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# Challenges of E-waste management in Sabah: A systematic review

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**Abstract**
E-waste management is becoming more complex as society's reliance on technology grows. Due to the effects on the environment and human health, proper disposal is essential. Through a systematic review of 25 articles using PRISMA methodology, this paper explores the e-waste challenges in Sabah, Malaysia. The study discovered that among the challenges are things like poor infrastructure, informal recycling, and little knowledge and awareness. This discovery offers insightful information that will help stakeholders, including policymakers, and researchers, develop sustainable solutions to the e-waste problems in Sabah in particular.

Keywords: E-waste; recycling; sustainalbe e-waste; environmental effects


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## 1.0 Introduction

Electronic waste (e-waste) is one of the global environmental challenges and public health issues due to the rapid increase in the production and usage of electronic devices. The improper disposal of e-waste will lead to adverse effects on the environment and public health. Hence a proper and formal waste management strategy is an effective strategy to deal with this issue. As a rapidly developing country with rapid technological advancement, Malaysia has seen a surge in e-waste generation. In 2021, the country accumulated a staggering 432 metric tonnes of e-waste. Sabah in particular has contributed significantly with a total of 19 metric tonnes, or 382 kilograms of e-waste collected within one week. Sabah's escalating e-waste production necessitates immediate attention and effective management to mitigate its negative effects on the environment and public health.

Considering the alarming e-waste scenario in Sabah, conducting a systematic review of the current challenges and knowledge assessment in e-waste management has become imperative. This review aims to provide a comprehensive understanding of the existing obstacles faced in managing e-waste effectively in Sabah. The methodical review plays a crucial part in consolidating and assaying the available literature, therefore furnishing precious information for policymakers, experimenters, and stakeholders to develop and apply strategies for the sustainable operation of e-waste in line with the aspiration of Sustainable Development Goals (SDGs). Effective e-

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waste management is crucial as one of the drivers to achieve Goal 3 (Good health and Well-being), Goal 6 (Clean water and Sanitation), Goal 11 (Sustainable Cities and Communities), and Goal 12 (Responsible Consumption and Production).

The main purpose of this systematic review is to analyze the current state of e-waste management in Sabah. Rather, this review aims to explain existing challenges including infrastructure issues, informal recycling, and limited awareness and knowledge. This study advances the comprehension of this uncharted territory, paying the way for innovative solutions that protect our environment and encourage a greener tomorrow. Furthermore, this systematic review contributes valuable insights to the broader field of e-waste management research, thus encouraging global efforts towards effective environmental protection and waste reduction. In Malaysia, the responsibility for managing e-waste lies under the Ministry of Environment and Water Malaysia (Kementerian Alam Sekitar dan Air Malaysia or KASA). The Malaysian Environment Department (DOE) and Sabah Kota Kinabalu City Hall (DBKK) are responsible for overseeing and implementing e-waste management initiatives in the country. The DOE in collaboration with City Halls across the country plays an important role in coordinating and regulating electronic collection, recycling, and disposal activities to protect human health and the environment. Despite the Ministry's efforts, there is still a need to comprehend the unique difficulties associated with managing e-waste in Sabah, as various studies have looked at the area's particular context. The systematic review intends to fill this research gap, contribute to a more thorough strategy for sustainable e-waste management throughout Malaysia, and provide insightful information for customized approaches in Sabah.

