International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Impact Factor: 6.882, Volume 05, No. 04(III), October - December, 2023, pp. 146-152

E-WASTE MANAGEMENT IN INDIA: ISSUES AND STRATEGIES

Dr. Kakuli Chowdhury*

ABSTRACT

Many issues plague India's current approaches to managing electronic waste. These include inadequate legislation, a lack of public awareness, hazardous informal recycling practices, difficulties in inventorying, and a refusal on the side of corporations to address the core issues. The effects include (i) the introduction of harmful substances into the waste stream without measures to prevent their known negative impacts on human and environmental health, and (ii) the loss of resources due to the disposal of economically valuable materials or the development of unhealthy conditions during informal recycling. The paper examines the related issues and potential solutions to this growing problem, considering the steps implemented in India. This article's goal is to propose a waste management system that would make numerous parties—including customers, importers, recyclers, regulatory agencies, and electronic device manufacturers and assemblers—responsible for collecting and recycling electronic trash.

Keywords: *E-Waste, Management, India, Recycling.*

Introduction

When compared to other global industrial sectors, the electronics industry stands head and shoulders above the others [1]. It has played an essential role in the sustained social, economic, and technological advancement of civilizations for the last several years. Any material that is disposed of or is required to be disposed of in accordance with national legislation is considered a waste according to the Basel agreement. There are two main types of waste: chemical and physical. There are several varieties of trash that it includes, and the phrase "e-waste" is just one of them. "Electronic waste," or "e-waste" as it's more commonly referred to, is an umbrella term encompassing a variety of obsolete electrical and electronic items. With the rise of consumer-targeted business strategies, rapid product obsolescence, and technological breakthroughs, a new environmental challenge has emerged. This problem is the threat posed by "Waste Electrical or Electronic Equipment (WEEE)" or "e-waste," which consists of obsolete electronic devices. Table 1 displays the many meanings of electronic waste from different conventions. When it comes to global garbage, e-waste is one of the fastest-growing categories. It is anticipated that by 2010, the percentage of WEEE in developing nations' total solid trash would have increased from one percent to two percent [2].

The first major challenge with WEEE creation is the sheer volume of material, and the second is finding a suitable location to dispose of it in an ecologically responsible way. Studies reveal that India produces around 3,300,000 tons of this rubbish year [3], and the overall amount of electronic trash generated by 2011 was over 4.8 tons, as projected. Approximately 113.26 million new cellular customers were added in 2008, with an average of 9.5 million added every month, according to data from TRAI . [4] While 168.11 million people made use of cellular services in 2003 and 2004, 261.97 million people did so between 2007 and 2018. Appliance sales, including air conditioners and microwaves, increased by about

* Professor in Chemistry, Government College Bibirani, Khairthal, Tijara, Rajasthan, India.

25% in 2006. During the 2006–2007 fiscal year, 4.2 million refrigerators were sold, representing a 17% increase in manufacturing compared to the previous year. Sales of washing machines were historically low in 2006, thus it was a banner year for the sector. Color televisions (CTVs) had a tripling of their retail sales by 2007 [5]. Out of the total quantity of electronic waste, only around 19,000 tons are recycled, with the informal sector accounting for 95% of that total. The valuable components included in electronic trash make recycling it a financially feasible option. These components include silver, gold, copper, and other strategic and precious metals. The uncontrolled recycling operations conducted by the informal sector pose a risk to both human and environmental health due to the disassembly of electronic debris and the extraction of precious materials [6]. This juxtaposition of a recently developed problem with an expanding economic opportunity is intriguing in light of the enormous amount of electronic garbage that is being generated and the fact that this waste comprises both beneficial and detrimental components. only around 2% of electronic trash contains harmful pollutants, whereas about 35% is plastic [7]. Iron, copper, aluminum, gold, and other metals are abundant in almost 60% of electronic trash. The informal sector processes and extracts recoverable by-products from electronic garbage using relatively basic and dangerous technologies. The difficulty stems from the fact that the recovery and extraction operations in the informal sector are completely uncontrolled. The collecting, sorting, and deconstruction activities carried out by the informal sector are advantageous to both society and the environment. Secondary processing is frequently more efficient than the informal sector's mostly manual processing. Because secondary processing is more efficient, this is the case, and the environmental advantages follow. In addition to ensuring the ecologically appropriate recycling of electronic trash, the social advantages linked with the maintenance and development of jobs within the industry contribute to its overall health. So, even when economies go from unregulated to regulated, the informal sector keeps playing a significant role [8]. The already massive issue of solid waste management in India has been exacerbated by electronic garbage. Free trade makes an already difficult situation much worse by making it easier for electronic waste from wealthy nations to reach underdeveloped countries [9]. The article provides realistic solutions for managing India's enormous amounts of electronic garbage. Both the origins of e-waste and the present legislation in India are covered in detail.

