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A STUDY EVALUATING CHALLENGES FACED BY SMES IN COMPLYING WITH E-WASTE MANAGEMENT NORMS

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Keywords	Abstract
E-Waste, Small and Medium Enterprises.	E-waste is a problem in the environment and SMEs are a key to the economic growth, employment generation and industrial development. With the increasing usage of electronic equipment by SME's compliance with E-waste Management Norms becomes significant to encourage responsible disposal of e-waste and sustainable business practices. This study aimed to understand the problems faced by SMEs in complying with E-waste Management Norms effectively and assist in formulating practical solutions for sustainable E-waste management. The test used in the current study in One Sample t-test. The findings of the study indicated that Difficulty in understanding e-waste norms, Lack of awareness of e-waste regulations, High cost of e-waste compliance, Difficulty in maintaining e-waste records, Difficulty in e-waste segregation, Lack of authorized recyclers, Difficulty in e-waste transportation, Complex government reporting requirements, Lack of trained employees, Lack of proper storage facilities, Difficulty in e-waste



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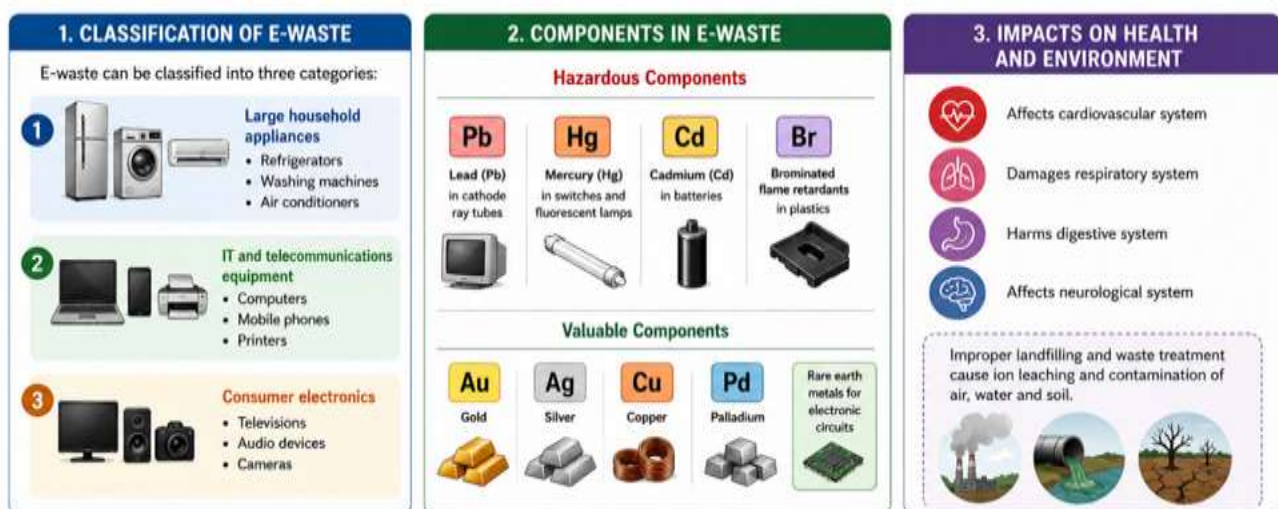
collection, Lack of technical knowledge, Limited financial resources, and Frequent changes in e-waste regulations are significant challenges faced by SMEs in complying with E-Waste Management Norms.

Introduction:

