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MORALITY BEFORE KNOWLEDGE

Waste management in schools as part of sustainable development

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ABSTRACT
Waste management in schools plays a crucial role in promoting sustainable development, as education serves as a precursor to raising awareness and instilling habits in society. This research seeks to understand the existing body of knowledge on waste management in schools, with a particular focus on primary to junior high school levels, as a facet of sustainable development over the period 2010 to 2023. The research uses bibliometric analysis through tools such as VOSviewer and Publish or Perish. The research yielded a total of 63 published articles. The main findings include: (1) the most publications on waste management in schools occurred in 2022, but the most influential year was 2021; (2) the number of publications, institutions, journal rankings, and countries that produced research in this field; (3) research collaboration was not significant; (4) the most prominent journals in this field were Recycling and Science of the Total Environment; and (5) the common themes of articles in this field include waste management in schools, waste impacts, waste management system evaluation, sustainable development, and environmental management. These results will greatly assist readers in identifying research priorities related to school waste management and sustainable development. The recognition of collaborative efforts between different countries will bring new issues to the forefront of school waste management research and encourage collaboration between nations. Practically, this study provides a comprehensive review of the literature on school waste management as an integral part of sustainable development.

KEYWORDS: bibliometric analysis; sustainable development; sustainable development education; waste management; waste management in school

1. Introduction

A recent review of the literature on waste management has attracted much attention at this time. Waste management is related to sustainable development, which is of concern to various countries, especially developing countries. Population growth has created new waste management problems. Worldwide, 7 to 9 billion tonnes of waste are produced every year. The waste generated, namely useless or unwanted by-products, is an unavoidable consequence of various processes. In addition, according to (Pujara et al., 2019) The expected global volume of municipal solid waste (MSW) is projected to exceed 2.2 billion tons per year by 2025. Waste is one of the most complex problems facing both developing and developed countries of the world. If we don't start intelligently analyzing how to manage human-generated waste on a global scale, we risk dramatically reducing the comfortable environmental footprint of life in the future (Seberini, 2020).

Waste management is a major concern in the education sector. The significant amount of waste generated by the daily activities of students, teachers, and staff during the school

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day is remarkable. The amount of waste generated varies according to everyone's consumption habits (Purnami, 2021). The more activity there is among students, teachers, and staff, the more waste there is. To anticipate the amount of waste generated in educational institutions, it is imperative that all components within schools prioritize sustainable waste management. Furthermore, by familiarizing students with the principles of sustainable waste management in the school environment as part of sustainable development, they can serve as role models for their families and help promote sustainable waste management practices in their communities (Muljaningsih and Galuh, 2018). Although there is a lot of research in the literature on municipal or other waste management, The amount of research conducted in the field of education between institutions and organizations is limited, especially education which is the basis for being forced to act responsibly towards the environment due to ethical and moral issues, because in the future students will be leaders in their respective environments (Hanedar et al., 2021a).

The same few studies on waste management mostly reveal waste management in urban areas and household waste. The difference is that this research reveals that the research landscape regarding waste management in schools, especially from elementary school to junior high school level, is still rarely researched. This research tries to uncover studies that focus on waste management in schools, especially elementary schools to junior high schools and analyze good waste management research starting from schools In the context of sustainable development. This study aims to present a complete picture of research on school waste management, especially from elementary school to junior high school as part of sustainable development, based on the Scopus database for 13 years, from 2010 to 2023. This analysis will provide an overview of previous research on school waste management, and will reveal current suggestions for further research in this area. These findings will greatly assist future researchers in determining the focus of research on school waste management as part of sustainable development. The identification of cross-country collaborations will develop existing issues or develop them into new new research, particularly in the area of research on waste management in schools, a facet of sustainable development that has the potential to foster cooperation among nations.

1.1 Waste Management

One approach to tackling the problem of waste is to develop strategies for efficient methods of minimizing the amount of waste generated. This is critical to maintaining the quality of life for individuals, ensuring environmental sustainability, and exploiting the economic opportunities associated with waste. In addition, waste can be used as an environmentally friendly source of energy (Saleh et al., 2020). In order to implement an efficient waste management system, it is imperative to understand the type of waste generated, the available resources, and the environmental conditions of the community (Pardini et al., 2020). Waste can be made more valuable and transformed into treasure by classifying it. In addition, waste classification can alleviate the need for waste treatment, enable waste to be burned without causing harm, generate electricity from waste, address the issue of nowhere to dump waste, and convert waste into energy for long-term use (Li et al., 2020). Waste management is seen as part of the production, collection, and disposal system. Another part of the relationship is a system for creating more sustainable operations (Ikhlayel, 2018). The management of waste, especially solid waste, includes various methods such as recycling, incineration, energy recovery, composting, or landfilling (Nanda and Berruti, 2021). Efficient management of solid waste is critical to mitigate its potential adverse effects on both health and the environment. However, existing solid waste management practices face numerous challenges. The implementation of an efficient waste management system that incorporates innovative technologies is critical to address the limitations of the current approach (Ihsanullah et al., 2022).

There are different types of waste, which come from different sources and are treated in different ways. In general, they are materials that are no longer used, stored, or disposed

of in nature and have an impact on the quality of life in general. Several sources of waste can be counted, but their impact on the environment is not so easy to calculate (Tulebayeva et al., 2020). Several studies discuss effective ways of managing waste. These include (Fatimah et al., 2020) by using information and communication technology (ICT) and the Internet of Things (IoT), developed countries can develop better and more economical waste management systems. ICT-IoT involves the use of sensors, data fusion, data analysis and artificial intelligence in waste management. It enables real-time monitoring and control of waste activities, optimal waste management, and the conversion of large and complex wastes into useful resources, materials, and energy.

