eISSN: 3031-9471 | pISSN: 3032-7245 | DOI: 10.69606/geography.v3i1.175

Pubsains Journal of Geographical Sciences and Education

https://journal.pubsains.com/index.php/jgs

[Review Article]

Check for updates

Critical Ecological Education on Waste Management: Preventions and Interventions in Europe and Challenges in Asia

Thoriqi Firdaus*

Department of Natural Science Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Yogyakarta, Indonesia

*Correspondance: thoriqifirdaus.2023@student.uny.ac.id

Article Info:

Received:
12 November 2024

Accepted:
24 January 2025

Published:
3 March 2025

Keywords:
Ecology; education; waste management; preventions; interventions.

Abstract

Waste management in Europe benefits from a holistic approach and high public awareness of environmental issues, while Asia faces significant challenges in managing the current waste crisis. This research analyzes European waste prevention and intervention efforts and explores the challenges of adapting these practices in Asia. A Systematic Literature Review (SLR) was conducted following PRISMA guidelines, utilizing secondary data from journals retrieved through Google Scholar, Crossref, and Scopus. Revealing that cultural, economic, and public awareness factors significantly influence the success of waste management efforts. Effective government policies and the implementation of ecological education are critical in fostering community engagement. The most essential thing in overcoming the waste crisis is the community's ecological awareness in managing waste. Education related to critical ecology is very much needed because one ecological awareness will unite all groups' perceptions into one interest. Critical ecological education can be a solution to waste management challenges.

Informasi Artikel:

Diterima:
12 November 2024

Disetujui:
24 Januari 2025

Dipublikasi:
3 Maret 2025

Kata kunci:
Ekologi; pendidikan; pengelolaan sampah; pencegahan; intervensi.

Abstrak

Pengelolaan sampah di Eropa diuntungkan oleh pendekatan holistik dan kesadaran masyarakat yang tinggi terhadap isu lingkungan, sementara Asia menghadapi tantangan signifikan dalam mengelola krisis sampah saat ini. Penelitian ini menganalisis upaya pencegahan dan intervensi sampah Eropa dan mengeksplorasi tantangan dalam mengadaptasi praktik ini di Asia. Tinjauan Literatur Sistematis (SLR) dilakukan dengan mengikuti pedoman PRISMA, memanfaatkan data sekunder dari jurnal yang diambil melalui Google Scholar, Crossref, dan Scopus. Faktor budaya, ekonomi, dan kesadaran masyarakat secara signifikan memengaruhi keberhasilan upaya pengelolaan sampah. Kebijakan pemerintah yang efektif dan penerapan pendidikan ekologi sangat penting dalam mendorong keterlibatan masyarakat. Hal terpenting dalam mengatasi krisis sampah adalah kesadaran ekologis masyarakat dalam mengelola sampah. Pendidikan terkait ekologi kritis sangat dibutuhkan karena satu kesadaran ekologis akan menyatukan semua persepsi kelompok menjadi satu kepentingan. Pendidikan ekologi kritis dapat menjadi solusi untuk tantangan pengelolaan sampah.

INTRODUCTION

Waste is a severe problem in several countries, especially in Asia. Improper waste management can indicate climate change (Hadi et al., 2023). Burning waste dramatically contributes to greenhouse gas emissions caused by carbon dioxide (CO_2) (Wahyudi, 2019). Meanwhile, dumping waste in final landfills using an open system and not properly managing it will produce methane (CH_4) emissions, which are much worse than CO_2 (Sitogasa, 2022). As a result, global temperatures became unstable and increased by more than 1.5 above pre-industrial temperatures (IPCC, 2022).

Waste thrown away in a dry environment with an open system will easily cause fires, especially if the disposal site is close to a forest area (Sarbatly & Sariau, 2022). Climate change will cause prolonged drought, so improper waste management will create more vulnerable conditions to fire (Upadhyay, 2020). Several types of plastic material are some of the most common fire triggers (Wibowo & Wulamdari, 2023).

The waste crisis needs more in-depth attention and is resolved immediately to maintain good care for the earth. The Asian continent is where most countries produce the most significant waste in the world (Andeobu et al., 2021). Based on data from the World Bank, it is stated that in 2020, China was the largest waste-producing country in the world, with 395.08 million tons. In second place was the United States with 265.22 million tons, followed by India with 189.75 million tons, Brazil with 79.07 million tons, and Indonesia ranks fifth, with 65.2 million tons of waste (Pirlea et al., 2023). The five largest waste-producing countries come from the Asian and American continents.

The waste management issue category is based on data from the Environmental Performance Index (2022b), which is based on three indicators: recycling, controlled solid waste, rates, and plastic pollution in the sea. It is stated that European countries carry out better management than other areas. However, several Asian countries, such as South Korea and Singapore, can compete with Europe in waste management, but the success of Asian countries is still minimal, unlike in Europe.

European countries can be used as a reference in terms of waste management. It is also inseparable from the data that the cleanest countries in the world are, on average, in the European region (Adedoyin et al., 2021). Indicators of the cleanest country lead to a better life, such as clean water and air, efficient waste handling, and adequate sanitation. The Environmental Performance Index (2022a) states that the cleanest countries are based on ecosystem vitality, climate change performance, and environmental health. Namely, there are several cleanest countries, the first being Denmark, with a score of 77.9, England 77.7, Finland 76.5, Malta 75.2, and Sweden 72.7. European countries dominate the five cleanest countries.

Waste management in Europe is better because of a holistic approach and high public awareness of environmental issues (Mazzucco et al., 2020). Most European societies understand the importance of responsible waste management and are more active in implementing environmentally friendly behavior (Rahim, 2020). It is closely related to the critical ecology of the waste crisis. Critical ecology refers to a human approach through thought and analysis that involves a deep understanding of the impact of problems arising from unsustainable waste management (Labobar & Kapojos, 2023).

Meanwhile, waste management in the Asian region faces several challenges in dealing with the current waste crisis. These challenges include several aspects, such as population growth and rapid urbanization, which can significantly increase the volume of waste (Budijaya, 2023). Changes in consumption patterns using single-use items can also increase the amount of waste produced (Farhan et al., 2023). Dependence on single-use plastic is a severe Asian problem (Puspita & Kresnawati, 2023). The lack of public awareness of environmental issues and the negative impact of consumption behavior on waste disposal needs attention in several Asian countries.

Ecological education plays a critical role in shaping the understanding and attention of the younger generation to participate in environmental and sustainability issues (Lasaiba, 2023). An ecological approach through education will create human resources who feel connected to environmental problems (Labobar & Kapojos, 2023). High awareness of the importance of protecting the environment has become part of the culture of people in Europe

to protect nature together and wisely (Azizah & Abdullah, 2024).

European countries' efforts to prevent and intervene in the waste crisis need to be studied by Asian countries. However, in following in the footsteps of countries in the European region, Asian countries will face challenges. Therefore, this research aims to analyze European prevention and intervention efforts and look at the challenges of implementing them in the Asian region.

METHOD

This research uses a Systematic Literature Review (SLR) to identify critical ecology for waste management through prevention and intervention efforts in Europe as an area with good management. Waste management in Europe will be used as a reference so that the Asian region can become a suitable region for waste management by identifying the challenges of waste management in the Asian region. The SLR was chosen in this research because this method can map, assess, and synthesize literature to develop knowledge in a particular field (Tranfield et al., 2003). Therefore, the SLR method makes it possible to identify research gaps to develop discoveries (Munaro et al., 2020).

The SLR method can limit bias in answering questions by synthesizing scientific evidence by collecting and processing information through research identification. The SLR method can use PRISMA (Preferred Reporting Items for Systematic Literature Reviews and Meta-Analyses) guidelines, namely reporting in a systematic review through a series of items based on scientific evidence (Page et al., 2021). Procedures for using PRISMA include identification, screening eligibility, and inclusion (Şalvarlı & Griffiths, 2021).

