networks. This was achieved through an iterative edge elimination process based on the centrality of the interrelationship, whereby the importance of edges in connecting disparate parts of the network was quantified (Ali *et al.,* 2023). This process isolated clusters by decomposing the network into smaller, cohesive subnetworks, thereby revealing distinct communities of closely related keywords that are more internally than externally connected (Freeman, 2011). The resulting clusters were then represented on a map, allowing for visualizing their internal cohesion and relevance.

3. RESULTS

The initial analysis examines the sources utilized by Peruvian authors for publication (Table 1). The *Proceedings of the LACCEI International*

Source	Documents	Cites
proceedings of the laccei international multi-conference for engineering, education and technology	31	13
science of the total environment	11	866
marine pollution bulletin	6	313
chemical engineering transactions	5	29
waste management	5	371
boletin de malariologia y salud ambiental	4	1
revista kawsaypacha: sociedad y medio ambiente	4	0
environmental monitoring and assessment	3	12
lecture notes in networks and systems	3	4
revista peruana de medicina experimental y salud publica	3	20
sapienza	3	2
10th ieee international conference on renewable energy research and applications, icrera 2021	2	2
2022 5th international conference on robotics, control and automation engineering, rcae 2022	2	2
advances in intelligent systems and computing	2	2
chemosphere	2	83
environmental science and engineering	2	0
environmental science and pollution research	2	18
international journal of advanced computer science and applications	2	10
iop conference series: earth and environmental science	2	2
journal of cleaner production	2	77
journal of ecological engineering	2	2
journal of environmental management	2	13
produccion y limpia	2	0
resources, conservation and recycling	2	70
revista peruana de biologia	2	21
salud, ciencia y tecnologia	2	10
scientia agropecuaria	2	4
universidad y sociedad	2	1
wit transactions on ecology and the environment	2	1

Table 1. Most highlighted publication sources.

Multi-Conference for Engineering, Education, and Technology is the most prolific source, with 31 publications. The journal *Science of the Total Environment,* which addresses global challenges related to waste management and environmental sustainability, occupies the second position with 11 publications. Other noteworthy journals include the *Marine Pollution Bulletin, Chemical Engineering Transactions,* and *Waste Management.* These reflect a focus on marine pollution and the application of chemical engineering to waste management. Meanwhile, journals such as *Boletín de Malariología y Salud Ambiental* and *Revista Kawsaypacha: Sociedad y Medio Ambiente* reflect an interest in public health and the relationship between waste and human well-being.

A significant number of the most productive sources are specialized international conferences, which cover a range of disciplines, including marine biology and ecological engineering. This illustrates the interdisciplinary character of the subject matter under investigation. Among these conferences are: Notable conferences include the *10th IEEE International Conference on Renewable Energy Research and Applications (ICRERA 2021),* the *2022 5th International Conference on Robotics, Control and Automation Engineering (RCAE 2022),* the *2021 7th International Congress on Innovation and Trends in Engineering (CONIITI 2021),* the *2022 International Conference on Mechanical Engineering and Power Engineering (MEPE 2022),* the *2023 IEEE Colombian Conference on Communications and Computing (COLCOM 2023),* and the *7th International Conference on Acid Rock Drainage (ICARD 2006).* The existence of journals and conferences about sustainability, the environment, and bioproducts suggests a growing inclination towards ecological and sustainable solutions.

In terms of institutional productivity, three institutions merit particular attention: The Universidad Privada del Norte has published 26 articles. In contrast, the Pontificia Universidad Católica del Perú and the Universidad San Ignacio de Loyola have published 22 and 19 articles, respectively. A notable group of public universities also merits mention, like the Universidad Nacional de Ingeniería, Universidad Nacional Mayor de San Marcos, Universidad Nacional Agraria La Molina, and Universidad Nacional del Centro del Perú. Notably, a diverse range of institutions are engaged in this field, encompassing not only public universities but also private universities, research centers, and specialized consultancies. In the context of specialized centers, the International Potato Center and the Center for Ornithology and Biodiversity (CORBIDI) merit particular mention. This indicates a concentration of research activity in specific niche areas that extend beyond the traditional university sector.

