WASTE MANAGEMENT IN HIGHER EDUCATION INSTITUTIONS: A BIBLIOMETRIC ANALYSIS OF PAST AND FUTURE RESEARCH TRENDS

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Abstract

This article aims to provide a comprehensive overview of waste management in higher education institutions, highlighting past research trends and potential future directions of articles. This article uses a bibliometric approach using 559 journals obtained from the Web of Science. Utilizing two analyses as mapping, namely (co-citation analysis and co-word analysis) to explore the current knowledge structure and identify future research directions related to waste management. Current research trends on waste management focus on developing frameworks and strategic implementation by considering certain important factors and decision-making strategies. In the future, articles on waste management will focus more on the overall framework and strategies for efficiently implementing waste management in higher education institutions, along with how to anticipate obstacles in its implementation. This article provides practical and theoretical benefits for further researchers and decision makers on waste management by increasing understanding of implementing waste management in higher education institutions. This article produces findings that can be utilized by researchers and decision makers in higher education institutions in implementing effective and efficient waste management, as well as encouraging continuous improvement efforts in the campus environment.

Keywords: Waste Management, Higher Education Institutions, Bibliometric Analysis, Co-Citation, Co-Word Analysis

INTRODUCTION

Campus as an educational institution not only functions as a place of learning but also as a place that actively produces waste from various academic activities. administration, to student activities. In Indonesia, especially in big cities, the problem of waste is a complex challenge, with significant impacts on the environment, health, and social aspects. Waste management on campus that is not optimal not only has a negative impact but also has the potential to worsen the waste issue at the national level (Defriatno & Herdianto, 2024). Lack of funds, inadequate infrastructure, weak policies, and the capacity needed to collect and manage waste because these limitations become obstacles to waste management in cities in developing countries (Ampong et al. 2024). Waste is generally divided into two types, namely organic and inorganic. Organic waste is waste that comes from the remains of living things, such as animals, humans, and plants, which undergo a process of decay or weathering. Inorganic waste is waste that comes from human activities and is difficult to decompose by bacteria, so it takes a long time, even hundreds of years to decompose (Hidayani et al. 2024).

There have been many previous studies discussing waste management, but the results of previous research have not provided a comprehensive picture of waste management trends from the past and future in higher education institutions. This article focuses on mapping the knowledge structure, identifying gaps in previous research, and providing useful insights for researchers, academics, and administrators in higher education institutions. This article can also provide opportunities and suggestions for efforts related to policy formation and practice in higher education. By highlighting significant previous publications, key articles, and future trends.

The main objective of this study is to thoroughly understand the previous literature related to waste management in higher education institutions. This article is structured based on the following specific objectives:

1. To investigate previous waste management research trends using co-citation analysis.
2. To investigate future waste management research trends using co-word analysis.

This article is structured in a well-structured format, consisting of a brief introduction. A comprehensive section describing the bibliometric methodology used, the results of the study focused on past and future research trends, the next section explains the implications

and limitations of the study and offers recommendations for future research and closes with the conclusions of the study.

RESEARCH METHOD

Bibliometric Approach

Bibliometrics is a quantitative analysis method used to measure and assess research results. Through this method, readers can understand research trends and the extent to which the research influences the development of science in various fields. Using a bibliometric approach has several significant advantages in examining research trends. Big data management, analysis allow researchers to manage and analyze large amounts of structured data, which is very helpful in identifying trends and compiling structural compositions in a scientific field (Passas, 2024). Bibliometrics provides quantitative data from publications and citations objectively, thus becoming a solid empirical basis for analyzing the development of a field of science (Donthu et al., 2021). Then the bibliometric approach utilizes VOSviewer software, which allows researchers to compile and visualize bibliometric maps clearly, even though they contain thousands of items (Župič & Cater, 2015).

This article uses two bibliometric analyses that are in line with the two objectives that have been conveyed:

1. Co-citation analysis is a bibliometric method used to analyze references in scientific publications to understand the structure of knowledge, main topics, and concepts in a field of science. In this method, several documents are considered related if they are often cited together by other documents; the more often they are cited together, the greater the possibility that both have the same focus or relevance (Manyani et al., 2024).
2. Co-word analysis is a technique used to map the structure of knowledge by looking at the frequency of occurrence of words in a collection of publications. The resulting co-word network is then visualized to help understand how a field of research has evolved.