Systematic Literature Review Design

The literature used as a reference has been researched systematically based on the PRISMA-selected reporting item guidelines through a three-step process based on identifying studies via databases and registers. The identification process using PRISMA guidelines is shown in Figure 1.

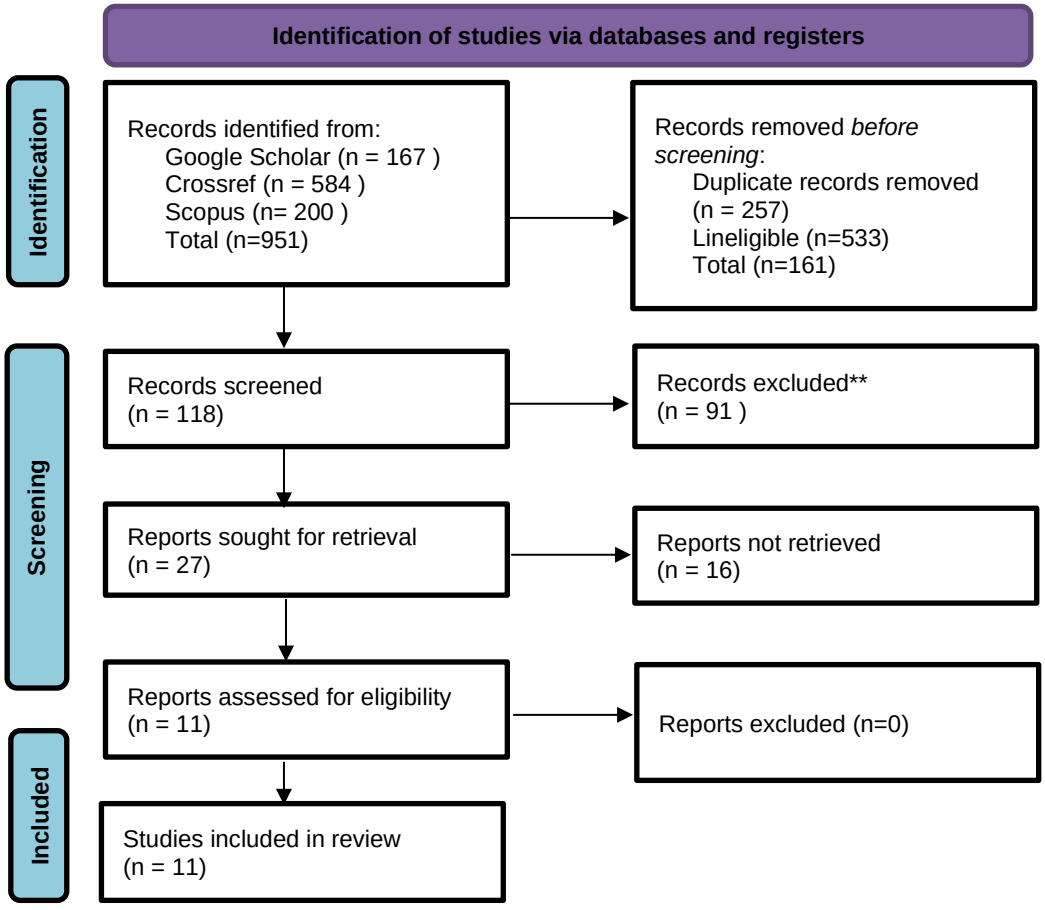

Figure 1. PRISMA

Identification

The flow for identifying research relevant to the topic is to use two initial sets of keywords: waste management in Europe and waste management in Asia. This research was done because it will compare waste management in the European region, the most prosperous region, with the Asian region, where waste management is still complex. In this identification process, research was taken from three sources, namely Google Scholar (167), Crossref (584), and Scopus (200), with a total of 951 studies.

Before entering the screening stage, duplicate articles from the three sources were identified. Based on the journal identification results, 257 out of 951 articles were duplicates. Apart from that, 533 ineligible articles were found with the characteristics of not having an abstract, the research not being on topic, and the articles not complying with the rules of scientific writing.

Screening

After excluding duplicate and identifying line obligations, 118 articles were obtained. In ensuring the quality and relevance of the contribution, only scientific articles published in journals with impact factors based on clarifying analytics have been included in the screening step. Thus, 91 articles were excluded, and the remaining 27 were retained. Then, the articles were filtered again by reading each article's title, abstract, and contents, so 16 articles were excluded.

Included

The eligibility criteria are asses based on the descriptive characteristics of the sample, namely research on (i) waste management problems in several countries in a region or continent. (ii) waste management prevention and intervention in the European region, considering that the European region has an effective and successful waste management system with data from several countries in the region to be the cleanest countries through several indicators. (iii) challenges in the Asian region due to waste and expected solutions.

RESULT AND DISCUSSION

The analysis framework based on content uses 11 articles included in the review is shown in Table 1. This analytical framework consists of several aspects: (i) author, namely to show articles that have been selected for review; (ii) investigation aspect, namely to show the category of articles in producing research; (iii) relevance, namely to show the relationship between the selected articles and research topics raised; (iv) option definition and criteria for selection, namely to indicate the content of the article that will be used as the basis for research.

Table 1. Analysis Framework Based on Content

Author	Investigated Aspect	Relevance	Option Definition and Criteria for Selection
Albizzati et al., 2024	Management Model	Prevention and Intervention Management	Waste management methodology through regulations recycles waste into usable materials and collects waste into energy sources. It aims to overcome climate change; apart from that, it also impacts employment because if the level of waste recycling is high, it can create jobs.
Agovino et al., 2020	Relationship analysis	Intervention Management	The positive effect of environmental regulations in recycling sustainable waste can have an impact on increasing company competitiveness.
Kolodiichuk & Kolodiichuk, 2020	Waste management toward environmental stability	Prevention and Intervention	The unavoidable process of generating industrial and household waste requires an adequate management system capable of creating environmentally friendly waste storage conditions with subsequent long-term disposal, ensuring waste recycling into raw materials. The paradigm for creating a recirculation economy must be based on the structural and functional support of a waste management system whose management system is provided by its territorial balance.

Author	Investigated Aspect	Relevance	Option Definition and Criteria for Selection
Dunajeva & Kostka, 2022	Government intervention in waste management	Intervention Waste Management	Poor environmental conditions due to waste and access to public services in creating a clean environment are closely related to government policy.
Abis et al., 2020	Collaboration Assessment	Waste Management	the EU incineration potential of bottom ash (BA) quantitative and qualitative features and management needs to increase the strategic role of waste recycling quotas, and the achievement of targets can no longer be doubted.
Mazzucco et al., 2020	Case study	Mitigation and Waste Intervention	A multi-directional community involvement strategy and consideration of environmental justice issues must be carried out for hazardous waste management and mitigation in encouraging environmental monitoring and local epidemiology using the best technology. Apart from that, active community involvement in awareness of the health impacts of preventing poor waste management
Chaine et al., 2023	Comparison of Europe and America in Waste Management	Challenges Waste Management	Regulatory authorities influence waste management in developing countries. Some challenges and opportunities in managing waste are from the technological and management aspects that require considerable funds. Besides that, legislative regulations governing waste management must receive more attention.
Stasiškienė et al., 2022	Waste Management Strategy	Barriers and Motivation	One of the innovations from plastic waste is bio-based, but this faces several economic, regulatory, technological, and social obstacles. The most formidable challenge of this innovation is an effective plastic waste management strategy.
Khan et al., 2022	Waste Analysis in Developing Countries	Challenges and opportunities	Organic components dominate waste in developing countries, and most waste management still uses the open dumping method. The lack of appropriate policies and regulations, as well as the lack of financial support and human resources with technical skills, are real challenges for developing countries.
Tun et al., 2020	Renewable Energy from Waste	Challenges and opportunities	Most Southeast Asian countries are developing countries with waste management systems, and the waste-to-energy sector is minimal. The big challenge in waste-to-energy technology in this region is very complicated because implementing most incineration plants fails due to the low calorific value of waste, high water content, high operational and maintenance costs, and waste sorting problems due to lack of community participation.
Herat, 2021	Waste management analysis	Challenges and solutions	Asian countries have developed several initiatives to achieve ESM, but many problems hamper their success and effectiveness. The solution that can be offered is that the government must encourage cooperation between society and the environment. Lack of infrastructure and financial resources is a problem that becomes a reference.