A small group of authors is responsible for the majority of scientific output in this field, with some publishing many articles. An illustrative example is that of De-la-Torre, G. E., whose research activities are oriented toward studies on contamination by protective equipment, the impact of microplastics, and contamination in marine fauna. The second most prolific author is researching circularity in agroforestry systems, climate change mitigation in landfills, climate action and food security, and solid waste management in urban environments. Other noteworthy contributors include Vázquez-Rowe, I.; Marin, M. V.; and Ziegler-Rodriguez, K. (see Table 2 for a complete list).

After analyzing the most cited articles (Table 3), it became evident that the first group of highly cited articles (with over 100 citations each) addressed several vital topics. These included the energetic use of agricultural waste, contamination by residues of personal protective equipment (PPE) during the global pandemic caused by the SARS-CoV-2 virus, solid waste management in Latin America, the environmental impact and public health implications of plastic waste related to the pandemic, and the evaluation and optimization of waste management practices. The second group of more highly cited studies (20-88 citations) addresses a range of topics related to solid waste management in urban and tourism contexts, the reuse of agricultural waste, anaerobic digestion, the environmental impact of microplastics and pharmaceuticals, the evaluation of climate change mitigation strategies, and the socio-cultural and economic variables that influence waste generation. Conversely, the least cited studies (0 citations) pertain to technological innovation and automation in waste management, recovery and reuse of organic and industrial waste, and waste management's

Author	Number of articles
De-la-Torre, G. E.	15
Vázquez-Rowe, I.	9
Kahhat, R.	8
Marin, M. V.	7
Ziegler-Rodriguez, K.	5
Rakib, M. R. J.	5
Pizarro-Ortega, C. I.	5
Izquierdo-Horna, L.	5
Dioses-Salinas, D. C.	5
Ramos, W.	4
Pretell, V.	4
Margallo, M.	4
Delgado, A.	4
Aldaco, R.	4
Zavala, S.	3
Yanayaco, D.	3
Rojas, J.	3
Requena-Sanchez, N.	3
Raymundo, C.	3
Morales Ramírez, M. J.	3
Iannacone, J.	3
Fernandez, G. I. L.	3
Damazo, M.	3
Camargo, S.	3
Balbin, N.	3

Table 2. Most productive authors.

environmental impact and public health implications. The least cited papers are predominantly from 2022 and 2023; thus, their citations may not yet be reflected in Scopus.

After establishing a threshold of occurrence for terms at a frequency of two, 442 words were identified (see Table 4). The term most frequently occurring in the corpus is "solid waste," with an occurrence of 81 times. Other frequently occurring terms include "waste management" and "solid waste management," which clearly emphasize solid waste management. Notably, the terms "article" and "Peru" appear highly frequently, indicating that they are used in various contexts or studies related to the terms on the map. The terms mentioned above also exhibit the highest edge strength on the map. This underscores their degree of influence, interconnectivity, and significance in linking the remaining topics.

Several terms appear in the co-word map with a low frequency but a high edge strength. Notable examples include "ingestion" (frequency: 2, edge strength: 80), "charcoal" (frequency: 2, edge strength: 79), "calcium" (frequency: 2, edge strength: 77), "particle size" (frequency: 2, edge strength: 75), and "chromium" (frequency: 2, edge strength: 73). Despite their low frequency, these words serve as pivotal connectors within the network. The high edge strength of these terms indicates that they have significant potential as core concepts in waste management research. Conversely, some terms appear frequently in the co-word map but have a low edge strength. Such are the cases of "environmental awareness" (frequency: 7, edge strength: 54), "conservation" (frequency: 5, edge strength: 34), "environmental pollution" (frequency: 5, edge strength: 52), "decision making" (frequency: 5, edge strength: 43), and "decision making" and "economic and social effects" (frequency: 4, edge strength: 38). These terms have considerable recognition in the research literature, yet their low edge strength suggests that they remain peripheral, not forming connections with the core terms in the network. These terms are employed in general discussions or specific scenarios, yet they do not facilitate connections with more critical or relevant terms.