By using co-citation and co-word analysis, researchers can provide a comprehensive picture of past and future research directions, as well as clarify emerging trends related to waste management in higher education institutions. The software used in this study is VOSviewer. VOSviewer was chosen because it is able to map and visualize bibliometric

networks, such as relationships between keywords, author collaboration patterns, and the development of research themes (Van Eck & Waltman, 2010). This software is effective in analyzing large-scale data and helps in creating easy-to-understand visual maps, which are essential for comprehensive analysis (Donthu et al., 2021).

Search Strategy and Data Collection Procedures

The findings and discussion of the search in Web of Science (WoS) were conducted on November 3, 2024. Web of Science is one of the databases used for co-citation analysis and co-word analysis. Web of Science can help researchers access data that can map the structure and dynamics in a scientific field (Župič & Cater, 2015). This database is well-known for supporting bibliometric analysis, as it provides a vast and reliable collection of scientific data, with over tens of millions of records in hundreds of disciplines used in articles (Singh et al., 2021). The database provides a comprehensive representation of leading researchers worldwide. The researchers used a search string to analyze relevant articles in the Web of Science (WoS) database. The main keywords used in this article focused on waste management and higher education institutions were diversified using synonyms, related terms, and their variations to retrieve metadata from the database: TS = (("waste management*" OR "waste disposal*" OR "waste handling*" OR "waste treatment*" OR "waste reduction*" OR "waste process*" OR "waste recycle*" OR "resource recover*" OR "solid waste management" OR "waste minimize*" OR "waste control*") AND ("campus*" OR "universit*" OR "collage*" OR "higher education" OR "HEI*" OR "higher learning" OR "IHL*")). This search accessed publications based on title, abstract, and keywords.

RESULTS AND DISCUSSION

Descriptive Analysis

The search results using the Web of Science database resulted in 559 articles being successfully obtained, with 5,365 citations and 5,271 without self-citations with an H-index of 35, with an average of 8.07 citations per article. Figure 1 shows the number of publications and citations from 2019 to November 3, 2024. The article shows the increasing relevance of studying waste management in higher education institutions. Based on the bibliometric analysis, there is a consistent growth in the number of publications and citations, reflecting

the growing interest in this field. This trend is expected to continue to increase as attention is paid to the efficiency of waste management in the context of sustainable waste management in the higher education sector. This increase in literature provides a significant contribution to the development of insights related to strategies and implementation of waste management in the campus environment.

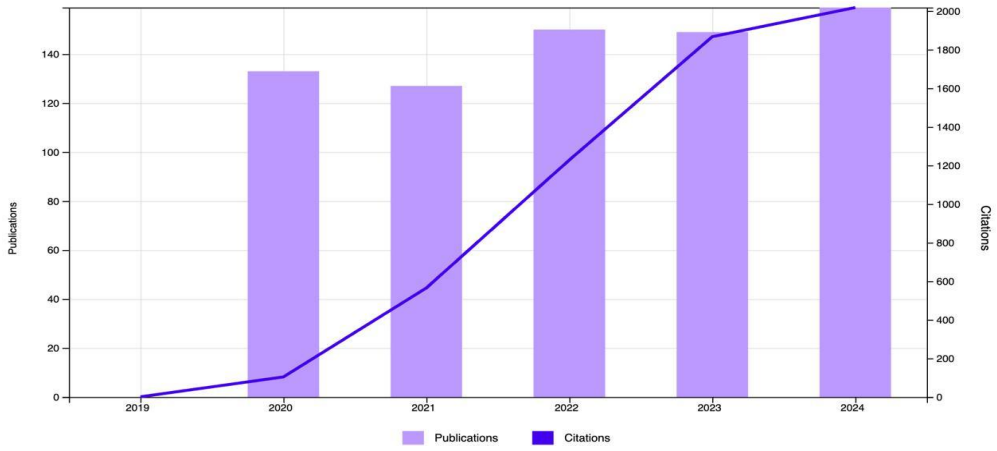


Figure 1.
Number of Publications and Citations on Waste Management in the WoS Database
Data Source: WoS database, retrieved on November 3, 2024