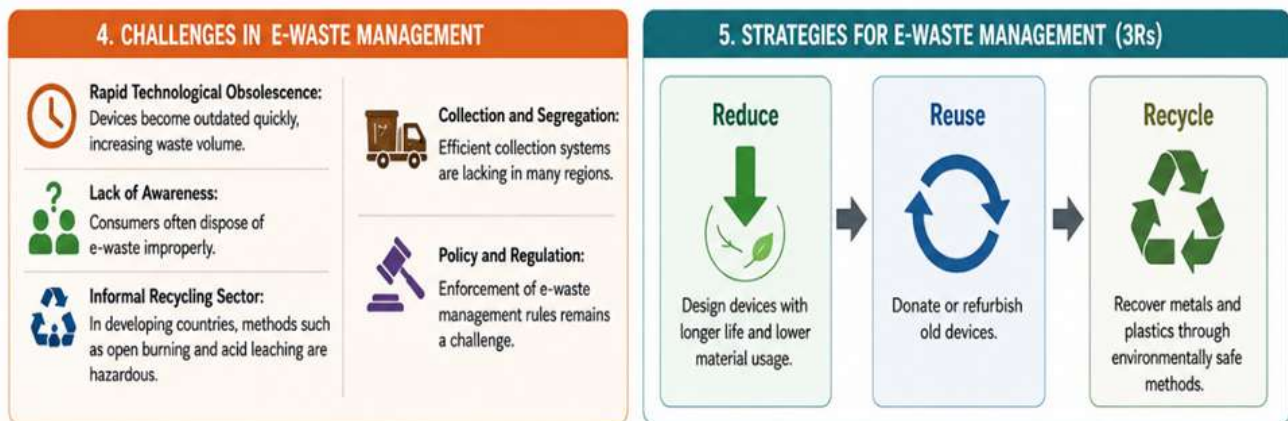
Electronic waste (e-waste) is a major concern in today's world because technology usage is increasing with an exponential rate, and electronic devices are becoming obsolete quickly. It includes a wide range of items that are thrown away such as “computers, mobile phones, TVs, fridges, and other household appliances”. The volume of e-waste is on the rise as the society is getting more dependent on the electronic devices for communication, entertainment, and daily activities. Soaring growth presents significant environmental and public health issues.

Waste from e-waste recycling can include “toxic chemicals like brominated flame retardants, cadmium, mercury and lead”. When these toxins are disposed of improperly, such as by incineration or landfill, they can pollute the air and soil, causing potential health risks and pollution to local communities. Moreover, e-waste is a growing problem as it contributes to a loss of resources and increased energy usage. Electronic devices include precious metals and rare-earth elements, which are used in the devices and are typically mined in an environmentally harmful way. The recycling of e-waste and recovery of these materials help to lower the need for raw material extraction, save natural resources and eliminate the impact of electronic device manufacturing on the environment. Although e-waste can be hazardous, there are few effective management strategies in many areas. There are extra risks to human health and the environment posed by informal recycling systems in developing countries that are usually unregulated and unsafely managed. Immediate steps are needed to establish comprehensive e-waste management, which focus on waste reduction, reusing and recycling. The e-waste problem is also significant in ensuring environmental sustainability and the health and well-being of both past and future generations (Anubhav, A, et al. 2024).

Figure No: 1 Overview of E-waste



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Recyclers in India are not equipped with advanced recycling technologies to efficiently and effectively recover more metals (Gaur et al., 2024; Kumar & Dixit, 2018). Likewise, there is no digitisation of E-waste collection supply chains. The digitization of the whole value chain would be helpful for E-waste collection and treatment as it could track product and recycled materials (Andersen, 2022; Khan & Ahmad, 2022). Digitalization is, however, difficult due to the absence of proper IT systems which affects the processes of E-waste management (Gaur et al., 2025). Furthermore, a lack of technical training of the workers is hampering E-waste management practices like sorting, segregation, dismantling, and recycling (Gaur et al., 2024; Kumar & Dixit, 2018). Lack of clear defined business strategies on these technical skills and training aspects can lead to low metal recovery, pollution and health problems for the workers (Hazelwood & Pecht, 2021; Khan & Ahmad, 2022). In addition, lack of awareness among workers regarding the mixed waste can be a challenge in segregation of e-waste. The labour of segregation, dismantling and recycling of E-Waste can be affected by toxic materials present in E-waste (Andeobu et al., 2021). The adoption of green practices like limiting the use of toxic items in business practices is not being done effectively in spite of the ban in E-waste rules (Garlapati, 2016; Premalatha et al., 2014).