Table 1: According to the Various Agreements, the Definition of Electronic Waste

Ref	Definition
EU WEEE Directive (EU, 2002a)	"Equipment that is electrical or electronic and is considered waste, including all components, sub-assemblies, and consumables that are a part of the product at the time of disposal." According to Article 1(a) of Directive 75/442/EEC, the term "waste" refers to "any substance or object which the holder disposes of or is required to dispose of in accordance with the provisions of national law in force."
Basel Conventi on Action Network (Puckett & Smith, 2002)	"It is important to note that the term e-waste refers to a wide variety of" electronic equipment that have been abandoned by their owners. These devices include big household appliances like refrigerators, air conditioners, mobile phones, personal stereos, and consumer electronics, as well as computers .
OECD (2001)	Any electronic device that is powered by an electric power supply that has reached the end of its useful life.
Sinha (2004)	A piece of electrically powered equipment that no longer fulfills the requirements of its original owner for the function for which it was purchased.
StEP (2005)	"The reverse supply chain" is what is meant by the term "e-waste."

Literature Review

Turaga, R. M. R., Bhaskar, K., Sinha, S., Hinchliffe, D., Hemkhaus, M., Arora, R., ... & Sharma, H. (2019). Electronic trash, or e-waste, is rapidly becoming one of the world's most rapidly growing waste sources. Mobile phones and laptops, among other electronic devices, produce this kind of trash when they have served their useful life. Worldwide, the yearly output of electronic waste is projected to surpass 50 million tons in 2020.2. India ranks among the top five countries in the world for electronic waste creation, with an estimated annual production of 2 million tons. The informal sector plays a significant role in India's electronic waste disposal, as it does in many other developing nations. This industry is responsible for processing almost 90% of all waste. Electronic waste contains a wide variety of materials, including plastic, wood, glass, metals (both ferrous and non-ferrous), rare earth elements, and precious metals. Using non-scientific methods to treat electronic waste is associated with several health and environmental consequences.3) Many countries, both developed and developing, have passed regulations addressing the points made above in the previous few decades.

Arya, S., & Kumar, S. (2020). Discarded electronics are a secondary source of gold, silver, and other precious metals. Urban mining of these metals has recently attracted a lot of interest due to its profitable prospects, increased economic potential, "source of livelihood, and, ultimately, the attainment of the agenda for Sustainable Development Goals (SDGs) 2030". However, due to the presence of toxic chemical components, the massive quantity of electronic waste becomes an overpowering problem at this time. The enormous quantity of electronic waste has given rise to complex problems around its disposal options, as it has detrimental effects on human and environmental health. In addition to technological know-how and a well-established administrative architecture, most wealthy nations also have practical technologies for dealing with electronic waste. When it comes to developing nations, though, things are different due to the abundance of challenges and the lack of situation-specific solutions. The lack of data inventory, illegal waste disposal, and treatment options are the three most important problems plaguing India's electronic waste value chain. Accordingly, this article's goal is to go over the strategic interventions that are in line with the regulations that are now in effect. To ensure long-term viability of the e-waste value chain, preservation of resources, enhancement of social welfare, mitigation of environmental consequences, and sustainable development in general, these measures are crucial. Furthermore, relevant solutions like bioleaching, life cycle assessment, eco-product design, circular resource management, extended producer responsibility, the polluter pays principle, and the 4R principle were recognized and taken into consideration as possible future directions for the Indian context. An key and highly recommended stage is the formalization of the informal sector into a publicly accessible recycling system.

Ganguly, R. (2016). Present practices for electronic waste management in India have many flaws, such as an inadequate inventory, dirty conditions of informal recycling, inadequate legislation, ignorance, and corporate unwillingness to tackle the big problems. As a result, hazardous compounds end up in the waste stream despite efforts to prevent their harmful impacts on people and the planet. When commercially useful materials are discarded or unsafe circumstances are created during informal recycling, recoverable by-products are also squandered. This article aims to provide a brief introduction to the concept of electronic garbage, including its history in India and the potential dangers it poses to human and environmental health. Additionally, it emphasizes the economics of recycling electronic waste, which includes both the established informal sector and the newly emerging official sector, and the pressing need for better-defined laws and regulations to deal with this problem.