## 2.0 Methodology

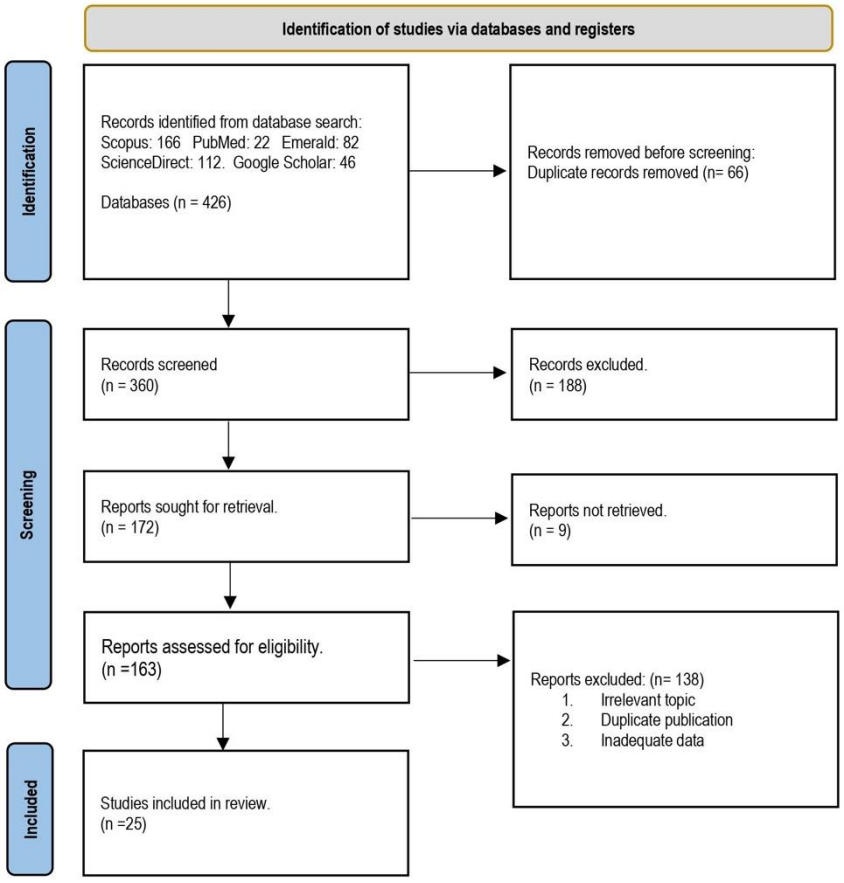


Fig. 1: Steps in the selection process of articles

The systematic review used the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) methodology to comprehensively analyze and synthesize relevant studies related to e-waste management in Sabah, Malaysia. The objective was to integrate the dispersed knowledge on the topic into a more consistent understanding. To achieve this, the methodology involved a comprehensive search across multiple databases including Scopus, PubMed, Emerald Insight, Science Direct, and Google Scholar. The utilization of multiple databases is essential as it provides a diverse array of sources, covering various disciplines such as environmental science, social science, and art and humanities.

The rationale for employing multiple databases is grounded in the recognition that e-waste management is a multifaceted subject that intersects with various fields. By casting a wide net across different databases, the study ensures a more thorough exploration of the existing literature, capturing diverse perspectives and insights. This approach enhances the robustness of the review, offering a

comprehensive view of e-waste management from different disciplinary angles. The search specifically targeted English-language research conducted between 2010 and 2023, aligning with the study's focus on recent developments in the field. This temporal range ensures the inclusion of up-to-date and relevant literature, reflecting the evolving nature of e-waste management practices.

Initially, 426 articles were identified, and the subsequent removal of 66 duplicates led to 360 articles undergoing the screening process. The screening involved a meticulous assessment of titles and abstracts, with the explicit aim of excluding articles not directly addressing e-waste management. This process resulted in a refined list of 172 relevant articles that met the predefined criteria. Subsequently, 163 selected papers were procured and thoroughly read. The assessment of these papers was based on specific criteria, including the exclusion of articles with irrelevant topics, the removal of duplicate publications, and the elimination of articles with inadequate data. The rigorous applications of these criteria resulted in the exclusion of 138 articles, leaving a carefully selected set of 25 papers that met the criteria for inclusion in the review.

The use of multiple databases in the methodology is justified by the need for a comprehensive and diverse exploration of e-waste management literature. This approach ensures the inclusion of a wide range of perspectives, enriching the synthesis of knowledge on this complex and evolving topic.

## 3.0 Findings

The review comprised a total of 25 final articles, the majority (19) classified as empirical papers. The remaining article encompassed a mix of global studies, literature reviews, and systematic reviews. Four themes emerged from the examination of the review findings, developed based on concepts consistently discussed in the literature. The study that systematically examined the management of electronic waste in Sabah, Malaysia Identified inadequate infrastructure, ineffective informal recycling practices, insufficient public awareness, and knowledge gaps as significant obstacles to achieving efficient waste management practices (Dinggai et al., 2020; George et al., 2019; Mapa et al., 2021). The assessment of challenges involved in managing e-waste in Sabah revealed critical issues acquired from diverse sources.