The informal sector is responsible for collecting a larger share of E-waste in developing countries, particularly domestic E-waste, compared to the formal sector, as the informal sector provides consumers with higher payment rates for E-waste (Ghulam & Abushammala, 2023; Leclerc & Badami, 2020). Due to limited awareness of formal and informal sectors, consumers engage in backyard recycling and give E-waste to informal sectors (Garlapati, 2016). The availability of limited collection centres, disposal centres and especially in rural and semi-urban areas, informal recycling and backyard recycling are also the major factors (Arya & Kumar, 2020; Gaur et al., 2025). The absence of any business strategies for cooperation models between producers, recyclers and consumers hinders E-waste management as revealed by several studies. Some examples are producers do not pay attention to the issue of eco-design in electronic products (Gaur et al., 2024), consumers send their E-waste to informal sectors, and formal sectors do not provide any information about recycling to the government (Andersen, 2022; Borthakur, 2020). Tax relaxation and subsidy is also an important aspect of E-waste management (Garg, 2021). The entire system can be affected by

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changes in tax relaxation or subsidy as the recycling, segregation and collection of E-waste involves a significant amount of funding. (Garg 2021).

Small and medium sized enterprises (SMEs) are also significant “generators, handlers, users, collectors and disposers of electronic equipment, and thus have an important role in ensuring compliance with E-waste management norms. SMEs might have challenges to meet these requirements due to limited “financial resources, lack of technical knowledge, lack of employee training, regulatory requirement awareness and limited access to authorised collection and recycling facilities”. Appropriate storage, segregation, transporting, documenting, record keeping, and coordinating with authorised recyclers may also be required for compliance, and can be an additional operational and financial challenge for smaller businesses. The literature suggests that the factors affecting good E-waste management practice among SMEs are regulatory enforcement, skilled staff, E-waste recycling infrastructure, public awareness, and coordination among the stakeholders (Sama & Ntangeki, 2025). It is therefore important to understand the technology, financial, infrastructural, organisational and regulatory issues that are unique to SMEs in order to ensure their adherence to the E-waste management norms.

Review of Literature:

1. **Agrawal and Singh (2026)** analysed the significant challenges in E-waste recycling and reverse supply chain operations using blockchain. The study indicated the technological, infrastructure, financial and regulatory bottlenecks in blockchain adoption. The results showed that “infrastructure limitations, high energy consumption, fear of technology failure, risk aversion, and the absence of blockchain compatible tools and applications” were some of the most significant challenges that hinder the adoption of blockchain technology in E-waste management.
2. **Kaur and Arya (2026)** discussed the problems associated with the integration of the informal E-Waste collectors into the formal E-Waste management system in India. Three major categories of barriers were found: institutional barriers, barriers to engaging with institutional recyclers, and barriers within the informal recyclers. These were the limited “awareness of the government policies, inconsistency in regulation, less awareness of registered recyclers, competitive pricing, limited operational capacity, focus on monetary value and inadequate awareness of the environmental impact” of inappropriate E-waste management practices.
3. **Faradillah et al. (2025)** evaluated the sustainable transboundary e-waste management readiness of Malaysia's recycling industry. The regulatory framework, financial status and technological infrastructure proved to be the most effective drivers for the industry's preparedness for SWEM. The results also indicated that competitiveness, innovation and workforce development were critical priorities in the supply chain to enhance the long-term sustainability of the industry and environmental performance.



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4. **Sama and Ntangeki (2025)** investigated the effect of regulatory capability factors on the performance of E-waste management in reverse logistics for the informal small and medium enterprises in Dodoma city, Tanzania. The study revealed that the enforcement of the “E-waste rules, availability of skilled people and recycling facilities, awareness and understanding by the public, and their familiarity with E-waste as a hazardous material are main factors affecting E-waste reverse logistics performance. The study thus put forward the need to enhance regulatory enforcement, technical skills, infrastructure, stakeholder participation and awareness in the improved sustainable E-waste management of SMEs.
5. **Kankanamge et al. (2025)** analysed the micro-level determinants of the formalization of informal E-waste Urban-mining practices in Sri Lanka. The study revealed that the cognitive, affective, leadership and behavioural factors were the ones that shaped resistance to formalisation among the informal-sector workers. The factors were observed to contribute to the reinforcement of informal practices, even in the face of the environmental, health and economic risks of informal E-waste management, suggesting that behavior and organizational issues should be taken into account in the process of policy formation to formalise E-waste.
6. **Maurya et al. (2025)** explored the status quo of E-waste management, highlighting the obstacles in collection and recycling as well as in disposal and required measures for sustainable E-waste management. The report has revealed that when E-waste is not handled properly, hazardous materials like lead, mercury and cadmium are a big threat to the environment and health. The results pointed out the critical role of urban mining, material recovery, and policy support in promoting sustainable E-waste management.
7. **Farhoq et al. (2024)** analysed the legal duties pertaining to the post-use management of EEW, including that of electronic manufacturing companies and their responsibilities towards the waste management service providers and consumers. The study concluded the need for the producers to put in place effective return mechanisms, to have the traceability of waste transfers and to hire a licensed waste management company. It also noted the role of responsibility, reporting, auditing, and technical standards, providing a clear definition of each, as important tools for compliance with environmental duties.
8. **Gaur et al. (2024)** carried out a systematic review on Sustainable E-waste Management, Circular Economy Practices and the problems encountered for effective E-waste management. The study has revealed 7 serious challenges: rules and policies, infrastructure, consumers’ behaviour, informal sectors, community culture, technology and economic factors. The study also found that practices of reuse, recycling, remanufacturing, refurbishment, repair, reduction, recovery and repurposing as important practices related to the circular economy, which will help to make the management of E-waste more sustainable.
9. **Agarwal et al. (2024)**, gave an overview of E-waste, composition and source of e-waste and its effects on environment and human beings. The study has concluded that the “improper disposal of E-Waste could lead to hazardous substances like lead, mercury, cadmium, Brominated Flame Retardants, contamination of soil, water and air”. The results also showed



