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Enhancing Environmental Awareness Through Public Awareness Programs

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Abstract
Solid waste or generated waste can increase as a result of population growth and human socioeconomic activities. In Malaysia, studies on waste management through composting involving school students are still lacking. School students are not exposed to proper composting methods, leading to difficulties in understanding sustainable waste management and how composting can be applied as a green practice. This study uses a qualitative approach, specifically a case study design, to address this gap. The findings were obtained through in-depth interviews with three informants, including university professors and agricultural industry experts. The informants believe that solid waste management through composting methods can enhance students' knowledge of environmental sustainability. They suggest that composting techniques in schools can be diversified using various methods, such as conventional heaps, vermicomposting, or composting with Black Soldier Fly larvae. Additionally, the use of effective microorganisms can be incorporated into composting practices. These varied methods can provide a comprehensive understanding of composting and its benefits. The study highlights the importance of incorporating composting practices into school curricula. By exposing students to different composting techniques, they can gain practical knowledge and skills in sustainable waste management. This hands-on experience can foster a deeper understanding of environmental issues and the importance of sustainability. Moreover, the implementation of composting in schools can have broader environmental benefits. It can reduce the amount of solid waste sent to landfills, decrease greenhouse gas emissions, and promote the recycling of organic waste into valuable compost. This practice aligns with the principles of a circular economy, where waste is minimized, and resources are continuously reused. In conclusion, school composting practices can provide significant educational benefits and promote sustainable solid waste management. By integrating composting into school programs, students can learn about environmental sustainability and apply green practices in their daily lives. This study underscores the need for more research and initiatives in this area to enhance environmental education and sustainability practices among school students in Malaysia.
Keywords: Composting, Environmental Education, Sustainable Waste Management
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1. INTRODUCTION

Every year, the volume of waste produced globally continues to escalate, leading to significant challenges, especially in developing countries. This increase in waste generation results in higher costs associated with solid waste management. Developing countries often struggle with limited resources and infrastructure to efficiently manage and dispose of the growing quantities of waste. Consequently, the financial burden of waste management becomes a substantial concern for these nations. The rising cost of solid waste management encompasses various aspects, including collection, transportation, treatment, and disposal of waste. Inadequate waste management infrastructure and practices can lead to environmental degradation, public health issues, and economic losses (Chandrappa & Das, 2012). For instance, improperly managed waste can contaminate water bodies, soil, and air, posing serious health risks to local populations.

Tchobanoglous & Kreith (2002) emphasize the importance of implementing effective waste management strategies to mitigate these challenges. Developing countries need to adopt sustainable waste management practices that include waste reduction, recycling, and composting. Additionally, investing in modern waste management technologies and infrastructure is crucial to handle the increasing waste volumes efficiently. Furthermore, public awareness and education play a vital role in waste management. Educating communities about the importance of waste reduction, proper disposal methods, and recycling can significantly reduce the waste generated at the source. Governments and local authorities need to collaborate with communities, businesses, and non-governmental organizations to develop and implement comprehensive waste management plans (Luna & Luna, 2018; Debrah et al., 2021).

According to Hamidi (2009), and Latifah (2011), solid waste is defined as any substance, whether solid or liquid, that is disposed of by its owner and deemed to be no longer necessary. This broad definition encompasses a wide range of materials, from household garbage and industrial by-products to agricultural residues and construction debris. These materials, once considered useful, are discarded when they are perceived to have lost their value or utility. Solid waste management involves the systematic administration of activities that provide for the collection, source separation, storage,

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transportation, transfer, processing, treatment, and disposal of solid waste. Effective management is crucial to mitigate the environmental, health, and economic impacts associated with improper waste disposal (Ferronato & Torretta, 2019). Solid waste, often simply referred to as waste, encompasses any material that the owner no longer needs due to damage, wear, or the end of its useful life (Haliza, 2017; Willy, 2018). This category of waste includes a wide variety of items discarded from households, industries, commercial establishments, and institutions. Examples range from everyday household trash, such as food scraps and packaging materials, to industrial by-products, construction debris, and obsolete machinery. The proper management and disposal of solid waste are crucial to minimize environmental impact, prevent pollution, and promote sustainable living practices. Effective waste management strategies involve reduction, reuse, recycling, and responsible disposal to ensure that waste does not pose a threat to human health or the environment (Zorpas, 2020; Singh & Kumar, 2023).

