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E-Waste Management: As a Challenge to Public Health in India

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ABSTRACT: Electronic waste (e-waste) is a rapidly growing environmental concern that poses significant challenges to public health, particularly in countries like India. With the rapid advancement of technology and the increasing use of electronic devices, the generation of e-waste has escalated to alarming levels. This study explores the impact of e-waste on public health in India and the challenges associated with its management. The improper handling and disposal of e-waste lead to the release of hazardous substances such as lead, mercury, cadmium, and brominated flame retardants into the environment. These toxic materials can contaminate soil, air, water, and food sources, resulting in severe health consequences for both humans and ecosystems. Adverse health effects include respiratory problems, neurological disorders, reproductive issues, and an increased risk of cancer. India, being one of the largest consumers of electronic products, faces a significant challenge in managing e-waste effectively. The country lacks comprehensive legislation and infrastructure for the proper collection, recycling, and disposal of e-waste. Informal recycling practices, characterized by unsafe methods and the involvement of marginalized communities, further exacerbate the health risks. Several initiatives have been undertaken by the Indian government and non-governmental organizations to address the e-waste challenge. The E-Waste Management Rules, 2016, were introduced to regulate e-waste handling, recycling, and disposal. The establishment of authorized recycling centers and the promotion of extended producer responsibility aim to shift the burden of e-waste management onto manufacturers.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

The amount of "e-waste," or electronic garbage, is currently a significant issue in India. Because electronic trash is the part of the official municipal waste stream that is increasing the fastest in the globe, its disposal is a significant environmental and public health concern. Electronic waste Electrical and electronic equipment refers to electrical or electronic items that have been carelessly abandoned, are excess, are old or defective. Since most Indians don't know how to properly dispose of electronic garbage, it is common for individuals to keep it in their homes. The intricate structure of this ever-growing trash makes it a rich source of metals like gold, silver, and copper that may be recovered and added back into the manufacturing process [1]–[3]. As a result, many different groups of individuals in India are employed by e-waste trading and recycling partnerships. In Delhi alone, there are over 25,000 employees, including minors, employed in crude dismantling plants where 10,000–20,000 tonnes of e-waste are handled yearly with bare hands. E-waste is dangerous to human health and our ecology when it is improperly disassembled and processed. Consequently, it has become apparent how important good e-waste management is. Reviewing the threats to public health as well as available defenses against this expanding threat is essential [4], [5].

The cost of e-waste

With the rise of e-waste in India, managing solid trash has become a challenging problem. In 2005, 1, 46,000 tonnes of garbage from damaged or outdated electronic and electrical equipment were predicted to have been produced; by 2012, this amount is anticipated to approach 8,00,000 tonnes. However, the Greenpeace Report states that India produced 380,000 tonnes of e-waste in 2007. Only 3% of this made it to the premises of the approved recyclers. This is due, in part, to the fact that many industrialized countries now dump their waste in India. According to a research by the Basel Action Network, 50–80% of the e-waste that the United States collects is sold to India, China, Pakistan, Taiwan, and many African nations. India is one of the world's fastest expanding economies, and the country's domestic demand for durable goods has been soaring. Worldwide sales of residential appliances, both big and small, increased by 53.1% between 1998 and 2002. According to another study, businesses and families in India throw away 1.38

million personal computers yearly, which accelerates the 10% annual growth rate of e-waste creation and has an impact on environmental health indices.

Impacts on Health

Lead, cadmium, beryllium, and brominated flame retardants are only a few of the dangerous metals pollutants found in electronic equipment (see Table 1). Over 60% of e-waste is made up of metals including iron, copper, aluminum, gold, and other metals. Plastics make up approximately 30% of the garbage, while hazardous pollutants make up just about 2.80%. The most pervasive dangerous heavy metal utilized in electronic gadgets for diverse reasons is lead, which offers a number of health risks owing to environmental pollution. Food, water, air, and soil can allow lead to enter biological systems. Because they absorb more lead from their surroundings than adults do and because it affects their nervous system and blood, children are more susceptible to lead poisoning. It was discovered that the recycling of e-waste in China, one of the main e-waste destinations, has contributed to the increasing blood lead levels in children. This was a result of the very rudimentary methods and procedures employed during recycling efforts. Numerous studies have shown the alarmingly high concentrations of hazardous heavy metals and organic pollutants in samples of Guiyu, China's dust, soil, river sediment, surface water, and groundwater. Skin damage, headaches, vertigo, nausea, persistent gastritis, and stomach and duodenal ulcers were all common among the locals in the same places. Furthermore, it was discovered that there was no discernible difference between boys and girls in the blood lead levels of youngsters, which were higher than the Chinese average [6], [7].

DISCUSSION

Current E-Waste Management Situation

India primarily relies on the unorganized sector for e-waste recycling since there are so few established e-waste recycling facilities. In the bulk of the country's urban slums, where untrained personnel perform risky processes without personal protective equipment, endangering not only their health but also the environment, over 95% of the country's e-waste is handled and processed. Facilities for recycling and treatment need a significant upfront investment, especially those outfitted with cutting-edge technical machinery and procedures. These laborers barely get Rs. 5 or 10 for disassembling a single computer component. Workers' lives are ruined for such a tiny sum. Such "backyard recyclers" lack equipment for human health protection, exhaust-waste gas treatment, or wastewater treatment facilities. Williams said that the issue seems to be getting worse despite receiving a lot of media attention and the implementation of various national level trade prohibitions. In order to analyze the effects and improper management of end-of-life electronic waste in underdeveloped nations, health risk assessments are also necessary.

Management of Electronic Waste

The "polluter pays principle" was established by the Environmental Act of 1986 to hold those responsible for pollution accountable for the costs associated with environmental harm. It is referenced in principle 16 of the Rio Declaration on Environment and Development, which is international environmental law. Extended producer responsibility is another name for polluter pays. The Environment Act of 1986 gives the federal and state governments the authority to adopt laws that protect the environment and people from exposure to trash that is poisonous and harmful. Any breach of this act's provisions or its published guidelines is punishable. If certain e-waste norms and regulations are broken, the offender may face such a penalty.

A official set of instructions for the correct and environmentally friendly handling and disposal of electronic trash was just released by CPCB India, who is now completing the set of regulations. With the aid of NGOs, the Ministry of Environment and Forests is now reviewing the regulations developed by producers of electronic equipment. E-waste is included in schedules 1, 2, and 3 of the "Hazardous Waste Rules 2003" and the Municipal Solid Waste Management Rule, 2000, per the updated recommendations released by CPCB in 2007. When an electronic device becomes e-waste, each maker of a computer, music system, mobile phone, or other electronic device will be "personally" accountable for the ultimate safe disposal of the equipment. A thorough technical manual on "Environmental Management for Information Technology Industry in India" has also been developed and distributed by the Department of Information Technology, Ministry of Communication and Information Technology. The DIT has also established demonstration projects at Indian Telephone Industries for the extraction of copper from printed circuit boards.

Many electronic businesses, including Apple, Dell, and HP, have launched different recycling programs in

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an attempt to educate consumers about the need of recycling e-waste. The "recycling campaign" for the Indian area was unveiled by Nokia India. Regardless of manufacturer, the campaign urged mobile phone customers to dispose of their unwanted phones and accessories at any of the 1,300 green recycling bins placed across the priority dealers and care facilities. Nokia also intends to start a program for managing electronic trash [8], [9]. The Delhi government's Department of Environment has also decided to include ragpickers in the city's general garbage management. They will get training, uniforms, ID cards, and employment as garbage cleaners. Since these eco-clubs will be engaging with the local ragpickers in that region, the department also plans to include them in this effort. Eco-clubs are already operating in over 1,600 government and private schools in the Capital.

E-Waste Management Research

To evaluate the current state of India's e-waste management system, to determine the precise scope and amount of the issue in Indian cities, and to build links with the unofficial recycling industries, many more environmental epidemiology studies are needed. These studies will provide useful information that will aid in creating an e-waste management action plan. India needs to start monitoring illnesses and the effects of e-waste on human health. The collection and recycling mechanisms must be improved in order to guarantee the sustainability of e-waste management systems. Establishing public-private partnerships would be ideal for establishing buy-back or drop-off locations. Another method for guaranteeing the sustainability of waste management is to charge upfront recycling costs. Finding the finest e-waste management technologies worldwide and effectively implementing them might be essential for a sustainable, futuristic development. The elimination of dangerous materials from electronic and electrical equipment and the encouragement of the adoption of safer replacements The Restriction of Hazardous Substances Regulations are widely used in the manufacturing of these products. There should be an increasing number of these safer alternatives that may be employed in electrical devices [10].

E-waste, or electronic waste, has become a significant challenge to public health in India due to the rapid growth of technology and its improper disposal. E-waste refers to discarded electronic devices, including computers, mobile phones, televisions, refrigerators, and other electronic appliances. These devices contain hazardous materials such as lead, mercury, cadmium, and brominated flame retardants that pose serious risks to human health and the environment when not managed properly. India, being one of the largest consumers of electronic goods, faces a growing e-waste crisis. The country generates a substantial amount of e-waste every year, with estimates suggesting that India produced approximately 3.2 million metric tons of e-waste in 2019, and this number continues to rise.

The improper handling and disposal of e-waste have several detrimental effects on public health. When e-waste is dumped in landfills or incinerated, harmful chemicals and heavy metals are released into the air, soil, and water, leading to pollution and contamination. These pollutants can enter the food chain, impacting agricultural produce and posing health risks to people. Direct exposure to e-waste can also lead to severe health consequences. Informal recycling practices, which are prevalent in India, involve dismantling electronic devices manually without proper protective measures. Workers, often unaware of the hazards, come into direct contact with toxic substances, leading to respiratory problems, skin disorders, and long-term health complications. Children and women, who are involved in e-waste recycling activities, are particularly vulnerable to the health hazards associated with e-waste.

Addressing the challenge of e-waste management requires a comprehensive approach involving various stakeholders. The government of India has taken steps to tackle the issue by implementing the E-Waste (Management) Rules in 2016, which mandates the proper disposal and recycling of e-waste. The rules emphasize the responsibility of producers, consumers, and recyclers in ensuring the safe handling and recycling of electronic waste. Furthermore, awareness campaigns and educational programs are essential to educate the public about the risks associated with e-waste and the importance of responsible disposal. Encouraging extended producer responsibility (EPR) can also play a significant role, wherein manufacturers take responsibility for the entire life cycle of their products, including the collection and recycling of e-waste.

Establishing proper e-waste collection centers, recycling facilities, and formalizing the informal sector are vital steps in creating a sustainable e-waste management system. Engaging in safe and environmentally friendly recycling processes, such as dismantling electronic devices using proper techniques and protective equipment, is crucial to

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safeguard the health of workers and prevent the release of hazardous materials. Additionally, promoting research and innovation in e-waste management technologies can help develop efficient recycling methods, including safe extraction of valuable materials from electronic waste while minimizing environmental and health risks. Controlling e-waste, or electronic waste, is essential to minimize its environmental and health impacts. Here are several strategies and practices that can help control e-waste:

Reduce Consumption:

One of the most effective ways to control e-waste is by reducing the consumption of electronic devices. Consider whether you truly need a new device before making a purchase. Opt for durable and repairable products that have a longer lifespan, reducing the frequency of disposal.

Donate or Sell:

Instead of discarding functioning electronic devices, consider donating them to charities, schools, or organizations in need. You can also sell them through online platforms or trade them in for discounts when purchasing new devices. This extends the lifespan of electronic products and reduces e-waste generation.

Responsible Recycling:

When electronic devices reach the end of their useful life, it is crucial to recycle them responsibly. Look for certified e-waste recycling facilities or authorized collection centers that ensure proper handling and disposal of e-waste. These facilities employ environmentally friendly methods to extract valuable materials and safely manage hazardous substances.

Extended Producer Responsibility (EPR):

Encourage manufacturers to take responsibility for the entire life cycle of their products through EPR programs. This includes setting up collection and recycling systems for their products once they reach the end of life. Supporting companies that practice EPR can help promote sustainable e-waste management.

Educate and Raise Awareness:

Create awareness among individuals, businesses, and communities about the importance of responsible e-waste management. Educate people about the environmental and health hazards associated with improper disposal and the benefits of recycling. Promote campaigns and initiatives that highlight the significance of controlling e-waste.

Promote Repair and Upcycling:

Encourage repair and upcycling of electronic devices whenever possible. Support local repair shops or do-it-yourself (DIY) repair initiatives. This not only extends the life of the device but also reduces the need for new purchases and subsequent e-waste generation.

Legislative Measures:

Advocate for strong e-waste management policies and regulations at the governmental level. Encourage policymakers to enforce and strengthen existing laws related to e-waste management. These regulations should address proper disposal practices, recycling standards, and penalties for illegal dumping of e-waste.

Consumer Awareness:

Educate consumers about the significance of purchasing electronic devices from reputable brands that prioritize sustainable practices and promote recycling. Encourage consumers to choose products that are energy-efficient and have minimal environmental impact throughout their life cycle.

Green Design:

Encourage electronics manufacturers to adopt green design principles. This involves designing products that are environmentally friendly, easily recyclable, and use fewer hazardous materials. Green design also focuses on minimizing the overall environmental impact of electronic devices.

International Cooperation:

Recognize that e-waste is a global issue and requires international cooperation. Support initiatives that promote responsible e-waste management practices globally and encourage collaboration among countries to address e-waste challenges collectively. Controlling e-waste requires a collective effort from individuals, businesses, manufacturers, and policymakers. By implementing these strategies and practices, we can significantly reduce the environmental and health impacts associated with electronic waste.

E-waste management presents a significant challenge to public health in India. The improper disposal and handling of e-waste contribute to environmental pollution and pose health risks to communities, particularly those involved in informal recycling practices. Effective management strategies, including proper disposal, recycling, and raising awareness, are essential to mitigate the health hazards associated with e-waste. A collaborative effort involving the government, manufacturers, consumers, and recycling industries is necessary to create a sustainable and safe e-waste management system that protects public health and the environment.

CONCLUSION

One of the world's most serious environmental challenges is the toxic nature of e-waste. The issue is becoming worse due to the rising volume of e-waste brought on by a lack of knowledge and the necessary skills. There is an urgent need to develop a preventative strategy in connection to the health risks of handling e-waste among these employees in India since a huge number of workers in this country are engaged in the crude disassembly of these electronic goods for their living and their health is at danger. These employees should get the necessary training on the safe management of e-waste and personal safety. Many technological solutions exist for managing e-waste, but before they can be implemented in the management system, it is necessary to develop the necessary legal framework, collecting system, logistics, and labor. Operational research and evaluation studies can be necessary for this. However, there is a need for increasing public understanding of the significance of appropriate e-waste disposal. Public education campaigns and the efficient application of e-waste management rules may motivate people and companies to adopt sustainable practices. To preserve the public's health, it is essential to strengthen the official recycling industry, provide employees the necessary training and safety equipment, and support research and innovation in e-waste management technology. In conclusion, e-waste presents a serious threat to India's public health. A multifaceted strategy comprising governmental changes, infrastructure creation, public education, and industry cooperation is needed to address this problem. India can reduce the health hazards connected with this growing issue and pave the path for a sustainable and healthier future by giving proper handling and disposal of e-waste top priority.

REFERENCES:

[1] A. Muhammad, M. Z. S. Muhammad Hussein, M. H. Zulfakar, and V. P. K. Sundram, 'Reverse logistics activities for household e-waste management: A review', *Int. J. Supply Chain Manag.*, 2020.

[2] A. Katti, M. B. Shinde, and N. V. Patil, 'Nursing students knowledge, attitude, and practice towards E-Waste management', *Journal of Critical Reviews*. 2020. doi: 10.31838/jcr.07.07.24.

[3] H. Ismail and M. M. Hanafiah, 'A review of sustainable e-waste generation and management: Present and future perspectives', *Journal of Environmental Management*. 2020. doi: 10.1016/j.jenvman.2020.110495.

[4] Monika and J. Kishore, 'E-waste management: As a challenge to public health in India', *Indian J. Community Med.*, 2010, doi: 10.4103/0970-0218.69251.

[5] S. Kumar *et al.*, 'Challenges and opportunities associated with waste management in India', *Royal Society Open Science*. 2017. doi: 10.1098/rsos.160764.

[6] R. Joshi and S. Ahmed, 'Status and challenges of municipal solid waste management in India: A review', *Cogent Environmental Science*. 2016. doi: 10.1080/23311843.2016.1139434.

[7] L. Chand Malav *et al.*, 'A review on municipal solid waste as a renewable source for waste-to-energy project in India: Current practices, challenges, and future opportunities', *J. Clean. Prod.*, 2020, doi: 10.1016/j.jclepro.2020.123227.

[8] K. K. Prajapati, M. Yadav, R. M. Singh, P. Parikh, N. Pareek, and V. Vivekanand, 'An overview of municipal solid waste management in Jaipur city, India - Current status, challenges and recommendations', *Renew. Sustain. Energy Rev.*, 2021, doi: 10.1016/j.rser.2021.111703.

[9] 'Solid Waste Management in Urban India: Imperatives for Improvement', *J. Contemp. Issues Bus. Gov.*, 2019, doi: 10.47750/cibg.2019.25.01.001.

[10] S. Dolui and S. Sarkar, 'Identifying potential landfill sites using multicriteria evaluation modeling and GIS techniques for Kharagpur city of West Bengal, India', *Environ. Challenges*, 2021, doi: 10.1016/j.envc.2021.100243.