The co-word network identified a group of words that exhibited high frequency but low citation impact. Examples of these words include: The following terms were identified as being particularly prevalent in the corpus yet exhibiting a relatively low citation impact: "solid waste," "sustainable development," "biogas," "environmental monitoring," "climate change," "waste treatment," "heavy metal," "polypropylene," and "biomass." These topics may be less frequently cited due to their intrinsic nature. These terms are well understood by the research community and represent established research instead of emerging concepts.

The co-occurrence map of terms revealed the existence of eight clusters, as illustrated in Figure 1. Cluster 1 comprises 90 words, representing the largest group. Cluster 2 is similar to Cluster 1, comprising 87 words. Clusters 3, 4, and 5 encompass many words, ranging from 56 to 65. The two most minor clusters are 7 and 8. A scatter plot based on X and Y coordinates is shown in Figure 1. It shows the spatially distributed terms.

Authors	Title	Year	Source	# of cites
Quispe I.; Navia R.; Kahhat R.	Energy potential from rice husk through direct combustion and fast pyrolysis: A review	2017	Waste Manage.	196
De-la-Torre G. E.; Rakib M. R. J.; Pizarro-Ortega C. I.; Dioses-Salinas D. C.	Occurrence of personal protective equipment (PPE) associated with the COVID-19 pandemic along the coast of Lima, Peru	2021	Sci. Total Environ.	185
De-la-Torre G. E.; Aragaw T. A.	What we need to know about PPE associated with the COVID-19 pandemic in the marine environment	2021	Mar. Pollut. Bull.	148
Torres F. G.; De-la-Torre G. E.	Face mask waste generation and management during the COVID-19 pandemic: An overview and the Peruvian case	2021	Sci. Total Environ.	129
Margallo M.; Ziegler-Rodriguez K.; Vázquez-Rowe I.; Aldaco R.; Irabien Á.; Kahhat R.	Enhancing waste management strategies in Latin America under a holistic environmental assessment perspective: A review for policy support	2019	Sci. Total Environ.	127
Rakib M. R. J.; De-la-Torre G. E.; Pizarro-Ortega C. I.; Dioses-Salinas D. C.; Al-Nahian S.	Personal protective equipment (PPE) pollution driven by the COVID-19 pandemic in Cox's Bazar, the longest natural beach in the world	2021	Mar. Pollut. Bull.	110
Dioses-Salinas D. C.; Pizarro-Ortega C. I.; De-la-Torre G. E.	A methodological approach of the current literature on microplastic contamination in terrestrial environments: Current knowledge and baseline considerations	2020	Sci. Total Environ.	108
Haddad M. B.; De-la-Torre G. E.; Abelouah M. R.; Hajji S.; Alla A. A.	Personal protective equipment (PPE) pollution associated with the COVID-19 pandemic along the coastline of Agadir, Morocco	2021	Sci. Total Environ.	104
Thiel M.; de Veer D.; Espinoza-Fuenzalida N. L.; Espinoza C.; Gallardo C.; Hinojosa I. A.; Kiessling T.; Rojas J.; Sanchez A.; Sotomayor F.; Vasquez N.; Villablanca R.	COVID lessons from the global south – Face masks invading tourist beaches and recommendations for the outdoor seasons	2021	Sci. Total Environ.	88
Nieto-Juárez J. I.; Torres-Palma R. A.; Botero-Coy A. M.; Hernández F.	Pharmaceuticals and environmental risk assessment in municipal wastewater treatment plants and rivers from Peru	2021	Environ. Int.	81
Garfí M.; Gelman P.; Comas J.; Carrasco W.; Ferrer I.	Agricultural reuse of the digestate from low-cost tubular digesters in rural Andean communities	2011	Waste Manage.	71
Gilardino A.; Rojas J.; Mattos H.; Larrea-Gallegos G.; Vázquez-Rowe I.	Combining operational research and Life Cycle Assessment to optimize municipal solid waste collection in a district in Lima (Peru)	2017	J. Clean. Prod.	60
Aragaw T. A.; De-la-Torre G. E.; Teshager A. A.	Personal protective equipment (PPE) pollution driven by the COVID-19 pandemic along the shoreline of Lake Tana, Bahir Dar, Ethiopia	2022	Sci. Total Environ.	52
Arbulú I.; Lozano J.; Rey-Maquieira J.	The challenges of municipal solid waste management systems provided by public-private partnerships in mature tourist destinations: The case of Mallorca	2016	Waste Manage.	52
Vriens B.; Peterson H.; Laurenzi L.; Smith L.; Aranda C.; Mayer K. U.; Beckie R. D.	Long-term monitoring of waste-rock weathering at the Antamina mine, Peru	2019	Chemosphere	48
Hatami T.; Rakib M. R. J.; Madadi R.; De-la-Torre G. E.; Idris A. M.	Personal protective equipment (PPE) pollution in the Caspian Sea, the largest enclosed inland water body in the world	2022	Sci. Total Environ.	47
De-la-Torre G. E.; Pizarro-Ortega C. I.; Dioses-Salinas D. C.; Ammendolia J.; Okoffo E. D.	Investigating the current status of COVID-19 related plastics and their potential impact on human health	2021	Curr. Opin. Toxicol.	43
Garfí M.; Ferrer-Martí L.; Villegas V.; Ferrer I.	Psychrophilic anaerobic digestion of guinea pig manure in low-cost tubular digesters at high altitude	2011	Bioresour. Technol.	40