Co-Citation Analysis

Using the same database, co-citation analysis revealed 7 out of 29,925 references that met the 44-occurrence threshold, resulting in three clusters. The threshold was decided based on the robustness of the literature generated in the analysis with relevant themes. This is like bibliographic fusion analysis, where too high a threshold risks filtering too much data and missing relevant clusters, while too low a threshold can result in too many clusters, resulting in duplicate themes (Geng et al., 2020). Table 1 shows the top 10 documents in the co-citation analysis.

Table 1.
Top 10 Documents with the Highest Number of Citations and Total Link Strength

Ranking	Publication	Number Of Citation Documents	Total Link Strength
1	Smyth et al. (2010)Reducing solid waste in higher education: The first step towards 'greening' a university campus	24	110
2	Whitehair et al. (2013)Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility	13	99
3	Armijo de Vega et al. (2008)Solid waste characterization and recycling potential for a university campus	25	93
4	Painter et al. (2016)Food waste generation and potential interventions at Rhodes University, South Africa	12	92
5	Quested et al. (2013)Spaghetti soup: The complex world of food waste behavior	11	89
6	Adeniran et al. (2017) Solid waste generation and characterization in the University of Lagos for sustainable waste management	24	88
7	Ellison et al. (2019)Every plate count: Evaluation of a food waste reduction campaign in a university dining hall	13	86
8	Stancu et al. (2016)Determinants of consumer food waste behavior: two routes to food waste	12	86
9	Pinto et al (2018)A simple awareness campaign to promote food waste reduction in a university canteen	11	83
10	Parfitt et al (2010)Food waste within food supply chains: quantification and potential for change to 2050	13	76

Source: Created by the Author Based on VOSviewer and Bibliometric Metadata

Figure 2 shows a network visualization of the co-citation analysis, showing three clusters, each representing a different theme. The authors labeled each cluster based on

inductive interpretation. Table 2 presents a summary of the co-citation analysis, including cluster numbers and colors, cluster labels, number of publications, and representative publications.

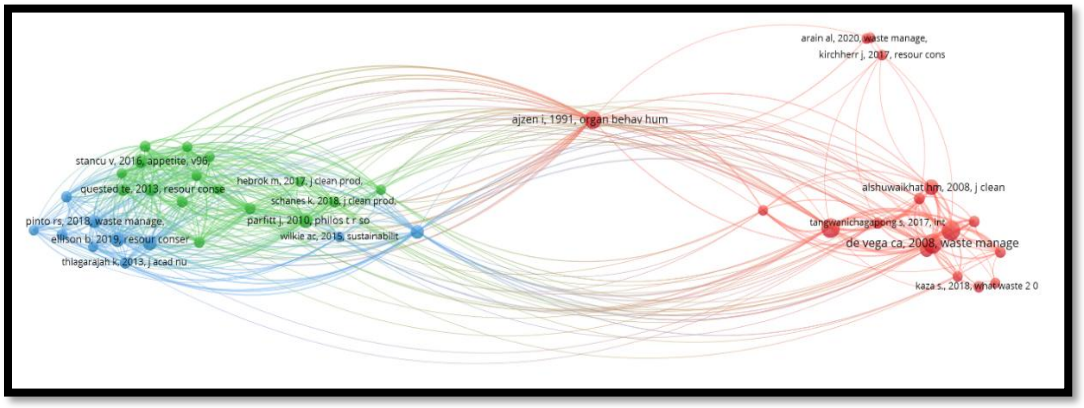


Figure 2.
Co-Citation Analysis Related to Waste Management
Source: Created by the author based on VOSviewer

Table 2.
Co-Citation Analysis Related to Waste Management in Higher Education Institutions

