

E-WASTE REVOLUTION: INDIA'S JOURNEY TOWARDS SUSTAINABLE ELECTRONIC WASTE MANAGEMENT

¹Shivangi Rajani, ²Dr. Jayant Sonwalkar

^{1,2}Devi Ahilya University, Indore

Abstract

This paper discusses the issue of management of E-Waste (EW) in India, driven by the rising consumption of electronic products. EW is a global problem as it is dangerous to human health and the environment due to the presence of toxic chemicals. In India, the informal sector is a dominant player in managing EW, which uses crude recycling methods that further worsens the issue. Even after the E-Waste Management Rules 2016, formal sector compliance and infrastructure are absent. This paper assesses the current situation, identifies the challenges, and offers recommendations such as improving infrastructure, enhancing legislation, awareness campaigns, and encouraging formal recycling. India can learn from the best practices prevalent globally, like the stringent laws of Switzerland and the technological advancement of Japan, and so forth to improve its EW management and reduce health risks.

Keywords: EW, sustainability, electronic waste management.

1. Introduction

Context and Rationale:

The subject of electronic waste has become a major global concern in the management of the environment, primarily because of development in the use of electronic devices and the associated waste. Of all wastes, EW is predicted to be the fastest-growing waste stream in India, presenting potential hazards to the natural environment and human beings (Vats& Singh, 2014). This is because the country is among the leading generators of EW, with proper management posing a difficulty. If EW is not disposed or recycled appropriately, it pollutes the environment, as toxic heavy metals and other dangerous chemicals in EW leech into the soil, water, and air degrading the quality of the environment and potentially affecting the health of all living organisms including the humans (Garlapati, 2016).

In India, the informal sector predominantly manages EW, employing rudimentary techniques that significantly contribute to environmental pollution and pose severe health risks, particularly to individuals involved in the disposal process (Biswas et al., 2020). The formal sector of economy, however, faces compliance issues on enforcement as well as lacks in infrastructure. However, some serious loopholes are still present in the country even after the implementation of E-waste Management Rules 2016. Solving these problems is critical in reversing the harmful effects of EW on the environment and fostering sustainable development.

Objectives:

- To systematically review and evaluate the existing EW management practices in India.
- To identify gaps in the current practices and propose potential improvements.

2. Research Questions

1. What are the current practices for EW management in India?
2. What are the challenges encountered in the implementation of these practices?
3. How effective are these practices in achieving sustainability goals?
4. Which global practices can be adapted to the Indian context?

3. Methodology**Search Strategy:**

The systematic literature review (SLR) was conducted using a comprehensive search strategy to identify relevant literature on EW management practices in India. The following databases were used to ensure a wide coverage of peer-reviewed and high-quality sources: Google Scholar, PubMed, IEEE Xplore, and Scopus. The search terms included combinations of keywords such as "EW management," "India," "sustainability," "recycling practices," and "environmental impact." Boolean operators (AND, OR) were used to refine the search queries and ensure the retrieval of relevant studies.

Inclusion and Exclusion Criteria:

To maintain the relevance and quality of the review, specific inclusion and exclusion criteria were established:

- **Inclusion Criteria:**
 - Publications from the last 10 years to capture recent developments and current practices.
 - Peer-reviewed articles, conference papers, government reports, and case studies.
 - Studies specifically focused on EW management in India.
 - Articles available in full text.
- **Exclusion Criteria:**
 - Non-English articles to avoid language barriers.
 - Articles without full text available to ensure access to complete information.

Data Extraction:

A standardized data extraction form was developed to systematically collect and organize information from each selected study. The form included the following fields:

- Title
- Authors
- Year of publication
- Objectives of the study
- Methodology used
- Key findings
- Conclusions
- Recommendations for EW management practices

The selected papers were reviewed and relevant data was extracted and recorded in the form. This systematic approach ensured consistency and facilitated the synthesis of information across different studies.