By using appropriate remote sensing and GIS techniques, in (Singh, 2019) concludes that significant improvements in waste management systems can be achieved. This study also shows that these techniques are increasingly being used in the design of landfills and landfill sites, and in the assessment of the environmental impact of landfill waste. Sustainable waste management systems in developed countries go through several stages: (1) reducing waste production at the source, (2) recycling and reusing, (3) converting waste into energy sources (energy waste), (4) avoiding or minimizing waste going to landfill.

A sustainable waste management system includes waste education strategies from an early age, creating a culture of waste awareness, waste education in schools, strict and detailed government regulations, and building a waste conscious society, community, government and private sector must be involved Sustainable Zero Waste Movement (Rahim, 2020). Regular evaluation of waste management systems is important to improve their performance (Bolingbroke et al., 2021). Surveys are one of the steps in waste management evaluation. According to the study (Sharma et al., 2020), the environmental management system "EMS" is the most important and critical element that influences all other elements involved, solid waste management can be more effective if it is focused on producing environmentally friendly products, implementing stringent legislation, creating a green reputation and supporting producers to follow circular economy practices.

1.2 Sustainable Development

Sustainable development was originally conceived as an issue of intergenerational equity in resource use, but since the 1990s there have been many ways of measuring sustainability, ranging from traditional economic ways such as GDP to ways that better reflect sustainable development goals (Swain and Yang-Wallentin, 2020). The view that innovation is a key driver of sustainability is widely accepted by academics, industry experts and government officials. Sustainability is an urgent issue that requires immediate action and change from government, industry and society at large (Amagir et al., 2020). Ensuring the well-being of future generations by meeting the needs of the present without compromising the ability of succeeding generations to meet their own needs is the foundation of sustainability (Withisuphakorn et al., 2019). Sustainable development has become an integral part of the global agenda, and concerted efforts are being made worldwide to achieve a more sustainable trajectory. Various goals and targets have been established to achieve this goal (Halkos and Gkampoura, 2021).

The United Nations has outlined 17 Sustainable Development Goals for the year 2030, which include 17 goals and 169 targets. These goals encompass a spectrum of challenges related to sustainable development, such as alleviating poverty, improving health and education, promoting sustainable urbanization, combating climate change, and protecting forests and oceans (Karyanto and Martiana, 2020). Food loss and waste (FLW) management is linked to the nth12 target, "Responsible Production and Consumption," through SDG 12.3: "Cut in half the amount of food wasted per person worldwide by 2030 at the retail and consumer levels and minimize food losses throughout production and supply chains (SC), including losses incurred after harvest"(Lemaire and Limbourg, 2019). The 2030 Agenda for Sustainable Development aims to ensure that development is driven by welfare and social inclusion, and that the biophysical balance of the planet is maintained. To achieve the Sustainable Development Goals (SDGs), fundamental changes are needed in today's

societies (van Vuuren et al., 2022). The presentation of strategies related to the circular economy and technology to contribute to all the Sustainable Development Indicators assessed in 2030. One that is in line with the sustainable development indicators is "waste management". The Circular Economy Strategy is ahead of the other two in terms of achieving the target of a "national recycling rate, tonnes of waste material recycled" (Fuldauer et al., 2019).

Activities and actions related to unused materials are called waste management. This includes activities such as collecting, transporting, treating, and disposing of waste. An important strategy in waste management is to prevent waste disposal, recycle, reuse, and recover materials that are still useful. This reduces the amount of waste sent to landfill, conserves natural resources, and saves energy. This helps to use resources more effectively and sustainably. Shaping sustainable waste management behavior in the community towards sustainable development (SDGs) can be a model for community behavior in waste management. Waste management, which is part of the environmental management system, contributes to the goal of sustainable development. Based on research (Ikram et al., 2019). In the case of company scope, companies that implement environmental management systems (EMS) have better CSR performance than companies that do not implement EMS. In addition, companies that implement EMSs have a positive and significant impact on health, environment, equity, and community, while companies that do not implement EMSs have a positive and significant impact on employee satisfaction and the economy. The research concludes that EMS can be an effective way for organisations to address economic, social, and environmental issues.

1.3 Waste Management in Schools as Part of Sustainable Development

In the case of company scope, companies that implement environmental management systems (EMS) have better CSR performance than companies that do not implement EMS. In addition, companies that implement EMSs have a positive and significant impact on health, environment, equity, and community, while companies that do not implement EMSs have a positive and significant impact on employee satisfaction and the economy. The conclusion of the research is that EMSs can be an effective way for organizations to address economic, social, and environmental issues (Adu et al., 2021).

One effort that can be made is to bring the waste management process into schools so that it can indirectly become part of the student's learning. It is hoped that what students learn at school will become something that survives in society and creates sustainable development. The habits and character of these students are built based on the learning process at school. Compared to developing technical treatment capacity, investing in education, prevention, and re-use activities is much more cost-effective, almost carbon-free, and efficient at treating waste (Fuldauer et al., 2019). According to (Nurfirdaus and Risnawati, 2019) in his research, he stated that the social and moral progress of students occurs through the need for imitation (imitating behavior) and modelling (presenting examples of behavior), while the attitudes, social and moral behavior of students can be formed through conditioning (getting used to responding) and imitation (copying) of the model. Therefore, the character and habits of students in society will later be included in the social and moral behaviour of students, including the protection of the environment through waste management, which has been built since school. This habit of the pupils will be a way of achieving one of the objectives of sustainable development in terms of health and environmental protection.

To address waste management and environmental challenges in developing countries, it is critical to integrate formal education on sustainable development at all levels of education. This has the potential to create transformative changes in society as a whole (Debrah et al., 2021a). In recent years, research on waste management has expanded not only in the business sector and household activities of society, but many have started to research in the education sector. In fact, several studies (Debrah et al., 2021b; Huang et al., 2019; Oloruntoba et al., 2022) thoroughly explored the aspects and methods of waste

management. The largest contribution of school waste is not only from offices and classrooms, but also from school canteens. There is less research on waste management in secondary schools compared to universities because universities are considered a small snapshot of society and a suitable environment for pilot programs (Liao & Li, 2019). Research (Naldi et al., 2021) shows that good waste management comes from good government regulations. According to (Narethong, 2020), good waste management comes from good city governance.