Authors	Title	Year	Source	# of cites
Estrada-Ayub J. A.; Kahhat R.	Decision factors for e-waste in Northern Mexico: To waste or trade	2014	Resour. Conserv. Recycl.	40
Mohammadi A.; Malakootian M.; Dobaradaran S.; Hashemi M.; Jaafarzadeh N.; De-la-Torre G. E.	Occurrence and ecological risks of microplastics and phthalate esters in organic solid wastes: In a landfill located nearby the Persian Gulf	2023	Chemosphere	35
Santillán L.; Saldaña-Serrano M.; De-La-Torre G. E.	First record of microplastics in the endangered marine otter (Lontra felina); [Primer registro de microplásticos en la nutria marina (Lontra felina)]	2020	Mastozoologia Neotropical	33
Arbulú I.; Lozano J.; Rey-Maquieira J.	The challenges of tourism to waste-to-energy public-private partnerships	2017	Renewable Sustainable Energy Rev	31
Vázquez-Rowe I.; Ziegler-Rodriguez K.; Margallo M.; Kahhat R.; Aldaco R.	Climate action and food security: Strategies to reduce GHG emissions from food loss and waste in emerging economies	2021	Resour. Conserv. Recycl.	30
Espinoza Pérez L.; Ziegler-Rodríguez K.; Espinoza Pérez A. T.; Vásquez Ó. C.; Vázquez-Rowe I.	Closing the gap in the municipal solid waste management between metropolitan and regional cities from developing countries: A life cycle assessment approach	2021	Waste Manage.	27
Zhang W.; Chai J.; Li S.; Wang X.; Wu S.; Liang Z.; Baloch M. Y. J.; Silva L. F. O.; Zhang D.	Physiological characteristics, geochemical properties and hydrological variables influencing pathogen migration in subsurface system: What we know or not?	2022	Geosci. Front.	25
Guerrero-Castillo P.; Reyes S.; Robles J.; Simirgiotis M. J.; Sepulveda B.; Fernandez-Burgos R.; Areche C.	Biological activity and chemical characterization of Pouteria lucuma seeds: A possible use of an agricultural waste	2019	Waste Manage.	25
Kannan G.; Mghili B.; De-la-Torre G. E.; Kolandhasamy P.; Machendiranathan M.; Rajeswari M. V.; Saravanakumar A.	Personal protective equipment (PPE) pollution driven by COVID-19 pandemic in Marina Beach, the longest urban beach in Asia: Abundance, distribution, and analytical characterization	2023	Mar. Pollut. Bull.	24
Izquierdo-Horna L.; Kahhat R.; Vázquez-Rowe I.	Reviewing the influence of sociocultural, environmental and economic variables to forecast municipal solid waste (MSW) generation	2022	Sustain. Prod. Consum.	22
Kiani M. S.; Van Waerebeek K.	A Review of the Status of the Indian Ocean Humpback Dolphin (Sousa plumbea) in Pakistan	2015	Adv. Marine Biol.	18
Mohamadi S.; Madadi R.; Rakib M. R. J.; De-la-Torre G. E.; Idris A. M.	Abundance and characterization of personal protective equipment (PPE) polluting Kish Island, Persian Gulf	2023	Sci. Total Environ.	17
Filimonau V.; Rosa M. S.; Franca L. S.; Creus A. C.; Ribeiro G. M.; Molnarova J.; Piumatti R. G.; Valsasina L.; Safaei A.	Environmental and carbon footprint of tourist accommodation: A comparative study of popular hotel categories in Brazil and Peru	2021	J. Clean. Prod.	17
Mghili B.; De-la-Torre G. E.; Aksissou M.	Assessing the potential for the introduction and spread of alien species with marine litter	2023	Mar. Pollut. Bull.	16
Ziegler-Rodriguez K.; Margallo M.; Aldaco R.; Irabien A.; Vazque-Rowe I.; Kahhat R.	Environmental performance of peruvian waste management systems under a life cycle approach	2018	Chem. Eng. Trans.	16
Churata R.; Almirón J.; Vargas M.; Tupayachy-Quispe D.; Torres-Almirón J.; Ortiz-Valdivia Y.; Velasco F.	Study of Geopolymer Composites Based on Volcanic Ash, Fly Ash, Pozzolan, Metakaolin and Mining Tailing	2022	Buildings	15