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that inadequate handling and disposal of e-waste can have a negative impact on the health and environment, emphasizing the need for “legislation, e-waste recycling, and public awareness” to mitigate the rising issue of e-waste.

10. **Moyo et al., (2022)** explored the obstacles to E-waste recycling in the context of a rapidly evolving regulatory landscape in South Africa (SA). The study concluded that strong collection network and sufficient local end-processing, refining and manufacturing capabilities were important prerequisites for developing a successful E-waste recycling industry. The results also highlighted that there was a need to tackle both the “availability and quality of E-waste inputs and the development of E-waste processing and manufacturing locally” at the same time.
11. **Turaga et al. (2019)** studied the problems and solutions related to E-waste management in India. The research identified main problems for effective E-waste management in the country as informal-sector E-waste practices, inadequate regulatory design and enforcement and lack of public awareness. The study also emphasized the need for a strong collaboration and participation of all stakeholders to create a comprehensive and effective E-waste management system.

Objectives of the Study:

1. To study about E-Waste and its environmental and health impacts.
2. To evaluate the challenges faced by SMEs in complying with E-Waste Management Norms.
3. To provide suggestions for effective E-Waste Management among SMEs.

Hypothesis:

H₀: There is no significant challenge faced by SMEs in complying with e-waste management norms.

H₁: There is a significant challenge faced by SMEs in complying with e-waste management norms.

Research Methodology:

Table No: 1 Research Methodology

Research Methodology	Details
Research Design	Descriptive
Data Collection	Primary and Secondary
Sampling Technique	Non-Probability Purposive Sampling
Sample Size	100 SMEs Manager
Sample Size Determination	An a priori power analysis was conducted using G*Power software (Faul et al.) to determine the minimum required sample size for the one-sample t-test. Based on the specified effect size, significance level, and statistical power, the required sample size was determined, and 100 SMEs were included in the study.
Statistical Technique	Parametric One-Sample t-test
Statistical Tool	R Studio Software



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Data Analysis and Interpretation:

Table No: 2 Challenges Faced by SMEs in Complying with E-Waste Management Norms (One Sample T-test)

Statement	Mean	t-value	p-value	Result
Difficulty in understanding e-waste norms.	4.182	28.614	0.000	Significant
Lack of awareness of e-waste regulations.	4.156	27.892	0.000	Significant
High cost of e-waste compliance.	4.214	31.276	0.000	Significant
Difficulty in maintaining e-waste records.	4.098	24.563	0.000	Significant
Difficulty in e-waste segregation.	4.126	25.841	0.000	Significant
Lack of authorized recyclers.	4.238	32.114	0.000	Significant
Difficulty in e-waste transportation.	4.117	25.376	0.000	Significant
Complex government reporting requirements.	4.091	23.984	0.000	Significant
Lack of trained employees.	4.173	28.047	0.000	Significant
Lack of proper storage facilities.	4.105	24.921	0.000	Significant
Difficulty in e-waste collection.	4.134	26.218	0.000	Significant
Lack of technical knowledge.	4.192	29.384	0.000	Significant
Limited financial resources.	4.225	31.642	0.000	Significant
Frequent changes in e-waste regulations.	4.168	27.531	0.000	Significant

The one-sample t-test results indicate that SMEs face significant challenges in complying with e-waste management norms. All 14 statements have mean scores above 4.00 and p-values of 0.000, indicating statistically significant challenges. The major challenges include the lack of authorized recyclers (Mean = 4.238), limited financial resources (Mean = 4.225), high cost of compliance (Mean = 4.214), and difficulty in understanding e-waste norms (Mean = 4.182).