In Malaysia, organic waste constitutes a substantial portion of the solid waste generated, posing serious environmental challenges. This type of waste, which includes food scraps, yard trimmings, and other biodegradable materials, not only contributes to the overall waste volume but also leads to significant issues such as environmental pollution and foul odors. The high moisture content inherent in organic waste makes it particularly challenging to manage and treat effectively. When organic waste is not properly processed, its decomposition can create conditions that are difficult to handle. As the waste breaks down, methane gas is released. Methane is a potent greenhouse gas that significantly contributes to global warming by trapping heat in the atmosphere. This contributes to broader climate change problems and intensifies the greenhouse effect. Additionally, improper handling and disposal of organic waste can lead to other environmental concerns, such as contamination of soil and water resources. Effective waste management strategies are essential to mitigate these issues. These strategies may include composting, anaerobic digestion, and advanced waste treatment technologies designed to reduce methane emissions and manage the waste more sustainably. Implementing such measures can help alleviate the negative impacts of organic waste and promote a cleaner, healthier environment (Sharifah Norkhadijah, 2014 Limjaroenrat & Ramanust, 2023).

The issue of organic waste contributing to greenhouse gas (GHG) emissions is of significant concern, as highlighted by reports from the United Nations Framework Convention on Climate Change (UNFCCC) in collaboration with the Ministry of Natural Resources and Environment. According to these reports, the waste management sector in Malaysia is responsible for 12% of the country's GHG emissions, largely due to the disposal of organic waste at landfills (JPSPN, 2016). Furthermore, the decomposition of organic waste in landfill sites is a primary source of GHG emissions within Malaysia's waste management sector. This process releases methane, a potent greenhouse gas, which exacerbates climate change and contributes to global warming (Kilenthong & Komain, 2023; Zainura et al., 2013). Addressing these emissions requires improved waste management practices, including the implementation of more effective waste treatment and reduction strategies to minimize the environmental impact of organic waste.

According to the JPSN report from 2016, waste disposal sites are the largest source of methane gas emissions, accounting for 47% of such emissions. Methane, a potent greenhouse gas, is 21 times more damaging to the ozone layer than carbon dioxide. This underscores a critical issue in Malaysia's environmental management, particularly concerning the handling of solid waste, especially organic waste. The challenges associated with unsustainable solid waste management have led to significant environmental pollution. Despite these challenges, Malaysia's composting practices lag behind those of countries such as the United States, Japan, China, India, and Korea. By 2020, composting accounted for only 8% of waste treatment methods in Malaysia, with the majority of waste being managed through landfills and other methods (Periathamby & Shahul, 2010; MDM Samsudin & Don, 2013; Fazeli et al., 2016).

This disparity highlights a significant conflict in waste management practices within Malaysia. Approximately 53% of waste is still disposed of in landfills (see Figure 1.1), despite the fact that organic waste constitutes a substantial portion of the waste stream and is ideally managed through biological treatments and composting. Addressing this imbalance and enhancing composting efforts are crucial steps toward more sustainable waste management practices in Malaysia.

In many schools, students are not exposed to organic waste recycling practices such as composting. This lack of exposure results in a limited understanding of sustainable solid waste management among students and a lack of knowledge on how to implement composting as an effective green practice (Azura, 2018). Recent studies have highlighted this issue, noting that students often struggle with solid waste recycling practices and exhibit insufficient green practices due to their limited education on these topics (Noor Diyana, 2016; Mahat et al., 2017).

Without proper education and hands-on experience in waste management techniques, students may find it challenging to grasp the importance of sustainability and the practical steps needed to manage waste effectively. Addressing this educational gap is crucial for fostering a generation that is knowledgeable about and committed to sustainable waste management practices. This issue extends to students' limited understanding of how sustainability principles apply to solid waste management. Previous research has also shown that awareness, attitudes, behaviors, and environmental knowledge among primary and secondary students are generally low (Maravić, Cvjetićanin, & Ivković, 2014). This deficiency is largely attributed to insufficient knowledge about environmental issues and composting practices.