The results were analyzed with several category reviews, namely the objectives and sample methodology in the first category. This category analyzes the goals to be achieved in each article, how these goals can be achieved or have been achieved, and whether the method

used in research uses empirical or theoretical applications. Therefore, based on the results of the analysis, prevention and intervention efforts in the European region and waste management challenges in the Asian region were found. Meanwhile, the research objectives regarding waste management strategies are found in articles that discuss both regions, namely Europe and Asia.

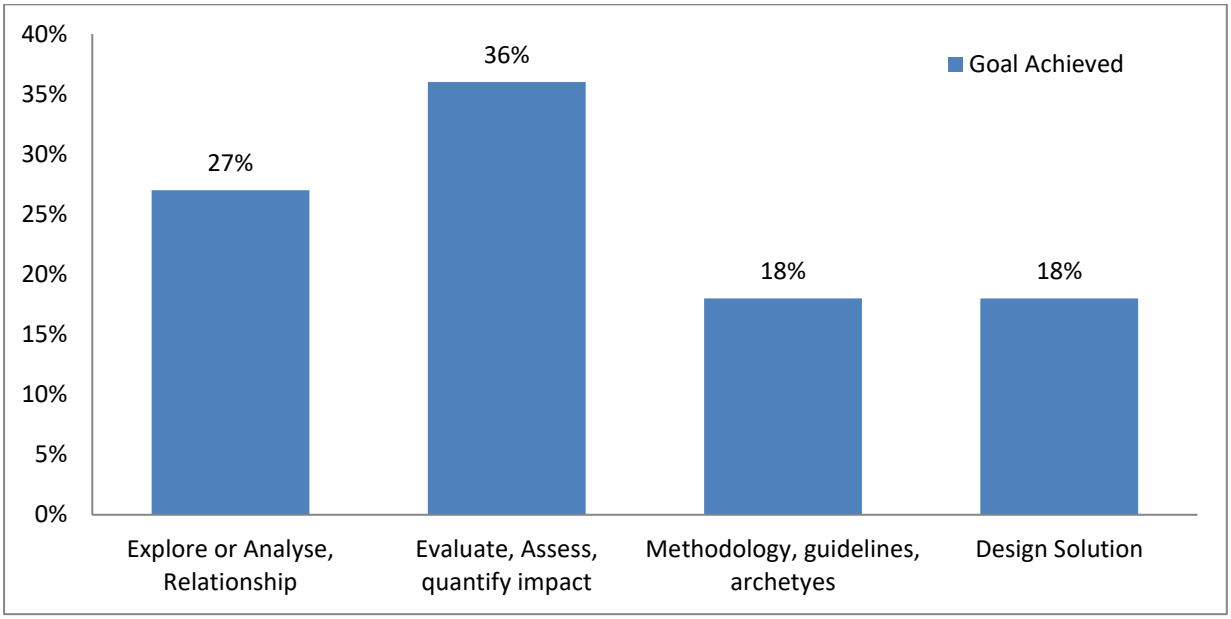

Figure 2. Goals Achieved by The Analyzed Articles

The data in Figure 2 indicates that evaluation of qualitative impact is the most frequently achieved goal among the articles, highlighting the emphasis on understanding nuanced, context-specific effects. Conversely, methodology and design-oriented goals are less represented, suggesting a gap or limited prioritization in these areas. Future research may benefit from balancing exploratory studies with a stronger focus on methodological frameworks and practical design solutions to bridge this disparity.

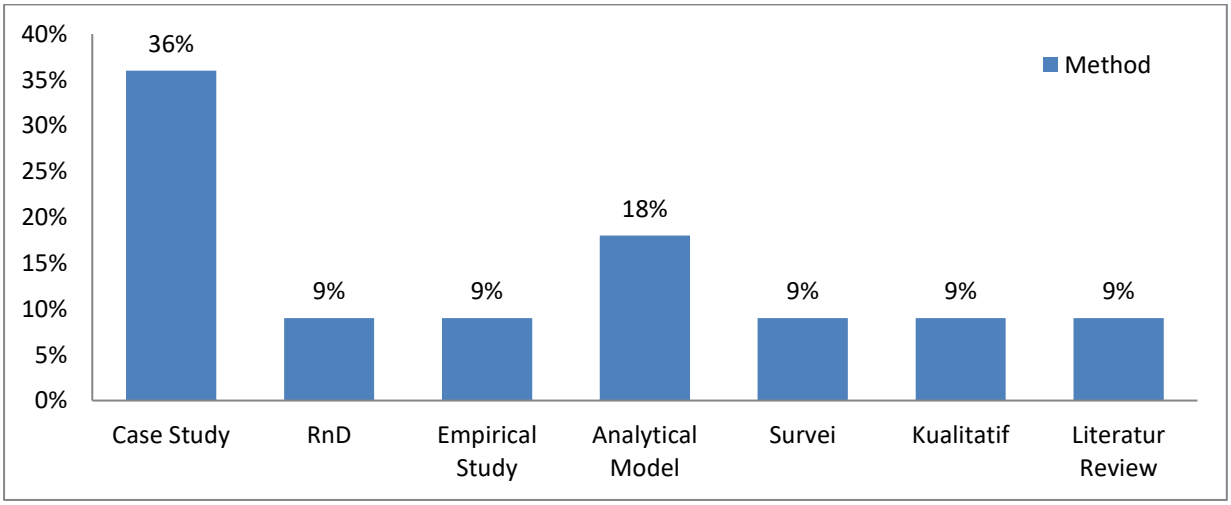

Figure 3. The Methodology Adopted by The Collection of Articles Analyzed

Figure 3 shows the most common method used is the case study, showing a strong preference for in-depth, practical exploration. Other techniques, such as RnD, surveys, and literature reviews, are less frequently used, indicating potential areas for broader methodological exploration in future research.

The second category is about geography. Geographic categories are classified based on the location of the research or research applied. Research contributions are distributed in two regions, namely Europe and Asia.