2. Methods

In searching and finding data sources related to "waste management in schools and its relation to sustainable development", the researchers used the Scopus database because of its very broad interdisciplinary coverage. There are several steps in the process of perfecting the data collected, which are detailed in Figure 1. The analysis is carried out in four steps: (1) collection of document records from the Scopus article database, (2) preprocessing and filtering of records, (3) construction and visualization of the network, and (4) analysis and interpretation (Han et al., 2020).

The first step is to collect records from the Scopus database. Researchers enter keywords to search the database. The keywords entered by the researcher are ("waste management" OR "waste bank") AND ("school"). The search results in 841 data publications. The next step is to preprocess and filter the data set, where the researcher evaluates the data according to specific criteria. Specifically, the researcher selects English publications in the form of journal articles and specifies the publication year range from 2010 to 2023. From the results of the screening of this data set, 360 publication documents were obtained according to the given criteria. This means that 481 publication data are discarded and do not follow the next process. The researcher then conducted a manual eligibility process of the 360 publication dataset by looking at the title and reading the abstract and evaluating publications that contain or include waste management variables in schools, especially at the elementary school to junior high school level, and produced 63 publications that could be included in the next process.

These data were retrieved on 25 July 2023 during the construction and visualization phase of the network using the VOSviewer application. The Scopus database was used to extract publication trends related to waste management in schools, and the final steps involved bibliometric analysis, namely analysis and interpretation. The results are presented visually through graphs created with Microsoft Excel software. Trends in publications and citations related to waste management in schools are presented annually from 2010 to 2023. Graphs illustrating the number of publications per year are generated using Microsoft Excel. The average number of citations per publication is then calculated using the same software. The geographical distribution of countries is plotted using Microsoft Excel, while the VOSviewer application is used to explore collaboration between countries. In order to identify the research focus on waste management in schools, the VOSviewer application is used for keyword analysis. A minimum threshold of 5 publications with keywords together is set to determine the focus of research events.

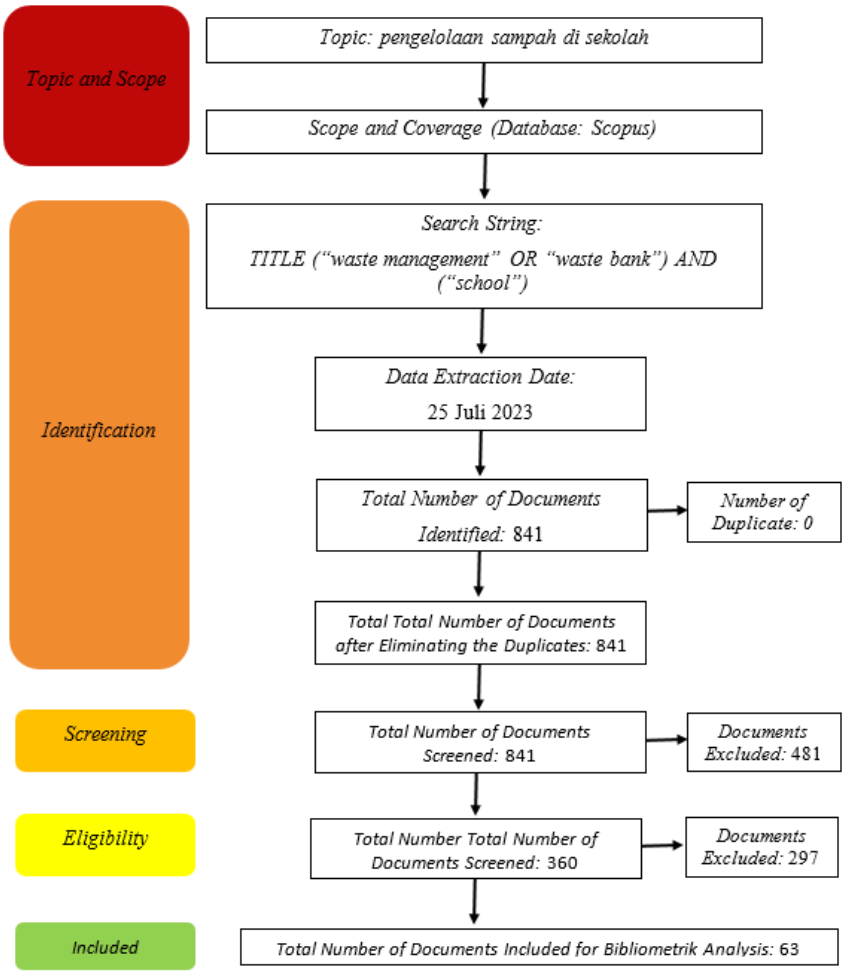

Figure 1. Data collection process

3. Results and Discussion

Following a data collection process, 63 publications on waste management that meet the specified criteria within the timeframe of 2010 to 2023 are subjected to a descriptive bibliometric analysis. This analysis includes discussion of publication trends, citation patterns, country and journal distribution, and research focus.

3.1 Trends in Annual Publications

Based on the Scopus database and the criteria for the analysis and interpretation steps, 63 publications on waste management in schools were selected for the period 2010-2023. The number of annual publications may reflect development trends in a particular field. This may indicate a growing interest in the field of study or no concentration at all. A total of 63 publications are grouped by year of publication, which can be seen in Figure 2 below.