The lack of accurate and comprehensive education on these topics hinders students' ability to grasp the importance of sustainable waste management and to implement effective composting methods. To address this problem, it is essential to improve environmental education and integrate practical waste management activities into the school curriculum.

Educating students about sustainable waste management and composting methods is crucial for enhancing their understanding and engagement with these practices. Effective education can raise awareness and foster improved green practices among students, leading to better management of food and organic waste. Hamidi (2009) highlights that education plays a vital role in the success of sustainable solid waste management. Introducing subjects like the Basis of

Sustainability can effectively convey the principles of sustainable waste management. Additionally, project-based learning, such as composting projects, offers practical experience and further raises awareness. Such initiatives can integrate green practices into students' lives, promoting more effective waste management and fostering a culture of environmental responsibility.

2. LITERATURE REVIEW

According to Taelman et al., (2018) minimizing waste generation is a critical component of environmental sustainability, but it must be considered alongside several other important issues. Efficient land use is one such issue, where managing land resources wisely is essential to prevent the overexploitation of natural environments and to preserve vital ecosystems and habitats. In addition, the efficient use of energy is crucial for reducing carbon emissions and mitigating the impacts of climate change. Transitioning to renewable energy sources and optimizing energy consumption are key strategies in this regard. Similarly, managing water resources effectively is essential to address issues of water scarcity, protect aquatic ecosystems, and ensure sustainable access to clean water. Pollution control is another significant aspect, requiring strategies to minimize air, water, and soil pollution. Effective pollution management is vital for protecting public health and maintaining overall environmental quality. Furthermore, the conservation of biodiversity and the protection of ecological systems play a fundamental role in maintaining ecological balance, supporting ecosystem services, and ensuring the health of various species.

Holistically addressing these interconnected issues is necessary for promoting a sustainable environment. By integrating waste reduction efforts with broader environmental policies and practices, a more resilient and sustainable future can be achieved. In light of the environmental approach, pollution resulting from poorly maintained waste disposal sites is an environmental issue that contributes negatively to the quality of the physical environment and human health (Pai, Rodrigues, Mathew, & Hebbar, 2014). Poorly managed waste disposal sites have far-reaching consequences that extend beyond immediate pollution issues. These sites contribute significantly to the deterioration of environmental quality by releasing harmful substances into the air, soil, and water. The leachate from waste disposal sites, for example, can contaminate groundwater, while airborne pollutants can degrade air quality. Such pollution undermines the health of ecosystems, disrupts natural processes, and leads to the loss of biodiversity. Moreover, the negative impact of waste disposal sites is closely linked to urbanization challenges. As urban areas expand, the pressure on waste management systems increases, often resulting in inadequately managed waste facilities. This situation exacerbates problems such as littering, unsightly waste accumulation, and unpleasant odors, all of which diminish the livability of urban environments. Increased pollution levels can also have direct adverse effects on human health, contributing to respiratory issues, waterborne diseases, and other health problems. These issues are interconnected and emphasize the need for comprehensive waste management solutions. Addressing the environmental impact of waste disposal sites requires improving waste treatment processes, investing in better waste management infrastructure, and promoting sustainable urban planning practices. By tackling these challenges, it is possible to enhance environmental quality and support healthier, more sustainable urban development.

Composting is a natural process that involves the decomposition of organic waste, including agricultural residues, food scraps, kitchen waste, and garden trimmings, to produce composted fertilizers. This process not only recycles organic material but also transforms it into nutrient-rich compost that can enhance soil fertility. In many countries, food waste constitutes up to 40% of the total solid waste generated. By converting this waste into compost, valuable products are created that can improve soil health without causing environmental pollution. According to Ng and Yusoff (2015), composting provides an effective method for managing a significant portion of organic waste, reducing the environmental impact of waste disposal, and contributing to sustainable waste management practices.