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Circular Economy Concepts for Managing Electronic Waste Sustainably: Problems and Management Choices

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ABSTRACT: The electronic and electrical industrial sector is exponentially growing throughout the globe, and sometimes, these wastes are being disposed of and discarded with a faster rate in comparison to the past era due to technology advancements. As the application of electronic devices is increasing due to the digitalization of the world (IT sector, medical, domestic, etc.), a heap of discarded e-waste is also being generated. Per-capita e-waste generation is very high in developed countries as compared to developing countries. Expansion of the global population and advancement of technologies are mainly responsible to increase the e-waste volume in our surroundings. E-waste is responsible for environmental threats as it may contain dangerous and toxic substances like metals which may have harmful effects on the biodiversity and environment. Furthermore, the life span and types of e-waste determine their harmful effects on nature, and unscientific practices of their disposal may elevate the level of threats as observed in most developing countries like India, Nigeria, Pakistan, and China. In the present review paper, many possible approaches have been discussed for effective e-waste management, such as recycling, recovery of precious metals, adopting the concepts of circular economy, formulating relevant policies, and use of advance computational techniques. On the other hand, it may also provide potential secondary resources valuable/critical materials whose primary sources are at significant supply risk. Furthermore, the use of machine learning approaches can also be useful in the monitoring and treatment/processing of e-wastes.

KEYWORDS: Circular Economy, Electronic Wastes, Environmental Health, Recycling Recovery.

INTRODUCTION

E-waste is any device that uses an electromagnetic field and electrical currents but is undesired, broken, or has reached the end of its useful life. It hides a broad variety of electrical equipment, from bulky home appliances to machinery for the telecom and IT industries. Additionally, it includes equipment from the toy, automotive, sports, and medical industries. various components of electrical and electronic equipment, such as cathode ray tubes, printed circuit boards, discarded batteries, and electric cables. As 69 elements from the periodic table, including precious metals, Critical Raw Materials, and noncritical metals like iron and aluminum, may be found in EEE, the material design of EEE is quite complicated [1].

The environment is producing several kinds of e-waste. Our houses, the IT industry, the car industry, the medical industry, and other companies that use electrical and electronic components might all be potential producers of e-waste. According to the European regulatory organizations for e-waste disposal, there are ten types of e-wastes. Due to the many dangerous inorganic and/or organic elements they may contain, discarded e-wastes may result in serious issues. Air conditioners, cars, microwave ovens, refrigerators, lights, washing machines, phones, and printers are a few prominent forms of e-waste that include toxic heavy metals that are very dangerous. Persistent organic pollutants, electrolytes, X-ray and radioactive compounds, as well as medical and laboratory equipment, are all utilized in chips, batteries, and other medical and laboratory equipment. These e-wastes may have a number of negative repercussions, and among the factors most to blame for their production include changes in regulation, shorter material lifespans, and technological advancements. Toxic heavy metals including lead, mercury, and chromium as well as persistent organic pollutants may be dangerous materials. Effects of electronic waste on environment and human health. If improperly managed, discarded e-wastes may have negative effects on both the environment and human health, such as chronic health problems and environmental damage. In the parts that follow, a particular section relating to issues brought on by e-waste is illustrated.

Environmental Impact

E-waste pollution of the environment, including the soil, water, and other biota, results from improper disposal practices. Heavy metals and particulate particles are reportedly released into the environment by e-waste disposal sites and recycling facilities. Hazardous and non-hazardous materials have been separated from e-waste into two categories. Heavy metals, polycyclic aromatic hydrocarbons, poly dibenzofurans, brominated diphenyl ethers, and polychlorinated dibenzo-p-dioxins are examples of hazardous chemicals. Non-hazardous substances include, among others, the metals Cu, Se, Pt, and Ag. When present in excess of permitted levels, both types of contaminants discharged by e-waste are harmful to the environment and human health. The effects of e-waste vary for the same kind of e-wastes since they rely on the age of the particular e-waste. Pollutants may be reduced or postponed by recycling, but the high volume of e-waste still results in a massive buildup of pollutants in landfills and the environment. E-waste recycling practices in developing nations like India, Nigeria, Pakistan, and China discharge heavy metals and other refractory pollutants into the environment. When these dangerous chemicals are released into the environment, they are quickly linked to several processes, including bioaccumulation, food contamination, and general exposure to ecological processes, which puts everyone at risk.

Affects Air Quality

Several different e-waste pollutants are released into the atmosphere as dust or odors. Humans are mostly exposed by ingestion, inhalation, and skin absorption. Due to their frequent breathing, high risk of in utero exposure, frequent breastfeeding, excessive hand-to-mouth activity, frequent food intake, and poor toxicant clearance rates, children and babies are thought to be the most vulnerable to improper handling of e-waste. The processing and recycling of e-waste at Guiyu, China, Agbogbloshie, Ghana, the National Capital Territory region, India Shershah, Pakistan, Lagos, Nigeria, and Dhaka, Bangladesh produces hazardous primary and secondary e-waste toxicants that are released into the environment. These toxicants include Hg, Pb, Cd, PCBs. However, depending on the sort of work being done in the neighborhood, the amount of toxins in the air may differ. For instance, significant amounts of Pb and Cu are released into the environment from recycling and disposal sites that are often connected with electrical components. Since these toxins may remain in one location for a very long period and can move over enormous distances, the atmosphere serves as a medium for their dispersion. These metals may be bio-accumulated in the life of water, soil, and plants and will have major negative effects on the intake of contaminated food or water since they are suspended in the form of particle matter and also become deposited on the soil surface and open water resources.

Affects Water Quality

Numerous studies have also shown that waste effluents are equally to blame for water contamination. Recent years have seen a plethora of research on the removal of various harmful dyes and heavy metals from water. Electrical and electronic equipment disposal companies and other e-waste-related activities use leaching and dissipating processes to release contaminants from e-waste into groundwater and surface water. According to research by Luo et al., the amount of polybrominated diphenyl ethers in sediment samples taken from the Nanyang River near Guiyu Town has greatly risen, and carp from this river had a high potential for bioaccumulation. Top predators in an aquatic habitat near an e-waste recycling factory ingested 1091 ng/g PBDE and 16,512 ng/g PCBs on a wet weight basis, according to research on snakes by Wu et al. In the Pearl River Delta, research on the water flow from downstream locations has shown an increased amount of PBDE and PCBs. In addition to PBDE, brominated flame retardants such decabromodiphenyl ethane and 1, 2-bis ethane, etc., were found in the Pearl River Delta's downstream areas. Water resources in the neighborhood with e-waste recycling and detention facilities don't meet general water quality criteria in terms of pH, total dissolved solids, hardness, chlorides, and conductivity.

Affects the Soil's Health

Recent decades have seen a dramatic rise in human activity, which releases small quantities of dangerous chemicals into the soil, polluting the soil as a result. Because they discharge metals and other toxins into the environment at greater quantities than other sources, waste recycling facilities are regarded as one of the primary causes of soil pollution. However, one of the most troublesome causes of e-waste contamination of the soil is the handling of e-waste using outdated techniques. A greater concentration of PCBs and PBDEs was observed in the plants, soil, and snails of Guiyu town. According to Luo et al., one of

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the causes of high levels of metals like Cd, Cu, and Pb in soil is the burning of metallic chips and electrical circuits. A greater value of PBDE was found in agricultural soils within a 2-kilometer radius of an e-waste recycling workshop, according to Luo et al. In a different investigation, soil from the same range was found to contain significant amounts of PCBs, PAHs, and polychlorinated dibenzo-p-dioxins and dibenzofurans. Numerous soil samples examined from the vicinity of the Loni, India e-waste recycling facility revealed very high metal concentrations. Nearly all of the soil samples analyzed were over the allowable limits, with the highest Pb concentration exceeding the recommendations. Additionally, high levels of Cd, Hg, Cr, and Zn have been found in this area. The dangerous toxins, including heavy metals, that are found in the soil may be readily assimilated by plant roots and transferred to the plant's numerous components, such as the stem, leaf, and fruit. Soil polluted by e-waste is one of the main causes of contamination for crops and vegetables [2], [3].

DISCUSSION

Influence on human health: Human health might be put at danger as a result of improper e-waste management, processing, and recycling practices. Hazardous compounds generated by e-waste may enter a person's body via skin contact, ingestion, or inhalation. Due to a lack of safety precautions, employees who handle or recycle e-waste run a significant risk of direct occupational exposure. Due to the diversity of exposure sources, routes, exposed individuals' characteristics, such as body weight, age, sex, and immunological state, as well as non-identical time periods of exposure, identifying e-waste exposure is particularly difficult. The key factor contributing to the widespread danger connected with e-wastes in people is contaminated water, air, soil, and food. Children who have been exposed to the e-waste in their environment or diet may be at higher risk. Hazardous compounds will be released into the body and retained in fatty tissues when individuals are exposed to e-waste pollutants, posing serious health risks. Humans may consume, inhale, or come into touch with metals on their skin. Oral exposure involves drinking contaminated water and eating contaminated food. It has been discovered that ingesting heavy metals is the major way that humans get exposed to them. From polluted soil, water supplies, or air deposition, heavy metals may potentially bio-accumulate into plant tissues. The rise in heavy metal concentrations in meat-based products is mostly caused by food items cultivated on soil that has been polluted with heavy metals.

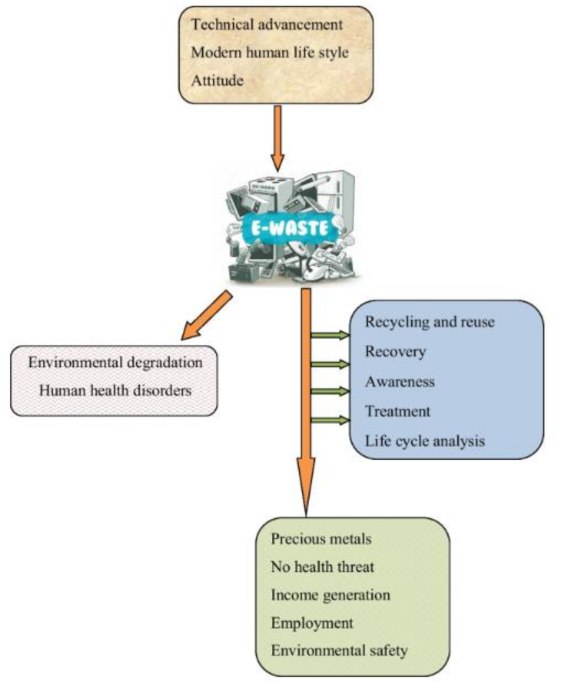

Figure 1: Illustrate the different form of e waste management.

It has been shown through several studies conducted by numerous researchers throughout the world that heavy metal causes a variety of human illnesses, including those affecting the neurological system, urinary system, cardiovascular system, blood, liver, kidney, learning disability, and urine. As a result, it is essential for local authorities and governmental entities to carry out a risk and exposure assessment study in the context of e-waste processing and recycling. According to reports, the WHO's suggested upper limit for dioxin levels in people has been exceeded as a result of the e-waste recycling facility in Guiyu, China. Dioxins are entering the human body through water, air, or foodstuffs and creating major health risks. The presence of dioxins over the allowable level has been identified in samples of human milk, hair, and placentas. According to a research by Ha et al., the soil and water in the vicinity of the Guiyu e-waste recycling plant exhibited high levels of heavy metals, which might have major negative consequences on surrounding employees and residents. Researchers from several fields conducted studies on e-waste in Ghana, China, and Bangalore, India and discovered that employees and residents

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there were exposed to high levels of heavy metals, polybrominated diphenyl ethers, dioxins, and other pollutants [4]. Figure 1 shown the different form of e-waste management.

Management Techniques for Electronic Waste

Because of the escalating demands of the consumer's perception, advancement of technology is one of the industries with the fastest growth rates. As a result, e-wastes are becoming more and more prevalent worldwide. Due to their rapid rate of production and improper handling, e-wastes have the potential to include various harmful substances as cadmium, lead, mercury, polybrominated diphenyl esters, etc. This puts the environment and other living things at risk. Therefore, it is necessary to investigate safe management techniques for e-waste on a priority basis. Figure 1 depicts the usual flow of electronic trash from manufacture to disposal. It is also comparable to the procedures needed to implement the circular economy idea, which calls for maximizing the use of resources from waste materials.

Valuable Metals are recovered from E-Waste

E-waste may provide revenue for both people and businesses. For instance, Bangalore produces over 18,000 MT of e-waste per year. These e-wastes do include certain valuable metals that may be recycled, including gold, silver, platinum, copper, aluminum, and rare earth metals. Additionally, potential for new commercial gains from them may be investigated.

Recycling Electronic Trash

Like other garbage, certain components of electronic waste, such as capacitors, circuit boards, and plastics, may be recycled. After the e-waste is burned, it is also feasible to produce energy since the plastic may be used as a feedstock for pyrolysis. However, further installations will be necessary for limiting dangerous emissions. Researchers from all around the globe are interested in thermo-chemical methods of producing energy from trash because they aid in recycling garbage. As the primary goal of recycling is to obtain valuable materials so that hazards to the environment and human health may be avoided, new materials can also be made using the recovered elements from e-waste. Recycling may also open up a number of commercial, employment, and other options for the community. According to research from the United Nations University, recycling e-waste would be good for society and environmental preservation. However, the success of effective recycling as well as management of e-wastes depends much on people's attitudes, knowledge, and actions.

E-Waste Recycling Using the Microrecycling Idea

E-waste offers private businesses an appealing commercial potential for metal recovery, but transporting such rubbish in quantity would be expensive. Smaller places may develop microrecycling plants for material recovery at a low cost. The microrecycling concept involves gathering and sorting e-waste materials from local communities at small-scale factories, which reduces transportation costs, raw material consumption, fossil fuel consumption, and environmental impact while producing recycled materials with added value for use in other applications. These microfactories use a variety of techniques, such as fractional heating to get materials from e-waste and the separation of different metals, polymers, and ceramics. In order to achieve careful separation of important metals and alloys, it is also possible to enable several reactions employing selective thermal transformation. Recently, it has been discovered that valuable materials may be produced from e-waste using unique and basic processes, such as the production of metals, metal nanoparticles, alloys, and nanoceramics. The major goal of this idea is to effectively, securely, and sustainably process and recycle e-waste at a smaller scale so as to be able to deliver value-added materials for the benefit of neighboring companies [5].

Creation of Efficient E-Waste Management Strategies

In many areas, effective policies have always been a great instrument for success. Take India as an example. Despite being a major center for the manufacture of electronic gadgets, India had ineffective rules when it came to managing its e-waste. The Indian environment ministry has, however, released several recommendations for the efficient treatment of e-waste. Between 1989 and 2016, Indian decision-makers created several waste management policies and recommendations. E-waste management regulations were initially created in 2009, but were combined with plastic waste regulations in 2011. E-waste management-related laws in India need to be seriously revised in order to ensure the safety of the environment and human health. But for the management of e-wastes to be successful, it has to be revised thoroughly. The majority of China's waste management strategies, like those in other countries, are centered on managing municipal solid waste. Following the discussions sparked by the 1989 Basel

Convention, the European Union played a significant role in establishing the regulations governing the treatment of e-waste in the early 2000s. The first significant law to set goals for ensuring the recycling, recovery, and treatment of various sorts of trash was the trash Electrical and Electronic Equipment Directive of 2002. In Europe, this directive served as a starting point for the subsequent development of several pieces of law. In nations including Canada, the USA, Japan, and Australia, national law was later developed using this instruction. According to Taneja et al. in the field of waste management, bibliometric research may also aid in the creation of effective policies for a certain topic. Grab et al. and Asokan et al. have made the claim that expanded producer responsibility principles, if included into the formulation of e-waste management policies and put into practice for the recycling and collecting of the e-wastes, might be a superior alternative for e-waste management.

Giving Waste Management Authority Employees Specialized Training

Processing, the use of tools, safety precautions, monitoring, supervision, and other processes are all involved in waste management, making it a multifaceted process. Because these qualified individuals may play important roles in the management of trash, trained people might be a major advantage for waste management authorities. The training for effective waste management may include a variety of stakeholders, such as academic institutions, research organizations, ministries, municipalities, the local public, technical people, etc. For successful e-waste management, a similar hierarchy may be used, which includes governing bodies, governmental and non-governmental organizations, business and society, etc.

Levying Severe Penalties to those who Violate

Waste management violations might result in a hefty penalty. The regulatory authorities should elucidate on the punishment provision for all parties involved. Every stakeholder's duties should be clearly stated in order to be carried out honestly and effectively. Furthermore, as e-waste management may also include certain toxic components, restrictions might be made quite stringent, particularly for offenders. The waste management agencies reward top performers with generous incentives. The regulatory authorities must include a mechanism for giving incentives to the best-performing businesses, societies, organizations, or sectors on the basis of the yearly waste audit report in addition to issuing penalties. As a result, it will foster some goodwill among the many parties involved in waste producers and their management. According to Cucchiella et al., NGOs and manufacturers need to be supported for the various e-waste management-related actions at various administrative levels.

Various Suggestions for Efficient E-Waste Management

For a brighter future, it is strongly advised that the 4Rs idea be included in e-waste management procedures. Such frameworks may be among the finest ways to ensure maximal recycling of electronic waste goods. In Spain, a well-illustrated recycling system was designed to handle e-waste so that it may reach the suppliers after being discarded by the customers. E-waste management has been noted to be greatly hampered by the lack of effective implementation of non-measurement of e-waste creation. Therefore, it is important to build an inventory that includes negative effects on the environment and living things in order to manage e-waste effectively at both the individual and municipal levels. Some frequent guidelines, such the following, may be stressed for improved e-waste management: Public awareness of e-waste's harmful effects on the environment and people, as well as its rules [6], [7].

Introducing Charges for Recycling

E-waste separation from home garbage must be required on an individual basis. To the greatest degree possible, efforts should be taken to restrict the use of electronic/electrical equipment, or their sparing usage should be promoted. For instance, a paperless option in banks and businesses may save paper while also reducing the need for application printers. Investigating the potential for digitization in all systems, including legacy systems. Computer monitors should be energy-efficient so that there is minimal energy usage. When not in use, electronic devices should be turned off. Depending on their lifespan and condition, computer electronics should be reused wherever feasible. Increased research efforts are necessary for improved e-waste management. According to Asus, a reputable corporation in Taiwan, eco-friendly electronic goods need to be produced.