Thakur, P., & Kumar, S. (2022). One form of solid waste that is rapidly expanding globally is e-waste. The export of electronic garbage, both domestically and outside, could be a contributing factor to this increase. There is cause for worry over the potential risks to human and environmental health posed by this solid waste stream, which is thought to include a mixture of valuable and hazardous materials. After the consumer development stage, there are several open efforts worldwide that aim to successfully manage electronic equipment. In response to the growing amount of electronic waste, environmental organizations in several developing nations, including China and India, have come up with and are implementing environmentally beneficial strategies and opportunities to reduce human impact on the environment. Many industrialized nations have made managing their electronic trash a top concern, and they have set up facilities to handle the vast amounts of electronic garbage that have been produced. Nevertheless, the full adoption of the WEEEs management system is hindered in low-income nations such as India due to economic factors, inadequate infrastructure, and the introduction of unsuitable laws. Our study's overarching goal is to give light on the evolution of electronic waste, its transnational movement, and the approaches taken by developed and developing nations to its treatment. We would spread these outcomes into both regulated and non-controlled nations to better manage electronic waste.

E-Waste in India

Since electronic waste is not separately collected in India, accurate statistics on the amount of electronic rubbish produced and disposed of annually are unavailable. Because of this, the level of environmental threat is unknown. When people in India need to get rid of old electronics, they usually just buy new ones and trade in the old ones. The preferred method is this one. About 78% of all computers in India are owned and used by businesses, according to research by Toxics Link (2003). Computers that have outlived their usefulness in businesses often end up for sale at auction. It is usual practice for educational institutions and humanitarian groups to take in old computers for recycling. Businesses and households in India are projected to manufacture 1.38 million outdated personal computers every year. Several sources have contributed to the estimations that have led to this value. Research released by the Confederation of Indian Industries (CII, 2006) estimates that 1,46,000 tons of electronic and electrical equipment ends up in India's landfills every year due to obsolescence or breakdown.

Household PC usage ranges from 0.39 to 1.70, depending on income class, according to a field survey that examined the typical usage and lifespan of personal computers (PCs), televisions (TVs), and mobile phones in the Indian metropolis of Chennai (Shobbana Ramesh and Kurian Joseph, 2006). Time spent on mobile phones ranged from 0.88 to 1.70 minutes, whereas that of televisions was between 1.07 and 1.78 minutes. At 5.94 years, 8.16 years, and 2.34 years, respectively, for personal computers, televisions, and mobile phones, lower-income families are in the minority. Alternatively, higher-income households tend to have longer usage periods for personal computers (3.21 years), televisions (5.13 years), and mobile phones (1.63 years). Despite India's comparatively modest rubbish production per person at the moment, the country's total absolute volume of garbage will be tremendous. Additionally, it is growing at a faster rate. The 80% growth rate of mobile phones is far greater than that of personal computers (20%) and televisions (18%). Researchers used a structured questionnaire to gauge participants' familiarity with electronic waste and their willingness to pay for its disposal at various points in the study. The survey found that about half of the population is aware of the harmful impacts of electronic items on both human and environmental health. Public willingness to pay for electronic waste management ranges from 3.57% to 5.92% of PC product cost, 3.94% to 5.95% of TV product cost, and 3.4–5% of mobile phone product cost.

Also, Agarwal (1998) and Toxics Link (2004) both state that a lot of electronic waste comes from foreign nations. Unfortunately, accurate estimates of the size of these transboundary e-waste streams are unavailable. The reason for this is that much of the e-waste trafficking is done covertly, pretending to gather "donations" or "reusable" equipment from affluent countries. It is hard to tell what proportion of imports are made of used electronic equipment since the government-collected trade data does not distinguish between new and old PCs and peripheral components .

Categorization of E-Waste

It is difficult to define electronic waste due to the large number of components, many of which include substances that are either considered hazardous or nonhazardous. According to the European Union Directive (EU 2002), there are 10 distinct categories of electronic waste that make up WEEE. There are many different types of WEEE, as shown in Table 2. Of these, items falling into the categories 1–4 account for 95% of the total [10].