Cluster No. and Color	Representing Publications	Number of Publications	Cluster Labels
1 (Red)	Adeniran et al (2017), Alshuwaikhat & Abubakar (2008),Arain et al (2020),Das et al (2019),Armijo de Vega et al (2008),Fagnani & Guimarães (2017),Forti et al (2020)	17	Advancing Sustainable Waste Management Practices: Challenges, Opportunities, and Pathways Across Sectors and Regions.
2 (Green)	Karim Ghani et al (2013),Graham-Rowe et al (2014),Hebrok & Box (2017),Knezevic et al (2019),Koivupuro et al (2012),Neff et al (2015)	16	Drivers of Behavior and Policy for Sustainable Waste Management Practices
3 (Blue)	Ellison et al (2019),Kallbekken & Sælen (2013),Painter et al (2016),Pinto et al (2018),Thiagarajah & Getty	10	Behavioral Strategies and Interventions to Reduce Food Waste in Institutional and Hospitality Settings

Cluster No. and Color	Representing Publications	Number of Publications	Cluster Labels
	(2013),Thyberg & Tonjes (2016)		

Source: Created by the Author Based on VOSviewer and Bibliometric Metadata

Cluster 1 (red): Advancing Sustainable Waste Management Practices: Challenges, Opportunities and Pathways across Sectors and Regions. Cluster 1, comprising 16 publications, focuses on Steps to improve sustainable waste management practices across sectors and regions. The articles reveal the challenges to be faced, inadequate infrastructure, and low public awareness. Adeniran et al. (2017) highlights the importance of source-based policies that engage communities to increase recycling and reduce waste in developing countries. Das et al. (2019) show that the application of technological innovations, such as e-waste management, can support the shift to a more efficient circular economic system. Kirchherr et al. (2017) also highlight the importance of a holistic approach in the circular economy to reduce dependence on natural resources and promote sustainability.

Cluster 2 (Green): Drivers of Behavior and Policies for Sustainable Waste Management Practices. Cluster 2 with 13 publications, focuses on factors influencing policies and behaviors related to sustainable waste management. Alshuwaikhat and Abubakar, (2008) explain that higher education institutions have a great opportunity to become models of sustainable practices through the integration of waste management strategies into campus policies. This article also highlights how important social norms and cultural values are in shaping individual behavior, as explained byAjzen, (1991)in the theory of Planned Behavior, which analyzes attitudes, subjective norms, and behavioral control as the main drivers of sustainable behavior. Zen et al. (2016) explain that the active involvement of students and staff in campus recycling programs can be a trigger for transforming the institutional environment to be environmentally friendly.

Cluster 3 (Blue): Strategies and Behavioral Interventions to Reduce Food Waste in Institutional and Hospitality Settings. Cluster 3 with 10 publications discusses strategic approaches and actions to reduce food waste, focusing on the institutional and hospitality

sectors, Graham-Rowe et al. (2014) explain that consumer awareness of the environmental impact of food waste is an important step in driving behavioral change. Ellison et al. (2019) examine the success of food waste reduction programs in the hospitality sector through the application of measurement tools and staff training. Meanwhile, Parfitt et al. (2010) emphasize the importance of combining policies and economic incentives to reduce food waste in the sector. Another study conducted by Russell et al. (2017) emphasizes the role of social norms in reducing food waste, especially when consumers have a better understanding of the food supply chain and its impact on the environment.

These three clusters demonstrate that sustainable waste management involves a multidisciplinary effort that encompasses technology, policy, and human behavior. From source-focused waste management to specific strategies for food waste reduction, this study provides important insights into pathways to global sustainability.

Co-Word Analysis

Using the same database, co-word analysis yielded 10 out of 3668 keywords that met 47 occurrence thresholds, resulting in 3 clusters. Similar to Co-citation analysis, too high a threshold can result in over-filtering, which causes relevant clusters to be missed, while too low a threshold can result in many clusters resulting in theme duplication (Geng et al., 2020).

Table 3.
Top 15 Keywords in Co-Word Analysis

Ranking	Keywords	Emergence	Total Knowledge Power
1	Management	59	168
2	Sustainability	68	166
3	Generation	29	100
4	Recycling	33	87
5	Foot Waste	38	86
6	Circular Economy	33	78
7	University	27	75
8	Behavior	34	74
9	Reduction	17	62
10	Waste Management	27	62
11	Impact	24	61
12	Attitudes	17	55
13	Consumption	19	55
14	Performance	25	55
15	Planet Behavior	14	46

Notes: Sorted by the number of occurrences.