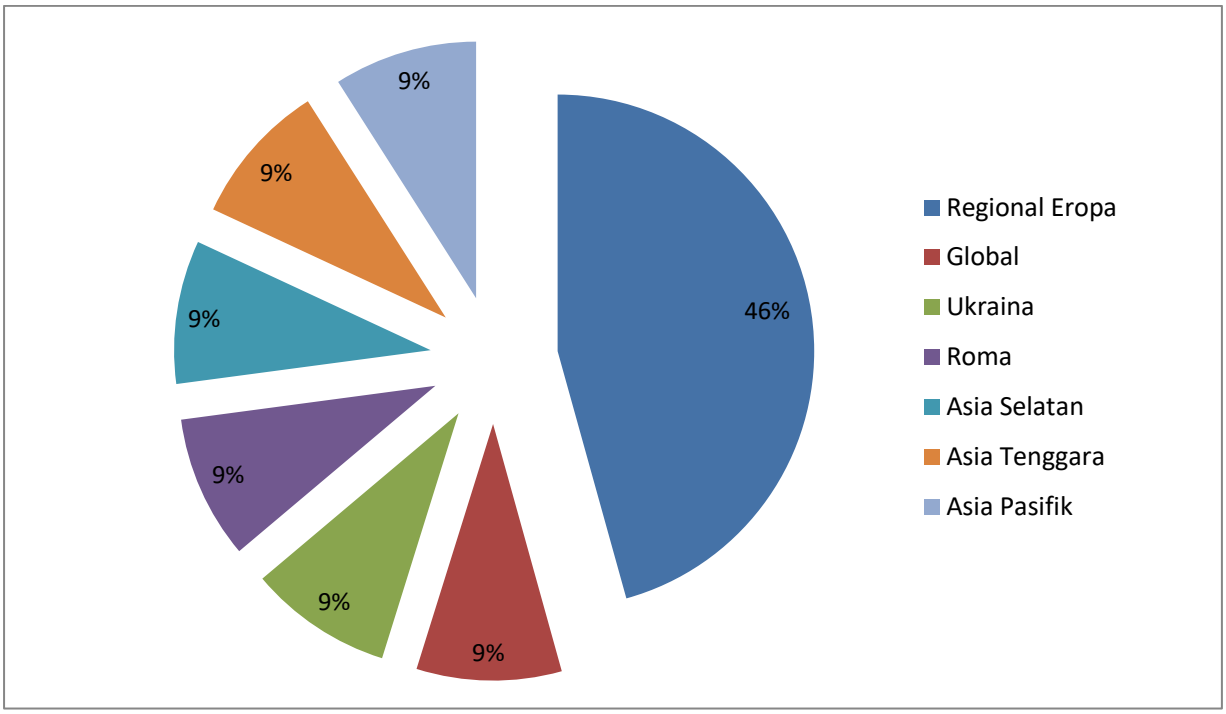

Figure 4. Geographic Distribution of Selected Publications

Based Figure 4 shows 11 selected publications in several regions. European regional areas that show prevention and intervention efforts towards waste management are in the research of Albizzati et al. (2024), namely in Austria, Germany, Italy, and Spain, by assessing municipal waste management's environmental and economic impacts. Research from Abis et al. (2020) includes all European Union countries. However, those who can manage waste using recycling methods are primarily in northern and central Europe (Austria, Belgium, Denmark, Finland, Germany, Netherlands, Norway, and Switzerland), while several countries In European regions such as Yugoslavia, Malta, the Aegean, and Romania, they still depend on landfilling for waste management. It shows that not all European countries have successfully prevented and intervened in the waste crisis with good management.

Research distributed in European regional areas is also found in the article by Mazzucco et al. (2020) on the case of waste fires in Italy, so there is a need for prevention and intervention efforts against waste landfills that are integrated with management and a policy framework to protect the environment. Research by Stasiškienė et al. (2022) is a prevention effort with bio-based and biodegradable plastic waste management strategies in Sweden, Germany, and Italy. Meanwhile, research by Kolodiichuk and Kolodiichuk (2020) in Ukraine and Dunajeva and Kostka (2022) in Rome discusses prevention efforts through national waste management strategies and government intervention.

Chaine et al. (2023) research in the European region discusses waste management challenges. The challenge in this research is that the European region has led the development of technology and regulations worldwide to provide a reference basis for waste management based on the latest technology. Therefore, the research sample was chosen in Scotland because this country has regional environmental responsibility and independent responsibility in managing waste.

Waste management challenges are often found in Asia. Based on research from Khan et al. (2022) regarding opportunities, challenges, and policies in managing waste into energy in developing countries in South Asia (Bhutan, India, Bangladesh, Nepal, Sri Lanka, Maldives,

and Pakistan). In Tun et al.'s (2020) research, the challenges of managing waste into energy also occur in Southeast Asia (Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam). However, Singapore has become a regional leader in developing waste into energy. In other countries, the main challenge is human resources regarding knowledge and skills at the level of technology, costs, and government policies. Meanwhile, in Herat's (2021) research, the problem and challenges are managing used electrical and electronic equipment waste in the Asia Pacific (Asia and Oceania combined). The problems and challenges of electronic waste in the Asia Pacific region are increasing due to used electronic waste being exported to Asian countries, especially India, China, Cambodia, Vietnam, Sri Lanka, Pakistan, the Philippines, and Bangladesh for reuse.

The geographic category was used because not all European countries manage waste well, but the majority of countries in Europe have done it effectively. This category is because there are strict laws and regulations from the European Union regarding waste management in the European region (Chaine et al., 2023). Apart from that, waste management challenges cannot fully occur in all Asian countries. Because the majority of countries in Asia are dominated by developing countries whose waste management systems are still limited (Tun et al., 2020). However, several countries in Asia, such as South Korea, Japan, and Singapore, have been able to manage waste well (Rahim, 2020).

The third category is regarding human resources. Humans play an essential role in the environment because whether the environment is damaged or not, the primary source is humans (Pata & Caglar, 2021). The relationship between the environment and humans is inseparable and mutually sustainable (Lai & Chen, 2020). Meanwhile, humans are rational creatures who can obey the rules. Environmental regulations need to be enforced, and awareness based on protecting the environment needs to be instilled in humans.

Environmental regulations in sustainable waste recycling can positively impact company competitiveness (Agovino et al., 2020). In addition, human thinking in managing waste will be open, and the waste sorting process will be carried out voluntarily based on awareness. However, the lack of appropriate policies and regulations, as well as the lack of financial support and human resources with technical skills, are real challenges for developing countries (Khan et al., 2020).

Based on the results of an SLR with an analysis of three aspects of the waste crisis: prevention, intervention, and challenges, further research will be carried out regarding research gaps. Research gaps will be carried out to develop new insights so they can be revealed. Gaps from several research results will become tools and solutions to problems (Table 2).

Table 2. Research Gap

Aspect	Category	Results and Research Agenda	Research Gap
Prevention	Objectives and Methodology	Recycling waste becomes a competitive economic cycle, avoiding product packaging that produces waste and turning waste into an energy source.	Cultural, economic, and public awareness factors greatly influence efforts to prevent the waste crisis. There is a gap in technological innovation between Europe and Asia in supporting waste management. The differences in economic aspects between the two regions mean that the business model developed influences the sustainability of waste management.
	Geography and approach	The effectiveness of waste management is carried out in the European region with several sophisticated equipment and expensive costs. Meanwhile, waste management is still in the analysis and development stage in the Asian region.	
	Human Resources	European society is very aware of the importance of cleanliness and the impact that waste can have. European society is not only aware of disposing of waste by sorting the types of waste but also makes waste a part of economic development. Meanwhile, waste management reaches the final disposal site in Asia without further processing.	