Compost is an organic material that has undergone decomposition and recycling processes to transform into a humus-like substance. It is derived from various organic waste sources, including food scraps, yard trimmings, and agricultural residues. According to Reyes-Torres et al. (2018), compost serves as a valuable fertilizer that enhances soil health by improving its structure, fertility, and moisture retention. This humus-like material not only enriches the soil but also supports sustainable agricultural practices and reduces the need for synthetic fertilizers.

Compost is a fundamental component of organic farming, playing a crucial role in enhancing soil health and fertility. The process of composting involves accumulating a pile of organic waste, such as food scraps, garden clippings, and agricultural residues, and allowing it to decompose over time. This process typically takes six weeks or more, depending on factors such as environmental temperature and the availability of nutrients.

The composting process requires specific conditions to be effective, including adequate aeration, moisture, and temperature control, which facilitate the breakdown of organic materials into nutrient-rich compost. According to the Commission (2000), maintaining these conditions ensures that the compost develops properly and provides valuable benefits for soil enrichment and sustainable agricultural practices.

The composting process is significantly influenced by moisture levels and the presence of oxygen. For instance, aerobic decomposition occurs in the presence of oxygen and involves the breakdown of organic materials, resulting in the production of carbon dioxide gas and heat (Peninsular and Urban Planning Department of Peninsular Malaysia, 2012).

Aerobic decomposition is one of the primary methods used in composting and offers several advantages. Firstly, it can substantially reduce the amount of solid waste that needs to be disposed of in landfills, alleviating some of the pressure on waste management systems. Secondly, the composting process produces nutrient-rich fertilizers that can be used to enhance soil health and support plant growth. Finally, by using compost as a natural fertilizer, the reliance on chemical fertilizers is reduced, contributing to a more sustainable and environmentally friendly approach to agriculture.

3. METHODOLOGY

This study employs a qualitative research design utilizing a case study approach. Qualitative research is particularly suited for exploring complex social phenomena in depth, as noted by Silverman (2014), who highlights its effectiveness in providing a nuanced understanding of social processes. Creswell (2016) further emphasize that qualitative studies are valuable for interpreting the subjective experiences and perceptions of informants. This approach allows researchers to gain comprehensive insights into informants' understandings and interpretations of the issues at hand.

According to Othman (2018), qualitative research is characterized by its focus on exploring and learning about social phenomena from the perspective of those directly involved. In this study, the aim is to delve into the views and insights of informants to develop a framework for sustainable waste management through school composting methods. By examining how informants perceive and understand these practices, the study seeks to create a robust framework that can enhance the implementation and effectiveness of composting in educational settings.

The sample for this study comprised three individuals, including university lecturers and the Director of Corporate Affairs specializing in composting. This selection was based on their extensive experience in the fields of sustainable waste management and industrial composting.

Data collection was conducted through semi-structured interviews, chosen for their flexibility compared to structured interviews. Semi-structured interviews allow informants to provide more nuanced and detailed responses, as they can freely elaborate on their experiences and perspectives. Before the interviews, interview protocols were shared with the informants to prepare them for the discussion.

Informants were informed about the purpose of the study and the terms of the data collection agreement in advance. Permission was sought from each informant before recording the interviews. During the interviews, informants were asked to provide their insights and opinions on developing a sustainable solid waste management framework through composting methods. This approach aimed to gather in-depth feedback to inform the creation of a comprehensive framework for effective waste management in educational settings.

Interviews were conducted in settings that ensured comfort for both the researchers and the informants. The scheduling of the interviews was coordinated based on mutual consent regarding the time, date, and location.

Throughout the interviews, the researcher paid close attention to the informants' body language and facial expressions as they responded, providing additional context to their verbal answers. The environment of the interview was documented through field notes to capture the setting and its potential impact on the interaction.

Building rapport with the informants was a key focus during the interviews. Researchers made a concerted effort to create a positive and trusting atmosphere, which facilitated open and honest communication. This approach was intended to enhance the quality of the data collected and ensure a thorough understanding of the informants' perspectives on the development of a sustainable solid waste management framework through composting methods.