Figure 3 shows a network visualization of the co-word analysis, with three clusters each representing a different theme. The author labels each cluster based on inductive interpretation. Table 4 presents a summary of the co-word analysis, including cluster numbers and colors, cluster labels, number of keywords, and representative keywords.

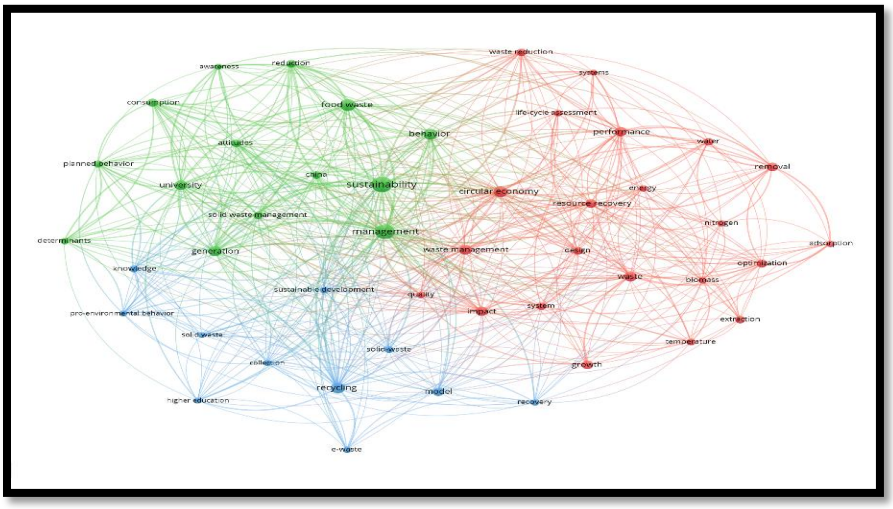


Figure 3.
Co-Word Analysis Related to Management
Source: Created by the Author Based on VOSviewer

Table 4.
Summary Of Co-Word Analysis Related to Waste Management in Higher Education Institutions

No. and Cluster Color	Keywords That Represent	Number of Keywords	Cluster Labels
1 (Red)	Adsorption, biomass, circular economy, design, energy, extraction	22	Innovative Approaches to Sustainable Resource Management: Integrating Adsorption, Biomass and Circular Economy Principles.

No. and Cluster Color	Keywords That Represent	Number of Keywords	Cluster Labels
2 (Green)	Attitudes, awareness, behavior, China, consumption, determinants	14	Exploring the Determinants of Consumer Behavior and Environmental Consciousness: Focus on Attitudes and Consumption Patterns in China.
3 (Blue)	Collection, e-waste, higher education, knowledge, model, pro-environmental behavior	11	Advancing Pro-Environmental Behavior in Higher Education: A Knowledge-Based Model for E-Waste Collection and Management.

Source: Created by the Author Based on VOSviewer and Bibliometric Metadata

Cluster 1 (Red): Innovative Approaches to Sustainable Resource Management: Integrating Adsorption, Biomass and Circular Economy Principles. Cluster 1 consisting of 22 keywords focuses on sustainable resource management increasingly shifting to technology-based approaches such as adsorption, and utilization of biomass to reduce waste and create added value from available resources. For example, adsorption has been proven effective in treating waste, especially in removing heavy metals, making it an important technology in wastewater management (Chen et al. 2021). On the other hand, biomass is not only used as a renewable fuel but also as a raw material for the production of green energy within the framework of a circular economy.(Geissdoerfer et al. 2020). A circular economy-based approach is also applied to reduce municipal waste by recycling materials up to 30% more efficiently, thereby significantly reducing carbon emissions.(Kalmykova et al., 2018). By using the life cycle concept, waste management can be optimized to ensure better resource sustainability (Guinée et al., 2022).