PRISMA Flow Diagram:

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to ensure a transparent and reproducible review process. The PRISMA flow diagram illustrates the phases of the review:

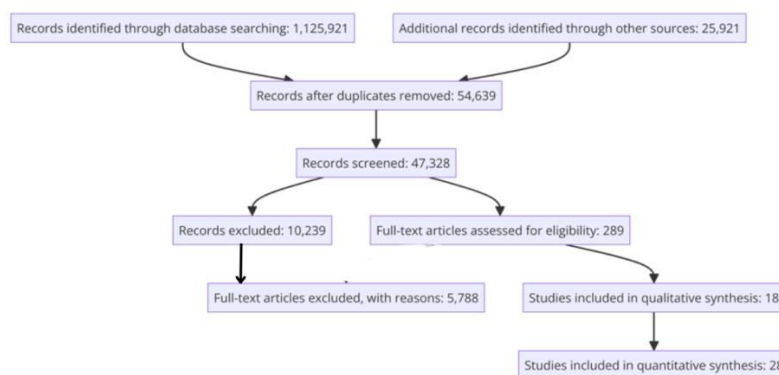


Figure 1: PRISMA Flow for research

The PRISMA flow diagram provides a visual summary of the selection process, highlighting the number of studies reviewed at each stage and the reasons for exclusion. This ensures the transparency of the methodology and allows for the replication of the review process.

4. Results

Overview of Selected Studies:

The papers published from 2008 to the end of 2022 have been taken into account. These studies comprised of qualitative, quantitative and combined approach in qualitative and quantitative research. The research methods employed in the reviewed papers were mostly qualitative,

including case-study and interview surveys that could offer significant and detailed information regarding the practice and issues of EW management in India (Garg & Adhana, 2019). Quantitative research, incorporating surveys and statistical analyses, was conducted to measure the efficiency and outcomes of various EW management strategies. This approach was selected for its ability to integrate both qualitative and quantitative research methods, providing a comprehensive and holistic perspective on the topic. The use of diverse methodologies enables a critical examination of the current EW management systems in India (Awasthi et al., 2016).

Current EW Management Practices:

India's EW management can be described in terms of a structured system where both the 'informal' and 'formal' systems are in operation. The formal facilities refer to the registered EW processors that are engaged in proper processing of wastes by following structures, policies or international standards in the formal sector (Awasthi & Li, 2017). These facilities employ new technologies in the process of depolarization, destroying, dismantling, refining, and eliminating EW in the least destructive or environmentally friendly ways (Bhaskar & Turaga, 2018). They are bound by legislation and policies like the E-waste Management Rules 2016, which gives rules concerning collection and proper management about the EW by manufacturers, importers and bulk consumers. These rules also ensure an extended producer responsibility (EPR) by making the producers responsible for taking back their products at their end use (Needhidasan et al., 2014).

While the formal sector is weak, informal players dominate EW management in India and they are not constrained by legal norms. This is due to the basic treatment techniques used by the informal EW handlers through open burning and acid baths to recover metals like gold and copper (Borthakur & Govind, 2017). These practices are very dangerous and highly toxic, causing environmental pollution and posing great health risks to the workers and communities in the vicinity. Nevertheless, the repercussions have kept on rising higher as the informal sector is really cheap and inefficient since there is a large pool of unskilled labor force (Annamalai, 2015).

Challenges:

The analysis revealed several significant issues in the proper handling of EW in India, as noted in the review. Firstly, there is a severely limited framework for the actual collection and sorting of EW (Thakur & Kumar, 2022). Big business houses of the formal sector have superior facilities to recycle used electronics, but these are highly constrained in terms of physical capacity and infrastructure to deal with the enormous quantities of EW expected (Dutta & Goel, 2021). Secondly, consumers and small-scale producers of EW are basically unaware of the environmental and health consequences that result from environmentally unsustainable methods

of disposing of EW. This results in a low recycling rate of recyclable materials, thus informal recycling systems being favoured (Kumar & Dixit, 2018).