Authors	Title	Year	Source	# of cites
Requena-Sanchez N.; Carbonel-Ramos D.; Moonsammy S.; Klaus R.; Punil L. S.; Ng K. T. W.	Virtual Methodology for Household Waste Characterization During The Pandemic in An Urban District of Peru: Citizen Science for Waste Management	2022	Environ. Manage.	14
De-la-Torre G. E.; Pizarro-Ortega C. I.; Dioses-Salinas D. C.; Ribeiro V. V.; Urizar Garfias Reyes D. F.; Ben-Haddad M.; Rakib M. R. J.; Dobaradaran S.	Micro- and mesoplastic pollution along the coast of Peru	2023	Environ. Sci. Pollut. Res.	12
Muñoz Perez S. P.; Garcia Chumacero J. M.; Charca Mamani S.; Villena Zapata L. I.	Influence of the secondary aluminum chip on the physical and mechanical properties of concrete	2023	Innov. Infrastruct. Solut.	11
Benazir Abate T.; Flores J. V.	Reduction of thermotolerant coliforms present in the sea water by means of micro-nanobubbles of air-ozone of the beach los pavos, Lima, Peru	2017	Chem. Eng. Trans.	11
Almirón J.; Roudet F.; Duquesne S.	Influence of volcanic ash, rice husk ash, and solid residue of catalytic pyrolysis on the flame-retardant properties of polypropylene composites	2019	J Fire Sci	11
Goyzueta G.; Trigos C.	La rinconada: Public health risks in the artisanal mining village in Puno, Peru; [Riesgos de salud pública en el centro poblado minero artesanal la rinconada (5200 MSNM) En Puno Perú]	2009	Rev. Peru. Med. Exp. Salud Publica	11
Quiñonez A. S.; Hernandez F.	Habitat use and conservation status of birds from El Paraíso wetland, Lima, Peru; [Uso de hábitat y estado de conservación de las aves en el humedal El Paraíso, Lima, Perú]	2017	Rev. Peru. Biol.	11
Izquierdo-Horna L.; Damazo M.; Yanayaco D.	Identification of urban sectors prone to solid waste accumulation: A machine learning approach based on social indicators	2022	Comput. Environ. Urban Syst.	10
Trinidad H.; Huamán-Melo E.; Delgado A.; Cano A.	Vascular flora from Villa María and Amancaes Lomas, Lima, Peru; [Flora vascular de las lomas de Villa María y Amancaes, Lima, Perú]	2012	Rev. Peru. Biol.	10
Vosooghnia A.; Polettini A.; Rossi A.; Vázquez-Rowe I.; Francini G.	Carbon footprint of anaerobic digestion combined with ultrasonic post-treatment of agro-industrial organic residues	2021	J. Environ. Manage.	10

Table 3. Most cited articles.