There are essentially two methods being used for managing e-waste in industrialized and poor countries. E-waste is often not recycled properly in underdeveloped countries, and suitable disposal procedures are also rarely followed. Additionally, developing countries take part in the recovery of valuable metallic components from e-waste imported from industrialized countries. Therefore, it would seem that effective methods for e-waste recycling, specialized training for the workforce, and the development of effective legislation might all contribute to the sustainable management of e-waste. Additionally, it is necessary to identify and constantly monitor the regulations, duties, and industries involved in producing electronic appliances and managing waste. For instance, since 2003, in Switzerland, the duties of production units and importing sectors have been assigned to follow the Extended Producer Responsibility and the Advance Recycling Fee regulations as detailed in the management of e-waste. Japan has also created the Consumer Pays model, which allows customers to return electronic devices to stores in exchange for predetermined payments. Similar to this, under National Electronic Action Plans, the US Environmental Protection Agency is in charge of better managing the e-waste produced in the nation. Some poor countries are also making an effort to manage their e-waste, such as Peru, which pioneered sustainable ways to e-waste management by developing skills to collect the garbage and then recycle it to safeguard both people and the environment. From 2007 to 2014, 30 cities produced 185 tons of mobile phones, which Columbia was able to recycle.

Anticipated Difficulties in Managing E-Waste

In addition to the availability of the aforementioned management techniques, there are several difficulties that might arise while managing e-waste. If we use Europe as an example, the majority of the populace is well aware of resource conservation and understands that overusing them is bad for the environment. In addition, many assert that they are actively participating in recycling, trash segregation, and money generation from wastes. In the interest of recycling and manufacturing, emerging nations are also importing e-waste from the OEC&D group of nations. Another problem with the repurposing of e-waste and the creation of business models from it is societal acceptability. Individual person behavior and wise decisions are also having a direct influence on the correct recycling of e-waste.

Future efforts should concentrate on raising local residents' understanding of the need to alter their behavior in order to quickly resolve any environmental catastrophe, including the management of e-waste. Thus, it would seem that with public involvement, the principles of the circular economy may be considerably secured to the fullest degree possible. Knowledge of pertinent technology, economic problems, circular economy concepts, and environmental issues should also be explored together as they may improve the effectiveness of product recycling and reuse. Environmental ethics, regulations, and education have also been shown to greatly increase the public's awareness of environmental protection. Consumers may also be forced to pay certain predetermined amounts of money, albeit this may depend on factors including gender, the specifics of a wedding, how easily recyclable the trash is, and the toxicity of the e-waste. E-waste management in India is a difficult work due to a lack of understanding of environmental preservation and recycling techniques, as well as ineffective legislation, financial concerns, etc.

After working with all the stakeholders, public acceptability and economic gain may help with improved e-waste management. Strict rules and regulations might also be important in the management of e-waste. In a similar vein, there are no legal frameworks for the recycling of e-waste in any African nations. However, they are skilled in recycling electrical or electronic equipment, and their rates are around 2-3 times higher than those of wealthy nations. With the help of government regulatory agencies and companies, Australia has a clear policy for recycling televisions and computers. The only Asian nations with e-waste management policies are China, India Japan, South Korea, and Taiwan. Taiwan, on the other hand, leads the pack with an impressive 82% rate of e-waste recycling, while Japan and South Korea only managed 75%. Policies for recycling and standard development are insufficient in other parts of the globe. Therefore, other nations need to create suitable legislation, especially for the handling of e-waste. Most importantly, since e-wastes can be used to produce fuel through pyrolysis and obtain precious metals like gold, silver, platinum, copper, and aluminum and are reusable and recyclable materials, they can also be used to create jobs through the development of business modules [8], [9].

CONCLUSION

Large volumes of electronic garbage are created globally as a consequence of ostensible upgrading initiatives. Along with certain valuable and recyclable materials, these e-wastes could also include some hazardous substances. Because of this, the environment and biosphere may also be harmed by their irresponsible management and open disposal methods. E-waste is typically handled improperly since the general public is unaware of its significance and the severity of its threats. E-waste may also include radioactive chemicals, which may harm plant tissues and eventually stop plant development. Radioactive substances in the soil may reduce a plant's ability to absorb nutrients. Aside from knowledge, main obstacles to efficient e-waste treatment include a lack of infrastructure, irresponsible consumption, the financial crisis, and others. However, certain beneficial practices, such as societal motivation, behavioural change, the availability of sufficient finances or incentives, the right availability of e-waste treatment facilities, and adoption of green practices, may lower the levels of these difficulties. Artificial intelligence and machine learning are two methods that may be used to improve e-waste management processes. The deployment of modern computational tools is also playing key roles in many fields. By using such strategies, economic viability may also be preserved. Along with realizing the principles of a circular economy, it will also assist in the partial or full realization of many other sustainable development objectives.

REFERENCES:

[1] P. Morseletto, 'Targets for a circular economy', *Resour. Conserv. Recycl.*, 2020, doi: 10.1016/j.resconrec.2019.104553.

[2] A. P. M. Velenturf and P. Purnell, 'Principles for a sustainable circular economy', *Sustainable Production and Consumption*. 2021. doi: 10.1016/j.spc.2021.02.018.

[3] J. Kirchherr, D. Reike, and M. Hekkert, 'Conceptualizing the circular economy: An analysis of 114 definitions', *Resources, Conservation and Recycling*. 2017. doi: 10.1016/j.resconrec.2017.09.005.

[4] J. Grafström and S. Aasma, 'Breaking circular economy barriers', *Journal of Cleaner Production*. 2021. doi: 10.1016/j.jclepro.2021.126002.

[5] D. Sumter, J. de Koning, C. Bakker, and R. Balkenende, 'Circular economy competencies for design', *Sustain.*, 2020, doi: 10.3390/su12041561.

[6] P. Morseletto, 'Restorative and regenerative: Exploring the concepts in the circular economy', *J. Ind. Ecol.*, 2020, doi: 10.1111/jiec.12987.

[7] S. Khan and A. Haleem, 'Investigation of circular economy practices in the context of emerging economies: a CoCoSo approach', *Int. J. Sustain. Eng.*, 2021, doi: 10.1080/19397038.2020.1871442.

[8] X. Vence and Á. Pereira, 'Eco-innovation and Circular Business Models as drivers for a circular economy', *Contaduria y Adm.*, 2019, doi: 10.22201/fca.24488410e.2019.1806.

[9] J. Camacho-Otero, C. Boks, and I. N. Pettersen, 'Consumption in the circular economy: A literature review', *Sustain.*, 2018, doi: 10.3390/su10082758.

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E-Waste Landscape Activity by Economy Type

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ABSTRACT: The management of electronic waste (e-waste) is influenced by various factors, including the economic landscape of different regions. This study examines the e-waste landscape activity based on economy type, considering developed economies, emerging economies, and low-income economies. It explores the unique characteristics, challenges, and opportunities faced by each economy type in managing e-waste. The study begins by highlighting the higher e-waste generation in developed economies due to higher consumption patterns and technological advancements. Developed economies often have more established e-waste management systems, including regulations, infrastructure, and recycling facilities. However, challenges persist in ensuring proper collection, recycling, and disposal practices to prevent environmental contamination and health risks. In emerging economies, rapid economic growth and increasing technological penetration contribute to significant e-waste generation. These economies face challenges in developing robust e-waste management infrastructure and implementing effective regulatory frameworks. Informal recycling practices often prevail, leading to health and environmental concerns. However, emerging economies also have opportunities to adopt sustainable practices from the outset and leverage technological advancements for efficient e-waste management.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

The management of electronic waste, or e-waste, is a critical challenge faced by different types of economies around the world. This study provides an overview of the e-waste landscape activity based on the economy type, including developed economies, developing economies, emerging economies, and informal economies. In developed economies, with their advanced technology and well-established waste management systems, there is a significant generation of e-waste. These economies have implemented strict regulations and extended producer responsibility schemes to ensure responsible disposal and recycling of electronic devices. Public awareness regarding e-waste management is also high in developed economies. Developing and emerging economies experience rapid growth in electronic consumption due to industrialization and technological advancements. These economies face unique challenges in managing e-waste, such as limited waste management infrastructure and resources. However, efforts are underway to establish e-waste management systems, including the development of recycling facilities and the implementation of regulations. These economies recognize the importance of addressing e-waste challenges and are working towards improving their waste management practices.

Informal economies, found in both developing and emerging economies, play a significant role in e-waste recycling. However, these informal sectors often lack proper safety measures, leading to environmental pollution and health risks for workers involved in informal e-waste recycling activities. This study emphasizes the need for collaborative efforts involving governments, industries, and civil society to address e-waste challenges in different economy types. It highlights the importance of establishing proper waste management infrastructure, implementing effective regulations, promoting public awareness, and integrating informal workers into formal waste management systems. By understanding the e-waste landscape activity based on the economy type, stakeholders can develop targeted strategies and interventions to mitigate the environmental and health impacts of e-waste. The abstract concludes with the recognition that effective e-waste management is crucial for sustainable development and the transition to a circular economy, ensuring the responsible and sustainable management of electronic waste in all types of economies.

From a forecasting perspective, it is anticipated that BRICS-related e-waste activity would most likely surpass developed nations' patent activity by 2014–15 at the earliest. This statement again summarises the international or other character of the patent activity originating from each economic grouping. While Western countries' activity is more globally

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distributed, the BRICS economies' activity is virtually wholly covered in only one patent jurisdiction. This investigation also reveals the non-BRICS emerging economies' activities, which is extremely extensive in terms of its protection system. For later use in drawing conclusions and to give readers a better understanding of the dynamics in the field, this section reviews and summarizes a number of key aspects of the global patent activity in e-waste. It shows the geographic scope of protection for each patent family arrayed over time and plotted next to the overall collection activity time-series analysis (in grey). Due to increased activity from China, Russia, and Korea, most of which are locally protected in only one patent jurisdiction, there has been a significant dilution in the amount of worldwide patent protection.

Low-income economies face unique challenges in managing e-waste due to limited resources, infrastructure, and capacity. They often lack formal e-waste management systems and struggle with the absence of regulations and proper recycling facilities. E-waste handling in these economies is often informal and associated with health hazards. However, there is potential for international support, capacity building, and technology transfer to assist low-income economies in establishing sustainable e-waste management practices. The study emphasizes the importance of tailored strategies and solutions for each economy type. Developed economies should focus on enhancing recycling efficiency, addressing consumer behavior, and advancing circular economy principles. Emerging economies need to prioritize building infrastructure, implementing regulations, and promoting responsible e-waste management practices. Low-income economies require support in capacity building, technology adoption, and financial assistance to establish formal e-waste management systems.

This kind of study often indicates that a technological sector is experiencing a second wave of more basic research, with the rising dangers for individual inventors being mirrored in their reluctance to spend extensively in the protection of their IP rights. The average number of subsequent filings for patent families in the e-waste landscape for families filed each year is shown together with the overall timeline of e-waste activity. The localization and specialisation in e-waste processing is what is driving the movement towards more local protection, as this landscape illustrates. However, this is more because the e-waste technical landscape is undergoing a diversification of geography than technology, and it is this localization and specialisation in e-waste processing that is driving the movement towards more local protection. How many patent families just include applications; number of patent families that comprise (at least) one patent that has been awarded; the percentage of patent families that solely include Chinese utility models. The average period between filing an application and publishing a granted patent in the same jurisdiction is shown in the graph [1].

As the date gets closer to the present, this chart will normally gravitate to zero since the study for recent years will only include applications for patents that were granted extraordinarily quickly. However, the graph does assist to demonstrate that the normal "patent pending" time period for the gathering of electronic trash is around 4 years from the time of original application to the time of grant publication. Between the office of first filing and the date of granted patent publication, there is an average patent pending time period. As this analysis may then be expanded to the national level to determine the status of each patent office in the collection. To prevent a bias towards the fast-granting outlier applications, the analysis in figure 19 leaves out any patent family that was submitted during the recent four years.

According to this assessment, the performance of some European patent offices seems to be greatest, with the granting of patents filed in Switzerland and France requiring less than 3 years [2]. Naturally, it is important to keep in mind each jurisdiction's grant procedures and restrictions, which may provide grants without considering innovation or inventiveness, for example.The main territories of China, South Korea, the United States, and Japan all converge on the dataset's average pendency of around four years, which may indicate some degree of regression to the mean.India has the highest levels of pendency for patent filings, with granted patents generally requiring five years to issue from the date of filing.Excludes patent applications submitted after 2008 owing to the average collection pendency term; average patent pendency time period; per patent authority; earliest first filing to grant publication.

The dynamics involved in maintaining the awarded patent rights in the context of e-waste are profiled in Figure 20 in this section's last paragraph.While patent rights are granted for a 20-year term, they do not automatically extend for 20 years without ongoing annuity or maintenance payments.The advantage of decreasing the administrative burden of possibly outmoded technology is that this preservation of patent rights enables the right owners to stop protecting innovations that advance more fast than a 20-year time frame. The necessity to protect rights implies that innovation is likely to become accessible to the public quicker than it would otherwise, according to the organisation that issues patents. With the exception of the United States, each country has a different calendar for maintaining patent rights, although most of them follow a yearly pattern. In the US, maintenance is done after the patent has been awarded at three predetermined periods of 31, 71, and 112 years. It should be emphasised that a patent family does not have to lose its protection in all countries at once. However, due to the different timetable, the demands of the US system often lead many firms to maintain patents in all other jurisdictions [3], [4].

DISCUSSION

As the figure is derived using the earliest initial filing year, it also includes estimated time frames for US patent maintenance taking into account a 4-year average pendency duration. Almost three quarters of awarded IP rights were still in effect 15 years after filing, and 80 to 85% of granted rights had been maintained for more than 10 years overall in the e-waste environment. This would suggest that a significant fraction of the field's patents have value and an economic return linked with them for patent owners. It also suggests that the market is not advancing quickly since during a 15-year period, few technology become significantly outmoded.The landscape of patent maintenance for e-waste; Labelled are approximate locations on US Maintenance Periods at 3 12, 7 12, and 11 12 years post grant - based on 4 year Pendency Period at USPTO shows the number of patent families that have been filed in 1, 2, or 3 patent jurisdictions, etc., to give an understanding of the IP strategy used by applicants in the e-waste landscape.
Out of the 8,867 patent families that have been filed overall in the e-waste landscape, 7,102 of them have only been filed in one country. This country is mostly where the Japanese and, more specifically, the Chinese-based organisations in the dataset, are located. Due to the expense of these patent families and the mere 695 patent families that have been filed in five or more locations, these inventions and the applicants behind them inevitably become more intriguing when determining the commercial interest of corporations and other organisations in e-waste technology. Distribution of the Number of Subsequent Filing Events throughout the Landscape; Evaluation of the Patent Protection Strategy of E-Waste Patent Applicants. About 1,700 patent families that were submitted in different patent jurisdictions were shown on the preceding graph. Now, the geographical source and time frame of activity for these data are examined in further depth. For patent families with two or more subsequent filings per family, the office of first filing is responsible [5], [6].
With just 14 records filed in multiple authorities, China, the second-largest source of e-waste patent activity overall, is comparable to nations like the Netherlands, Austria, Sweden, and Australia. This figure also demonstrates the distribution of patent activity filed in multiple authorities over time. The graphs provide both the annual absolute numbers of patent families and a normalised scale version to enable the identification of activity patterns. By comparing the activity reported in each given year to the overall activity reported throughout all years, the normalisation is carried out. The activity trend reveals that volumes are fixed into the same patterns up until 2008, at which point there is a significant divergence. This divergence is probably linked to the time lag created when patent families are submitted in several patent sites. Therefore, a data artefact unique to patent data is most likely responsible for this difference [7].
When compared to the multi-authority patent families, the whole collection's activity has increased more quickly, which is the second thing of interest. This emphasises the very local character of the mostly recent Chinese and Russian patent activities. The number of patent families each year for multi-authority patent families compared to the whole e-waste collection (left); the same timeline but with a normalised y-axis for comparing activity rates (right).Asia is where the largest bulk of e-waste activity comes from, followed by Europe. The fact that the United States contributes such a little amount of activities suggests that US organisations may not be very interested in e-waste technologies.
Post-2000 has seen the most activity in terms of e-waste patent invention. There are two separate periods of activity during this time: a first, secondary peak in 2000, which then declines, and a second, growing phase that may not be finished yet. The two stages of activity are principally fueled by a decline in the production of patents from Japanese firms and an accompanying large-scale increase of activity from China. However, the majority of Chinese (and to a lesser degree Japanese) patent activity is regional. Just 15 out of 1,430 innovations with initial filings in China have been transferred to another patent authority, or 1% of all inventions. The total is comparable to far

smaller economies like the Netherlands, Austria, Sweden, and Australia [8], [9].

The e-waste landscape can vary significantly based on the type of economy in a particular region or country. The economy type influences the consumption patterns, technological advancements, waste management infrastructure, and regulatory frameworks related to e-waste. Here is a detailed description of the e-waste landscape activity based on different types of economies:

Developed Economies:

Developed economies, characterized by high levels of industrialization and advanced technology, tend to generate substantial amounts of e-waste. These economies have a higher per capita consumption of electronic devices, resulting in a larger volume of discarded electronics. However, they also possess well-established waste management systems, including recycling facilities and strict regulations for e-waste disposal. E-waste management programs in developed economies often involve extended producer responsibility (EPR) schemes, where manufacturers are responsible for collecting and recycling their products. Additionally, public awareness about the importance of recycling and responsible disposal is relatively high in developed economies.