Regulatory enforcement is another major consideration. In India, awareness of the E-waste Management Rules 2016 is effective, though its implementation is mostly ineffective (Ravindra & Mor, 2019). There is no regulation of informal operators who operate without much supervision. The lack of sufficient funding is a primary factor hindering the development of an effective EW management system (Gautam et al., 2022). The practice of formally disposing of recyclable materials also requires a considerable commitment in terms of investment, which is regrettably rare (Agrawal & Mittal, 2017). Moreover, from the end-users' and suppliers' perspective, there are economic pains involved in going through formal recycling mechanisms since most people prefer going for the non-formal method, which is cheaper (Patil & Ramakrishna, 2020).

Effectiveness:

At the moment, various current practices of electronic waste management in India fall into different categories of efficiencies and inefficiencies (Hossain et al, 2015). The more formally organized sector, albeit small, has shown that environmentally sustainable methods of recycling and disposal of electronic waste exist (Ari, 2016). It helps to minimize the emissions of dangerous materials into the surroundings and resource recycling, thus striving for the creation of a circular economy (Kumar et al., 2016). However, because of the low coverage and handling capacity, the bulk of the EW finds its way to the informal sector and entails environmentally unsustainable practices with many associated health risks (Sharma et al., 2020).

The informal sector is more economical because its services cost less and materials are returned faster (Vats & Singh, 2014). Meanwhile, the U.S. benefits economically but overlooks the environmental and public health impacts (Rathore, 2020). The existing laws and policies have not fully explained how they effectively disincentivize the informal actors or encourage proper recycling (Laha, 2014). Hence, to sum it up, the efficacy of EW management practices in India is yet to show sustainability improvements toward environmentally sound EW management practices (Mary & Meenambal, 2016).

Best Practices:

Considering the review, several successful experiences of EW management in other countries are also outlined that might be suitable for adoption in the Indian context (Rene et al., 2021). For example, regarding EW management, Switzerland boasts intricately developed legislation and has vast coverage on boosting awareness about EW. In the context of the Swiss system, there is a very high response from customers in the subject matter of recycling due to the availability of convenient points for deposition of materials and a responsive legal action in the capacity of the enforcement of producer responsibility (Srivastava & Pathak, 2020). The implementation of

similar approaches in India might improve awareness and enactment of e-scrap laws and regulations (Rautela et al., 2021).

Currently, in Japan, the EW management has achieved high efficiency level of recycling through installation of technology (Shreyas Madhav et al., 2022). Automation and robotics in the dismantling of EW provide minimal human contact with associated dangers and improve the efficiency of recovering valuable parts (Awasthi et al., 2019). When such technologies are introduced in India, it could be of significance to formal recycling centers to enhance their operations security and effectiveness.

A perspective of Germany on EW management has indicated that EPR is a significant aspect of this process. Generally, the depository of German regulations states that the manufacturers of these products are to fund the collection and recycling of their production (Shittu et al., 2021). This approach not only shifts the burden on manufacturers but also influences the design of products more sustainably (Verma, 2020). To further improve the efficiency of EPR regulations in the country, it is necessary to continue its development and ensure strict compliance with the established measures in India. Since this would contribute to the regulation of EW and make producers more responsible (Koshta et al., 2021).

Nevertheless, there are other methods, and one of them is the use of the successful practice of Public-Private Partnerships (PPPs), which have been implemented in several countries including the USA and Australia (Bridgens et al, 2019). PPPs involve a convergence of the strength of the two sectors; the government sector to provide the necessary supervision while the private sector provides the much-needed efficiency and creative ideas (Kapoor et al., 2021). Formation of PPPs in India could enable the introduction of proper infrastructure development through attracting the required investment and could also result in the setting up an efficient and comprehensive EW management (Ashfaq & Khatoon, 2014; Awasthi et al., 2018).