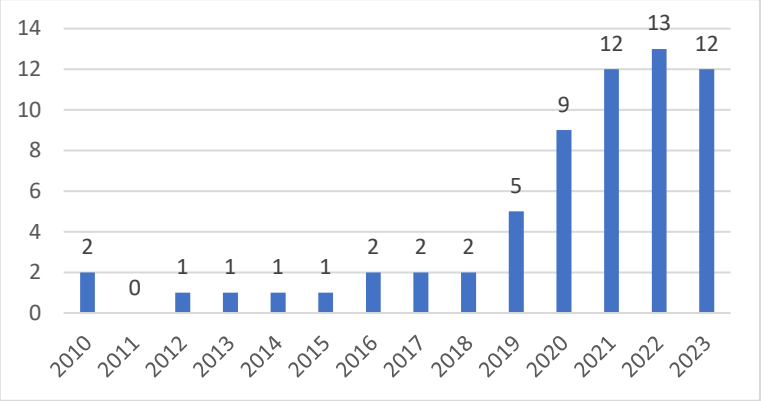

Figure 2. Annual publication of waste management in schools

Figure 2 shows the trend of annual publications of waste management research in schools from 2010 to 2023. Waste management research in schools had minimal growth from 2010 to 2018, starting with 2 publications in 2010. The annual growth rate is 7.14%. Cumulatively, the trend increases from 2019 with 5 publications and gradually increases to a high of 13 publications in 2022. Referring to the graph above, although 2023 has 12 studies and less than 2022, it will basically continue to increase until the peak of studies in the next few years, considering that this study was conducted in the middle of the year.This shows that research on waste management in schools can be an opportunity for researchers in this field.

Publication trends related to waste management in schools as part of sustainable development from 2010 to 2023 have increased, especially from 2021 to 2023. Waste management must be given special attention so as not to cause negative impacts on society and the environment (Syarifah et al., 2022), as well as in research. This research trend on waste is very useful to make people aware and interested in maintaining a clean and healthy living environment, can be more active and responsible for the surrounding environment, and can find the right solution in overcoming existing waste management problems (Khoiriyah, 2021).

Publications in 2021 with a total of 12 publications have been cited 9 times. The most cited article in 2021 is a study by (Debrah et al., 2021) entitled "Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review", the study states that students in secondary schools and students in high schools have a positive view of the environment and high awareness of environmental issues, but lack direct training from teachers to guide students in solid waste quality management practices. The environmental knowledge gap between young and old in developing countries contributes to ecological or waste management problems, leading to unsustainable development, with significant consequences in low-income countries. This article has been cited 57 times.

3.2 Citation Trend

Table 1 shows the citation trends related to waste management in schools from 2010 to 2023. Similar to the annual publication trend, the 63 publications are organized by their respective publication years. The table provides an overview of the total number of publications per year, NCP, TC, C/P values and other relevant parameters.

Table 1. Publication citation analysis

Year	TP	NCP	TC	C/P	C/CP	h	G
2010	2	1	18	0.50	9	1	2
2011	0	0	0	0	0	0	0
2012	1	1	5	1	5	1	1
2013	1	1	9	1	9	1	1
2014	1	1	7	1	7	1	1
2015	1	1	8	1	8	1	1
2016	2	2	79	1	40	2	2
2017	2	1	22	0.50	11	1	2
2018	2	2	25	1	13	2	2
2019	5	5	33	1	7	3	5
2020	9	7	56	0.78	6	3	7
2021	12	9	90	0.75	8	4	9
2022	13	8	30	0.62	2	4	5
2023	12	3	3	0.25	0	1	1

Notes. TP=total of publication, NCP=number of cited publication, TC=total citations, C/P=average citations per publication, C/CP=average citations per cited publication, h=h-index, g=g-index

Table 1 shows the citation trends related to school waste management from 2010 to 2023. Similar to the annual publication trend, the 63 publications are categorized by their respective publication years. The table provides an overview of the total number of publications per year, NCP, TC, and C/P values, among others.

Notably, the highest h-index and g-index values are associated with publications in 2021, with an h-index of 4 and a g-index of 9. Thus, it can be concluded that 2021 will have a significant impact on this research. The 12 publications cited in 2021 accumulate a total of 90 citations, indicating that at least 12 of these publications were cited 7 times each.

The citation trend related to waste management in schools in the context of sustainable development, from 2010 to 2023, is reflected in the TC value in Table 1. It can be seen that the publication from 2021 has 90 citations, with the highest h-index and g-index values. This underscores the significant impact of the year 2021 on research related to school waste management. Table 2 below shows the 12 2021 articles with the highest citation counts.

Tabel 2. Article published in 2021

No	Authors (year)	Title	Source title	Citation
1	(Elnakib et al., 2021)	Food waste in schools: A pre-/post-test study design examining the impact of a food service training intervention to reduce food waste	International Journal of Environmental Research and Public Health	4
2	(Hanedar et al., 2021b)	Waste management and zero waste practices in educational institutions	Environmental Research and Technology	1
3	(Bakri, 2021)	ECO-Pesantren assessment study of Islamic Boarding School in Banda Aceh, Indonesia	Journal of Islamic Architecture	0
4	(Palmer, Metcalfe, et al., 2021)	The efficacy and cost-effectiveness of replacing whole apples with sliced in the national school lunch program	International Journal of Environmental Research and Public Health	0
5	(Debrah et al., 2021b)	Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review	Recycling	57
6	(Palmer, Herritt, et al., 2021)	A Systems Examination of Food Packaging and Other Single-Use Item Waste in School Nutrition Programs	Journal of Nutrition Education and Behavior	5
7	(Pascuas-Rengifo et al., 2021)	Psychometric properties of an instrument that measures adolescent attitudes towards	Revista de Psicologia (Peru)	2

		electronic waste management; [Propriétés psychométriques d'un instrument qui mesure les attitudes des adolescents envers la gestion électronique des déchets]; [Propriedades psicométricas de um instrumento que mede as atitudes dos adolescentes em relação ao gerenciamento eletrônico de resíduos]; [Propiedades psicométricas de un instrumento que mide las actitudes de los adolescentes hacia la gestión de residuos electrónicos]		
8	(Magrini et al., 2021)	A framework for sustainability assessment and prioritisation of urban waste prevention measures	Science of the Total Environment	14
9	(Mkhonto & Mnguni, 2021)	The impact of a rural school-based solid waste management project on learners' perceptions, attitudes and understanding of recycling	Recycling	2
10	(Herdiansyah et al., 2021)	Parental education and good child habits to encourage sustainable littering behavior	Sustainability (Switzerland)	3
11	(López-Alcarria et al., 2021)	Water, waste material, and energy as key dimensions of sustainable management of	Water (Switzerland)	2

		early childhood eco-schools: An environmental literacy model based on teacher action-competencies (ELTAC)		
12	(Hartatil et al., 2021)	Waste Management Modelling in Siak Regency	Review of International Geographical Education Online	0