Aspect	Category	Results and Research Agenda	Research Gap
Intervention	Objectives and Methodology	The government plays a significant role in Europe's waste management process by implementing governance regulations and prevention efforts in generating waste. Apart from that, the European Union also plays a significant role in implementing waste-related policies. Meanwhile, waste management regulations in the Asian region are less strict in following up.	Community participation and awareness of the importance of protecting the environment influence community response and involvement in overcoming the waste crisis, in addition to environmental education, which can change community behavior patterns to take part in managing waste. The effectiveness of government policy implementation between Europe and Asia includes compliance analysis, impact measurement, and long-term evaluation. Apart from that, participation from all groups, including the private sector and especially civil society, in determining the policy process will provide insight into innovations in environmental policy that encourage waste management practices.
	Geography and approach	European Union state institutions intervene in waste management in countries in the European region. In contrast, governments in the European region implement regulations based on agreements between European countries in making policies and procuring waste recycling equipment for energy and the economy. Meanwhile, in the Asian region, the government does not facilitate the provision of further waste management tools.	
	Human Resources	The role of European society is significant in terms of managing waste. Apart from self-awareness of the waste crisis, which can endanger the environment, European society makes waste something that can improve the economy and create an economy that does not produce waste. Meanwhile, the majority of Asian people in developing countries are still prone to throwing rubbish carelessly and using seas and rivers as rubbish dumps.	
Challenges	Objectives and Methodology	Turning waste into renewable energy and creating environmentally based waste management are challenges that Asia has not resolved. Meanwhile, there are challenges and strategies for bio-based and biodegradable waste in Europe.	Cultural factors and public awareness of the importance of waste management in Asia are still low. It is not supported by waste management infrastructure such as recycling facilities and final disposal sites, which involve technology, distribution facilities, and infrastructure capacity due to the absence of innovative funding strategies to overcome the crisis. Geographical conditions are a particular challenge in the Asian region related to urbanization, population growth, and the geographical distribution of waste, which differs from European regions. Meanwhile, the involvement of the private sector is a challenge in carrying out joint initiatives to encourage waste management.
	Geography and approach	The large number of developing countries in Asia means that waste management is still a significant challenge. Few countries can create an environment free from the waste crisis in the Asian region. Contrasts Europe, where the challenge is not to produce waste.	
	Human Resources	The lack of responsibility of producers in processing waste and leaving it to pile up will create a waste crisis in the Asian region, whereas in the European region, people who act as producers will make the waste recycled or produce without producing waste.	

Aspect	Category	Results and Research Agenda	Research Gap
Management	Objectives and Methodology	It created an economic cycle by recycling waste, producing energy from waste, and avoiding production that produces waste.	Differences in waste collection and processing systems between Europe and Asia need to involve an analysis of the efficiency of recycling systems, technology, and facilities in management. Technological innovation and research between Europe and Asia still experience gaps in smart technology, data-based solutions, and the newest and most effective waste management methods. Government policy limits plastic use, and policies are in place for disposing and managing waste. There is a need for collaboration between international partnerships to determine the direction of waste management strategies.
	Geography and approach	Waste management in the European region is carried out in collaboration between European Union countries by helping each other handle and process waste through procuring equipment and building waste processing facilities. The Asian region needs to get support from developed countries in the Asian region in collaboration to create an Asian region free of waste.	
	Human Resources	Government regulations play a crucial role in creating a clean environment. Regulations related to waste management need to be tightened and carried out systematically with the encouragement of all parties. Apart from that, a critical ecological approach between society and the environment is needed to create a society that is aware of the importance of processing waste and responsible for the cleanliness of the surrounding environment.	

Waste Crisis Prevention

High environmental awareness has become a culture of European society (Saari et al., 2021). Caring for the environment and preserving life on earth has become part of the lifestyle of European society. Using recyclable products with sustainable consumer behavior has become a societal paradigm and habit (Khan et al., 2020). Meanwhile, culture in Asia varies significantly between several countries. The majority of countries in Asia are still developing countries whose cultural communities do not care enough about the importance of protecting the environment (Kabir & Khan, 2020). Several Asian countries, such as Japan and South Korea, have shown a high awareness of good waste management (Rahim, 2020). However, this must be imitated by other Asian countries to create a good environment.

Apart from cultural factors, which are the gap between Europe and Asia, economic factors are also of concern. Countries in the European region have stronger economies that can support investment in green technology recycling infrastructure, which improves the economic cycle by promoting environmental projects (Koestoer & Setiowati, 2023). Meanwhile, the economy in several Asian countries is experiencing rapid growth, but it is not commensurate with the economic disparities of the people (Hasibuan & Sahdila, 2023). A challenge for several countries is allocating resources for environmental protection, but this must be done with innovation and government policies.

Waste Crisis Intervention

The community is the intervention that plays the most role in the waste crisis. Community participation in high environmental awareness can reduce waste by managing waste efficiently and organizing waste recycling programs (Brotosusilo et al., 2020; Kala & Bolia, 2020). People's habits of refusing illegal waste disposal and choosing products based on environmental friendliness will reduce the impact of the waste crisis. Achieving this requires integrating environmental education through the school curriculum to form a generation aware of the central role of individuals and their environment.

Apart from community participation and all groups, the role of government policy is one of intervention in waste management (Xiao et al., 2020). Strict regulations relating to the environment must have a legal structure where the level of compliance is monitored, and sanctions must be applied. Apart from that, this

policy requires collaborative efforts between regions in Asia and internationally to support collaboration and technology exchange in overcoming the current waste crisis.

The intervention effort in European research is managing waste by taking an economic approach based on recycling and the environment's life cycle (Albizzati et al., 2024). The relationship between waste recycling rates in Europe can increase the competitiveness of companies in a circular economy (Agovino et al., 2020). The European Union considers packaging waste one of the main points in a circular economy by avoiding waste going to landfills (Eurostat, 2018).

Waste management will be the basis for sustainable development strategies and economic cycle action plans in Europe (Kolodiichuk & Kolodiichuk, 2020). However, recycling and incineration waste management in several European countries also requires the provision of bottom ash incinerators following the economic cycle strategy (Abis et al., 2020). Waste management aims to create waste as goods suitable for reuse and become an economic cycle in Europe, as well as create competitiveness for companies not to produce waste with several innovations. Meanwhile, in developing countries, especially in Asia, processing waste into the economic cycle is still challenging because waste components that can be recycled, such as glass and metal, are minimal (Khan et al., 2022).

Waste Management Challenges

Lack of funding to adopt waste management technology is a challenge faced by developing Asian countries (Khan et al., 2022). Waste management in Europe can adopt faster technology for recycling waste by using waste monitoring sensors and artificial intelligence (Czekała et al., 2023). Waste management technology innovation in Europe will focus on utilizing waste in renewable energy, and minimizing the overall environmental impact will become a priority.

Meanwhile, waste management technology in the Asian region is related to practical solutions that can be applied on a large scale to overcome complex waste crisis problems (Gollakota et al., 2020). This is due to the focus on problems in the Asian region regarding very rapid population growth and urbanization (Anser et al., 2020). Therefore, critical ecology and waste management education must be improved to achieve environmentally responsible human resources (Anwar et al., 2020). Critical ecology education is hoped that society can carry out the economic cycle with environmentally friendly products and not create waste.

The lack of coordination and collaboration between the government, private, and community sectors can hamper efforts to overcome the waste crisis. Therefore, education related to critical ecology is very much needed because one ecological awareness will unite all groups' perceptions into one interest. Critical ecological education can solve waste management challenges in the Asian region.

Critical Ecological Education

Critical ecology is an awareness of the relationship between humans and nature through thinking and analysis that involves deep understanding and solving environmental problems wisely (Labobar & Kapojos, 2023). Awareness of critical ecology makes people understand the impact of human activities on the environment (Galli et al., 2020). Understanding the consequences of irresponsible policies and consumption patterns will result in a waste crisis resulting from unsustainable management. Additionally, awareness between each individual regarding the actions taken will affect the ecosystem, making humans responsible and more environmentally friendly (Han, 2021). Education regarding critical ecology needs to be improved, especially in science learning.

Ecology is a part of science learning that can utilize the environment as a learning object (Zulhalifah et al., 2021). Ecological education is an effort that can potentially overcome environmental crises that will or are currently occurring (Gule, 2020). Ecological awareness can appreciate biodiversity and the importance of playing a role in maintaining environmental balance (Lasaiba, 2023). It can improve sustainable waste management behavior by viewing the environment as an integrated system between humans and nature.

Successful critical ecological education can also create human resources into policymakers with a sense of ecological awareness. High critical ecological awareness for the government supports advocacy to create policies to support environmental conservation. It will create policy support focusing on

sustainability, environmentally based waste management, and ecosystem protection.