Thus, the study concludes that it is imperative for India to recognize that successful electronic waste (EW) management necessitates comprehensive, multi-faceted planning. (Supian et al., 2015). Enhancement of the formal sector in this area, increased public awareness of the concept and strict compliance with the relevant regulations and legislation is required. Simultaneously, the adoption of appropriate international practices and the promotion of innovation in recycling technologies for electronic waste can significantly enhance the effectiveness of waste treatment (Breivik et al., 2014; Naik & Eswari, 2022). If India can manage these issues and implement necessary changes to better align with global best practices, then the impacts of EW on the environment and health of our planet can be reduced (Beula & Sureshkumar, 2014).

5. Discussion

Synthesis of Findings:

The presented systematic review provides evidence of dual structures of EW management in India that can be distinguished as the formal and the informal sectors. There is an analysis that points out that the issues of capacity and infrastructural constraints hinder adherence to best practices in the formal sector (Kumar et al., 2017). On the other hand, the informal sector that manages a vast percentage of the EW employs dangerous procedures that have unpleasant consequences on the environment and human health (Mishra et al., 2017). The study reveals that there are some concerns in the EW management policy since awareness, infrastructure, and financial incentives are the constraints towards great achievement (Suja et al., 2014).

The issues highlighted, including the poorly developed and unavailability of required infrastructure, scanty community awareness, and compromised standards of regulatory compliance, significantly complicate the EW management practices in India (Hashmi & Varma, 2019). Even worse, the informal sector dominates the Comrades Marathon as it erases all the efforts of the formal sector besides spreading environmental degeneration and health repercussions. Financial challenges also worsen these problems because formal recycling facilities are expensive to set up and maintain. (Masud et al., 2019).

Recommendations:

As for the case of EW management in India, complex changes are called for. Here are key recommendations based on the synthesis of findings:

i.) Strengthen Infrastructure:

- To increase the quantity and quality of available facilities, involve more money in the development and improvement of these services throughout the nation.
- Expansion of more collection points as well as establishing those that will suit the intensive areas both in the urban and rural settings.
- Examine the possession and application of additional innovations for dismantling and recycling in order to enhance productivity and safety in the process.

ii.) Enhance Regulatory Enforcement:

- Lay more emphasis on the compliance of laws by enhancing surveillance and enhancing punitive measures on anyone violating these laws.
- Require restricted licensing for all handlers and recyclers of EW.
- To make the benefit real, encourage transparency and accountability through timely reporting and auditing.

iii.) Promote Public Awareness:

- Encouraging proper EW management should be conducted through radio and television commercials, billboards, and fliers; all should be intended for the nationwide community.
- Advocate for the recycling process and ensure that the consumers are provided with the correct information concerning disposal practices and related centers.
- Engage elders, women, and men of influence to encourage people to embrace the formal practices of recycling.

iv.) Incentivize Formal Sector Participation:

- Offer various forms of incentives like rebates, discounts, or credits to organizations and people for them to consider recycling with proper waste disposal facilities.
- Retailers and manufacturers should be made to undertake their EPR schemes more effectively to collect their products for recycling.
- Government should engage in partnering with private players to seek capital and skills from them through PPPs.

v.) Integrate Best Practices:

- Include best practices from international countries like how Switzerland developed a complete recycling policy and technologically advanced ways for EW adopted by Japan.
- Urging government, industry, and academia sector to work collectively in sourcing and nurturing creativity, especially for Indian conditions.
- Making use of pilot projects to introduce new strategies as well as growing successful campaigns and projects.

6. Conclusion**Summary of Key Findings:**

A systematic review presented in this paper with regards to the management of EW in India discusses a sharp divide between the formal and informal sectors. The formal sector fully observes legal provisions on environmental protection but sadly it lacks adequate infrastructure and capacity. On the other hand, the informal sector is virtually in charge of ‘managing’ EW through unauthorized methods, adversely affecting the environment and human health in the process. The review highlights the importance of key issues that include inadequate and poor infrastructure, low community awareness, poor and/or weak regulatory compliance, and limited funding. The established EW management strategies are hence not effective, and there is a need for overall measures.