In Table 2 above, the research conducted by (Debrah et al., 2021a) was cited 57 times, meaning that this research is the most cited in 2021. The article by (Debrah et al., 2021a) titled "Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review," which explains that to bridge the knowledge gap between youth and parents on solid waste management, environmental education should be integrated into schools at all levels in developing countries. While the second most cited research is the research by (Magrini et al., 2021) entitled "A framework for sustainability assessment and prioritization of urban waste prevention measures" which was cited 14 times. The article explains that waste prevention (WP) can play an important role in promoting sustainability and decarbonization. This is done through a framework for sustainability assessment and prioritization of waste prevention measures (WPMs) at the consumer level. First, several MTPs are selected based on relevant criteria. Second, the impacts are assessed in terms of environmental, economic and social sustainability from a life cycle perspective. Then, a set of meaningful validity and effectiveness indicators are selected and calculated.

3.3 Geographical Distribution and Links Between Countries

The nation shown in Figure 3 below represents the country of origin of the author. Geographically, the distribution of the top 10 countries of origin for authors with the highest number of publications is shown in the following figure.

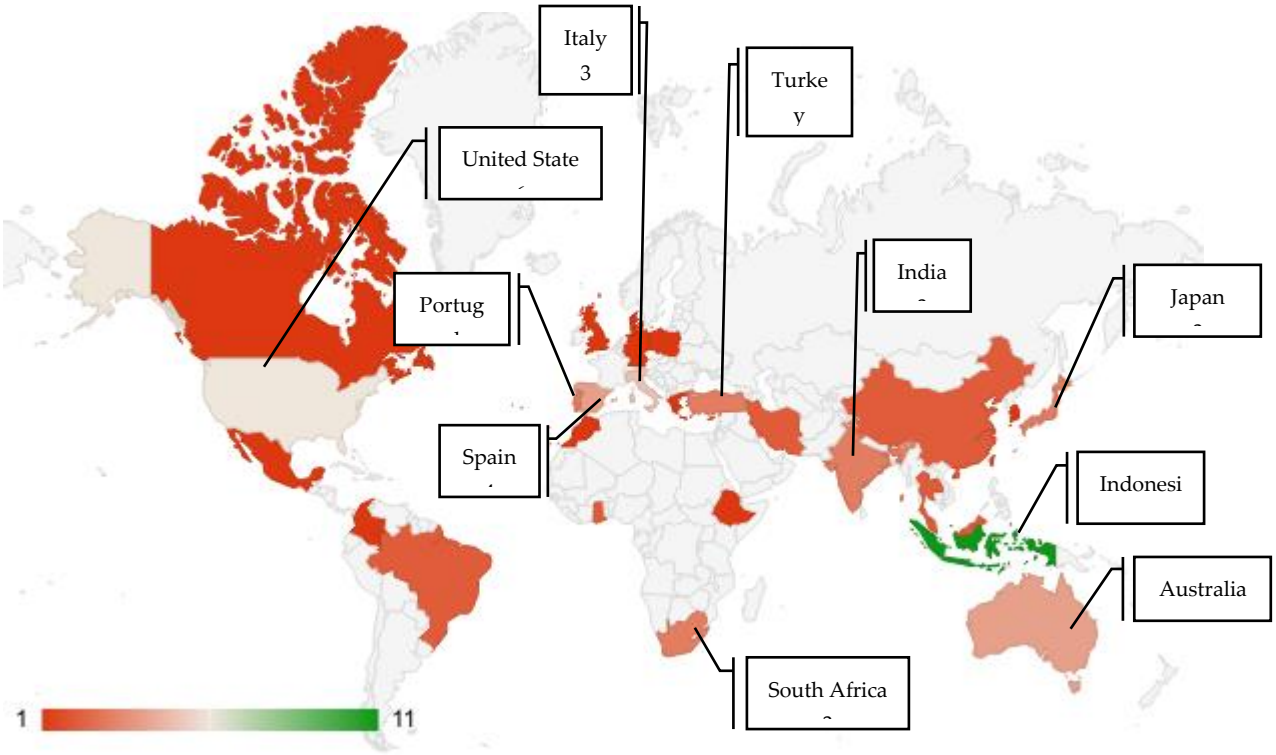

Figure 3. Geographical distribution of publications

As shown in Figure 3 Indonesia emerges as the most influential country in research on waste management in schools. This is evident from the significant number of publications originating from Indonesia, amounting to 11 documents related to waste management in schools, with 3 documents specifically addressing waste issues in schools. The data distribution shows that numerous countries outside the Asian continent have not contributed significantly to this field and are not related to the four countries mentioned above. This highlights the dominance of the Asian continent, particularly Indonesia, in publications in this area.

Patterns of international collaboration are illustrated in Figures 4 and 5 below. Notably, no threshold is set at this stage, meaning that countries with only one document in this field are presented, regardless of their collaboration status with other nations. Figures 4 and 5 show the 30 countries included in the display.