Table 2: Different Categories of WEEE

Sr. No	Category	Label	% Contribution
1	Large home appliances and appliances	Large HH	42.1
2	A modest family home	Small HH	4.7
3	Equipment for the general public	ICT	33.9
4	It is lighting apparatus.	CE	13.7
5	Electrical and electronic	Lighting	1.4
6	Playthings, as well as recreational and athletic gear	E&E tools	1.4
7	In the case of medical devices, with the exception of all goods that have been deployed and contaminated,	Toys	0.2
8	The equipment used for monitoring and control	Devices used in medicine	1.9
9	Automated dispensing machines	M&C	0.1
10	Automated dispensing machines	Dispensers	0.7

Impacts of E-Wastes

Electronic trash has the ability to inflict widespread environmental damage due to the use of hazardous materials in their manufacture (Mehra, 2004). Primary components of such garbage include cathode ray tubes (CRTs), printed board assemblies, capacitors, mercury switches and relays, batteries, liquid crystal displays (LCDs), photocopying machine cartridges, selenium drums (photocopiers), and electrolytes. These wastes include various forms of lead, mercury, and hexavalent chromium, among other dangerous compounds . These wastes also include electrolytes. Despite its relative obscurity, e-waste contains a number of harmful substances. These include lead and cadmium in circuit boards, mercury in switches and flat screen monitors, cadmium in computer batteries, polychlorinated biphenyls (PCBs) in older capacitors and transformers, and brominated flame retardants on PCBs, plastic cases, cables, and polyvinyl chloride (PVC) insulation that, when burned, release extremely toxic dioxins and furans. There are printed circuit boards in all electronic devices that contain lead (in the form of solder), brominated flame retardants (often ranging from 5 to 10 percent by weight), and antimony oxide (about 12 percent by weight), which is also present as a flame retardant (Devi et al, 2004). The chemical makeup of these PCBs makes them extremely hazardous.

The disposal of electronic waste in landfills poses a threat of lead seepage into groundwater. Ramachandra and Saira (2004) state that crushing and burning the CRT might release toxic fumes into the air. All sorts of rechargeable batteries are packed into these things. When destroyed in fires or dumped in landfills, the toxic chemicals contained in each of these batteries might cause environmental contamination. The amount of cadmium found in just one cell phone battery is enough to pollute 600 cubic meters of water (Trick, 2002). There is a great deal of dangerous contamination caused by the anticipated medium- and long-term effects of cadmium seeping into the dirt surrounding the disposal site, and landfills contain a lot of cadmium (Envocare, 2001). Electronic device housings and printed circuit boards often include brominated flame retardants. The environmental and human health risks posed by some of these flame retardants are self-evident. Because plastics are so easily ignited, this is the result.

- **Impacts of Informal Recycling**

India physically separates the various components of accumulated electrical and electronic waste. Pcbs, CRTs, wires, plastics, metals, condensers, and other parts like batteries—which are now gaining value—are all part of these fractions. For disorganized recyclers, it's a way of life, yet they endanger not just themselves but also the ecosystem due to their ignorance. The valuable fractions undergo a series of conditioning and refining processes to produce components with dual reuse potential: as secondary raw materials and as direct reusable components. No elaborate machinery or PPE is required for the extraction of the different materials. Although it is done totally by hand, the only equipment utilized to finish the job are screwdrivers and hammers. It is not uncommon for both children and women to be included during the surgery. Dispose of garbage components with no resale or reuse value in open landfills. These parts are set ablaze outside. The production of fugitive emissions and slag containing heavy metals that are detrimental to human health is a direct outcome of the environmental problems associated with backyard smelting using crude procedures. One of the outcomes of CRT breaking operations is the risk of injuries from cutting and chemicals used to remove heavy metals. Another result is the difficulty in breathing produced by shredding, burning, and other procedures. They employ powerful acids for the aim of extracting precious metals like gold. Workers can be exposed to dangerous chemicals over time if they are compelled to operate in confined places without proper ventilation and if they do not possess the requisite technical abilities. It is possible to extract copper from wires by burning polychlorinated biphenyls (PCBs) found in older capacitors and transformers and brominated flame retardants found on printed circuit boards, plastic casings, cables, and polyvinyl chloride (PVC) cable insulation. These substances can release highly hazardous dioxins and furans.

Examining the societal and environmental impacts of electronic trash on a larger scale finds a mixed bag of pros and cons (Alastair, 2004). Some people think that recycling old electronics can enhance infrastructure, create more jobs, and open up new sources of raw materials and gadgets. This will hasten the region's economic development even further. To be sure, the new wealth and benefits aren't distributed fairly, and it's not always the case that electronics contribute to society's growth. Small, dispersed, and hard to regulate companies make up the bulk of those that "recycle" electronic waste. The low labor costs are a direct outcome of high unemployment rates, poor peasants migrating within the country, and the lack of political mobilization or protest from affected villages. These villages see e-waste as their only hope for a sustainable income or entry into modern development projects. Because they are so embedded in the shadow economy, they are not counted in official statistics and hence remain virtually unnoticed by the state.