Developing Economies:

Developing economies experience a rapid increase in electronic consumption as they undergo industrialization and technological advancements. These economies face unique challenges in managing e-waste due to limited waste management infrastructure and resources. The collection and recycling systems for e-waste may be underdeveloped, leading to improper disposal practices such as open burning or informal recycling methods. Developing economies often rely on informal sectors, where individuals engage in manual dismantling and extraction of valuable materials from e-waste, often without proper safety measures. However, there is growing recognition of the e-waste problem in developing economies, leading to the implementation of stricter regulations and the establishment of formal recycling facilities.

Emerging Economies:

Emerging economies are characterized by rapid economic growth, urbanization, and technological advancements. These economies experience a significant increase in electronic device consumption as more people gain access to technology. The e-waste landscape in emerging economies can be diverse, with variations in waste management infrastructure, regulatory frameworks, and public awareness. Some emerging economies have made significant progress in establishing e-waste management systems, including the development of recycling facilities and the implementation of regulations. However, challenges remain, such as inadequate collection systems, lack of awareness, and limited financial resources. Collaborative efforts involving government, industry, and civil society are crucial to address e-waste challenges effectively in emerging economies.

Informal Economies:

Informal economies exist in both developing and emerging economies, where a significant portion of economic activity occurs outside formal regulations and structures. In the context of e-waste, informal economies play a substantial role in the collection, recycling, and disposal of electronic devices. Informal e-waste recycling practices often involve manual dismantling, extraction of valuable materials, and disposal of hazardous substances in uncontrolled environments. This informal sector is prevalent in regions with limited formal waste management infrastructure. Addressing the challenges of informal e-waste recycling requires a multi-faceted approach, including formalizing the sector, providing training and education on safe recycling practices, and integrating informal workers into the formal waste management system.

The e-waste landscape activity varies significantly depending on the type of economy in a particular region or country. Developed economies with advanced technology and well-established waste management systems generate substantial amounts of e-waste. These economies often have strict regulations, extended producer responsibility schemes, and high levels of public awareness regarding responsible e-waste disposal.

On the other hand, developing and emerging economies face unique challenges in managing e-waste due to limited waste management infrastructure and resources. These economies experience a rapid increase in electronic consumption as they undergo industrialization and technological advancements. While some progress has been made in establishing e-waste management systems, challenges such as inadequate collection systems, lack of awareness, and limited financial resources remain.

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Informal economies, present in both developing and emerging economies, play a significant role in the collection, recycling, and disposal of e-waste. However, informal e-waste recycling practices often lack proper safety measures, leading to environmental pollution and health risks. Addressing the e-waste challenge requires a multi-faceted approach that involves government initiatives, industry participation, and public awareness campaigns. It is crucial to establish proper waste management infrastructure, implement effective regulations, and promote responsible disposal practices. Collaboration between stakeholders, including governments, industries, civil society organizations, and informal workers, is essential to ensure sustainable e-waste management across all types of economies. By implementing comprehensive e-waste management strategies, economies can mitigate the environmental and health risks associated with e-waste, promote circular economy principles, and contribute to a more sustainable future. The ongoing efforts to control e-waste by economy type are essential for protecting the environment, conserving resources, and safeguarding public health.

CONCLUSION

Overall, the e-waste landscape varies based on the type of economy. Developed economies generally have more established e-waste management systems, while developing and emerging economies face challenges in managing the growing volume of e-waste. It is crucial for all types of economies to prioritize e-waste management, including the implementation of effective regulations, the development of recycling infrastructure, and public awareness campaigns to ensure responsible disposal and minimize the environmental and health impacts of e-waste. Due to increased activity from China, Russia, and Korea, most of which are locally protected in only one patent jurisdiction, there has been a significant dilution in the amount of worldwide patent protection. Patents that are submitted in many countries often come from Japan, the US, and Germany. Technically, the landscape may be broken down into three main ideas.Items like plastics and metals that are being salvaged and repurposed from e-waste streams.sources of e-waste, including as batteries, displays, cables, and printed circuit boards, and how these sources are processed.the procedures and logistics involved in treating or recycling e-waste, including magnetic sorting, IT-related recycling system administration, and similar things.

REFERENCES:

[1] M. C. B. de Araújo, J. S. Silva-Cavalcanti, M. M. Vicente-Leal, and M. F. da Costa, 'Análise do comercio formal e informal na Praia de Boa Viagem, Recife, Pernambuco, Brasil', *Rev. Gestão Costeira Integr.*, 2012, doi: 10.5894/rgci329.

[2] Greencape, 'Waste: Market Intelligence Report 2020', *Waste*, 2021.

[3] R. Grant, 'E-waste challenges in Cape Town: Opportunity for the green economy?', *Urbani Izziv*, 2019, doi: 10.5379/urbani-izziv-en-2019-30-supplement-001.

[4] R. Grant and M. Oteng-Ababio, 'Formalising E-waste in Ghana: An emerging landscape of fragmentation and enduring barriers', *Dev. South. Afr.*, 2021, doi: 10.1080/0376835X.2020.1823822.

[5] A. M. and M. Schluep, 'e-Waste Assessment Tanzania', *UNIDO e-waste Initiat. Tanzania*, 2011.

[6] T. R. I. Analytics, 'Patent Landscape Report on E-Waste Recycling Technologies', *World Intellect. Prop. Organ.*, 2013.

[7] Z. Chen, J. Zhang, M. Liu, Y. Wu, and Z. Yuan, 'Immobilization of metals in contaminated soil from E-waste recycling site by dairy-manure-derived biochar', *Environ. Technol. (United Kingdom)*, 2018, doi: 10.1080/09593330.2017.1365947.

[8] R. GRANT, 'E-waste challenges in Cape Town', *Urbani Izziv*, 2019.

[9] I. Barletta, J. Larborn, M. Mani, and B. Johannson, 'Towards an assessment methodology to support decision making for sustainable electronic waste management systems: Automatic Sorting Technology', *Sustain.*, 2016, doi: 10.3390/su8010084.

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Technical Segmentation of the E-Waste Landscape

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ABSTRACT: The technical segmentation of the e-waste landscape is a process that categorizes electronic waste based on its technical characteristics, composition, and potential environmental impact. This study provides a concise overview of the significance and benefits of technical segmentation in managing and addressing the challenges associated with e-waste. Electronic waste, or e-waste, has become a growing concern globally due to the rapid proliferation of electronic devices and their shorter lifecycles. To effectively manage e-waste, it is crucial to understand its diverse nature and tailor appropriate strategies for recycling, treatment, and disposal. Technical segmentation offers a systematic approach to categorize e-waste based on factors such as device type, material composition, size and weight, age and generation, functional status, and end-of-life stage.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

The management of electronic waste, or e-waste, requires a comprehensive understanding of its technical segmentation. This study provides an overview of the technical segmentation of the e-waste landscape, focusing on the categorization of different types of electronic devices and their associated challenges in disposal and recycling. The technical segmentation of e-waste includes various categories such as consumer electronics (e.g., televisions, mobile phones), IT equipment (e.g., computers, printers), household appliances (e.g., refrigerators, washing machines), and communication devices (e.g., routers, modems). Each category presents unique characteristics, including varying material compositions, sizes, and hazardous substances, which pose specific challenges in their management.

The study discusses the challenges related to the technical segmentation of e-waste, such as the presence of valuable materials that can be recovered through recycling, as well as hazardous substances that require proper handling and disposal to minimize environmental and health risks. It highlights the importance of adopting specialized recycling processes to extract valuable materials effectively while ensuring the safe management of hazardous components. Furthermore, the study emphasizes the need for proper collection and separation of different e-waste categories to facilitate efficient recycling. It underscores the significance of implementing effective collection mechanisms, including designated collection points, take-back programs, and collaborations with manufacturers, to ensure the proper segregation of e-waste based on its technical characteristics. The study concludes by acknowledging the importance of raising awareness among consumers, businesses, and policymakers about the technical segmentation of e-waste. It emphasizes the role of education and information campaigns to promote responsible disposal practices, encourage recycling initiatives, and foster a circular economy approach to e-waste management. Understanding the technical segmentation of the e-waste landscape is essential for developing targeted strategies, policies, and infrastructure to effectively manage e-waste. By addressing the challenges associated with different types of electronic devices, stakeholders can work towards sustainable e-waste management, resource recovery, and the reduction of environmental and health impacts.

By categorizing e-waste according to device type, such as mobile phones, computers, or televisions, specific recycling requirements and processes can be identified. Additionally, considering the material composition of e-waste allows for the identification of valuable components for recovery and the appropriate handling of hazardous substances. Size and weight considerations play a role in determining logistics and recycling facilities, while age and generation segmentation help address the differing technologies

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and materials present in older and newer devices. Technical segmentation also enables the identification of specific challenges and opportunities associated with different types of e-waste. It supports the development of targeted collection programs, specialized recycling processes, and policies and regulations that address environmental concerns and promote resource recovery. Furthermore, it contributes to the identification of valuable materials that can be extracted and reused, reducing the reliance on raw materials and minimizing environmental impacts.

Three major categories may be drawn from the segmentation: E-waste sources include both end-of-life devices, like telecommunications equipment, displays, medical equipment, etc., as well as individual parts that can be found in multiple device streams, like batteries, printed circuit boards, and individual electronic components. Methodologies for processing materials, such as waste stream sorting, waste logistics, disassembly or dismantling, chemical separation/treatment, smelting or heat treatment, or decontamination initiatives. Material recovery refers to recognising patent innovations with particular recovered objects or treated materials, such as dealing with hazardous waste in end-of-life products, metal recovery, or plastic recycling. Decontamination, chemical separation, and metal extraction are the three main areas of innovation in e-waste processing. Since chemical extraction of metals is probably a significant process step in and of itself, it is probable that the maxima in metal extraction and chemical separation are connected [1], [2]. As was said above, individual innovations may occur in numerous categories.

Additional subjects under consideration include:

1. Wire removal
2. Heat treatment or melting
3. E-waste sorting,
4. E-waste pulverisation

Battery disposal, treatment, and recycling; handling printed circuit boards; and wire or cable treatment are the three areas of e-waste that continue to dominate patent activity. These three subjects account for more than half of all patents collected, making them the main e-waste waste streams. A variety of components and end products are covered in the secondary themes. The majority of the electrical components on a printed circuit board are capacitors, which are made up of unusual and often dangerous materials utilized as dielectrics. Another frequent PCB sub-component is LEDs, which are normally packaged discretely and include a variety of materials including semiconductors, ferrous and non-ferrous metals, and polymers. Magnetic components are an intriguing class since neodymium and other rare earth metals are probably found in them in large quantities.

These three subjects computers/laptops, displays, and home appliances represent the main categories of "end product" kinds addressed in the landscape. Be aware that displays are a bit of a hybrid issue since they may be either components or end products, such as televisions or computer monitors, or they can be a part of a mobile device, laptop, or tablet. The absence of activity in this area has sparked a lot of interest in telecoms equipment. The graphic chosen for the front page of this report focuses on the significant volume of mobile device trash. Driven by the subscriber business model and the industry's rapid technological advancement, mobile phones account for a sizable share of e-waste streams in the majority of nations. However, the patent landscape does not reflect this viewpoint. Further research on this topic will be done at a later time. The most common materials recovered from e-waste are plastics and ferrous metals, followed by "other" non-ferrous metals other than copper, nickel, zinc, aluminum, and tin.

The most often stated non-ferrous metals on the list are copper and tin. Be aware that a large fraction of the secondary things indicated in the retrieved materials could be influenced by solder regulation. In the past, different ratios of lead and tin were employed to make solder in different uses. The replacement of lead in solder alloys by pure tin, but more often tin, silver, and copper solders, has occurred as a result of a significant effort in recent years to remove dangerous lead from consumer electronics. Lead, tin, silver, and copper all have activity peaks, and the topics of copper and silver recovery have both risen considerably above those of tin recovery, suggesting a trend that corresponds with a change in legislation affecting the solder business. Additionally, silver seems to be the main noble metal recovered from e-waste, which is probably due to solder regulations, such as the 2011 European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Directive (RoHS) [3], [4].

DISCUSSION

The main shifts in patent activity in technological categories with more than 100 patent families that have taken place since 2006. The production of patents has increased significantly in four areas: Dealing with hazardous cadmium and battery disassembly are probably two connected issues since rechargeable nickel-cadmium batteries consume the majority of the cadmium used in industrial applications. Conveyor belt use in waste stream sorting and e-waste logistics operations obtaining rare earth metals, the categories for noble metals, all of which exhibited increase during the previous five years, are also highlighted in the graph. The majority of themes have seen a rise in production, which is consistent with the general development in activity since 2006 throughout the whole landscape. However, a number of categories have decreased, with the biggest drops being in the waste streams from domestic appliances (which overlap slightly with the project collection) and in the PCB treatment and decontamination processes. Due to its possible off-topic character in pure e-waste streams, this latter concern generated considerable discussion throughout the project. In fact, the topic is closely related to the use of these materials in power transformers, which are more often used for electrical distribution than e-waste specifically. Technical segmentation of the e-waste landscape refers to the process of categorizing electronic waste based on its technical characteristics, composition, and potential environmental impact. This detailed description explores the various aspects and considerations involved in the technical segmentation of e-waste [5], [6].

E-waste, or electronic waste, comprises discarded electrical and electronic devices, including computers, smartphones, televisions, refrigerators, and other consumer electronics. Due to rapid technological advancements and shorter product lifecycles, the generation of e-waste has been increasing globally, posing significant environmental and health risks if not managed properly. To effectively manage and address the challenges associated with e-waste, it is essential to understand its technical composition and characteristics. Technical segmentation provides insights into the different types of e-waste and allows for tailored strategies for recycling, treatment, and disposal. The technical segmentation of e-waste involves categorizing it based on several factors, including:

Device type: E-waste can be classified according to the type of electronic device, such as mobile phones, computers, televisions, and printers. Each device type may have distinct components, materials, and recycling requirements.

Material composition: E-waste contains various materials, including metals, plastics, glass, and hazardous substances such as lead, mercury, and brominated flame retardants. Segmentation based on material composition helps identify valuable components for recovery and proper handling of hazardous substances.

Size and weight: E-waste can range from small handheld devices to large appliances. Size and weight considerations are crucial for determining appropriate recycling facilities and transportation logistics [7], [8].

Age and generation: E-waste can be further segmented based on its age and generation. Older electronic devices may contain different materials or technologies compared to newer ones, necessitating specific recycling techniques.

Functional status: E-waste can be categorized based on its functional status, whether it is working, partially working, or non-functional. Functional devices may have higher reuse potential, while non-functional ones may require specialized recycling processes.

End-of-life stage: E-waste can be classified based on its end-of-life stage, such as discarded devices from households, businesses, or the manufacturing sector. Understanding the sources and origins of e-waste can help develop targeted collection and recycling programs.

The technical segmentation of e-waste is essential for establishing appropriate recycling and treatment facilities, designing efficient collection systems, and implementing effective policies and regulations. It helps identify valuable components and materials that can be recovered through recycling and supports the development of specialized recycling processes for hazardous substances. Additionally, technical segmentation facilitates the identification of specific challenges and opportunities associated with different types of e-waste, enabling the development of strategies to mitigate environmental impacts and promote resource recovery. However, technical segmentation alone is not sufficient to address the complex issues surrounding e-waste management. It should be complemented with other considerations, such as social and economic factors, legal frameworks, and extended producer responsibility programs. Collaboration between stakeholders, including governments, manufacturers, recycling industries, and consumers, is crucial for developing comprehensive e-waste management systems that prioritize environmental sustainability, human health, and resource efficiency [9], [10].

The technical segmentation of the e-waste landscape involves categorizing electronic devices based on their types and characteristics. This segmentation is crucial for understanding the unique challenges associated with different types of e-waste and developing effective strategies for their disposal and recycling. Here is a detailed description of the technical segmentation of the e-waste landscape, along with relevant facts:

Consumer Electronics:

Consumer electronics include devices used for personal entertainment and communication, such as televisions, mobile phones, laptops, and gaming consoles. They contain a wide range of materials, including plastics, metals (such as gold, silver, and copper), glass, and electronic components. Fact: It is estimated that approximately 45 million metric tons of electronic waste were generated from consumer electronics globally in 2016.

IT Equipment:

IT equipment comprises devices used for information technology purposes, including computers, servers, printers, scanners, and networking devices. These devices contain various valuable metals, such as gold, silver, palladium, and platinum, as well as hazardous materials like lead, mercury, and brominated flame retardants. Fact: According to a United Nations report, the global e-waste generation from IT equipment reached 12.3 million metric tons in 2019.

Household Appliances:

Household appliances encompass electronic devices used in homes, such as refrigerators, washing machines, air conditioners, and kitchen appliances. These appliances contain a mix of metals, plastics, glass, and electrical components. They often have refrigerants, oils, and other hazardous substances that require proper disposal. Fact: The International Energy Agency estimated that around 53 million metric tons of e-waste were generated globally from household appliances in 2019.

Communication Devices:

Communication devices include equipment used for telecommunications and networking, such as routers, modems, switches, and cables. These devices contain metals like copper, aluminum, and precious metals, as well as plastics and electronic components. Fact: It is projected that the number of connected devices globally will reach around 75 billion by 2025, contributing to the growing volume of e-waste from communication devices.

The technical segmentation of e-waste is essential because different categories of electronic devices require specialized recycling processes. These processes involve extracting valuable materials through techniques like dismantling, shredding, sorting, and recovery of metals, plastics, and other components. Simultaneously, hazardous substances need to be carefully handled and disposed of to prevent environmental pollution and health risks. To effectively manage e-waste, proper collection and separation mechanisms are crucial. Establishing designated collection points, implementing take-back programs by manufacturers, and promoting responsible consumer behavior through awareness campaigns are essential steps in ensuring the effective segregation of e-waste based on its technical characteristics.