Table 1. Overview of challenges of e-waste management

| Authors | Themes | | | |
|---|---|---|---|---|
| | Inadequate infrastructure | Informal recycling practices | Insufficient Public awareness | Knowledge gaps |
| Afroz et al., (2013, 2020) | √ | | | √ |
| Andeobu et al., (2021) | | | | √ |
| Awasthi et al., (2023) | | √ | | |
| Blake et al., (2019) | | | √ | |
| Chibunna et al., (2012) | | | √ | |
| Dinggai et al., (2020) | √ | √ | √ | √ |
| Garcia et al., (2021) | | √ | | |
| George et al., (2019) | √ | √ | √ | √ |
| Hamzah et al., (2020) | | | √ | |
| Heacock et al., (2016) | | | √ | |
| Hossain et al., (2015) | | | √ | |
| Kang et al., (2020) | √ | | | |
| Kumar et al., (2022) | | √ | | |
| Mapa et al., (2021) | √ | √ | √ | √ |
| Miner et al., (2020) | | | √ | |
| Nduneseokwu et al., (2017) | | | | √ |
| Nuwematsiko et al., (2021) | | | | √ |
| Okwu et al., (2022) | | √ | | |
| Omondi et al., (2022) | √ | | | |
| Ongondo et al., (2011) | | √ | | |
| Rajesh et al., (2022) | | | √ | |
| Siddiqua et al., (2022) | | | | √ |
| Tran & Salhofer, (2018) | √ | | | |
| Yong et al., (2019) | | √ | | |

### *3.1 Inadequate infrastructure*

Inadequate infrastructure challenges are crucial, as highlighted by Afroz et al., (2020) and Kang et al., (2020). Insufficiently equipped recycling facilities and outdated technologies hinder effective waste disposal processes. The emphasis on collective efforts to invest in adequately furnished recycling facilities and modernizing obsolete technologies is paramount. The absence of designated e-waste collection centers and the lack of formalization in the recycling sector exacerbate disposal inefficiencies (Tran & Salhofer, 2018). He added the study on informal e-waste and end-processing in Vietnam highlights critical issues related to air emission and wastewater treatment, signaling pervasive challenges. These findings are relevant to Sabah's e-waste management challenges, emphasizing the importance of improving recycling facilities and processes to minimize environmental and health risks. Additionally, Omondi et al., (2022) highlighted that e-waste disposal in open dump sites in developing countries accentuates the absence of legal frameworks and regulations, further complicating effective e-waste management. These challenges collectively emphasize the intricate nature of addressing e-waste concerns on various fronts.

### *3.2 Informal recycling practices*

Finding from a Nigerian study revealed that the majority of informal recyclers engage in WEEE activities due to job unavailability, underscoring the need for alternative livelihood opportunities to deter illicit recycling practices (Okwu et al., 2022). As said by Awasthi et al., (2023) and Ongondo et al., (2011), evaluating strategic management gains importance in developing countries. In Sabah, such an assessment can help identify the gaps and shortcomings in the current informal recycling practices. Understanding the specific challenges faced by the informal sector enables policymakers to implement targeted interventions for formalizing and regulating the recycling process. The fortification of formal e-waste management not only protects the environment and public health but also enhances the socio-economic conditions of informal workers in the sector (Garcia et al., 2021; Kumar et al., 2022; Yong et al., 2019).

*3.3 Insufficient public awareness*

Next, the challenge of e-waste management in Sabah, Malaysia is limited awareness appearing as a significant obstacle, aligning with findings by Chibunna et al., (2012) and Hamzah et al., (2020). Implementing public awareness programs involving local communities in e-waste collection and recycling is crucial to encourage sustainable management practices. Educational initiatives should focus on the importance of recycling for environmental preservation and educate on proper e-waste disposal methods. Hossain et al., (2015) and Rajesh et al., (2022) suggest strong legislation and policies are crucial to combat e-waste in Sabah then adopting a circular economy approach, as highlighted in Heacock et al., (2016) can contribute to sustainable e-waste management. By contemplating these insights, Sabah will be able to create effective strategies to surmount the challenges of limited awareness and promote responsible e-waste management practices.

Miner et al., (2020) research conducted in Jos, Nigeria, revealed a lack of awareness regarding appropriate e-waste management practices among the households surveyed. Most respondents were oblivious to the potential dangers associated with improper electronic waste disposal, indicating a significant knowledge gap. This finding highlights the need to conduct similar surveys in Sabah to assess the level of awareness among the local population and identify areas requiring awareness-building programs. Blake et al., (2019) conducted a case study in Whangarei, New Zealand, which revealed a lack of awareness regarding electronic device recycling channels. This prompted some residents to dispose of e-waste in general waste receptacles, thereby diminishing the efficacy of the voluntary e-waste recycling program. This case study underscores the significance of assessing the awareness of existing e-waste management programs in Sabah to identify potential knowledge gaps and enhance public participation.

By addressing these challenges with evidence-based methodologies, Sabah can develop an effective and sustainable e-waste management system that safeguards the environment and public health. To address these concerns and establish a greener, healthier Sabah, policymakers, academics, and stakeholders must work together. With solid infrastructure, laws, and awareness activities, Sabah can lead the way in responsible e-waste management.