Implications for Policy and Practice:

The conclusion of this paper holds significant policy implications for future policy formulation and implementation, the players in the automotive industry, and society in general. Policymakers should also note that there is a necessary call for enhancement of the regulatory standards and

their enforcement so that they are implemented by both the formal and the informal economy. For such policies to have any influence and effectiveness; they should be supported by a sound inspection system and severe penalties should be imposed in the event of non-compliance. Further, it also requires investment in infrastructure to develop and expand the coverage/processing capacities in the desired recycling channels. To extended parties, the EPR should be implemented even more enthusiastically as this will minimize complications and optimize accountabilities to manage the sustainable product lifecycle. Government should employ its efforts towards subsidizing or providing incentives such as tax reductions to encourage companies to recycle through the formal sector. Other measures are also relevant, such as the promotion of consumer education, because consumers will only recycle EW appropriately if they are aware of the correct processes to follow. Raising public awareness on the consequences that EW has on the environment and health, as well as introducing the advantages of legitimate recycling increases the involvement rates and contributes to sustainable EW management.

Future Research Directions:

Community research should explore a few research areas in more detail to improve EW management in the future. The current study aims at carrying out an economic analysis of EW recycling with the view of comparing the costs and revenues of varying recycling facilities. Appreciation of the effects on the economy could bring increased support and involvement of both parties to the market. Moreover, the study of the unorganized EW sector and its effect on the management system is needed. Further studies should entail an assessment of the extent of environmental degradation and the effects on the health of informal workers as well as examining the concept of candidates being absorbed into the formal economy through the extension of special internships. It is also worthy of investigation to look at how technology can help enhance the management of EW. Technological solutions, for instance, automation and applications of new recycling forms increase EW processing efficiency and reduce the risks associated with such work. The success stories documented in other technologically advanced countries can therefore act as prototypes for replicating similar projects in the Indian context. In conclusion, it should be pointed out that more research in the field of EW management should be conducted at the intersection of economics, environmental science, and technology to effectively tackle challenges related to handling of waste electrical and electronic equipment and to build the ground for a better future.

Therefore, it could be concluded that there are strategies that can be implemented to enhance EW policies in India and decrease the amount of EW produced but the issue is still a major problem. An improvement in the existing infrastructure for the collection, transportation, recycling and disposal of EW along with the upgrading of laws for its proper enforcement, increased public awareness about the problems, its effects, and the advent of efficient technology can still be done for the preservation of the environment a sustainable India.