The management of electronic waste, or e-waste, is a complex and pressing global issue. This abstract provides an overview of the technical segmentation of the e-waste landscape, highlighting the categorization of electronic devices and the significance of understanding their specific characteristics and challenges.

The technical segmentation of e-waste involves classifying electronic devices into different categories based on their types and composition. This segmentation is crucial for effective waste management, as it allows for tailored strategies and approaches to address the specific requirements of each category. Consumer electronics, including devices like televisions, mobile phones, and laptops, contain a variety of materials such as plastics, metals, glass, and electronic components. IT equipment, such as computers, printers, and servers, comprises valuable metals like gold and silver, as well as hazardous substances like lead and mercury. Household appliances, including refrigerators and washing machines, consist of a mix of metals, plastics, and electrical components. Communication devices, such as routers and modems, contain metals like copper and aluminum, as well as plastics and electronic components.

Each category of e-waste presents unique challenges in terms of material recovery, hazardous substance management, and proper disposal. Valuable materials within electronic devices can be recovered through recycling processes, reducing the need for raw materials extraction. However, the presence of hazardous substances necessitates careful handling and environmentally sound disposal practices to prevent environmental contamination and public health risks. Proper collection and separation mechanisms are essential for effective e-waste management. Establishing dedicated collection points, implementing take-back programs by manufacturers, and raising public awareness about responsible disposal are vital steps in facilitating the effective segregation of e-waste based on its technical characteristics.

By understanding the technical segmentation of the e-waste landscape, policymakers, waste management professionals, and stakeholders can develop targeted strategies and policies to address the challenges associated with specific categories of electronic devices. This understanding enables the implementation of appropriate recycling techniques, the adoption of sustainable waste management practices, and the promotion of a circular economy approach. The technical segmentation of the e-waste landscape plays a crucial role in facilitating effective e-waste management. By recognizing the unique characteristics and challenges of different types of electronic devices, stakeholders can develop tailored solutions, minimize environmental and health risks, and promote sustainable practices in the management of e-waste.

CONCLUSION

While technical segmentation is a crucial step in managing e-waste, it should be complemented by broader considerations such as social, economic, and legal factors. Collaboration among governments, manufacturers, recycling industries, and consumers is essential to establish comprehensive e-waste management systems that prioritize environmental sustainability and resource efficiency. In conclusion, technical segmentation plays a vital role in understanding the e-waste landscape and developing targeted solutions for its management. By categorizing e-waste based on its technical characteristics, composition, and potential environmental impact, stakeholders can implement tailored strategies for recycling, treatment, and disposal, ultimately working towards a more sustainable and responsible approach to e-waste management. The technical segmentation of the e-waste landscape enables a deeper understanding of the challenges and opportunities associated with different types of electronic devices. By considering the unique characteristics of each category, stakeholders can develop targeted strategies for responsible disposal, efficient recycling, and resource recovery, thus contributing to the transition towards a circular economy and minimizing the environmental and health impacts of e-waste.

REFERENCES:

[1] P. Venkata Ramana, T. Michael, M. Sumi, and S. Kammila, “The State of the Global Clean and Improved Cooking Sector,” *ESMAP GACC*, 2015.

[2] P. N. Marheni, I. Safni, and S. S. Girsang, “Keanekaragaman jenis serangga pada pertanaman bawang merah (Allium ascalonicum L) asal biji di berbagai ketinggian,” *J. Pertan. Trop.*, 2018.

[3] D. M. Sudi, “Efektivitas Dewan Pengawas Syariah pada Perbankan,” *Disertasi UIN Syarif Hidayatullah Jakarta*, 2015.

[4] E. M-J. Saarinen, Q. U. Belfast, J.-P. Aumasson, and Kudelski Security, “The BLAKE2 Cryptographic Hash and Message Authentication Code (MAC),” *Constr. Build. Mater.*, 2015.

[5] L. Jara and J. Juárez, “Relaciones Interpersonales y Desempeño Laboral en los trabajadores del Centro de Salud Morales, 2015,” *Rev. Peru. Obstet. y Enfermería*, 2015.

[6] A. Chapuel and J. Reyes, “Obtención de una película biodegradable a partir de los almidones de semilla de aguacate (Persea americana Mill) y banano (Musa acuminata AAA) para el recubrimiento de papaya,” *J. Wind Eng. Ind. Aerodyn.*, 2019.

[7] R. Grant, “E-waste challenges in Cape Town: Opportunity for the green economy?,” *Urbani Izziv*, 2019, doi: 10.5379/urbani-izziv-en-2019-30-supplement-001.

[8] R. Grant and M. Oteng-Ababio, “Formalising E-waste in Ghana: An emerging landscape of fragmentation and enduring barriers,” *Dev. South. Afr.*, 2021, doi: 10.1080/0376835X.2020.1823822.

[9] T. R. I. Analytics, “Patent Landscape Report on E-Waste Recycling Technologies,” *World Intellect. Prop. Organ.*, 2013.

[10] A. M. and M. Schluep, “e-Waste Assessment Tanzania,” *UNIDO e-waste Initiat. Tanzania*, 2011.

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Overview of Technical Approaches to E-Waste Commercialization

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ABSTRACT: The increasing generation of electronic waste (e-waste) has created a pressing need for effective and sustainable management strategies. Within this challenge, there is an opportunity for commercialization through innovative technical approaches. This study provides an overview of the technical approaches to e-waste commercialization, highlighting their significance, benefits, and challenges. The overview begins with recycling and material recovery, which involves the extraction of valuable metals and components from discarded electronic devices. Advanced recycling technologies enable the efficient separation and processing of e-waste, facilitating the recovery of precious metals and other valuable materials for reuse in the production of new electronic products. Refurbishment and reuse are also key technical approaches to e-waste commercialization. Functional devices are repaired, upgraded, and made available for resale or donation, extending their lifespan and reducing the demand for new devices. This approach promotes a circular economy and provides affordable options for consumers. Component harvesting is another approach that focuses on extracting reusable parts and components from e-waste. These salvaged components find applications in repairs, prototyping, or as building blocks for new electronic devices. This approach caters to the needs of repair technicians, hobbyists, and small-scale manufacturers.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Therefore, given the high prices these materials command owing to their limited availability, the increase in patent activity about their extraction from e-waste streams makes sense. The commodification of e-waste streams for the extraction of valuable materials like rare earths therefore seems to be confirmed by the patent landscape [1]. Demonstrates the relationship between rare earth recovery patents and the different e-waste streams. With compelling evidence in the form of magnetic components, batteries, and displays, this supports the use of the different rare earths that are now known in contemporary consumer electronics. Review of Rare Earth Metal Recovery by Processing Technology with a Special Focus on Rare Earth Metal Recovery; Analysis of E-Waste Sources of Rare Earth Metal Recovery. The table has been expanded further to show which processing industries have a disproportionate number of patents from rare earth metal extraction families. Based probably on the unique characteristics of the particular element under discussion, chemical separation seems to be the main method of extraction for rare earths at the moment, followed by magnetic separation. Data sanitization and destruction are crucial considerations to protect personal and confidential information during e-waste commercialization. Technical approaches such as secure erasure methods and physical destruction of storage media ensure the proper handling of sensitive data, enhancing trust and confidence in the recycling and reuse processes [2], [3].

Energy recovery is an emerging approach that converts non-recyclable e-waste components into energy through processes like incineration or gasification. This method harnesses the heat or electricity generated for industrial processes or power generation, reducing reliance on fossil fuels. While technical approaches offer promising opportunities for e-waste commercialization, challenges remain. These include the high costs of advanced recycling technologies, the need for efficient collection and sorting systems, and the development of robust supply chains for recovered materials. Environmental considerations, such as proper hazardous substance management and pollution prevention, are also critical for sustainable e-waste management [3], [4].

The majority of new patent applications for rare earth extraction are from companies with headquarters in Japan, and this activity is expanding significantly. The secondary source is the US, although there is no growing tendency there. Despite having a modest level of production, China is showing an increasing interest in the industry. Rare Earth Metal E-Waste Activity Timeline by Office of First Filing Country. The amount of patent families pertaining to mobile devices did not match expectations, as was noted previously in the research. In part, it was considered that the development of e-waste as a subject of intensive worldwide innovation was related to the trend towards quicker device throughput, which was mainly evident in the market for mobile devices. Businesses typically update their product catalogue once a year, and consumers and subscribers are strongly encouraged to "upgrade" their mobile device at the same time. Mobile phones or other telecommunications equipment are mentioned in e-waste patents, however, very seldom [5], [6].

There Might Be Two Causes for This Difference:

In current jargon, it is difficult to distinguish between mobile devices and "computing" hardware since they are so closely related to one another. It's possible that e-waste technology was divided into two categories: computers/laptops and telecommunications devices. Mobile device-specific e-waste innovation focuses more on the components within the device than the device itself. Therefore, innovation in mobile device processing and recycling spans a number of different areas, including screens, batteries, printed circuit boards, etc. The sector's overlap with the computers/laptops category, as well as the displays, batteries, and PCB components industries, is somewhat highlighted by this research. Metals and polymers have dominated recycling technologies in the past. Focus is being placed on the e-waste from batteries and printed circuit boards in mobile devices, which is one of the growth areas in the recovery of mobile device e-waste.

1. Growing use of chemical separation methods
2. Decontamination of waste streams from mobile devices
3. Recovering silver from portable electronics.

The theme idea map provides a summary of the general nature of processing mobile device e-waste. The equitable distribution of these papers throughout the globe, as seen by the red highlighted patent families that specifically identify telecommunications equipment, supports the findings presented above. In order to analyze innovation activity beyond the simple quantity of patents or patent applications within a certain industry, metrics have been added to the dataset used in this study. By examining the key technological topics at the level of commercialization and investment within the e-waste ecosystem, this part takes this a step further. As was previously said, there is a significant correlation between the amount of financial expenditure needed and the number of various regions in which a single application is submitted. Simply said, the amount of expenditure increases with the number of countries where protection is sought since there are more legal counsel engaged and there is a chance that expensive operations like translation will be necessary. The sections that are located farther right and higher up the chart are increasing and have received more investment, making the chart a kind of SWOT analysis (strength, weakness, opportunity, threat). Other technical areas within the graphic that cluster together are not labelled, just the sectors that stand out from the study.

Smaller subjects addressed by this high-level approach include "other" recovered materials not specifically mentioned, including ceramics or rubbers, as well as rare earth metals. However, there has been a significant surge in patent activity related to the extraction or recovery of noble metals (such as gold, silver, or platinum) from e-waste streams as well as the recovery of rare earth metals.Rare earth metals are among the technologies with the most extensive geographic protection, in addition to their rapid growth. When considered together, this data clearly suggests that the sector is a significant rising subject of interest to patent applicants. Additionally, rare earth extraction is the focus of US-based effort; more US-based applicants filed patent families than Chinese-based applicants. 90% of rare earth metals are extracted mostly in China, and the commodities are not often traded openly. Given this situation, US (and also Japanese and European) electronics firms have a strong incentive to source these crucial components outside of the restricted market. It was found that legislation pertaining to solder may be the driving force for development in a certain class of recovered materials. In the past, different ratios of lead and tin were employed to make solder in different uses. The replacement of lead in solder alloys by pure tin, but more often Tin, Silver, and Copper solders, has been made possible by a strong campaign in recent years to remove deadly lead from consumer electronics [7].

Lead, tin, silver, and copper all have activity peaks, and the topics of copper and silver recovery have both risen considerably above those of tin recovery, suggesting a trend that corresponds with a change in legislation affecting the solder business. Additionally, silver seems to be the main noble metal recovered from e-waste, which is probably because of solder

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regulations, such as the 2011 European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Directive (RoHS). Mobile phones and other telephony equipment are included in e-waste patents far less often than other things, despite the possibility that these products make up a significant fraction of actual e-waste streams. There might be two causes for this difference:

Mobile device e-waste technology may have been divided between the computers/laptops category and the telecommunications device category since mobile devices are closely related to "computing" equipment and it is difficult to distinguish between the two in current jargon. Mobile device-specific e-waste innovation focuses more on the components within the device than the device itself. Therefore, innovation in mobile device processing and recycling spans a number of different areas, including screens, batteries, printed circuit boards, etc. The emphasis on battery and printed circuit board e-waste inside mobile devices, as well as the growing usage of chemical separation methods and decontamination of mobile device waste streams, are all emerging markets in the recovery of mobile device e-waste. The amount of silver recovered from mobile devices is also increasing, adding a data point to the picture viewed over the whole landscape [8], [9].

DISCUSSION

E-waste, or electronic waste, is a rapidly growing global issue that poses significant environmental and health risks if not managed properly. However, within the challenge of e-waste lies an opportunity for commercialization, where innovative technical approaches can be employed to extract value from discarded electronic devices. This detailed description provides an overview of various technical approaches to e-waste commercialization, highlighting their benefits, challenges, and potential for sustainable resource recovery.

Recycling and Material Recovery:

Recycling is a primary technical approach to e-waste commercialization. It involves the recovery and processing of valuable materials from discarded electronic devices. Advanced recycling technologies, such as mechanical shredding, separation techniques, and hydrometallurgical processes, are utilized to extract precious metals (gold, silver, copper), rare earth metals, and other valuable components from e-waste. These recovered materials can be reused in the manufacturing of new electronic products, reducing the demand for virgin resources and contributing to a circular economy.

Refurbishment and Reuse:

Refurbishing and reusing electronic devices is another important aspect of e-waste commercialization. Functional devices are repaired, upgraded, and made available for resale or donation. This approach not only extends the lifespan of electronic devices but also reduces the need for new production. It provides affordable options for consumers, particularly in developing countries, and promotes a more sustainable consumption pattern by reducing e-waste generation.

Component Harvesting:

Component harvesting involves the extraction of reusable parts and components from discarded electronic devices. Components such as circuit boards, processors, memory chips, and displays can be salvaged and sold separately. These components are often in demand by repair technicians, hobbyists, or small-scale manufacturers, who can use them for various purposes, including repairs, prototyping, or building new electronic devices [10].

Data Sanitization and Destruction:

Given the sensitive nature of data stored in electronic devices, data sanitization and destruction are critical considerations in e-waste commercialization. Technical approaches, such as secure erasure methods, data wiping, and physical destruction of storage media, ensure that personal and confidential information is properly handled to prevent unauthorized access or data breaches. Proper data management not only protects privacy but also enhances trust and confidence in e-waste recycling and reuse processes.

Energy Recovery:

Energy recovery is an emerging technical approach in e-waste commercialization. It involves the conversion of non-recyclable e-waste components into energy through processes such as incineration, gasification, or pyrolysis. These processes can generate heat or electricity, which can be harnessed for various purposes, including industrial processes or power generation. Energy recovery from e-waste helps reduce the reliance on fossil fuels and can contribute to a more sustainable energy mix.

While technical approaches to e-waste commercialization offer promising opportunities, several challenges need to be addressed. These include the high costs of advanced recycling technologies, the need for effective e-waste collection and sorting systems, and the development of efficient supply chains for recovered materials. Additionally, environmental considerations, such as the proper handling of hazardous substances and the prevention of pollution during recycling processes, must be prioritized to ensure sustainable e-waste management. E-waste, or electronic waste, is a growing concern globally due to its environmental and health implications. However, with the right technical approaches, e-waste can also be seen as a potential source of valuable materials and a platform for commercialization. This detailed description explores various technical approaches to e-waste commercialization, highlighting their benefits and providing relevant facts:

Recycling and Material Recovery:

Recycling is a fundamental approach to e-waste commercialization. It involves the systematic extraction of valuable materials from discarded electronic devices. Metals such as gold, silver, copper, and palladium can be recovered from circuit boards, connectors, and wiring. Plastics, glass, and other materials can also be recycled. Fact: A metric ton of e-waste can contain more gold than 17 tons of gold ore.

Refurbishment and Resale:

Refurbishment involves repairing and upgrading discarded electronic devices to extend their lifespan. Refurbished devices can be resold in the market, providing an opportunity for economic value generation and reducing the demand for new electronic products. Fact: Refurbished electronics can cost significantly less than new devices, making them more accessible to consumers.

Component Harvesting:

Component harvesting involves extracting functional components, such as processors, memory modules, and screens, from discarded electronic devices. These components can be tested, refurbished, and used in the repair or manufacturing of new devices. Fact: Component harvesting reduces the need for raw material extraction and minimizes electronic waste generation.

Advanced Recovery Techniques:

Advanced recovery techniques utilize innovative methods to extract valuable materials from e-waste. These techniques include hydrometallurgical processes, which use chemical solutions to dissolve and recover metals, and pyrometallurgical processes, which use high temperatures to separate metals from other components. Fact: Advanced recovery techniques enable the extraction of rare and precious metals that may not be economically viable through traditional recycling methods.

Energy Recovery:

E-waste can also be utilized as a source of energy through processes such as incineration and gasification. These methods convert the organic materials present in e-waste into heat or electricity. Fact: Energy recovery from e-waste can help reduce the demand for fossil fuels and contribute to renewable energy generation.

It is important to note that while these technical approaches offer potential benefits, they also pose challenges. E-waste often contains hazardous substances, such as lead, mercury, and brominated flame retardants, which require careful handling and appropriate treatment to prevent environmental contamination and health risks. Therefore, implementing proper environmental and safety measures is essential. Moreover, e-waste commercialization requires supportive policies, regulations, and infrastructure. Governments and industry stakeholders need to collaborate to create a favorable ecosystem for e-waste management, including establishing collection systems, incentivizing recycling and responsible disposal practices, and promoting awareness among consumers. various technical approaches to e-waste commercialization offer opportunities to recover valuable materials, reduce environmental impacts, and create economic value. By adopting these approaches and implementing effective e-waste management strategies, we can transform e-waste from a challenge into an opportunity, promoting sustainability, resource conservation, and a circular economy mindset.