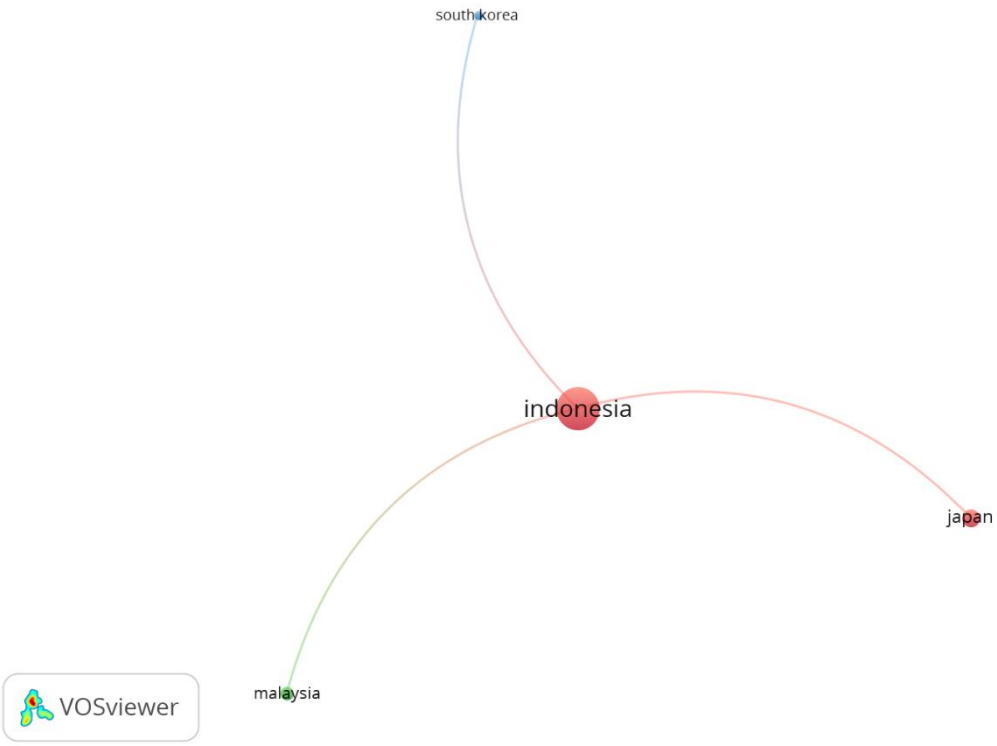

Figure 4. Cooperation relations between countries

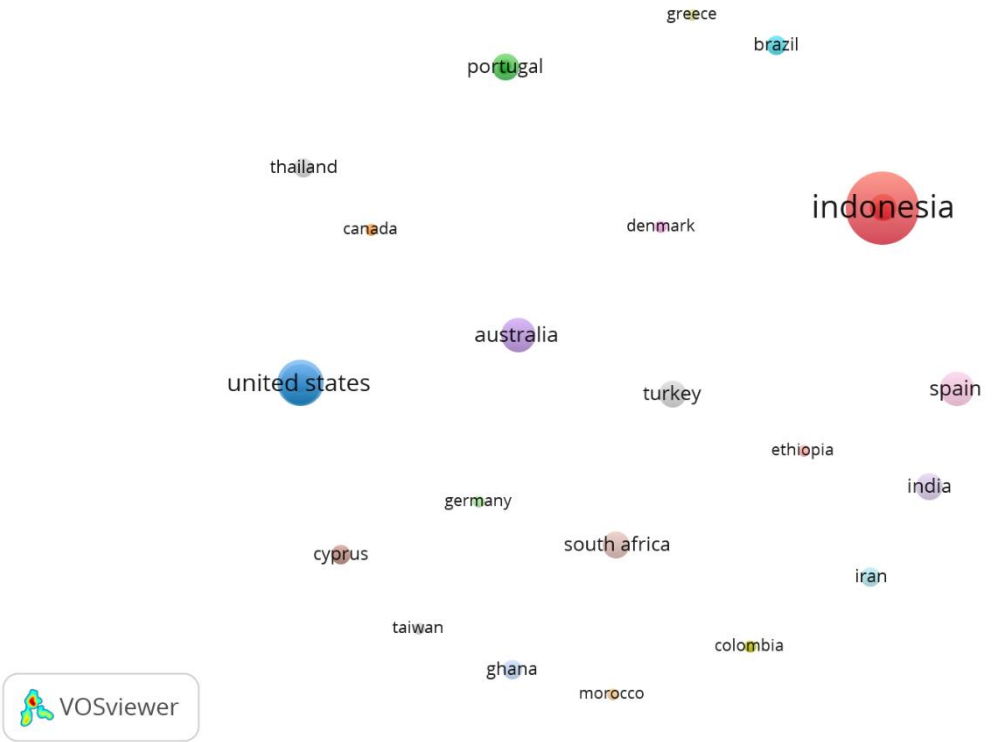

Figure 5. Distribution of the author's country of origin

As shown in Figure 5, the circles representing Indonesia, the United States, Australia, and South Africa have significantly larger diameters than other countries, indicating a particularly high level of publication activity. Figure 4 from VOSviewer shows that Indonesia has collaborations with three other countries, while the remaining countries have

no such connections, meaning that only four nations are involved in collaborative efforts in this area.

The top five countries with the highest number of publications on waste management in schools and its relationship to sustainable development are Indonesia, the United States, Italy, Australia, and Spain. Among these, Indonesia stands out as the country with the most publications in this area. Over a period of 13 years, Indonesia has contributed 11 documents on waste management in schools. The collaborative landscape is dominated by four countries - Indonesia, Japan, Malaysia and South Korea. Indonesia has three collaborations, while the other countries have one each. This suggests that Indonesia has a significant impact on research on waste management in schools and its link to sustainable development.

3.4 Journal Rating

The ranking of journals related to publications on waste management in schools in the context of sustainable development is determined by the quartile (Q) values. These journal rankings are available on the Scimagojr website, and the distribution of these rankings is visually presented in Figure 6 below.