Each cluster occupies different areas within the diagram. Within the terms representing the clusters, we identify the following:

1. Cluster 1: intersection between agriculture and waste management.
2. Cluster 2: chemical processes in waste reduction.
3. Cluster 3: waste management in aquatic environments.
4. Cluster 4: intersection between agriculture and waste management with emphasis on approaches, practices and strategies.
5. Cluster 5: agro-industrial wastes.
6. Cluster 6: impact of solid waste on air and water pollution.
7. Cluster 7: social perspectives on environmental issues.
8. Cluster 8: eco-efficiency in the building sector.

The identified clusters reflect the diversity of approaches in solid waste research, encompassing a range of disciplines, including agriculture, chemical processes, and eco-efficiency in construction. It is evident that most of the topics within the identified clusters align with the research areas that are most actively pursued by leading authors in the field.

Word	Frequency	Total link strenght
solid waste	81	915
waste management	43	643
article	36	885
peru	33	570
solid waste management	26	455
municipal solid waste	25	384
human	22	543
recycling	18	256
plastic	17	418
pollution	17	210
waste disposal	17	404
plastic waste	16	364
sustainable development	16	183
covid-19	15	385
marine pollution	14	372
pandemic	14	374
nonhuman	13	319
plastics	12	352
biogas	11	156
controlled study	11	308
environmental impact	11	191
anaerobic digestion	10	200
environmental monitoring	10	270
greenhouse gases	10	203
marine environment	10	260
personal protective equipment	10	296

Table 4. Keywords' distribution frequency.

4. FINAL NOTES

The findings of this study indicate that a technical and interdisciplinary approach characterizes Peruvian research on solid waste. The primary avenues for disseminating research in this field are conferences and journals focused on environmental management and sustainability. Furthermore, it was noted that this field of study is predominantly represented by private and public universities, in contrast to other types of institutions, such as research centers or public or private organizations.

A limited number of researchers are at the forefront of the field regarding authorship. Thematic orientations align closely with the themes identified in the map of co-occurrence of terms. Peruvian scholars' research can be grouped into eight key themes. Peruvian research on solid waste has a pronounced emphasis on agricultural topics, as evidenced by their prominence in three of the eight identified thematic clusters.

Conflict of interests

I declare that there are no conflicts of interest.

Statement of data consent

The data generated during the development of this study has been included in the manuscript.

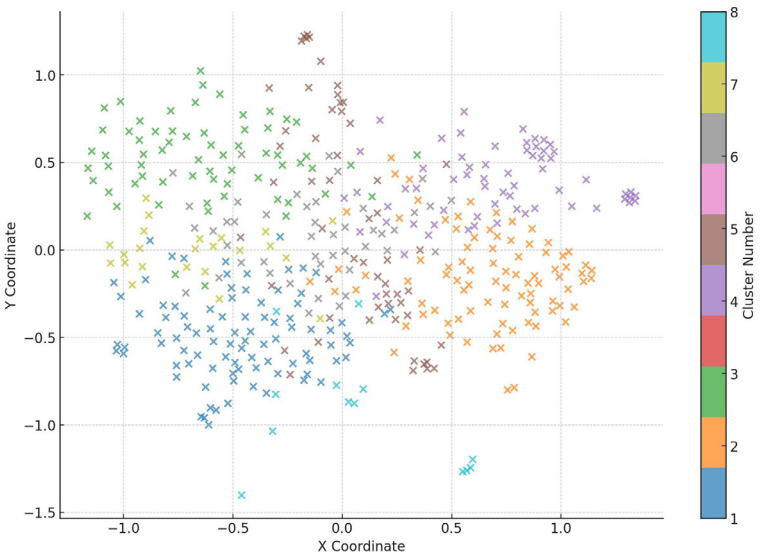

Figure 1. Term co-occurence network.

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