CONCLUSION

In conclusion, technical approaches to e-waste commercialization present a pathway to transform the e-waste challenge into an opportunity for sustainable resource recovery. Through recycling, refurbishment, component harvesting, data sanitization, and energy recovery, valuable materials and components can be extracted from e-waste, reducing the demand for virgin resources and contributing to a more circular and resource-efficient economy. However, the successful implementation of these approaches requires a holistic approach involving industry collaboration, supportive policies, and public awareness to drive the transition towards a sustainable e-waste management paradigm.

REFERENCES:

[1] J. P. Maulida, 'Implementasi Smart Governance Oleh Pemerintah Provinsi Dki Jakarta Melalui Aplikasi Qlue Di Tahun 2019', 2020.

[2] J. Joo, E. E. Kwon, And J. Lee, 'Achievements In Pyrolysis Process In E-Waste Management Sector', *Environmental Pollution*. 2021. Doi: 10.1016/J.Envpol.2021.117621.

[3] H. J. P. L. De Souza *Et Al.*, 'Pelletization Of Eucalyptus Wood And Coffee Growing Wastes: Strategies For Biomass Valorization And Sustainable Bioenergy Production', *Renew. Energy*, 2020, Doi: 10.1016/J.Renene.2019.12.015.

[4] T. Roy, S. Sahani, D. Madhu, And Y. Chandra Sharma, 'A Clean Approach Of Biodiesel Production From Waste Cooking Oil By Using Single Phase Basno3 As Solid Base Catalyst: Mechanism, Kinetics & E-Study', *J. Clean. Prod.*, 2020, Doi: 10.1016/J.Jclepro.2020.121440.

[5] A. José Sosa-Olivier And R. José Laines-Canepa, 'Refining Of The Solid Fraction Of Sheep Feces Digestates From An Anaerobic Digester', *Ing. E Investig.*, 2020, Doi: 10.15446/Ing.Investig.V40n2.83364.

[6] S. Jung, J. Lee, Y. K. Park, And E. E. Kwon, 'Bioelectrochemical Systems For A Circular Bioeconomy', *Bioresource Technology*. 2020. Doi: 10.1016/J.Biortech.2020.122748.

[7] M. Tossavainen *Et Al.*, 'Conversion Of Biowaste Leachate To Valuable Biomass And Lipids In Mixed Cultures Of Euglena Gracilis And Chlorophytes', *Algal Res.*, 2018, Doi: 10.1016/J.Algal.2018.08.007.

[8] J. T. M. C. Rodrigues And L. Werner, 'Forecasting Methods Of Generation Of Waste Electrical And Electronic Equipment: A Systematic Review', *Exacta*, 2019, Doi: 10.5585/Exactaep.V17n3.8301.

[9] A. E. Krauklis, C. W. Karl, A. I. Gagani, And J. K. Jørgensen, 'Composite Material Recycling Technology—State-Of-The-Art And Sustainable Development For The 2020s', *Journal Of Composites Science*. 2021. Doi: 10.3390/Jcs5010028.

[10] Z. Hameed *Et Al.*, 'Gasification Of Municipal Solid Waste Blends With Biomass For Energy Production And Resources Recovery: Current Status, Hybrid Technologies And Innovative Prospects', *Renew. Sustain. Energy Rev.*, 2021, Doi: 10.1016/J.Rser.2020.110375.

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India's E-Waste Management: Problems and Solutions

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ABSTRACT: India, like many other countries, faces significant challenges in managing the growing issue of electronic waste (e-waste). This study provides an overview of the problems associated with e-waste management in India and explores potential solutions to address this pressing environmental and public health concern. India is one of the world's largest producers of e-waste due to its rapid economic growth and increasing consumption of electronic devices. However, inadequate infrastructure, limited awareness, and ineffective regulations contribute to the inefficient management of e-waste in the country. The problems associated with e-waste management in India include informal and unsafe recycling practices, improper disposal leading to environmental pollution, occupational health hazards for workers, and the unorganized nature of the e-waste sector. The lack of robust recycling facilities and the absence of a comprehensive regulatory framework exacerbate these challenges.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Electronic waste, that is, waste arising from end-of-life electronic products such as computers and mobile phones, is one of the fastest growing waste streams in the world today. Annual global production of e-waste is estimated to surpass 50 million tons in 2020.2 India is among the top five e-waste producing countries in the world with estimated annual production of 2 million tons. Like some of the other developing countries, e-waste management in India is dominated by the informal sector with estimates of more than 90 per cent of the waste being processed in this sector. E-waste contains several precious metals, rare earth metals, ferrous and non-ferrous metals, plastic, wood and glass. Unscientific practices in the processing of e-waste are associated with several environmental and health externalities. In response to these concerns, many developed and developing countries have, over the past few decades, introduced regulations.

Extended Producer Responsibility and E-Waste

EPR, one of the more widely used approaches for regulating e-waste globally, places the responsibility of the end-of-life management of products on the manufacturers or the producers. Conceptually, EPR is designed to make the manufacturers internalize the external costs associated with the end-of-life disposal of their products. The Organisation for Economic Co-operation and Development specifies two broad objectives of EPR approach.5 First, the EPR shifts part of the burden of waste management from the local governments to the upstream producers. Second, by forcing the internalization of the external costs of disposal, the EPR is expected to provide incentives for producers to take environmental considerations into their product design. For example, the producers would have an incentive to design their products using materials that are more recyclable or less toxic if EPR makes the producers internalize the social costs of disposal after the useful life [1], [2].

Under the EPR approach, the producers can be made responsible in four distinct ways. Economic responsibility makes the producers pay, typically a tax, towards the costs of e-waste processing. Physical responsibility involves mandating, for example, take back of the products from the consumers, after their useful life. The product take back requirements may also enforce collection rate targets. Information responsibility might mandate providing information on the attributes of the products, including such requirements as product labelling. Finally, liability rules might specify financial liability for environmental damage and clean up. EPR regulations may include any one or a combination of these four types of producer responsibilities. India’s first e-waste regulations, known as E-waste Rules, 2011 used EPR approach and required the producers of electronic products to set up collection centres and inform the consumers on how the used electronic products can be returned to the collection centres. Early evaluation of these rules showed that while they may have created demand for new formal dismantling and recycling centres, the rules have largely been ineffective in improving the existing practices.

Partly as a result of the regulations, during the last eight years, Indian e-waste sector has been witnessing several changes: more serious efforts on the part of the producers, expansion of the formal waste management sector, emergence of producer responsibility organizations, and attempts to develop indigenous technologies to process and recover different components of e-waste, to name a few. However, despite these developments, the bulk of e-waste continues to be handled by the informal sector in India.

The objective of this colloquium is to take stock of the current status of the e-waste management ecosystem by identifying various challenges that the sector faces and potential paths for improvements. The colloquium brings together nine articles from national and global sectoral experts on different aspects of e-waste related to technology, finance, policies and regulations, formal and informal sector, business and PROs. The experts come from diverse work backgrounds such as government, international developmental organizations, civil society organizations, industry and academia [3], [4].

Taken together, the articles in the colloquium identify several challenges, such as the inadequate resources to monitor and enforce regulations, lack of awareness among the consumers regarding the nature of e-waste and the associated regulations and a narrow focus on compliance on the part of the producers. The central theme that cuts across all the articles, however, is the role of informal sector. A strong, well-established network of individuals operates in this sector, primarily in the collection of e-waste but also in recovery and recycling. The sector generates livelihoods to a large population, mostly belonging to the marginalized sections of the society. The practices they employ, however, are unscientific and unsafe, posing risks to their own health and potentially imposing environmental and health costs on the larger society. Most of the articles in the colloquium grapple with this dilemma: How to bring this strong network of people into a robust e-waste management system, which can preserve their livelihoods while simultaneously mitigating the external costs associated with e-waste processing and disposal. Satish Sinha draws upon his close to two decades of experience in working with the waste management sector, and in particular, the informal sector, to bring out the nuances of how the evolving e-waste landscape is affecting or getting affected by the informal sector in India.

Financing of e-waste management systems within an EPR approach is an important aspect and Deepali Sinha Khetriwal provides specific roadmap and milestones. Verena Radulovic, who is associated with the United States Environmental Protection Agency, brings a global perspective by bringing out insights on the role of voluntary industry standards based on her experience of the context in the United States and her fieldwork in Indian e-waste sector. PRO is an emerging institution within the e-waste ecosystem in the country and Pranshu Singhal, in his capacity as the founder of one of the first PROs in India, draws on his own experience to identify various steps that help PROs play a constructive role in e-waste management in India. Businesses are expected to play significant role in creating a robust market for e-waste and Kalyan Bhaskar, one of the co-editors of this colloquium, brings out these aspects of e-waste. Finally, producers are the central regulated entities within the existing EPR regulations, and Hitesh Sharma’s article calls for a rethink on the role of producers within the EPR framework, arguing for a more shared responsibility approach to managing e-waste.

DISCUSSION

Public Policy for E-Waste Management in India

India’s e-waste regulations, employing the EPR approach, came into effect in May 2012, with further amendments in 2016. The seven years of implementation has had limited impact on the larger e-waste management system in the country. On the positive side, the regulations may have led to establishment of hundreds of new recycling and dismantling units, formally registered with regulatory authorities. The 2016 amendments, which sets collection rate targets for producers of electronic products, appears to have generated greater seriousness among the producers to comply with the regulations. More generally, the regulations could be credited with bringing greater attention to the e-waste problem among the various stakeholders. Clearly, we are a long way from developing a policy framework that could facilitate a robust e-waste management system in the country.

E-Waste Management: Issues and Challenges for Policy

Poor information on e-waste generation rates: The 2012 regulations acknowledged the lack of waste

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inventories as a limitation and placed the responsibility of developing state-wise e-waste inventories on the respective state pollution control boards. Seven years since these regulations, to our knowledge, no SPCB has released an inventory as yet. The sales data on electronic products, which is an important input in the estimation of e-waste quantities, is often available at the national-level aggregation, making it challenging to produce inventories at the state levels. In addition to domestic generation, e-waste is also imported from developed economies, often illegally. There is little understanding of the nature and amount of e-waste that gets imported into the country. Designing systems for effective collection, transportation and processing requires reasonably accurate knowledge of waste generation, composition and flows.

Environmentally unsustainable informal sector practices: Despite the growth in the formal dismantling and recycling sector, the actual waste processed in the formal sector still remains very low. Anecdotal evidence indicates that most of these formal facilities are operating well below their approved capacities because of their inability to source enough waste. The lack of awareness regarding e-waste and costs of returning the end-of-life equipment to formal collection centres are reducing the willingness of household and institutional consumers to return their waste to formal sector. Most importantly, the informal sector, through the convenience of household collection and monetary incentives, makes it more attractive for consumers to return their waste, relative to the formal sector, which is yet to invest in robust systems of collection and processing. The informal e-waste sector provides livelihoods to millions of people, often belonging to the most marginalized groups; on the other hand, the sector's waste management practices pose serious environmental and health hazards to the workers themselves as well as the larger public. This presents a potential moral dilemma for public policy and sustained success of any e-waste management system will hinge on our ability to resolve this dilemma [5], [6]. Frictions in markets for the end-of-life products: The inability to reliably source e-waste quantities that create economies of scale restricts entry of private players, such as PROs to set up e-waste management systems in the formal sector. For example, employing effective recycling technologies for e-waste may require significant upfront capital expenditures, which may not be justified for private entities in the absence of certainty around sourcing of enough quantities of e-waste. Also, these markets suffer from information barriers. First, given that e-waste recycling is a relatively new business, potential lack of information on cost-effective recycling technologies itself could be a market barrier. Second, the low awareness, partly because of the lack of reliable information on e-waste management among consumers, affects the functioning of markets. Public policy may have to play a greater role in enabling better markets for e-waste.

Inadequate regulatory design and enforcement: In the 2012 regulations, the mandatory take back system for producers, without accompanying collection targets, provided no incentives to take responsibility and thus induced little improvements in e-waste management practices. This was addressed in the 2016 amendments, which provided more regulatory certainty by specifying gradual and increasingly stricter collection targets. Nevertheless, the regulatory design places a significant burden on the already ill-equipped regulatory agencies. The regulators are expected to review the EPR plan submitted by the producers, grant authorization and enforce the provisions of the EPR plan. The regulations also specified elaborate standards and processes for other entities—collectors, dismantlers, recyclers and bulk consumers—and require the agencies to enforce compliance with these standards. Regulatory capture by lobbies that benefit from poor enforcement, lack of transparency and unwillingness to publicly share information on compliance and regulatory actions have long afflicted environmental regulatory enforcement in India, and e-waste regulations are no exception. This poses a significant public policy challenge to the future of e-waste management in the country.

Creating a Robust E-waste Management System

By constantly evaluating the effectiveness of e-waste regulation and bringing in necessary regulatory changes, the government may have to play a facilitating role to bring together various stakeholders in the system. We outline a few steps that should be considered to move forward.

Informal sector:

The first step would be to more explicitly recognize the informal sector as a critical stakeholder in any future e-waste regime. Addressing the problem of informal sector e-waste practices requires a greater understanding of the sector itself in terms of their incentives and challenges. Engagement with the informal sector workers and the groups, in a manner that recognizes their right to livelihoods, builds trust and develops a shared understanding of the problems along with potential solutions, is a critical initial step. The government should institute a platform that facilitates consultations among various stakeholders such as the informal sector workers, NGOs working with the informal sector, third party private entities such as PROs and registered recyclers and manufacturers. Such forums could be constituted under the Ministry of Environment, Forest and Climate Change at the central level and under the State Departments of Environment at the state level. Working towards such cross-sector partnerships while evolving clearly defined roles for each stakeholder would be an important goal.

Policy instruments under EPR:

The government would need to rethink the policy instruments under the EPR approach. In the presence of an informal sector with strengths in collection logistics, a mandatory take back with collection targets may not be the ideal instrument. Producer responsibility could come in many varieties other than mandatory take back. Economic instruments such as advanced recycling fee or advanced disposal fee on every unit of the product sold in the market would relieve the producers of the physical responsibility of collection and the revenues generated could be used to develop markets for the end-of-the-life products. The revenues, which go into a separate fund, could be used in several ways. Some examples include subsidize consumers to deposit their e-waste at designated centres, directly fund recyclers or PROs and assist informal sector workers in training or skill development or provide greater social security net to the workers. These decisions may be made within the consultative forum recommended in the previous point on informal sector. The key problem with economic instruments would be to determine the right fee. Principles of economics would suggest a fee equivalent to the marginal external cost of the end-of-life equipment. While the assessment of such external costs is difficult in practice, the fee should be high enough to fund a robust, environmentally safe e-waste processing and disposal. A sufficiently high fee would also provide incentives for design for environment changes in product design, which has been one of the primary goals of EPR approach globally. In the long run, to further incentivize DoE changes, the fee could be based on such factors as the ease of dismantling, recyclability and environmental impact of materials used in the equipment. The policy framework should also focus on the development of indigenous technologies and/or technology transfer to encourage widespread application of environment-friendly e-waste recycling technologies [7].

Regulatory Enforcement:

Shifting to economic instruments such as an ADF would also relieve the regulatory burden since the producers need not be regulated anymore. The long experience with tax collection should make it easy to divert the ADF on electronic products to a separate fund. The SPCBs and the Central Pollution Control Board will still be required to monitor and enforce compliance with the standards specified for collection centres, dismantlers, recyclers and PROs. The MoEFCC must make the regulatory actions related to e-waste transparent. Regulatory actions such as authorizations and their conditions, data on inspections of registered facilities and compliance status of inspected facilities should all be made publicly available for scrutiny. A few SPCBs already provide some of these documents publicly on their websites, but these practices should be institutionalized as part of the regulations across the country. Developing a regularly updated and publicly available inventory of district-wise generation of e-waste quantities by e-waste type , waste composition and flows will also play an important role in enforcement.

E-waste Imports:

Under the existing regulations, e-waste is not allowed to be imported for final disposal but can be imported for reuse and recycling. In the absence of adequate infrastructure in the country for recycling, we should seriously consider banning all kinds of imports, similar to what China did recently. In order to develop accurate estimates of e-waste, data on imports must be integrated with the e-waste inventory.

Public Awareness:

The current e-waste regulations require the producers to provide, on their websites, information on the impacts of e-waste, appropriate disposal practices and such other issues. They are also required to run awareness campaigns at regular intervals. Many producers have already provided information on their websites, but evidence shows that the overall awareness levels, even among bulk consumers, remain low. Stricter guidelines/regulations to the producers on the frequency and mode of these awareness campaigns might improve the situation. Alternatively, the producers should be mandated to run these campaigns through grassroots-level organizations working in the area of e-waste. The government on its part should consider integrating e-waste awareness campaigns with other waste streams such as batteries and municipal solid waste. Research on effective messaging techniques and evaluation of information campaigns could also form a part of the government's role. These awareness efforts should be geared towards not only achieving safe handling of e-waste but also reducing consumption of electronic products in the long run. Overall, the public awareness generation initiatives should be based on partnerships and collaboration among various stakeholders [8], [9]. India faces significant challenges in e-waste management due to its rapid technological growth, increasing consumerism, and inadequate infrastructure. This detailed description explores the problems associated with e-waste management in India and proposes potential solutions to address this pressing issue. Relevant facts are provided to support the discussion:

Growing E-Waste Generation:

India is one of the largest generators of e-waste globally, with an estimated volume of 2 million metric tons in 2020. This is projected to increase to 5.2 million metric tons by 2030. Fact: The average Indian generates approximately 2.7 kg of e-waste annually.