*3.4 Knowledge gaps*

According to a similar study conducted in the UAE, many consumers were oblivious to the environmental impacts of e-waste and lacked knowledge of appropriate disposal techniques. Consequently, a substantial number of respondents discarded their obsolete electronic devices in landfills, contributing to the expanding e-waste problem (Siddiqua et al., 2022). This sentence emphasizes the importance of evaluating the knowledge and attitudes of Sabah's residents towards e-waste management to address similar consumer behaviors.

A study in Uganda indicated a lack of knowledge concerning the laws governing e-waste management and disposal. The paper advises encouraging e-waste handling techniques including reuse, repair, recycling, and safe disposal to close this gap (Nuwematsiko et al., 2021). Sabah may experience similar difficulties managing e-waste, demanding focused initiatives and education to improve sustainable e-waste practices in the area. Sabah needs effective e-waste management to safeguard the environment, and public health, and promote a circular economy.

In Sabah, similar to the study by Afroz et al., (2013) households may exhibit knowledge about the environmental and health impacts of WEEE. However, the low participation rate in recycling (3% to 2%) reflects a concerning challenge. To address this, the government can implement effective legislation, establish convenient collection centers, and conduct awareness campaigns to motivate households in Sabah to recycle their WEEE. Collaboration between government and non-government stakeholders is vital for successful extended producer responsibility (EPR) programs. Investment in recycling infrastructure and technology transfer can ensure safe e-waste management, prioritizing the safety of scrap collectors and recyclers. Moreover, a regional policy framework can be explored in Sabah to leverage economies of scale effectively.

China and India revealed that inadequate knowledge and awareness among e-waste handlers contributed to improper recycling practices and potential health risks (Andeobu et al., 2021). This emphasizes the importance of promoting education and training programs among informal recyclers in Sabah to ensure proper handling of e-waste. Moreover, Nduneseokwu et al., (2017) highlight that economic incentives and infrastructure alone may not be sufficient to drive individuals' intentions and behaviors toward proper e-waste management. Therefore, raising awareness and educating the public about the significance of e-waste management could play a crucial role in encouraging responsible practices in Sabah.

## 4.0 Discussion, contribution, and future research

This review has provided valuable insights into the condition of e-waste management in the region. This review has identified critical challenges and knowledge gaps that impede effective e-waste management practices in Sabah, Malaysia, through a comprehensive analysis of existing research. These findings have important implications for policymakers, waste management authorities, and other regional stakeholders involved in the management of e-waste. In total, 7 publications from 25 articles highlighted key points in the study.

Three papers covered the disposal method (Garcia et al., 2021; Kumar et al., 2022; Ongondo et al., 2011),2 articles covered the informal sector engagement (Afroz et al., 2020; Kang et al., 2020), and 2 article cover awareness understanding (Chibunna et al., 2012; Hossain et al., 2015). The remaining studies are not included because they do not focus on the contribution to the discussion of various aspects of e-waste management challenges and potential solutions in Sabah, Malaysia.

*4.1 Discussion*

The absence of consciousness among households and consumers concerning the suitable disposal procedures for electronic waste stands as one of the essential discoveries of this study. A considerable number of individuals remain oblivious to the prospective environmental and health hazards that are linked to inappropriate disposal of electronic waste (Ongondo et al., 2011). This incongruity of knowledge highlights the necessity for targeted public awareness campaigns aimed at educating the populace on the importance of appropriate management of electronic waste and its implications for the environment and public health.

Furthermore, the review has brought attention to the substantial participation of the informal sector in the management of electronic waste in Sabah. The informal sector indeed plays a crucial role in the handling and recycling of electronic waste. However, due to insufficient knowledge and awareness among informal recyclers regarding the perilous nature of e-waste, improper recycling practices, and consequent environmental pollution may ensue. The current situation necessitates the establishment of education and training initiatives that will elevate the competence and methodologies of non-formal recyclers and facilitate their incorporation into established recycling frameworks.

The review also reveals the limited infrastructure and recycling facilities for e-waste management in Sabah. Lacking modern recycling facilities, Malaysia is faced with low household participation in e-waste management (Afroz et al., 2020). To surmount this obstacle, if e-waste collection boxes are provided to the nearest community and e-waste management information is distributed, household participation in e-waste management will increase.

*4.2 Contribution*

This assessment presents a detailed grasp of the situation of e-waste management in the area by highlighting the existing difficulties and knowledge gaps. The findings serve as a foundation for evidence-based plans and initiatives to enhance Sabah's e-waste management procedures.