Waste Management Strategies

The best way to deal with electronic trash is to reduce its amount. It is important for designers to prioritize making products that can be repaired and/or upgraded. Use of less hazardous, readily recoverable, and recyclable materials should be prioritized. Refurbishment, remanufacturing, disassembly, and reuse should all be possible with these materials. Ramachandra and Saira (2004) state that material recycling and reusing constitute the next tier of practical options for reducing electronic waste. It is possible to lessen the quantity of electronic trash by recycling materials like as metals, plastic, glass, and others. If these options are considered, there's a chance they might reduce energy waste and stop the release of toxic chemicals into the environment.

Everyone from producers to shoppers to government officials at the state and local levels has to start taking this issue seriously today. By doing so, we can be confident that we're addressing all of the important aspects shown in Figure 1 in a coordinated fashion. In order to foster businesses like this, a national regulatory framework and a "e waste-policy" are urgently required. Whoever develops an e-waste policy should be someone well-versed in the challenges. This is why it's crucial for businesses to start working together on rules while still including consumers. Improving the efficiency of collection and recycling systems is crucial for the long-term viability of electronic waste management systems. One way to achieve this is by forming public-private partnerships to set up buy-back or drop-off locations. Another approach is to build in additional funding, like advance recycling fees, into the design of the systems.

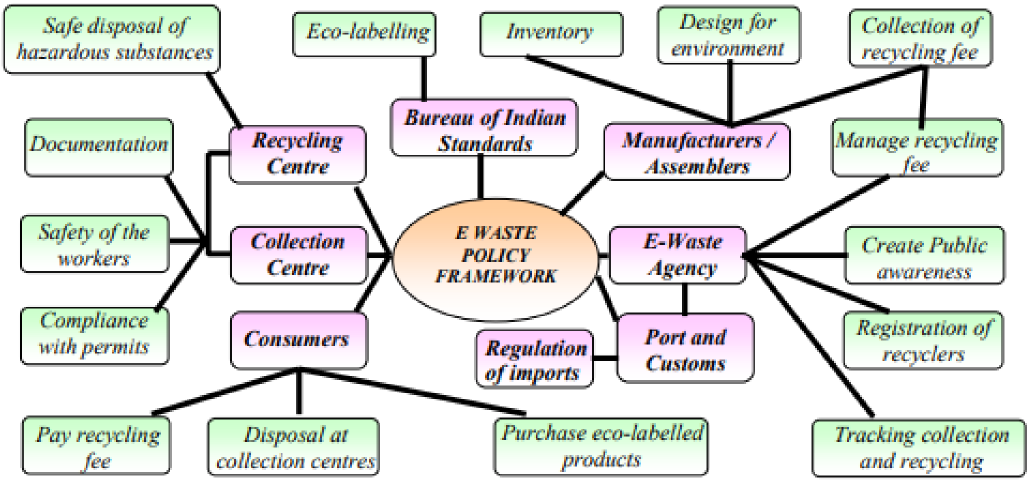

Figure 1: Various components of India's electronic waste management system

Environmental and Health Effects of e-Waste

All of the negative effects on the environment caused by hazardous waste may be traced back to its many emissions, including primary, secondary, and tertiary ones. Primary emissions are the hazardous waste components of electronic waste, as opposed to secondary emissions, which are usually the consequence of inadequate treatment of electronic waste and lead to the generation of furans and dioxins. Among these dangerous byproducts include heavy metals including lead, arsenic, mercury, and PCBs. Tertiary emissions are produced when hazardous material is recycled because harmful chemicals are used in the process [27]. White goods refer to common household equipment; brown goods to more specialized items like televisions and cameras; and grey goods to more complex items like computers, printers, and scanners. The majority of consumer electronics fall into the "white goods" category. Researchers found that compared to white and brown products, gray ones were much riskier [28–29].

Because of their complex composition, EEEs represent a threat to human and environmental health if not handled properly. Some of their constituent parts include toxic substances. The improper execution of recycling and disposal processes is a common cause of these hazards.