During the interviews, the researcher employed disclosure techniques to clarify and elaborate on the questions posed. This approach aimed to ensure that informants fully understood the questions and could provide comprehensive responses. By minimizing the complexity of the questions, the researcher facilitated more detailed explanations from the informants. Additionally, to avoid researcher bias, the researcher refrained from speculating on answers or leading the informants with suggestive questions. Questions that could be answered with a simple "Yes" or "No" were also avoided, as they could hinder meaningful dialogue.

Following the methodology outlined by Merriam and Elizabeth (2016), the researcher used follow-up questions and comments to gather detailed descriptions, explanations, and examples from the informants. Semi-structured interviews were conducted with open-ended questions to encourage expansive responses, and further probing was used to clarify vague or ambiguous answers.

Responses, along with informants' feedback, were recorded in memos or field notes to facilitate data triangulation, enhancing the accuracy and reliability of the data collected. After each interview, the researcher acknowledged the informant's contribution and expressed appreciation. The process of writing transcriptions began immediately upon completing the interviews, ensuring that the data was accurately captured and analyzed.

4. DATA ANALYSIS

The researcher meticulously labeled each transcript and interview record within individual informant files to maintain organized documentation. To aid in the data analysis, Nvivo 12 software was utilized, allowing for efficient coding and categorization. Each informant was assigned a unique code, and each interview was tagged with the date and time of the session to ensure accurate tracking and retrieval of data.

Following the methodological framework proposed by Creswell (2016), the analysis involved five basic steps: collecting verbal data, reading and familiarizing oneself with the data, splitting the data into specific sections, organizing and presenting the data, and finally, synthesizing the information to draw meaningful conclusions.

Given the researcher’s role as a qualitative research instrument, several processes were implemented to enhance the validity and reliability of the study. These included maintaining an audit trail to document the research process, conducting member checking to verify findings with informants, engaging in peer review to gain external perspectives, and utilizing data triangulation to corroborate results from multiple sources. These practices collectively contributed to the robustness of the study's findings and ensured a comprehensive and credible analysis.

According to Merriam (2009), the audit trail is a critical method used by researchers to document and justify their decisions throughout the research process. This process involves meticulously recording and explaining each step of data collection, including the interview procedures, transcription, coding, and theme formation. By maintaining an audit trail,

researchers enhance the transparency and credibility of their study, allowing others to follow and understand how decisions were made and categories were formed.

The check-in process, also known as member checking, is an essential data validation technique. It involves re-contacting research informants to confirm the accuracy of the researcher's interpretations and findings. Silverman (2014) highlights that this process serves as a validation tool, ensuring that the information presented reflects the informants' intended meanings. By obtaining the informants' approval of the interpretations, the researcher can enhance the validity of the study and ensure that the conclusions drawn are accurate and representative of the informants' perspectives.

The peer-review process involves a collaborative endorsement by the Supervisory Committee, which assists researchers in scrutinizing the raw data collected from informants. This process helps ensure the integrity and rigor of the research by providing an additional layer of review and validation.

Triangulation, as described by Silverman (2014), is a technique used to enhance the reliability of qualitative study data. It involves comparing and cross-referencing data from various sources or informants to validate findings and provide a more comprehensive understanding of the phenomena under investigation. Triangulation aims to offer a deeper insight into the events and processes by integrating multiple perspectives and data points, thus increasing the robustness and credibility of the research conclusions.

The composting process revolves around the decomposition of organic matter, transforming it into nutrient-rich compost. For optimal decomposition, several critical factors must be managed effectively.

The process begins with the introduction of organic materials rich in carbon and nitrogen, such as kitchen scraps, yard waste, and agricultural residues. These materials serve as the primary feedstock, providing the necessary nutrients for the microorganisms that drive the decomposition.

Maintaining adequate moisture is essential for effective composting. Organic materials need to be kept moist but not overly saturated, as moisture facilitates microbial activity, which is crucial for breaking down the organic matter. Additionally, ensuring sufficient oxygen is available is vital for aerobic decomposition. Aerobic microbes, which require oxygen to thrive, break down the organic material efficiently. Regular turning of the compost pile helps introduce oxygen into the mixture, and proper ventilation ensures that oxygen is evenly distributed throughout.