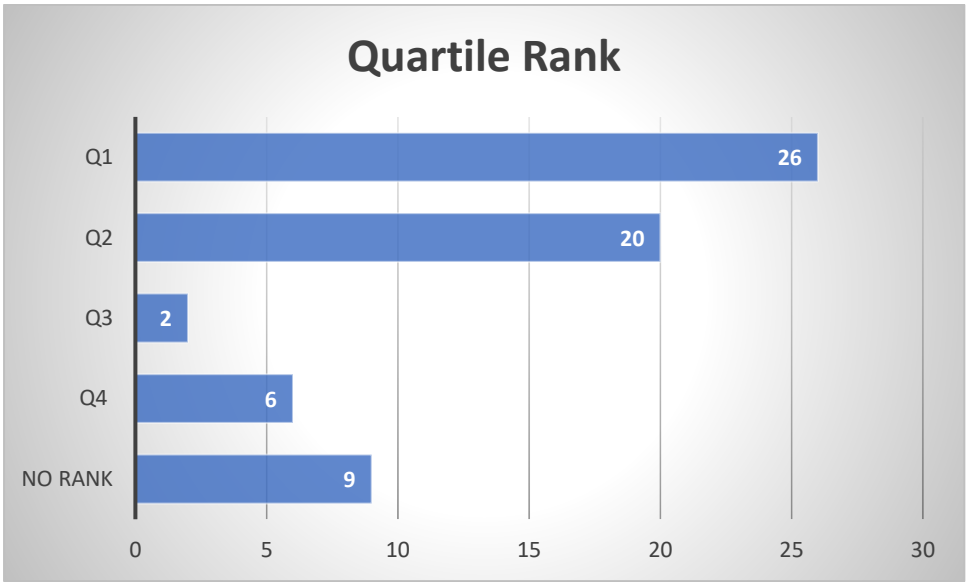

Figure 6. Ranking based on journal quartile values

Figure 6 above shows that the predominant share of publications in journals that focus on research on waste management in schools as an aspect of sustainable development falls within the Q1 level, comprising 26 journals. The second position is held by journals with a Q2 rating, which includes 20 journals. In addition, there are 9 journals that currently do not have a quartile value, indicating a need to improve the quality of publications on waste management in schools to reach the level of journals already categorized with quartile values.

Considering the ranking of the selected journals based on the most cited publications within the period from 2010 to 2023, Table 3 shows the ranking of the top 10 most cited publications.

Table 3. Top 10 journal rankings for school waste management in the context of sustainable development

No	Authors (years)	Title	Citation	Peringkat
1	(Sperling & Bencze, 2010)	"More than particle theory": Citizenship through school science	18	Q2
2	(Amagir et al., 2020)	Measuring the effect of environmental education for sustainable development at elementary schools: A case study in Da Nang City, Vietnam	38	Q1
3	(Debrah et al., 2021b)	Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review	57	Q2
4	(Hosseininia & Ramezani, 2016)	Factors influencing food waste during lunch of fourth-grade school children	20	Q1
5	(Zorpas et al., 2017)	Effectiveness of waste prevention program in primary students' schools	22	Q1
6	(Magrini et al., 2021)	A framework for sustainability assessment and prioritization of urban waste prevention measures	14	Q1
7	(Rada et al., 2016a)	Analysis and measures to improve waste management in schools	41	Q1
8	(Lagorio et al., 2018)	Food waste reduction in school canteens: Evidence from an Italian case	23	Q1
9	(Stefanelli-Silva et al., 2019)	University extension and informal education: Useful tools for the bottom-up ocean and coastal literacy of primary school children in Brazil	11	Q1
10	(Derqui et al., 2020)	Building and managing sustainable schools: The case of food waste	25	Q1

The table above shows that the average journal rank of the 10 most cited publications is Q1. However, the publication with the most citations is in 2021 and has a Q2 journal ranking. This means that both Q1 and Q2 journal rankings have a strong influence on research in this field. Judging by the reputation of the most cited journal rankings, they are classified as average with Q1 and only two journals with Q2 ratings.

Based on the publications with the highest number of citations, 8 of the 10 publications are classified as Q1 journals and 2 are classified as Q2 journals. The article by Debrah et al. (2021a) titled "Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review," has received the highest number of citations, with 57 citations from 2010 to 2023. However, it is noteworthy that this article is categorized with a Q2 ranking. In second place, the article by Rada et al. (2016b) titled "Analysis and measures to improve waste management in schools" has a Q1 journal ranking and has accumulated 41 citations. This suggests that the research landscape on waste management as an integral part of sustainable development is well established and worthy of further exploration.

3.5 Research Focus

At this point, the researcher sets a threshold by considering shared keywords, specifically those that appear with a minimum of 5 or more publications. This means that keywords used together in 5 or more publications are displayed in the keyword shared appearance using VOSviewer. After implementing this threshold, only 22 of the original 164 keywords remained, as shown in Figure 7.