Lymphocytes are destroyed, growth retardation is brought on by the unfavorable influence on human reproductive systems (male and female). Some of the major health consequences of the illness are these. The hazardous chemicals included in e-waste pose a threat to vital organs including the liver and kidneys in addition to the central nervous system. Without proper protective gear, prolonged exposure to these compounds increases the risk of skin cancer, anemia, carcinogenic tumors, and hormonal problems. Problems including hypertension and mental health difficulties also exist [30].

Conclusion

The already enormous task of managing solid trash in India is become much more difficult due to the explosion of electronic waste, especially computer waste. Quantification, features, current disposal techniques, environmental ramifications, and any other pertinent elements should be part of an urgently needed full review of the current and future situation. The environmentally appropriate disposal of electronic waste can only be achieved via the establishment of national and/or regional institutional infrastructures. Included in these systems should be mechanisms for collecting, transporting, treating, storing, recovering, and disposing of electronic waste. It would be beneficial for manufacturers and private enterprises to work together to build infrastructure for electronic waste collection, exchange, and recycling.

Model facilities that employ eco-friendly recycling and recovery technologies and procedures are anticipated to be established. The development of standards for the collection and eventual disposal of electronic trash is imminent. The establishment of rules for electronic waste, the enforcement of controls over its import and export, and the encouragement of infrastructure development should all be part of policy-level interventions. A take-back program that encourages producers to make products with fewer dangerous components, easier to disassemble, reuse, and recycle, and with less trash as an outcome could help reduce waste. There should be deposit or refund programs, reporting requirements, enforcement mechanisms, and goals for electronic device collection, reuse, or recycling if we want to encourage consumers to send their old devices back for processing. Designing for end-of-life management should be a primary focus when creating new electronic items.

References

1. Thakur, P., & Kumar, S. (2022). Evaluation of e-waste status, management strategies, and legislations. International Journal of Environmental Science and Technology, 19(7), 6957-6966.
2. Ganguly, R. (2016). E-Waste management in India-An overview. International Journal of Earth Sciences and Engineering, 574-588.
3. Arya, S., & Kumar, S. (2020). E-waste in India at a glance: Current trends, regulations, challenges and management strategies. Journal of Cleaner Production, 271, 122707.
4. Turaga, R. M. R., Bhaskar, K., Sinha, S., Hinchliffe, D., Hemkhaus, M., Arora, R., ... & Sharma, H. (2019). E-waste management in India: Issues and strategies. Vikalpa, 44(3), 127-162.
5. Chalana, A., Singh, K., Sharma, S., Bhardwaj, V., & Rai, R. K. (2023). E-waste management: prospects and strategies. In Microbial technology for sustainable e-waste management (pp. 303-318). Cham: Springer International Publishing.
6. Wath, S. B., Vaidya, A. N., Dutt, P. S., & Chakrabarti, T. (2010). A roadmap for development of sustainable E-waste management system in India. Science of the Total Environment, 409(1), 19-32.
7. Heeks, R., Subramanian, L., & Jones, C. (2015). Understanding e-waste management in developing countries: Strategies, determinants, and policy implications in the Indian ICT sector. Information Technology for Development, 21(4), 653-667.
8. Pariatamby, A., & Victor, D. (2013). Policy trends of e-waste management in Asia. Journal of Material Cycles and Waste Management, 15, 411-419.
9. Debnath, B., Das, A., & Das, A. (2022). Towards circular economy in e-waste management in India: Issues, challenges, and solutions. In Circular Economy and Sustainability (pp. 523-543). Elsevier.
10. Mundada, M. N., Kumar, S., &Shekdar, A. V. (2004). E-waste: a new challenge for waste management in India. International journal of environmental studies, 61(3), 265-279.
11. Kumar, S., Agarwal, N., Anand, S. K., & Rajak, B. K. (2022). E-waste management in India: A strategy for the attainment of SDGs 2030. Materials Today: Proceedings, 60, 811-814.
12. Lakshmi, S., & Raj, A. (2017). A review study of e-waste management in India. Asian Journal of Applied Science and Technology (AJAST) Volume, 1, 33-36.
13. Wath, S. B., Dutt, P. S., & Chakrabarti, T. (2011). E-waste scenario in India, its management and implications. Environmental monitoring and assessment, 172, 249-262.
14. Biswas, A., Singh, S. G., & Singh, S. G. (2020). E-waste management in india: Challenges and agenda. Centre for Science and Environment, 1-58.
15. Garg, C. P. (2021). Modeling the e-waste mitigation strategies using Grey-theory and DEMATEL framework. Journal of Cleaner Production, 281, 124035.

❖◆❖