Informal Sector Recycling:

A significant challenge in India's e-waste management is the prevalence of the informal sector. A large portion of e-waste is handled by informal recyclers, who often lack proper equipment, knowledge, and safety measures. This leads to environmental pollution and health hazards due to the unsafe extraction of valuable materials. Fact: It is estimated that around 95% of e-waste in India is processed by the informal sector.

Lack of Infrastructure:

India faces a lack of adequate e-waste collection infrastructure, including authorized collection centers and recycling facilities. Many areas, especially in rural regions, lack proper e-waste disposal mechanisms. This results in improper disposal, including burning or dumping e-waste in landfills, rivers, or open areas. Fact: Only about 10-15% of e-waste in India is formally recycled.

Limited Awareness and Compliance:

There is a lack of awareness among the general public regarding the hazards of e-waste and the importance of proper disposal. Compliance with e-waste regulations, such as the E-Waste Management Rules introduced in 2016, is also a challenge. Fact: A survey conducted in India found that only 12% of respondents were aware of e-waste collection centers.

Solutions to address India's e-waste management challenges:

Strengthening Legislation and Enforcement:

Stricter enforcement of e-waste management rules and regulations, including monitoring and penalizing non-compliant entities, can drive responsible disposal practices. This can be achieved through increased coordination between government bodies, regulatory authorities, and law enforcement agencies.

Building Infrastructure:

Investments in e-waste collection centers, recycling facilities, and formal treatment plants are essential to improve infrastructure for proper disposal and recycling. Establishing collection mechanisms in remote areas and incentivizing recycling industries can enhance accessibility and encourage responsible e-waste management.

Promoting Awareness and Education:

Raising public awareness about the hazards of e-waste and the importance of proper disposal is crucial. Educational campaigns targeting consumers, businesses, and educational institutions can promote responsible e-waste management practices and encourage recycling initiatives.

Encouraging Extended Producer Responsibility (EPR):

Implementing effective EPR schemes can hold producers accountable for the entire lifecycle of their products, including proper e-waste management. This can incentivize manufacturers to design products with recyclability in mind and establish take-back programs for their electronic devices.

Supporting Formalization of the Informal Sector:

Integrating informal recyclers into the formal e-waste management system through training programs, capacity building, and providing access to proper infrastructure can improve recycling practices and ensure the safety and well-being of workers involved. India's e-waste management faces significant challenges, but viable solutions exist to address them. Strengthening legislation, building infrastructure, raising awareness, promoting EPR, and formalizing the informal sector are key steps to establish a robust e-waste management framework. By implementing these solutions, India can effectively mitigate the environmental and health risks associated with e-waste while unlocking the economic potential of resource recovery and sustainable practices.

CONCLUSION

The explosion of electronic products over the last decade or so and the corresponding rapid raise in e-waste pose a significant environmental challenge to the governments, particularly in developing countries. The limited impact that India's seven-year old regulations have had is an indication of the challenges that the country faces as far as e-waste management is concerned. This article identifies informal sector e-waste practices, poor regulatory design and enforcement, and low awareness as some of the challenges that India faces. Meaningful engagement of all the stakeholders should be central to developing a robust e-waste management system of the future. Addressing the challenges of e-waste management in India requires a comprehensive and multi-stakeholder approach. The collaboration of government, industry, civil society, and the public is essential to create a sustainable and efficient e-waste management system that protects the environment, promotes resource recovery, and safeguards human health. In conclusion, India faces significant challenges in managing e-waste, but efforts are underway to address these issues. By strengthening regulations, building infrastructure, promoting awareness and education, encouraging producer responsibility, formalizing the informal sector, and fostering international cooperation, India can pave the way for effective e-waste management and contribute to a sustainable future.

REFERENCES:

[1] K. Bhaskar and R. M. R. Turaga, 'India's E-waste rules and their impact on E-waste management practices a case study', *J. Ind. Ecol.*, 2018, doi: 10.1111/jiec.12619.

[2] A. Borthakur and M. Govind, 'Emerging trends in consumers' E-waste disposal behaviour and awareness: A worldwide overview with special focus on India', *Resources, Conservation and Recycling*. 2017. doi: 10.1016/j.resconrec.2016.11.011.

[3] R. M. R. Turaga and K. Bhaskar, 'Epr and Policy Instruments for E- Waste Management: a Review and Lessons for India ' S New E-Waste Regulations', *Sixt. Int. Waste Manag. Landfill Symp.*, 2017.

[4] M. Dwivedy, P. Suchde, and R. K. Mittal, 'Modeling and assessment of e-waste take-back strategies in India', *Resour. Conserv. Recycl.*, 2015, doi: 10.1016/j.resconrec.2015.01.003.

[5] V. N. Pinto, 'E-waste hazard: The impending challenge', *Indian Journal of Occupational and Environmental Medicine*. 2008. doi: 10.4103/0019-5278.43263.

[6] J. E. Corwin, '"Nothing is useless in nature": Delhi's repair economies and value-creation in an electronics "waste" sector', *Environ. Plan. A*, 2018, doi: 10.1177/0308518X17739006.

[7] M. K. Jhariya, K. P. Sahu, and A. Raj, 'E-waste, a new challenge to the environmentalists', *Nature Environment and Pollution Technology*. 2014.

[8] C. Mukherjee, J. Denney, E. G. Mbonimpa, J. Slagley, and R. Bhowmik, 'A review on municipal solid waste-to-energy trends in the USA', *Renewable and Sustainable Energy Reviews*. 2020. doi: 10.1016/j.rser.2019.109512.

[9] S. F. dos Santos *et al.*, 'Post-harvest losses of fruits and vegetables in supply centers in Salvador, Brazil: Analysis of determinants, volumes and reduction strategies', *Waste Manag.*, 2020, doi: 10.1016/j.wasman.2019.10.007.

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An overview on Recycling Technology

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ABSTRACT: Recycling technology plays a crucial role in achieving sustainable waste management and resource conservation. This study provides an overview of various recycling technologies, their processes, and their significance in promoting a circular economy. The overview begins with mechanical recycling, which involves the physical processing of waste materials to extract valuable components. Mechanical recycling processes, such as sorting, cleaning, shredding, and grinding, enable the recovery of materials like plastics, metals, paper, and glass for reuse in the production of new products. Chemical recycling, also known as feedstock recycling, offers an alternative approach for challenging-to-recycle materials. Through chemical reactions, waste materials, especially complex polymers, can be converted into basic chemicals or fuels, serving as valuable feedstock for various industries. Biological recycling, including composting and anaerobic digestion, focuses on the decomposition of organic waste. Microorganisms break down organic matter into compost or biogas, diverting organic waste from landfills, reducing greenhouse gas emissions, and producing valuable soil amendments or renewable energy.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

An overview of recycling technology provides a comprehensive examination of the various technologies and processes used in the recycling industry to recover valuable resources from waste materials. Recycling technology plays a critical role in mitigating environmental impacts, conserving natural resources, and reducing waste generation. This detailed description will explore the key aspects and technologies involved in recycling, including collection, sorting, processing, and the transformation of waste into reusable materials. The first step in the recycling process is the collection of waste materials. This can be done through curbside collection programs, drop-off centers, or specialized recycling facilities. The overview of recycling technology discusses different collection methods and the importance of effective waste management systems in ensuring the availability of recyclable materials for processing.

Sorting and separation are integral processes in recycling technology. Waste materials are sorted based on their composition and properties, such as plastics, paper, metals, glass, and organic waste. Various sorting technologies are employed, including manual sorting, automated sorting machines, magnetic separators, eddy current separators, and optical sorting systems. These technologies facilitate the separation of different materials, enabling efficient recycling and maximizing the recovery of valuable resources. Once the waste materials are sorted, they undergo processing to transform them into reusable materials. This involves various recycling technologies tailored to specific waste streams. For example, plastics can be mechanically processed through shredding, grinding, and extrusion to produce plastic pellets for manufacturing new plastic products. Paper and cardboard can be pulped and de-inked to produce recycled paper. Metals are melted down and refined to be used in the production of new metal products. Glass is crushed and melted to create new glass containers or fiberglass products. Organic waste can be composted or processed through anaerobic digestion to produce biogas and organic fertilizers.

Advanced recycling technologies have emerged in recent years, aiming to tackle more challenging waste streams and increase recycling rates. These technologies include chemical recycling, which uses chemical processes to break down plastics into their molecular components for the production of new plastics or fuels. Additionally, advancements in electronic waste recycling have allowed for the extraction of valuable metals and components from discarded electronic devices, reducing the environmental impact associated with electronic waste disposal. The overview also highlights the importance of quality control in the recycling process. Recycled materials must meet specific quality standards to ensure their suitability for use in manufacturing processes. Quality control measures, such as testing for contaminants and maintaining consistency in material properties, are essential to maintain the integrity of recycled materials and promote their market acceptance. Furthermore, the overview discusses the role of innovation and research in driving advancements in recycling technology. Ongoing efforts focus on improving the efficiency of recycling processes, developing new recycling methods for challenging waste streams, and exploring opportunities for waste-to-energy conversion.

Thermal recycling utilizes heat to convert waste materials into energy. Incineration burns waste at high temperatures, generating heat for electricity or heating systems, while gasification converts waste into syngas for energy generation or chemical production. Thermal recycling reduces waste volume and provides a source of renewable energy. Electrometallurgical processes are specifically designed for electronic waste (e-waste) recycling. Valuable metals like gold, silver, and copper are recovered through electrolysis, reducing the need for mining and minimizing environmental impacts. Effective reverse logistics, involving well-designed collection systems, transportation, and sorting, are crucial for efficient recycling. These systems ensure that recyclable materials are collected and delivered to appropriate recycling facilities.

Implementing recycling technologies offers numerous benefits, including resource conservation, waste volume reduction, energy generation, and environmental protection. However, challenges such as cost, infrastructure limitations, and the need for consumer education and participation remain. Recycling technology provides essential tools for achieving sustainable waste management and resource conservation. Mechanical, chemical, biological, thermal, electrometallurgical recycling, and effective reverse logistics contribute to the circular economy by recovering valuable materials, reducing waste, and minimizing environmental impacts. Continued research, investment, and collaboration are vital for further advancements and widespread adoption of recycling technologies [1], [2].

DISCUSSION

Recycling technology plays a crucial role in addressing the challenges of waste management, resource depletion, and environmental sustainability. This detailed overview provides insights into various recycling technologies, their processes, and their significance in promoting a circular economy.

Mechanical Recycling:

Mechanical recycling is one of the most common and widely used recycling technologies. It involves the physical processing of waste materials to extract valuable components. In this process, materials such as plastics, metals, paper, and glass are sorted, cleaned, and transformed into reusable raw materials through processes like shredding, crushing, grinding, and sieving. Mechanical recycling enables the recovery of materials for the production of new products, reducing the need for virgin resources.

Chemical Recycling:

Chemical recycling, also known as feedstock recycling or advanced recycling, involves the conversion of waste materials into basic chemicals or fuels through chemical reactions. This technology is particularly useful for materials that are challenging to mechanically recycle, such as mixed plastics or contaminated materials. Chemical recycling can break down complex polymers into their basic building blocks, which can be used as feedstock for the production of new materials or energy generation.

Biological Recycling:

Biological recycling, also known as composting or organic recycling, focuses on the decomposition of organic waste materials. This process utilizes microorganisms to break down organic matter, such as food waste, yard waste, and agricultural residues, into compost or biogas. Composting is commonly used for organic waste in home and commercial settings, while anaerobic digestion is employed to produce biogas through the decomposition of organic waste in the absence of oxygen. Biological recycling helps divert organic waste from landfills, reduces greenhouse gas emissions, and produces valuable soil amendments or renewable energy [3], [4].

Thermal Recycling:

Thermal recycling involves the use of heat to convert waste materials into energy. There are two primary thermal recycling processes: incineration and gasification. Incineration involves burning waste at high temperatures, generating heat that can be used for electricity generation or heating systems. Gasification is a more advanced process that converts waste into a synthesis gas (syngas), which can be used for various purposes, including energy generation, chemical production, or fuel synthesis. Thermal recycling reduces waste volume, minimizes landfill usage, and provides a source of renewable energy.

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Thermal recycling, also known as waste-to-energy or energy recovery, is a process that involves the conversion of waste materials into energy through thermal treatment methods. It is a sustainable waste management approach that combines waste disposal with energy generation, helping to reduce the reliance on fossil fuels and minimize the environmental impact of waste disposal.

The thermal recycling process typically involves the following steps:

1. **Waste collection and sorting:** Waste materials, such as municipal solid waste (MSW), industrial waste, or biomass, are collected and sorted to remove recyclable materials and hazardous waste. The remaining waste is prepared for thermal treatment.
2. **Incineration:** The waste is subjected to high temperatures in an incineration facility. Combustion processes, such as mass-burn incineration or refuse-derived fuel (RDF) combustion, are employed to convert the waste into heat.
3. **Energy recovery:** The heat generated from incineration is used to produce steam, which drives a turbine to generate electricity. The electricity generated can be supplied to the grid or used for on-site energy needs, such as powering the incineration facility or nearby facilities.
4. **Air pollution control:** To minimize the release of harmful emissions, such as particulate matter, heavy metals, and dioxins, from the incineration process, strict air pollution control measures are implemented. These include the use of scrubbers, filters, and other emission control technologies to clean the flue gases before they are released into the atmosphere.
5. **Residue management:** After the incineration process, the remaining ash, called bottom ash, and any air pollution control residues, called fly ash, are collected and treated. These residues may undergo further processing, such as metal recovery or stabilization, before being disposed of in a controlled manner.

Thermal recycling offers several advantages. It reduces the volume of waste that goes to landfill, thus conserving valuable land resources. The process also provides a source of renewable energy, reducing the reliance on fossil fuels and contributing to the transition towards a low-carbon economy. In some cases, the heat generated from the process can be utilized for district heating or industrial processes, further improving energy efficiency. Furthermore, thermal recycling can be a viable solution for waste streams that are not easily recyclable or have limited recycling options. It helps to recover energy from non-recyclable materials that would otherwise end up in landfills, thereby maximizing resource utilization. However, it is important to note that proper waste management hierarchy should be followed, with waste reduction, reuse, and recycling prioritized over thermal recycling. Waste prevention and recycling efforts should be promoted to minimize waste generation and maximize material recovery.

Electrometallurgical Processes:

Electrometallurgical processes, such as electrolysis, are used to recover valuable metals from electronic waste (e-waste). Through these processes, metals like gold, silver, copper, and palladium can be separated and purified for reuse. Electrometallurgical recycling minimizes the need for mining and reduces the environmental impact associated with metal extraction.

Reverse Logistics:

Reverse logistics is an essential aspect of recycling technology that focuses on the efficient collection, transportation, and sorting of recyclable materials. It involves establishing well-designed collection systems, often through partnerships between recycling companies, waste management authorities, and consumers. Reverse logistics ensures that recyclable materials are collected and delivered to appropriate recycling facilities for further processing[5], [6].

Reverse logistics is a process that involves the management of the flow of goods and materials from the point of consumption back to their point of origin or another destination for the purpose of value recovery, proper disposal, or recycling. Unlike traditional forward logistics, which focuses on the movement of goods from manufacturers to end consumers, reverse logistics deals with the reverse flow of products and materials. The reverse logistics process begins with the collection of products that are no longer needed, defective, expired, or returned by customers. These products are then transported back to designated locations, such as distribution centers or recycling facilities, for further evaluation and processing.

Once the products are received, they undergo various activities, including sorting, inspection, refurbishment, repair, or disposal. Depending on the nature of the products and their condition, different strategies are employed. For instance, if the products are still in good condition, they may be refurbished or repackaged for resale as refurbished or renewed products. If the products are damaged or defective, they may undergo repairs or component replacement before being reintroduced into the market. In cases where the products cannot be reused, they are recycled or disposed of in an environmentally responsible manner. Reverse logistics also involves managing customer returns. This includes processes such as product return authorization, return transportation, and assessment of returned items for potential refurbishment or disposal. By effectively managing customer returns, companies can enhance customer satisfaction, reduce waste, and recover value from returned products. Another aspect of reverse logistics is managing the disposal of hazardous materials or products that pose environmental risks. This requires compliance with applicable regulations and ensuring proper handling, treatment, and disposal of such materials to minimize negative environmental impacts.

The implementation of reverse logistics offers several benefits. It can help companies reduce costs associated with waste disposal and the acquisition of new materials. By recovering value from returned or unused products, companies can recoup some of the initial investment and potentially increase profitability. Reverse logistics also supports sustainability efforts by promoting recycling, reducing waste, and minimizing the environmental footprint associated with product disposal. Efficient reverse logistics requires effective communication, collaboration, and coordination among various stakeholders, including manufacturers, retailers, logistics providers, and recycling facilities. Advanced technologies, such as barcode scanning, tracking systems, and data analytics, play a crucial role in optimizing the reverse logistics process by providing visibility, traceability, and decision support.

The development and implementation of advanced recycling technologies are vital for achieving a sustainable and circular economy. These technologies enable the recovery of valuable resources from waste, reduce the reliance on virgin materials, minimize energy consumption, and mitigate environmental impacts. However, challenges such as the high cost of advanced recycling technologies, limited infrastructure, and the need for consumer education and participation remain [7], [8]. Technologies, and innovations involved in the recycling industry. From waste collection and sorting to processing and transformation, recycling technology plays a vital role in resource recovery and waste reduction. By implementing and advancing recycling technologies, we can contribute to a more sustainable and circular economy while reducing the strain on natural resources and minimizing environmental impacts.

Recycling technology plays a crucial role in addressing the growing challenge of waste management and resource conservation. This detailed description provides an overview of recycling technology, highlighting its importance, various recycling processes, and relevant facts:

Importance of Recycling Technology:

Recycling technology is essential for minimizing waste generation, conserving resources, reducing environmental impacts, and promoting a circular economy. By extracting valuable materials from waste, recycling technology helps reduce the need for raw material extraction, saves energy, and mitigates pollution associated with landfilling or incineration.