Prevention and Intervention Succeed in Europe and the Challenges of Implementation in Asia

The majority of countries in the European region have succeeded in managing waste well, namely by making the waste recyclable. However, there are also a small number of countries in Europe that still use the landfilling system to manage their waste. The success of European countries in managing waste cannot be separated from the role of the government, which provides strict regulations regarding limits and the amount of waste people can dispose of in final landfills. Even though waste is still thrown into landfills, the process uses environmentally friendly technology.

Limiting the amount of waste disposed of in landfills can make people think about not producing waste in their activities. The zero waste program encourages the use of environmentally friendly products. Reducing waste is done using items that can be used continuously (not single use).

Developing countries in the Asian region have financial limitations in providing waste recycling technology. Several developing countries have done similar things in waste management to those in Europe: sorting waste by providing three different waste bins. It aims to ensure that waste can be recycled again. However, in reality, people in this area often ignore and do not understand the function of these three trash cans. Lack of education for the community, the level and quality of education will significantly influence people's behavior in all their activities.

Based on the results of a survey by the United Nations Development Program (2018) regarding human development rankings, it is stated that the survey results from 189 countries placed the majority of countries in the Asian region in positions 100 and above, especially in the Southeast Asia region. Several Southeast Asian countries that rank 100 and above are the Philippines (113), Indonesia (116), Vietnam (117), East Timor (132), Laos (139), Cambodia (146), and Myanmar (148). However, there are also several countries in the Asian region that rank high, namely Hong Kong (7), Singapore (9), Japan (19), South Korea (23), Brunei Darussalam (23), and Malaysia (52).

Asian countries with high rankings in terms of human development ranking align with the country's waste management level. Singapore is a regional leader in waste-to-energy management (Tun et al., 2020). Apart from that, Japan and South Korea can manage waste well (Rahim, 2020). It shows that the quality of human resources greatly influences waste management activities. Therefore, education is an essential factor that significantly influences people's behavior, and awareness of the importance of individual waste management will encourage waste management nationally and even globally.

The lack of education in human resource development has created several challenges in Asia. The first is limited infrastructure and waste management resources. It can be overcome if people in the Asian region have critical and innovative skills so they do not just wait for programs from the government in terms of waste management. Communities can create their waste management and innovations without producing waste. This limitation can be overcome if the development of educated human resources is successful.

The second challenge is the social and economic inequality of developing countries in the Asian region. Limited waste management resources arise due to social and economic inequality in society. It is also due to the lack of community innovation in managing waste into goods of economic value. Suppose society looks at efforts to prevent the European waste crisis, namely turning waste into usable goods and recycling them again. Recycling waste management can become a circular economy in the European region.

Meanwhile, Indonesia does not have sufficient resources to manage waste. However, this will be different if we have innovative and critical human resources to manage waste and transform it into economic value. Social and economic inequality and limited infrastructure and management resources can be overcome.

The third challenge is the culture and behavior of society in terms of disposing of, managing, and avoiding the creation of waste in the Asian region. A lack of public awareness of the waste crisis and low public education causes this challenge. Low education and lack of education regarding waste management will influence people's culture and behavior towards waste.

Apart from that, implementing government regulations on waste management must be accompanied by ecological education for the community so that people will be aware of the importance of managing waste responsibly. A structured waste collection and processing system by sorting and recycling will be successful if all individuals are involved. Education will significantly influence the level of individual behavior. Therefore, critical ecological education must be given more attention to overcome the waste crisis in the Asian region.

Critical Ecological Education as Crisis Waste Solution

Environmental issues are fundamental to be integrated with the education process. It aims to prepare students to face future challenges, especially the waste crisis. Students must be critical of environmental problems because they are directly related to the sustainability of human life and other living creatures. Environmental problems can be addressed through critical ecological education.

Ecology discusses the interrelated relationship between humans and the environment (Resfina, 2020). However, ecology does not only discuss ecosystems but behavior with ethics and life-related life related to the larger social environment. Therefore, the waste crisis is caused by the instability of the ecological system, causing problems for humans and the environment.

Prevention and intervention efforts towards waste management in Europe cannot be separated from human resources critical to ecology. Critical ecology can create an innovative society that is sensitive to the environment. One indicator that makes most of Europe the cleanest country and able to manage waste well is that ecological education has been embedded in the learning process. Besides, human resource development through critical ecology can create tangible action for the environment, not producing waste.

If humans are critical of ecology, then all forms of activity can avoid the occurrence of waste. Even though waste is produced, the management process can become a valuable system and a high income for the community. The circular economy in Europe starts with critical ecological education, which has become a culture for society. A paradigm shift towards waste, initially considered useless to something of high economic value, cannot occur naturally. However, something like that comes from critical ecological education systemized in learning.

Critical ecological education is crucial in dealing with various crises, especially waste. Higher education can create innovation in managing waste. Waste that can be managed can not only be used for goods that still resemble waste but in a different form but can be produced in factories such as eco-enzymes, bio-batteries, bio-ethanol, bioactivation, and fertilizers derived from fruit and vegetable waste. This knowledge is obtained from the educational process and critical ecology, which can create innovation during a crisis.

Apart from impacting the community's economy, efforts to manage waste and turn it into something that has economic value occur due to the success of critical ecological education. Critical ecology can also address the lack of waste management infrastructure and resources. It can happen because if critical ecological education is embedded in every individual, the habit of producing waste will decrease, even if every activity considers the absence of waste produced.

Critical ecological education will also create a society that has a clean culture. Community culture can be created due to knowledge and thought processes, while waste occurs due to community behavior, which becomes a habit. Community behavior results from education. Therefore, the success of critical ecology education will greatly determine waste management in the Asian region.

SWOT Analysis for Critical Ecological Education in Prevention and Intervention Efforts as Well as Solutions to Face Waste Management Challenges

Strengths

Critical ecological education can increase public awareness regarding the importance of sustainable waste management. The main factor causing the waste crisis that occurs in several countries in the Asian region is people who do not care about the environment, especially waste. Throwing rubbish carelessly and not planning sustainable waste disposal, such as sorting, is a form of lack of public awareness. Critical ecological education is a solution to

changing society's paradigm, ultimately creating behavior and culture in a society that cares about the environment.

Critical ecology that enters the education system will create holistic education. The direction of education so far has been less successful in forming technical aspects because it is still guided mainly by theories regarding environmental ecosystems without paying attention to the impacts on various fields. Critical ecological education will be more integrated, considering various fields, primarily social, environmental, and economic, through waste management. Critical ecology will create critical innovation in overcoming problems in income in the economic sector, forming a circular economy. Meanwhile, social and environmental aspects will create a society that is aware and cares about all its activities so that they do not produce waste.

Apart from that, community participation and all parties will continue coordinating to overcome the waste crisis through proper management. Critical ecological education will be able to encourage all parties so that they do not only depend on the government. However, government programs must be emphasized again to develop human resources through critical ecological education. Various sectors will collaborate in managing and efforts to not produce waste through awareness gained from the education system.

Weaknesses

Critical ecological education requires access to all levels of society to create awareness in each individual. Meanwhile, not all communities have the same access to critical ecological education. The vital role of the government in providing policy regulations for critical ecological education systems in every field of life. Critical ecological education can be integrated with various fields but requires an integrated education system.

Changing people's behavior in managing waste sustainably is a big challenge. However, individuals will slowly create self-awareness of the environment through an education system that includes critical ecological values. It also requires efforts from all parties to create a culture of managing waste well.

Opportunities

This critical ecological education has an excellent opportunity to overcome the problem of the waste crisis that is occurring. With the awareness of all communities, there will be opportunities for collaboration between governments, business people, non-governmental organizations, and several stakeholders to provide holistic critical ecological education. Critical ecological education will be strongly supported because, apart from overcoming environmental problems, it can also create economic improvements.