References

1. Agrawal, S. R., & Mittal, D. (2017). Need of an online EW market in India. *International Journal of Environment and Waste Management*, 19(1), 21-41.
2. Annamalai, J. (2015). Occupational health hazards related to informal recycling of EW in India: An overview. *Indian journal of occupational and environmental medicine*, 19(1), 61-65.
3. Ari, V. (2016). A review of technology of metal recovery from electronic waste. *EW in transition—From pollution to resource*, 122-158.
4. Ashfaq, A., & Khatoon, A. (2014). Environmental impacts and assessment of electronic waste management. *International Journal of Current Microbiology and Applied Sciences*, 3(7), 772-779.
5. Awasthi, A. K., & Li, J. (2017). Management of electrical and electronic waste: A comparative evaluation of China and India. *Renewable and Sustainable Energy Reviews*, 76, 434-447.
6. Awasthi, A. K., Cucchiella, F., D'Adamo, I., Li, J., Rosa, P., Terzi, S., ... & Zeng, X. (2018). Modelling the correlations of EW quantity with economic increase. *Science of the Total Environment*, 613, 46-53.
7. Awasthi, A. K., Li, J., Koh, L., & Ogunseitan, O. A. (2019). Circular economy and electronic waste. *Nature Electronics*, 2(3), 86-89.
8. Awasthi, A. K., Zeng, X., & Li, J. (2016). Environmental pollution of electronic waste recycling in India: A critical review. *Environmental pollution*, 211, 259-270.
9. Beula, D., & Sureshkumar, M. (2021). A review on the toxic EW killing health and environment—Today's global scenario. *Materials Today: Proceedings*, 47, 2168-2174.
10. Bhaskar, K., & Turaga, R. M. R. (2018). India's E-Waste Rules and Their Impact on E-Waste Management Practices: A Case Study. *Journal of Industrial Ecology*, 22(4), 930-942.
11. Biswas, A., Singh, S. G., & Singh, S. G. (2020). EW management in india: Challenges and agenda. *Centre for Science and Environment*, 1-58.
12. Borthakur, A., & Govind, M. (2017). Emerging trends in consumers' EW disposal behaviour and awareness: A worldwide overview with special focus on India. *Resources, Conservation and Recycling*, 117, 102-113.
13. Breivik, K., Armitage, J. M., Wania, F., & Jones, K. C. (2014). Tracking the global generation and exports of EW. Do existing estimates add up?. *Environmental science & technology*, 48(15), 8735-8743.
14. Bridgens, B., Hobson, K., Lilley, D., Lee, J., Scott, J. L., & Wilson, G. T. (2019). Closing the loop on E-waste: A multidisciplinary perspective. *Journal of Industrial Ecology*, 23(1), 169-181.
15. Dutta, D., & Goel, S. (2021). Understanding the gap between formal and informal EW recycling facilities in India. *Waste Management*, 125, 163-171.
16. Garg, N., & Adhana, D. (2019). EW management in India: A study of current scenario. *International Journal of Management, Technology And Engineering*, 9.

17. Garlapati, V. K. (2016). EW in India and developed countries: Management, recycling, business and biotechnological initiatives. *Renewable and Sustainable Energy Reviews*, 54, 874-881.
18. Gautam, A., Shankar, R., & Vrat, P. (2022). Managing end-of-life solar photovoltaic EW in India: A circular economy approach. *Journal of Business Research*, 142, 287-300.
19. Hashmi, M. Z., & Varma, A. (2019). *Electronic Waste Pollution*. Springer, Switzerland, https://doi.org/10.1007/978-3-030-26615-8_13.
20. Hossain, M. S., Al-Hamadani, S. M., & Rahman, M. T. (2015). E-waste: a challenge for sustainable development. *Journal of Health and Pollution*, 5(9), 3-11.
21. Kapoor, N., Sulke, P., & Badiye, A. (2021). EW forensics: An overview. *Forensic Science International: Animals and Environments*, 1, 100034.
22. Koshta, N., Patra, S., & Singh, S. P. (2021). Estimation of EW at micro level for reverse logistics: A case of Delhi. *Journal of Cleaner Production*, 314, 128063.
23. Kumar, A., & Dixit, G. (2018). An analysis of barriers affecting the implementation of EW management practices in India: A novel ISM-DEMATEL approach. *Sustainable Production and Consumption*, 14, 36-52.
24. Kumar, A., Holuszko, M., & Espinosa, D. C. R. (2017). EW: An overview on generation, collection, legislation and recycling practices. *Resources, Conservation and Recycling*, 122, 32-42.
25. Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, S. J., Arya, S., ... & Cheeseman, C. (2017). Challenges and opportunities associated with waste management in India. *Royal Society open science*, 4(3), 160764.
26. Laha, S. (2014). Informality in EW processing: An analysis of the Indian experience. *Competition & Change*, 18(4), 309-326.
27. Mary, J. S., & Meenambal, T. (2016). Inventorisation of EW and developing a policy—bulk consumer perspective. *Procedia Environmental Sciences*, 35, 643-655.
28. Masud, M. H., Akram, W., Ahmed, A., Ananno, A. A., Mourshed, M., Hasan, M., & Joardder, M. U. H. (2019). Towards the effective EW management in Bangladesh: a review. *Environmental Science and Pollution Research*, 26(2), 1250-1276.
29. Mishra, S., Shamanna, B. R., & Kannan, S. (2017). Exploring the awareness regarding EW and its health hazards among the informal handlers in Musheerabad area of Hyderabad. *Indian journal of occupational and environmental medicine*, 21(3), 143-148.
30. Naik, S., & Eswari, J. S. (2022). Electrical waste management: Recent advances challenges and future outlook. *Total Environment Research Themes*, 1, 100002.
31. Needhidasan, S., Samuel, M., & Chidambaram, R. (2014). Electronic waste—an emerging threat to the environment of urban India. *Journal of Environmental Health Science and Engineering*, 12, 1-9.
32. Patil, R. A., & Ramakrishna, S. (2020). A comprehensive analysis of EW legislation worldwide. *Environmental Science and Pollution Research*, 27(13), 14412-14431.