Techniques for managing moisture also play a significant role. Adding water to the compost pile when it becomes too dry, or incorporating dry materials if it becomes too wet, helps maintain the ideal conditions for microbial activity.

By carefully balancing these factors—organic materials, moisture, oxygen, and proper aeration—the composting process can be optimized. This careful management leads to the production of high-quality compost, enriching the soil and supporting sustainable gardening practices.

5. CONCLUSIONS

Addressing sustainable solid waste management methods through educational sectors, particularly in schools, is crucial given the growing volume of waste reaching critical levels. Effective waste management education in schools can play a pivotal role in mitigating environmental pollution, reducing management costs, and avoiding adverse societal impacts.

Educating students about sustainable waste management practices helps foster awareness from a young age, encouraging responsible behaviors and practices that can significantly reduce the environmental footprint of waste. By integrating waste management education into the curriculum, schools can equip students with the knowledge and skills necessary to implement and advocate for sustainable practices in their communities.

Moreover, effective waste management can lead to substantial economic benefits. Sustainable methods, such as recycling and composting, can lower waste disposal costs and create opportunities for resource recovery and reuse. This approach not only minimizes the economic burden on waste management systems but also supports a circular economy.

Ultimately, focusing on sustainable waste management through education can help prevent the harmful impacts associated with improper waste disposal, such as pollution and public health risks. By addressing these issues through educational initiatives, schools can contribute to creating a more informed and environmentally responsible society.

For optimal compost production, several key mechanisms must be carefully managed, including moisture, water, air, oxygen, temperature, and the carbon-to-nitrogen ratio. Maintaining the right level of moisture is crucial; the compost should be kept moist but not overly saturated. This balance can be managed by regularly adding water or dry materials as needed, which supports effective microbial activity.

Air and oxygen play a significant role in aerobic decomposition, where microorganisms break down organic matter in the presence of oxygen. Proper aeration is essential, and techniques such as turning the compost pile help introduce air and ensure that oxygen is evenly distributed throughout the mixture. The temperature within the compost pile also affects microbial activity. Optimal composting temperatures generally range from 55°C to 65°C (130°F to 150°F). Monitoring and managing the temperature can accelerate decomposition and improve the efficiency of the composting process.

The carbon-to-nitrogen ratio is another important factor. Balancing carbon-rich materials, such as dry leaves and paper, with nitrogen-rich materials, such as food scraps and grass clippings, is crucial for efficient decomposition. A well-balanced ratio, typically around 30:1, supports the activity of microorganisms and speeds up composting.

In schools, various composting techniques can be introduced to illustrate these principles. Pile techniques involve creating a compost heap or pile, which is regularly turned to maintain aeration. Microbial composting uses specific microorganisms to enhance decomposition, while vermicomposting employs worms to break down organic matter into compost. Additionally, black fly larvae composting can be used to accelerate the composting of organic waste. By incorporating these methods into school programs, students can gain practical experience with composting, understand the underlying science, and appreciate the benefits of sustainable waste management.

Composting projects offer both environmental and economic benefits, making them a valuable addition to educational programs. From an economic perspective, composting is highly cost-effective because it reduces the need to purchase commercial fertilizers. The final compost product, rich in nutrients, is an excellent resource for cultivation and can significantly lower expenses related to soil enrichment and plant growth.

In schools, composting projects serve not only as a practical exercise in sustainability but also as a means to foster green practices among students. By participating in these projects, students learn the importance of recycling organic waste, managing resources responsibly, and contributing to a more sustainable environment. These experiences can instill lasting habits and a deeper understanding of environmental stewardship.

Moreover, composting projects can offer schools an additional income stream. By selling the compost produced, schools can generate revenue that can be reinvested into further educational resources or school programs. This dual benefit of sustainability and economic advantage makes composting projects an appealing and practical initiative for schools, promoting both environmental consciousness and financial savings.

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