The results of critical ecological education will create innovative human resources in developing new technology for waste management. Apart from that, critical communities will also carry out all their activities without producing waste. If society produces waste, society will be responsible for managing the result of critical ecological education. Critical ecological education, besides providing a great opportunity to deal with crises, also provides an excellent opportunity to improve the quality of society.

Threats

Lack of public interest in environmental issues can hinder the success of critical ecology education. However, this can be packaged in the education system. A critical ecological approach to various fields will create public awareness of environmental issues. Apart from that, if environmental issues relate to all fields, it will be straightforward to create a culture of society that cares about the environment by utilizing each individual's knowledge of the field in which they are working.

The influence of some business interests can hinder the implementation of critical ecological education towards the waste crisis. It can cause some business interests to conflict with critical ecological principles. Furthermore, unstable government policy changes can also threaten the success of implementing critical ecology. However, with integration and agreement from all fields and coordination, critical ecological education will be able to solve all the waste crisis problems that occur in developing countries in the Asian region.

CONCLUSION

Cultural, economic, and public awareness factors greatly influence efforts to prevent the waste crisis. High environmental awareness has become a culture in European society, and the culture of people in developing countries in Asia

is less concerned about the importance of protecting the environment. Meanwhile, countries in the European region have a more robust economy that can support waste management compared to those in Asia. The importance of government policy is in efforts to collaborate between regions in Asia and internationally to support collaboration and technology exchange in overcoming the current waste crisis. The lack of adequate technology in managing waste can be overcome by collaborating between several countries to overcome the crisis. However, the level of public awareness in actively protecting the environment must start with each individual. Awareness of critical ecology will make people understand the impact of human activities on the environment. Therefore, ecological education is an effort that can potentially overcome environmental crises that will occur or are currently occurring by creating human resources with ecological awareness.

REFERENCE

Abis, M., Bruno, M., Kuchta, K., Simon, F. G., Grönholm, R., Hoppe, M., & Fiore, S. (2020). Assessment of The Synergy Between Recycling and Thermal Treatments in Municipal Solid Waste Management In Europe. *Energies*, *13*(23), 1–15. https://doi.org/10.3390/en13236412

Andeobu, L., Wibowo, S., & Grandhi, S. (2021). An Assessment of E-Waste Generation and Environmental Management of Selected Countries in Africa, Europe and North America: A Systematic Review. *Science of The Total Environment, 792*, 148078. https://doi.org/10.1016/j.scitotenv.2021.148078

Adedoyin, F. F., Alola, A. A., & Bekun, F. V. (2021). The Alternative Energy Utilization and Common Regional Trade Outlook in EU-27: Evidence From Common Correlated Effects. *Renewable and Sustainable Energy Reviews*, *145*, 111092.

Agovino, M., Matricano, D., & Garofalo, A. (2020). Waste Management and Competitiveness of Firms in Europe: A Stochastic Frontier Approach. *Waste Management*, *102*, 528–540. https://doi.org/10.1016/j.wasman.2019.11.021

Albizzati, P. F., Foster, G., Gaudillat, P., Manfredi, S., & Tonini, D. (2024). A Model to Assess The Environmental and Economic Impacts of Municipal Waste Management in Europe. *Waste Management*, *174*, 605–617. https://doi.org/10.1016/j.wasman.2023.12.029

Anser, M. K., Alharthi, M., Aziz, B., & Wasim, S. (2020). Impact of Urbanization, Economic Growth, and Population Size on Residential Carbon Emissions in The SAARC Countries. *Clean Technologies and Environmental Policy*, *22*(4), 923–936. https://doi.org/10.1007/s10098-020-01833-y

Anwar, N., Mahmood, N. H. N., Yusliza, M. Y., Ramayah, T., Faezah, J. N., & Khalid, W. (2020). Green Human Resource Management for Organisational Citizenship Behaviour Towards The Environment and Environmental Performance on A University Campus. *Journal of Cleaner Production*, *256*, 120401.

Brotosusilo, A., Nabila, S. H., Negoro, H. A., & Utari, D. (2020). The Level of Individual Participation of Community in Implementing Effective Solid Waste Management Policies. *Global Journal of Environmental Science and Management*, *6*(3), 341–354. https://doi.org/10.22034/gjesm.2020.03.05

Budijaya, M. I. (2023). Pengelolaan Sampah dalam Perspektif Kebijakan Publik di Kota Tasikmalaya. *Indonesian Journal of Education and Humanity, 3*(4), 64-70.

Chaine, C., Hursthouse, A. S., McLellan, I., Viza, E., & Miller, J. (2023). The Challenge of Plastic Management for Waste Electrical and Electric Equipment Recycling in The Global South: A Case Comparison between Europe and Latin America. *Recycling*, *8*(5), 71. https://doi.org/10.3390/recycling8050071

Czekała, W., Drozdowski, J., & Łabiak, P. (2023). Modern Technologies for Waste Management: A Review. *Applied Sciences, 13*(15), 8847.

Dunajeva, J., & Kostka, J. (2022). Racialized Politics of Garbage: Waste Management in Urban Roma Settlements in Eastern

Europe. *Ethnic and Racial Studies*, *45*(1), 90–112. https://doi.org/10.1080/01419870.2020.1863442

Environmental Performance Index. (2022a). *The Top 10 Cleanest Countries*.

Environmental Performance Index. (2022b). *Waste Management*.

Eurostat. (2018). *Energy, Transport and Environment Indicators*.

Farhan, A., Lauren, C. C., & Fuzain, N. A. (2023). Analisis Faktor Pencemaran Air dan Dampak Pola Konsumsi Masyarakat di Indonesia. *Jurnal Hukum dan HAM Wara Sain*, *2*(12), 1095–1103.

Gollakota, A. R., Gautam, S., & Shu, C. M. (2020). Inconsistencies of E-Waste Management in Developing Nations–Facts and Plausible Solutions. *Journal of Environmental Management*, *261*, 110234. https://doi.org/10.1016/j.jenvman.2020.110234

Galli, A., Iha, K., Pires, S. M., Mancini, M. S., Alves, A., Zokai, G., & Wackernagel, M. (2020). Assessing the Ecological Footprint and Biocapacity of Portuguese Cities: Critical Results for Environmental Awareness and Local Management. *Cities*, *96*, 102442.

Gule, Y. (2020). Konsep Eduecologi dalam Pendidikan Agama Kristen Konteks Sekolah. *Fidei: Jurnal Teologi Sistematika Dan Praktika*, *3*(2), 181–201. https://doi.org/10.34081/fidei.v3i2.183

Hadi, W., Rahmayanti, H., Aulia, F., Habel, R. H., Hanifah, I., & Widodo, M. S. (2023). Pemberdayaan Pengetahuan Masyarakat dalam Isu Perubahan Iklim Melalui Kegiatan Penyuluhan di SMK Yapinuh Muara Gembong Bekasi. *Prosiding Seminar Nasional Pengabdian Kepada Masyarakat*, SNPPM2023L-52.

Han, H. (2021). Consumer Behavior and Environmental Sustainability in Tourism and Hospitality: A Review of Theories, Concepts, and Latest Research. *Journal of Sustainable Tourism*, *29*(7), 1021–1042. https://doi.org/10.1080/09669582.2021.1903019

Hasibuan, R. U., & Sahdila, R. (2023). Pengaruh Distribusi Pendapatan Terhadap Kemiskinan di Indonesia. *JEBIMAN: Jurnal Ekonomi, Bisnis, Manajemen dan Akuntansi*, *1*(6), 750–756.

Herat, S. (2021). E-waste Management in Asia Pacific Region: Review of Issues, Challenges and Solutions. *Nature Environment and Pollution Technology*, *20*(1), 45–53.