33. Rathore, G. J. S. (2020). Circulating waste, circulating bodies? A critical review of EW trade. *Geoforum*, 110, 180-182.
34. Rautela, R., Arya, S., Vishwakarma, S., Lee, J., Kim, K. H., & Kumar, S. (2021). EW management and its effects on the environment and human health. *Science of the Total Environment*, 773, 145623.
35. Ravindra, K., & Mor, S. (2019). EW generation and management practices in Chandigarh, India and economic evaluation for sustainable recycling. *Journal of Cleaner Production*, 221, 286-294.
36. Rene, E. R., Sethurajan, M., Ponnusamy, V. K., Kumar, G., Dung, T. N. B., Brindhadevi, K., & Pugazhendhi, A. (2021). Electronic waste generation, recycling and resource recovery: Technological perspectives and trends. *Journal of Hazardous Materials*, 416, 125664.
37. Sharma, M., Joshi, S., & Kumar, A. (2020). Assessing enablers of EW management in circular economy using DEMATEL method: An Indian perspective. *Environmental Science and Pollution Research*, 27(12), 13325-13338.
38. Shittu, O. S., Williams, I. D., & Shaw, P. J. (2021). Global EW management: Can WEEE make a difference? A review of EW trends, legislation, contemporary issues and future challenges. *Waste Management*, 120, 549-563.
39. Shreyas Madhav, A. V., Rajaraman, R., Harini, S., & Kiliroor, C. C. (2022). Application of artificial intelligence to enhance collection of EW: A potential solution for household WEEE collection and segregation in India. *Waste Management & Research*, 40(7), 1047-1053.
40. Srivastava, R. R., & Pathak, P. (2020). Policy issues for efficient management of EW in developing countries. In *Handbook of Electronic Waste Management* (pp. 81-99). Butterworth-Heinemann.
41. Suja, F., Abdul Rahman, R., Yusof, A., & Masdar, M. S. (2014). e-Waste Management Scenarios in Malaysia. *Journal of Waste Management*, 2014(1), 609169.
42. Supian, N. S., Shah, G. L., & Yusof, M. B. M. (2015). Current waste generation of EW and challenges in developing countries: an overview. *Malaysian Journal of Civil Engineering*, 27(1).
43. Thakur, P., & Kumar, S. (2022). Evaluation of EW status, management strategies, and legislations. *International Journal of Environmental Science and Technology*, 19(7), 6957-6966.
44. Vats, M. C., & Singh, S. K. (2014). EW characteristic and its disposal. *International Journal of ecological science and environmental engineering*, 1(2), 49-61.
45. Vats, M. C., & Singh, S. K. (2014). Status of EW in India-A review. *transportation*, 3(10), 16917-16931.
46. Verma, A. K. (2020). EWs and their impact on environment and public health. *International Journal of Applied Research*.