Cluster 2 (green): Exploring the Determinants of Consumer Behavior and Environmental Consciousness: Focus on Attitudes and Consumption Patterns in China**.** Cluster 2 consists of 14 keywords focusing on environmental awareness of society as a major factor in forming sustainable consumption patterns, especially in countries such as China which face major challenges in waste management (Zhang et al., 2024). The Theory of Planned Behavior (TPB) provides a framework for understanding how attitudes, subjective norms, and behavioral control influence individuals' intentions and actions in supporting the environment (Ajzen, 1991a). In addition, pro-environmental behaviors such as reducing energy consumption and managing household waste are closely correlated with positive attitudes toward sustainability (Chen et al., 2019). Therefore, the approach through education and social campaigns is an effective strategy for increasing environmental awareness in urban communities.

Cluster 3 (blue): Advancing Pro-Environmental Behavior in Higher Education: A Knowledge-Based Model for E-Waste Collection and Management. Cluster 3 consists of 11 keywords focusing on Higher education institutions that have an important role in encouraging environmentally friendly behavior through electronic waste (e-waste) management and material recycling efforts.(Baldé et al., 2022). Students who participate in knowledge-based waste management programs tend to experience increased environmental awareness, which in turn contributes to reducing the carbon footprint on campus.(Lim & Hayder, 2019). Studies show that knowledge-based approaches, such as training and the use of technology for e-waste collection, increase recycling rates by 25% (Forti et al., 2020).

This article provides significant benefits in the development of theory in the field of waste management, especially in the context of higher education institutions. Using a bibliometric approach analysis, this article maps past and future research trends and expands the understanding related to sustainable waste management. The study conducted by Adeniran et al. (2017) explains the importance of a holistic approach based on a circular economy to support efficient waste management in developing countries. Then, Graham-Rowe et al. (2014) explain that social norms and cultural values play an important role in shaping waste management behavior, in line with the theory of Planned Behavior by Ajzen (1991). Besides that,(Ellison et al., 2019)And(Pinto et al., 2018) explain that a simple

environmental awareness campaign can increase participation and reduce waste in the campus environment. Thus, this article provides a comprehensive theoretical framework for understanding and developing more effective waste management strategies, relevant in the context of higher education institutions and environmental sustainability in various regions.

This article provides an understanding for managers of higher education institutions to improve the effectiveness of waste management. The results of the article show that a circular economy-based approach and innovative technologies, such as absorption and biomass (Kalmykova et al., 2018), can be applied to reduce waste and improve resource efficiency. Then, the importance of involving students and staff in waste management programs, as explained by (Zen et al., 2016), can be an effective strategy for creating a culture of sustainability on campus. Simple environmental awareness campaigns have also been shown to significantly increase participation and reduce waste (Ellison et al., 2019). Then, the implementation of policies that are integrated with sustainability practices, as explained by (Alshuwaikhat & Abubakar, 2008) can help higher education institutions become models of sustainable waste management. By utilizing this article, campus managers can design waste management strategies that are more effective, and efficient, and follow global sustainability principles.

This article has several limitations. First, the bibliometric analysis in this article only uses data from one database, namely the Web of Science. So, it has the potential to ignore relevant publications from other sources. Second, although this article uses co-citation analysis and co-word analysis, the results still require further verification through qualitative studies or direct experiments in higher education institutions. Therefore, further researchers can consider using a wider database to get more comprehensive coverage. In addition, further researchers can combine bibliometric methods with field studies or in-depth interviews to gain more perspectives on waste management in higher education institutions.

CONCLUSION

Bibliometric analysis review presents the perspectives on waste management implementation in higher education institutions, through co-citation analysis and co-word analysis, this study provides an overview of past and future research trends on waste

management in higher education institutions. A total of 559 articles on waste management were retrieved from the WoS database. The studies have been increasing steadily and are expected to continue to increase in the coming years, which contributes to its significance in implementing waste management in higher education institutions. This can ultimately improve performance and continuous improvement in higher education institutions. Co-citation analysis resulted in three research themes that represent past research trends, which discuss waste management practices, behavioral drivers in waste management, and strategies for reducing food waste. Co-word analysis resulted in three research themes that provide research directions for future researchers on waste management, which discuss innovative approaches to sustainable resource management, consumer behavior, and environmental awareness, and promote pro-environmental behavior in higher education.

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