IPCC, J. R. (2022). Global Warming of 1.5° C: IPCC Special Report on Impacts of Global Warming of 1.5° C Above Pre-Industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. *Cambridge, UK: Cambridge University Press*. https://doi.org/10.1002/9780470996621.ch50

Kabir, Z., & Khan, I. (2020). Environmental Impact Assessment of Waste to Energy Projects in Developing Countries: General Guidelines in The Context of Bangladesh. *Sustainable Energy Technologies and Assessments*, *37*, 100619.

Kala, K., & Bolia, N. B. (2020). Waste Management Communication Policy for Effective Citizen Awareness. *Journal of Policy Modeling*, *42*(3), 661–678.

Khan, I., Chowdhury, S., & Techato, K. (2022). Waste to Energy in Developing Countries—A Rapid Review: Opportunities, Challenges, and Policies in Selected Countries of Sub-Saharan Africa and South Asia Towards Sustainability. *Sustainability*, *14*(7), 3740. https://doi.org/10.3390/su14073740

Khan, M. S., Saengon, P., Alganad, A. M. N., Chongcharoen, D., & Farrukh, M. (2020). Consumer Green Behaviour: An Approach Towards Environmental Sustainability. *Sustainable Development*, *28*(5), 1168–1180. https://doi.org/10.1002/sd.2066

Koestoer, R. H., & Setiowati, R. (2023). *Dinamika Kebijakan Lingkungan Global dalam Perspektif Lokal*. Depok: Universitas Indonesia Publishing.

Kolodiichuk, I., & Kolodiichuk, V. (2020). Formalization of The Waste Management Task in Ukraine for Ensuring The Environmental Stability of Eastern Europe. *Journal of Eastern European and Central Asian Research*, *7*(1), 51–60. https://doi.org/10.15549/jeecar.v7i1.353

Labobar, J., & Kapojos, S. (2023). Literasi

Ekologis Literasi Ekologis: Implementasi Pendidikan Lingkungan Hidup bagi Siswa SMP Negeri Se-Distrik Sentani. *Civics Education and Social Science Journal (CESSJ)*, *5*(2), 94–109.

Lai, S. L., & Chen, D. N. (2020). A Research on the Relationship between Environmental Sustainability Management and Human Development. *Sustainability*, *12*(21), 1–20. https://doi.org/10.3390/su12219001

Lasaiba, M. A. (2023). Menggugah Kesadaran Ekologis: Pendekatan Biologi untuk Pendidikan Berkelanjutan. *Jendela Pengetahuan*, *15*, (1), 1–14.

Mazzucco, W., Costantino, C., Restivo, V., Alba, D., Marotta, C., Tavormina, E., Cernigliaro, A., Macaluso, M., Cusimano, R., Grammauta, R., Tramuto, F., Scondotto, S., & Vitale, F. (2020). The Management of Health Hazards Related to Municipal Solid Waste on Fire in Europe: An Environmental Justice Issue? *International Journal of Environmental Research and Public Health*, *17*(18), 1–15. https://doi.org/10.3390/ijerph17186617

Munaro, M. R., Tavares, S. F., & Bragança, L. (2020). Towards Circular and More Sustainable Buildings: A Systematic Literature Review on The Circular Economy in The Built Environment. *Journal of Cleaner Production*, *260*, 121134. https://doi.org/10.1016/j.jclepro.2020.121134

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., Mcdonald, S., … & Mckenzie, J. E. (2021). PRISMA 2020 Explanation and Elaboration: Updated Guidance and Exemplars for Reporting Systematic Reviews. *The BMJ*, *372*. https://doi.org/10.1136/bmj.n160

Pata, U. K., & Caglar, A. E. (2021). Investigating The EKC Hypothesis with Renewable Energy Consumption, Human Capital, Globalization and Trade Openness for China: Evidence from Augmented ARDL Approach with A Structural Break. *Energy*, *216*, 119220.

Pirlea, A. F., U. Serajuddin, D., Wadhwa, M., & Welch, E. (2023). *Atlas of Sustainable Development Goals 2023*. Wahington DC: World Bank.

Puspita, R. A., & Kresnawati, M. A. (2023). Kerjasama Jepang-Asean dalam Mengurangi Marine Plastic Debris Asean di Kawasan Indo Pasifik. *Aliansi: Jurnal Politik, Keamanan dan Hubungan Internasional*, *2*(2), 104-111.

Rahim, M. (2020). Strategi pengelolaan sampah berkelanjutan. *Jurnal Sipilsains*, *10*(2), 151–156. http://ithh.journal.ipb.ac.id/index.php/p2wd/article/view/22930

Resfina, D. (2020). Sosialisasi Ekologi Teologi Bagi Jemaat Gksi Immanuel Bagi Penghijauan di Kecamatan Kuala Behe. *Jurnal PKM Setiadharma*, *1*(2), 13–19. https://doi.org/10.47457/jps.v1i2.57

Saari, U. A., Damberg, S., Frömbling, L., & Ringle, C. M. (2021). Sustainable Consumption Behavior of Europeans: The Influence of Environmental Knowledge and Risk Perception on Environmental Concern and Behavioral Intention. *Ecological Economics*, *189*, 107155.

Şalvarlı, Ş. İ., & Griffiths, M. D. (2021). Internet Gaming Disorder and Its Associated Personality Traits: A Systematic Review Using PRISMA Guidelines. *International Journal of Mental Health and Addiction*, *19*(5), 1420–1442. https://doi.org/10.1007/s11469-019-00081-6

Sarbatly, R., & Sariau, J. (2022). Assessment and A Case Study of Small-Scale Incinerators for Municipal and Agriculture Waste Disposal in Rural Regions. *Waste Management, Processing and Valorisation*, 61–76.

Sitogasa, P. S. A. (2022). Penerapan Solid Waste Management Tool (SWMT) sebagai Analisis Gas Rumah Kaca Hasil Penanganan Sampah di Kota Kediri. *Jurnal Ilmiah Sistem Informasi dan Ilmu Komputer*, *2*(2), 7–15.

Stasiškienė, Ž., Barbir, J., Draudvilienė, L., Chong, Z. K., Kuchta, K., Voronova, V., & Leal Filho, W. (2022). Challenges and Strategies for Bio-Based and Biodegradable Plastic Waste Management in Europe. *Sustainability*, *14*(24), 1–17. https://doi.org/10.3390/su142416476

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Tun, M. M., Palacky, P., Juchelkova, D., & Síťař, V. (2020). Renewable waste-to-energy in Southeast Asia: Status, Challenges, Opportunities, and Selection of Waste-to-Energy Technologies. *Applied Sciences*, *10*(20), 7312.

Upadhyay, R. K. (2020). Markers for Global Climate Change and Its Impact on Social, Biological and Ecological Systems: A Review. *American Journal of Climate Change*, *9*(3), 159.

Wahyudi, J. (2019). Greenhouse Gases Emissions from Municipal Solid Waste Burning Using IPCC Model. *Jurnal Litbang: Media Informasi Penelitian, Pengembangan dan IPTEK*, *15*(1), 65–76.

Wibowo, K., & Wulamdari, W. (2023). Pengolahan Sampah Plastik (*Polypropylene*) Menjadi Bahan Bakar Minyak. *Jurnal Kesmas Asclepius*, *5*(2), 137–145.

Xiao, S., Dong, H., Geng, Y., Tian, X., Liu, C., & Li, H. (2020). Policy Impacts on Municipal Solid Waste Management in Shanghai: A System Dynamics Model Analysis. *Journal of Cleaner Production*, *262*, 121366.

Zulhalifah, Z., Melita, A. S., & Syukur, A. (2021). Pemanfaatan Nilai Ekologi Ekosistem Mangrove sebagai Sumber Belajar IPA di SMAN 3 lembar. *Jurnal Pengabdian Magister Pendidikan IPA*, *4*(2), 49-52. https://doi.org/10.29303/jpmpi.v4i2.662