The review underscores the significance of advancing public consciousness and educational initiatives to tackle the deficiency of awareness among households and consumers. Hossain et al., (2015) in their study said, that by promoting knowledge and understanding of the potential environmental and health consequences associated with the incorrect disposal of electronic waste, these campaigns may stimulate responsible conduct and cultivate a societal ethos of enduring waste management. Also, this review accentuates the crucial significance of the unstructured sector in the management of electronic waste. Kumar et al., (2022) believe the understanding of informal recyclers in the formal recycling systems with the aid of educational and training schemes can augment their understanding and practices, resulting in more secure and ecologically sustainable recycling procedures.

*4.3 Future research*

Several areas of prospective inquiry could be undertaken to advance electronic waste management in Sabah, employing the discoveries of this comprehensive review as a structural basis. Firstly, exhaustive investigations can be conducted to scrutinize the societal and cultural elements that impact the perspectives and conduct of consumers about electronic waste disposal. Because of Chibunna et al., (2012) believe that understanding these factors can help tailor awareness campaigns to resonate with local people and drive positive change.

Secondly, it is imperative to note that extensive research ought to be conducted to delve into innovative financing models for e-waste management. This will go a long way in tackling the financial challenges currently being encountered by stakeholders in their quest to implement sustainable waste management programs. Identifying funding sources and incentives can facilitate the development of robust and effective recycling initiatives (Garcia et al., 2021).

On top of that, research in the future should investigate the findings of technology-based approaches in elevating e-waste management in Sabah. For instance, a study by Kang et al., (2020), suggests that smart collection systems based on the Internet of Things (IoT) be used to handle and recycle e-waste from homes. Finally, by studying IoT-based collection systems and conducting comparative research, valuable insights and innovative strategies can be gained for improving e-waste management in Sabah.

The identified challenges and knowledge gaps underscore the need for targeted interventions, such as public awareness campaigns and education programs for informal recyclers, to improve e-waste management practices. The review's contribution lies in consolidating existing research and providing evidence-based recommendations for policymakers and stakeholders involved in e-waste management in Sabah. By exploring areas of future research, Sabah can develop effective and sustainable strategies for managing e-waste and mitigating its environmental and health impacts.

## 5.0 Conclusion

This systematic review offers an assessment of electronic waste management in the context of Sabah. The outcomes highlight an urgent requirement for specific interventions aimed at bridging knowledge deficiencies and enhancing electronic waste disposal methods in Sabah, Malaysia. In addition, this review underscores the deficiency in knowledge among households and consumers about appropriate e-waste disposal practices, consequently resulting in environmental contamination and health hazards. To encourage responsible e-

waste management practices in the community, it is essential to bridge this information divide through public awareness campaigns and education programs.

Moreover, the participation of the informal sector in the management of electronic waste presents obstacles in guaranteeing appropriate disposal and recycling. The education and training of informal recyclers and integration into formal recycling systems can improve community understanding and practices, ultimately promoting safer and more ecologically sound recycling procedures. The inadequate infrastructure and recycling facilities for electronic waste management in Sabah necessitate immediate attention. Crucially, the investment in contemporary recycling technology and the enhancement of recycling infrastructure are essential in facilitating effective and sustainable electronic waste management practices.

This systematic study contributes by emphasizing the value of international collaboration in addressing the e-waste issue and by offering insights relevant to certain regions. This study provides insightful insights that may guide policies and initiatives adapted to the local environment by contrasting Sabah's difficulties with those experienced by other areas. Future studies should concentrate on comprehending the social and cultural aspects impacting e-waste management practices to progress e-waste management in Sabah. For sustainable waste management programs, it is also crucial to investigate novel funding structures, make use of technology-driven solutions, and carry out long-term research studies to evaluate the success of awareness efforts.

Lastly, this comprehensive review holds significant importance as a fundamental tool for decision-makers, regulatory bodies, and interested parties who aim to construct empirically supported measures for the proficient management of electronic waste in Sabah. By addressing the established hindrances and deficiencies in knowledge, Sabah can pioneer the path toward a more sustainable and ecologically accountable approach to handling electronic waste in the region.

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## Paper Contribution to Related Field of Study

About the management of e-waste in Sabah, Malaysia, this paper significantly contributes to the field of sustainable development policy. Through a systematic review, it demonstrates the current issues related to the region's e-waste practices. The paper synthesizes data from several studies and offers crucial insights for decision-makers, waste authorities, and environmental stakeholders. These insights are crucial for developing better strategies and policies that ultimately improve Sabah's e-waste management practices.

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