The findings further show that SMEs experience difficulties related to technical knowledge, employee training, e-waste segregation, transportation, collection, record maintenance, storage, and government reporting requirements. Since all p-values are below 0.05, the challenges are statistically significant. Overall, the results confirm that SMEs encounter substantial difficulties in meeting e-waste management requirements, particularly due to financial, technical, infrastructural, and regulatory constraints.



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Table No: 3 Summary of Hypothesis Testing

Hypothesis 1: H ₀ There is no significant challenge faced by SMEs in complying with e-waste management norms. H ₁ There is a significant challenge faced by SMEs in complying with e-waste management norms.			
Test used	Results	Interpretation	Null/ Alternate
One sample t – test	H ₀ was rejected and H ₁ is accepted p value < 0.05	The results show that the There is a significant challenge faced by SMEs in complying with e-waste management norms	Alternate accepted

Figure No: 2 Challenges Faced by SMEs in Complying with E-Waste Management Norms



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Conclusion:

The results showed that SMEs have significant problems with compliance with the E-Waste Management Norms. The challenges do not only include regulatory considerations, but also knowledge of the regulations, awareness, financial resources, record keeping, segregation, collection, transportation, and access to certified recyclers. SMEs also face problems of trained manpower and technical knowledge, suggesting that human resource and technical capacity plays a key role in attaining effective e-waste management. The complexity of reporting and often changing regulations compound the challenge of keeping up with compliance. In general, the results indicate that the compliance of e-waste management among SMEs is affected by the complex and interconnected regulatory, financial, infrastructural, technical and operational constraints. More clarity in regulation, awareness, easier access to authorized recycling facilities, training, infrastructure and financial and institutional assistance are needed for solving these issues. Improving these areas will help SMEs enhance their compliance and help achieve better E-Waste management.

The results are in line with previous research which highlighted regulatory, infrastructural, technological, financial and awareness-related barriers as major issues for effective e-waste management. Turaga et al. (2019) pointed out some major hurdles in India, such as poor regulatory design and enforcement, low awareness, and challenges faced by the informal sector. Likewise, Kumar and Dixit (2018) found that there were some systemic barriers, such as lack of awareness, policy issues, infrastructure, and other policy issues related to e-waste management in India. Gaur et al. (2024) also pointed out rules and policies, infrastructure, technology, and economic factors as some of the primary constraints of sustainable e-waste management. The current results confirm these observations in the SME environment, as problems with understanding norms, record keeping, reporting demands, authorisation of recyclers and access to financial and technical resources were identified. Therefore, the findings confirm previous findings that there is a need to enhance the support for e-waste compliance through regulatory support, the availability of infrastructure, technical capacity and coordination of stakeholders.

Suggestions:

- The government should issue simplified and clear guidelines to take into consideration the understanding of SMEs about E-waste Management Norms and its compliance.
- Frequent awareness and training programs must be conducted to enhance the awareness of SMEs regarding E-waste regulation, safe handling, segregation and disposal procedures.
- Financial incentives like subsidies and tax exemption should be given to lower the cost burden of E-waste collection, transportation, storage and recycling.
- Creating a larger network of authorised recyclers and collection centres to ensure that SMEs can easily access formal E-waste disposal centres.
- It is essential to develop user-friendly digital systems that would help in the management of the E-Waste records, reporting, tracking, and other compliance-related activities.



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- Co-ordination among various stakeholders such as Government agencies, SMEs, authorised recyclers etc. should be enhanced for effective implementation of E-waste Management Norms.

AUTHOR(S) CONTRIBUTION

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CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

PLAGIARISM POLICY

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will take care by all authors. Journal and editors are not liable for aforesaid matters.

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