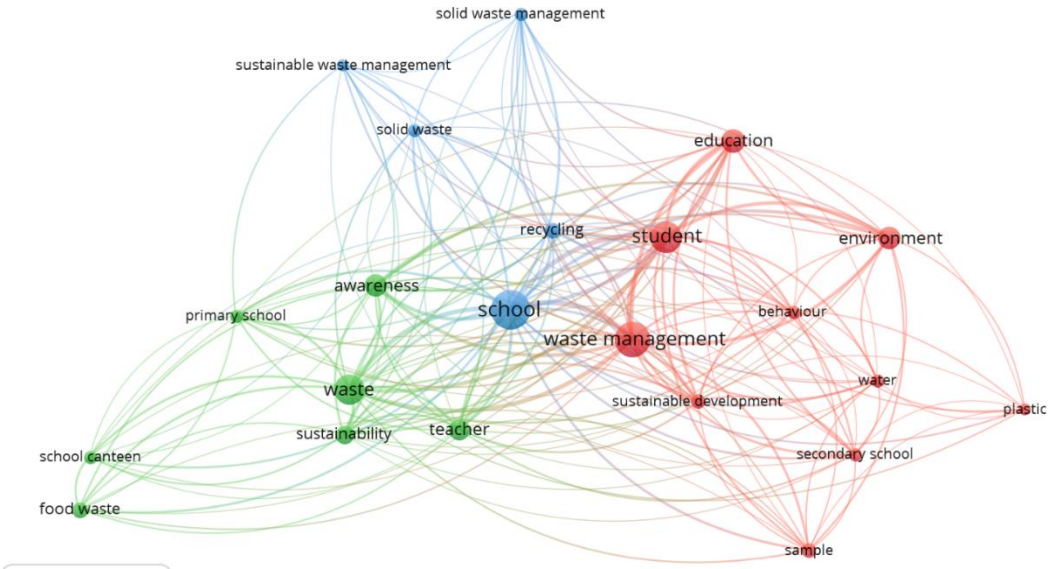

Figure 7. Co-Occurrence of Keywords (Occurrence Threshold ≥ 5)

The research focus can be seen in the clusters shown in Figure 7, where different colors represent different research clusters related to school waste management. Three prominent clusters are identified, with red being the largest, followed by green and blue. This indicates a tripartite division of the research focus into the following parts: 1) The first cluster (in red) consists of 10 items, with keywords such as waste management, students, and education having the largest circle diameters. This suggests that the first research cluster focuses on waste management as an integral aspect of sustainable development, with particular attention to students and education; 2) The second cluster (in green) includes 7 items, with keywords such as waste, awareness, and teachers standing out as the largest circles. This means that the second research cluster focuses on waste-related issues, awareness and the role of teachers, especially in relation to the state of waste management in schools; 3) The third cluster (in blue) consists of 5 items with keywords such as school and waste as the focus of the research. This indicates that the third research cluster is specifically focused on the relationship between schools and solid waste.

In summary, the research focus related to waste management in schools as part of sustainable development can be categorized into three distinct parts: 1) waste management, students and education; 2) waste, awareness and teachers; 3) school and solid waste.

The focus of the first research cluster, which focuses on waste management, students and education, is consistent with the perspective presented by Debrah et al. (2021a), which emphasizes the need for formal education on sustainable development at all levels of education to address environmental challenges in developing countries. This approach is seen as instrumental in catalyzing societal change. According to Minelgaitė and Liobikienė (2019), the most effective strategy for addressing waste issues is to promote behaviors such as reduction, reuse, and recycling. As a result, waste management in schools plays a crucial role in education, particularly in influencing the character and habits that shape students' future in society.

The second area of research focuses on waste, awareness, and teachers. In order to achieve effective waste management, it is imperative that educators have a comprehensive understanding of environmental education. Only through such awareness can they effectively sensitize future generations to issues such as pollution, challenges, and potential solutions. In particular, there is a significant gap between the attitudes of individuals and their actual behavior. Therefore, it is recommended that educators, as influential role models, not only cultivate positive attitudes, but also actively engage in environmentally friendly practices, as emphasized by Dalu et al. (2020).

A key strategy to mitigate the negative impact of waste on the environment is to implement the principles of reduce, reuse, recycle and recover within the framework of a circular economy. Therefore, educational institutions should pay special attention to shaping students' perspectives and attitudes. These factors play a pivotal role in determining students' environmental behavior, underscoring the critical need to assess the level of students' environmental awareness, particularly in the context of solid waste management in academic institutions, as highlighted by Owojori et al. (2022).

An example of character education activities in school waste management in research (Lian et al., 2020) explains that activities that can be carried out are teachers together with students to clean the school environment every morning. Teachers not only give instructions, but also participate in sweeping, picking up trash, and mopping the floor of the teacher's room. Then the used waste is transformed into useful items such as drinking bottles, flower vases, pencil cases, flower pots, and garden decorations, classroom decorations, and environmental care is carried out from the classroom to the schoolyard. Examples of these activities are intended to instill habits that will last until the students are adults. This means that the link between awareness and the role of educators is very important in terms of waste management in schools. Studies in this area have not been widely researched, so it is an area that can be developed for further research.

The third area of research focuses on schools and solid waste. As noted by Chatira-Muchopa et al. (2019), schools generate various types of waste, including paper, plastic, furniture, food, vegetables, stationery, and canned goods. The receptacles used to dispose of waste in schools include standard dustbins, cardboard boxes, plastic bags, old tables, and open dustbins. In addition, Masawat et al. (2021) identify four primary types of waste commonly found in school waste, namely recyclable waste, organic waste, regular waste, and hazardous waste. These findings underscore that solid waste issues in schools have a significant impact on the school environment itself. Consequently, there is an urgent need for researchers to address and further develop research on solid waste in schools.

4. Conclusions

Currently, the number of publications dealing with school waste management in the context of sustainable development is still on an upward trend, with no peak expected in the foreseeable future. Within the broader context of sustainable development, waste management practices continue to evolve in various settings, including school environments and communities at large. Various methods have been developed, ranging from traditional approaches to modern technology-based techniques. However, progress in school waste management as part of sustainable development has not been as substantial as in waste management at the societal level.

The predominant theme in published research on school waste management in the context of sustainable development is to explore both best practices and the various challenges and solutions encountered in this area. There is a notable emphasis on the promotion of international cooperation in the field of school waste management in the context of sustainable development, underlining the need for continued efforts to strengthen and disseminate research results.

In (Hernández-Torrano and Ibrayeva, 2020) states that a bibliographic analysis is not able to fully capture the current state and development of a field. This research and its

findings are included in the statement. Due to the limited search sources, this research may exclude some relevant publications and topics. Therefore, future research should consider various database sources (e.g., WoS, Google Scholar, ERIC) to obtain a more representative map of waste management research in schools.Despite its limitations, this study is considered a thorough and pertinent review of the literature on waste management in schools, particularly in the context of sustainable development.

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