Various Recycling Processes:

Mechanical Recycling:

Mechanical recycling is a common method that involves the physical separation and sorting of recyclable materials. It typically involves processes such as shredding, sorting, washing, and pelletizing. This process is suitable for materials like plastics, paper, glass, and metals. Fact: Mechanical recycling of plastic bottles can save up to 84% of the energy required to produce new bottles.

Chemical Recycling:

Chemical recycling, also known as feedstock recycling, involves the breakdown of waste materials into their chemical components for reuse or conversion into new products. It can handle complex and mixed waste streams that are challenging to mechanically separate. Fact: Chemical recycling can enable the recycling of plastics that are difficult to mechanically recycle, such as multilayer or heavily contaminated plastics.

Biological Recycling:

Biological recycling, also called composting or biodegradation, involves the breakdown of organic waste materials through natural processes. This method is commonly used for food waste, yard waste, and certain types of paper. Fact: Composting organic waste can help reduce methane emissions, a potent greenhouse gas, by diverting it from landfills.

Thermal Recycling:

Thermal recycling refers to processes that use heat to convert waste materials into energy or valuable products. This includes incineration, gasification, and pyrolysis. These methods can generate heat, electricity, or biofuels from waste materials while minimizing the volume of waste. Fact: Modern waste-to-energy plants can convert waste into electricity, powering thousands of households while reducing the need for fossil fuel-based energy generation.

Electrochemical Recycling:

Electrochemical recycling involves the use of chemical reactions and electricity to break down and separate waste materials. This technology is particularly promising for the recycling of batteries and electronic waste, where valuable metals can be recovered. Fact: Electrochemical recycling can recover high-purity metals from electronic waste with minimal environmental impact.

Facts about Recycling:

1. Recycling one ton of paper saves around 17 trees, 7,000 gallons of water, and 4,100 kWh of energy.
2. Aluminum cans can be recycled indefinitely without losing quality, saving up to 95% of the energy needed to produce new aluminum.
3. Recycling one ton of plastic can save approximately 5,774 kWh of energy.
4. Recycling one ton of glass can save enough energy to power a 100-watt light bulb for four years.

By implementing various recycling processes, valuable materials can be recovered, energy can be saved, and environmental impacts can be reduced. Embracing recycling technology is crucial for building a sustainable future, promoting a circular economy, and mitigating the challenges associated with waste generation and resource depletion.

CONCLUSION

Recycling technology offers a diverse range of approaches to address waste management challenges and promote resource conservation. Through mechanical recycling, chemical recycling, biological recycling, thermal recycling, electrometallurgical processes, and effective reverse logistics, valuable materials can be recovered, waste volumes reduced, and energy generated. Continued research, investment, and collaboration among governments, industries, and communities are necessary to optimize recycling technologies, improve. an overview of recycling technology provides a detailed exploration of the processes,

REFERENCES:

[1] L. Zhang and Z. Xu, 'A review of current progress of recycling technologies for metals from waste electrical and electronic equipment', *Journal of Cleaner Production*. 2016. doi: 10.1016/j.jclepro.2016.04.004.

[2] M. Rahmani, L. Gui, and A. Atasu, 'The Implications of Recycling Technology Choice on Extended Producer Responsibility', *Prod. Oper. Manag.*, 2021, doi: 10.1111/poms.13279.

[3] J. Rybicka, A. Tiwari, and G. A. Leeke, 'Technology readiness level assessment of composites recycling technologies', *J. Clean. Prod.*, 2016, doi: 10.1016/j.jclepro.2015.08.104.

[4] A. E. Krauklis, C. W. Karl, A. I. Gagani, and J. K. Jørgensen, 'Composite material recycling technology—state-of-the-art and sustainable development for the 2020s', *Journal of Composites Science*. 2021. doi: 10.3390/jcs5010028.

[5] D. Damayanti, L. A. Wulandari, A. Bagaskoro, A. Rianjanu, and H. S. Wu, 'Possibility routes for textile recycling technology', *Polymers*. 2021. doi: 10.3390/polym13213834.

[6] F. Xiao, S. Yao, J. Wang, X. Li, and S. Amirkhanian, 'A literature review on cold recycling technology of asphalt pavement', *Construction and Building Materials*. 2018. doi: 10.1016/j.conbuildmat.2018.06.006.

[7] P. Aleksandar, T. Danijela, A. Slavko, J. Dragan, and P. Milan, 'Evaluation and choosing of recycling technologies by using FAHP', *Acta Polytech. Hungarica*, 2016, doi: 10.12700/aph.13.7.2016.7.8.

[8] Z. A. Kader, A. Marshall, and J. Kennedy, 'A review on sustainable recycling technologies for lithium-ion batteries', *Emergent Materials*. 2021. doi: 10.1007/s42247-021-00201-w.

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National Legal Regime on E-Waste Management in India

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***ABSTRACT:** The choice of disposal depends not only on the legislative framework of a particular country and its implementation but also on vigilant and aware citizenry of the nation state. E-waste is one of the fastest growing post-consumer waste streams. It can be anticipated that the quantity of e-waste is likely to increase by much higher proportion than ever happened and at the same time it is quite disappointing to know that e-waste management practices and policy level initiatives are at the nascent stage and are still undeveloped. The main difficulty in regulating e-waste is that it's major collection, transportation, processing and recycling is predominantly in the hands of unorganized sector which though well networked but at the same time is totally unregulated and mostly handled by unskilled workers who hardly have any knowledge about the right methods to handle the same. Since all the modern nation states are coming across the problem of e-waste, to deal with these various international agreements and conventions have been enacted and have been signed by the nation states on global level. As far as India is concerned, various issues involved in e-waste management include impact of e-waste on human physiology and environment, issues regarding recycling, massive unorganized sector that deals in e-waste, legal framework implemented so far to control e-waste and lack of awareness among people with regard to disposal of e-waste. The entire paper brought to the knowledge of researcher recent scenario on e-waste management which helped researcher to quote facts and figures wherever required.*

***KEYWORDS:** E-Waste, Disposal, Hazardous Substances, Management, Recycling.*

INTRODUCTION

Today environment is clearly at high risk from different kinds of harms associated with human origin and development. It includes variety of pollution, ozone layer depletion, global warming, deforestation, global warming, climate change etc. In order to tackle the environmental harms which are primarily caused by human intervention and unmindful use of natural resources, it is extremely important to develop strategies for altering human behavior from harsh conduct towards environmentally friendly practices. Though this can be done with intervention of education, sensitization, ethics, family pressure etc. but effectiveness of the same remains in doubt. Whereas law works as a tool of socio-legal transformation its intervention in the sphere of environment is of recent origin. Accordingly, there has emerged variety of national legislations to tackle the growing problems pertaining to environment degradation. The Department related Parliamentary Standing Committee on Science & Technology, Environment & Forests has clearly mentioned in its 192nd Report titled as "Functioning of the Central Pollution Control Board" that e-waste is going to be a big problem in the future due to change in lifestyles and increase in living standards of the population.1 Therefore this report anticipated the rising threat from e-waste. Further, UNEP on "Recycling from E-Waste to Resources" has examined impact of electronic devices as cooling equipment ozone depletion substances like CFCs on the environment. In addition, National Green Tribunal directed the MoEFCC to arrange a meeting of various stakeholders involved and propose a scheme for effective e-waste management. 1 In such context, it becomes important to understand the existing e-waste legal regime and its evolution in India. At the same time it is also vital to make brief comparative analysis of legislative frameworks of developed and developing nations [1], [2].

Current E-Waste Management Scenario in India:

Majority of the activities associated with management and regulation of e-waste beginning from collection, dismantling, segregation, transportation and dumping are majorly performed by unorganized sector in informal way. E-waste being a source of rich and expensive metals, its recycling is a good source of revenue or income for many in India. Activities which are carried out in an unorganized sector are performed

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in informal ways. Informal mechanisms involve manual labor and intensive practices involving rudimentary methods of resource recovery and recycling. Informal sector plays a historic role in waste management practices and e-waste management is no exception to the same with an estimate of 95 per cent of e-waste recycled through the informal sector. India generates approximately 18 lakh tonnes of e-waste in an year and growing with the pace of 30 per cent annually.

Of this, about 5 per cent is brought by 153 approved recyclers and dismantlers while the remaining is picked up by the informal or unorganized sector which extracts maximum profitable metals out of it and dumps the remains of the same into landfills. Currently most of the e-scrape or e-waste goes to scrape dealers and from there it reaches dismantlers and recyclers in the unorganized or informal sector and there they employ rudimentary processes under uncontrolled conditions which contributes in causing environmental degradation.3 Predominance of informal sector in e-waste management is apparent and is further corroborated with the literature available on the subject. The reasons for such predominance are as follows: Absence of adequate infrastructure of waste management; The quantity and composition of materials that are recovered from e-waste and their market value; Provides employment to millions in urban and peri urban sectors. Absence of strict enforcement of legislations specifically dealing with e-waste viz. implementation of extended producer responsibility; A key concern regarding informal sector is primarily based on the hazardous nature of processes and mechanisms involved in recycling process [3].

DISCUSSION

Development of E-Waste Legislation in India:

Waste management has always been an important issue in context of environmental legislations. Development of laws on e-waste management started with indirect legislative measures on the subject such as Rules, 1989. It was a decade back that Government of India formulated regulatory measures to address the concern of e-waste management and disposal directly. Prior to this, there were legislations to tackle environmental pollution coming from improper disposal of only solid wastes. These legislative measures though comprise of strong framework dealing with solid wastes but failed to effectively encompass in itself the mechanism to handle and dispose e-waste. Absence of linkage between measures to handle solid waste and e-waste due to distinctive properties of e-waste made the regulations unproductive in dealing with e-waste disposal. The issue of e-waste, its handling and disposal assumed importance with progressive stride in sector of information technology. This was first brought to the notice in Parliament on December 23, 2005 through a private Member's Bill on Electronic Waste Bill, 2005. The Bill was introduced in RajyaSabha by Shri Vijay J. Darda, Hon'ble Member of Parliament from Maharashtra. The Bill acknowledged the fact that when every household is consumer of number of EEE but there are no guidelines on handling and disposal of such EEE which contains toxic wastes.4 Once EEE become obsolete or discarded by consumers, these are either thrown into garbage bins or sold to scrape dealers who dismantle the same and extract valuable metals and throw the toxic residue into landfills. Throwing toxic waste like e-waste into landfills is definitely not the right method of handing and disposing the toxic waste and have disastrous consequences on human health and environment. 13 Therefore the Bill sought to develop proper mechanism for handling and disposal of e-waste by prescribing norms and fixing certain responsibilities on consumers, recyclers and manufacturers for all matters related to it. The Bill however, lapsed in July 2010 with the retirement of the member from Rajya Sabha.

The committee classified the industries into three categories Category A, B and C depending on their adverse impact on the environment. The court ordered to close Category C limestone quarries and observed that: "the consequence of this order made by us would be that the lessees of lime-stone quarries which have been directed to be closed down permanently under this order, would be thrown out of business in which they have invested large sums of money and expended considerable time and effort. This would undoubtedly cause hardship to them, but it is a price that has to be paid for protecting and safeguarding the right of the people to live in healthy environment with minimal disturbance of ecological balance and without avoidable hazard of them and to their cattle, homes and agricultural land and under affectation of air, water and environment." Later the interpretation was so widened that the top Court in Tarun Bharat SanghCase7 intervened to protect wildlife and forest wealth from the dangers of mininghappening in and around Sariska sanctuary in district Alwar of Rajasthan.

The court observed that: “This litigation concerns environment. A great American Judge emphasizing the imperative issue of environment said that he placed Government above big business, individual liberty above Government and environment above all. The issues and concerns in this case far transcend the trivialities and inhibitions of an adversarial litigation. All the parties must be forthcoming in a concerted effort to find a satisfying solution to the problem which, in more ways than one, is typical of the Indian predicament. We are, therefore, entitled to expect that the State Government and the mining-entrepreneurs in their own enlightened self-interest will discard the adversarial litigation stance. The issues of environment must and shall receive the highest attention from this Court.” Article 32 and Article 226 of the Constitution of India have been handy tools to deal with the issues related to the environment. The powers of the Supreme Court of issuing directions under Article 32 and that of the High Courts to do the same under Article 226 have attained noteworthy significance in development of environmental litigation. Nearly 95 percent of action taken on environmental issues is brought to the notice of Court through PIL. Courts have been using these extraordinary powers to correct or compensate the past maladies or unmindful conduct of the exploiters of natural resources and to check ongoing and future assaults on the environment [4], [5].

Environment Protection Laws in India:

The decision to protect environment was taken at Stockholm Convention in June, 1972 in which India participated to take requisite steps for the protection and improvement of human environment. Participation and ratification of various international conventions on environment protection necessitated further action to implement the decision of not only protecting and improving the environment but also prevention of hazards on human beings, other creatures, plants and property.

The Hazardous Wastes Rules, 2008:

With the success of introducing e-waste in HW Rules, 2003 and with the further endeavour to frame suitable legislation to deal with illegal dumping of e-waste, Government of India enacted HW Rules, 2007 to ban transboundary movement of hazardous waste as obligated by Basel Convention to a member state. On September 24, 2008 these Rules were notified in as HW, 2008 by the MoEFCC in lieu of Rules, 1989 except in respect of things done or omitted to be done before enforcement of 2008 Rules.11 These Rules contained detailed provisions with regard to handling, disposal and transboundary movement of e-waste. These Rules require the person wanting to start a recycling or reprocessing hazardous waste unit is required to take permission from CPCB. Further the waste generated has to be sent to a registered recycler or reprocessor having system of environmentally sound management facilities to take on the process of recovery. Before granting registration to the recyclers or re processors of waste, Central Pollution Control Board is required to satisfy itself regarding availability of environmentally sound technology, requisite technical capabilities, adequate facilities and equipment for recycling or reprocessing of hazardous waste. The second category which is traded under Open General License includesmaterials like steel, iron, zinc scrape, waste of copper and its alloys. Lastly, the third category deals with hazardous wastes prohibited from export and import and these include mercury and mercury bearing compounds, wastes containing arsenic, beryllium, thallium, chromium compounds etc. In addition Rules contain provisions for Coordination Committees for the purpose of strong implementation [6].

The management of e-waste in India is governed by a comprehensive national legal regime that aims to regulate the generation, collection, transportation, storage, and disposal of electronic waste. This detailed description provides an overview of the national legal framework on e-waste management in India, highlighting key legislation, regulatory authorities, and relevant facts:

E-Waste (Management) Rules, 2016:

The E-Waste (Management) Rules, 2016, is the primary legislation governing e-waste management in India. These rules provide a legal framework for the environmentally sound management of e-waste and the responsibility of various stakeholders involved in the lifecycle of electronic products. Fact: The E-Waste (Management) Rules, 2016, superseded the earlier E-Waste (Management and Handling) Rules, 2011, and expanded the scope of regulations.

Extended Producer Responsibility (EPR):

The E-Waste (Management) Rules, 2016, introduced the concept of Extended Producer Responsibility (EPR), which holds producers accountable for the entire lifecycle of their products, including their management after their end-of-life. Producers are required to implement strategies for collection, take-back, and environmentally safe disposal of e-waste generated from their products. Fact: EPR provisions incentivize producers to design products with recyclability and environmental sustainability in mind.

Central Pollution Control Board (CPCB):

The Central Pollution Control Board (CPCB) is the apex regulatory authority responsible for implementing and enforcing e-waste management rules in India. The CPCB formulates guidelines, monitors compliance, and coordinates with State Pollution Control Boards and other agencies to ensure effective implementation of e-waste management regulations.

State Pollution Control Boards (SPCBs):

Under the E-Waste (Management) Rules, 2016, State Pollution Control Boards (SPCBs) have a crucial role in the implementation and enforcement of e-waste management regulations at the state level. They are responsible for granting authorizations, monitoring compliance, and coordinating e-waste management activities within their respective states.

E-Waste Management System (EWMS):

The E-Waste (Management) Rules, 2016, require the establishment of an E-Waste Management System (EWMS) to facilitate the collection, transportation, and recycling of e-waste. This system includes authorized e-waste collection centers, dismantlers, recyclers, and refurbishers, all registered with the appropriate regulatory authorities. Fact: The EWMS aims to create a robust infrastructure for the environmentally sound management of e-waste.

Prohibition of Import of E-Waste:

India prohibits the import of e-waste under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Importing e-waste for disposal, recycling, or any other purpose is strictly prohibited, ensuring that the country does not become a dumping ground for hazardous electronic waste.

Penalties and Enforcement:

The E-Waste (Management) Rules, 2016, prescribe penalties for non-compliance with e-waste management regulations, which can include fines, imprisonment, or both. Regulatory authorities conduct inspections, audits, and take appropriate enforcement actions against non-compliant entities to ensure adherence to the legal requirements.

Facts about E-Waste Management in India:

1. India generated approximately 2 million metric tons of e-waste in 2020, making it one of the largest generators globally.
2. The average Indian generates approximately 2.7 kg of e-waste per year.
3. Only about 10-15% of e-waste in India is formally recycled, highlighting the need for improved e-waste management practices.

In conclusion, the national legal regime on e-waste management in India, governed by the E-Waste (Management) Rules, 2016, provides a comprehensive framework for the environmentally sound management of electronic waste. The implementation of Extended Producer Responsibility, the establishment of the E-Waste Management System, and the roles of regulatory authorities such as the CPCB and SPCBs are crucial in ensuring compliance and effective e-waste management. The legal framework aims to mitigate the environmental and health hazards associated with e-waste while promoting responsible disposal, recycling, and resource conservation.

The management of electronic waste (e-waste) is a pressing issue worldwide, and India has taken significant steps to address it through a comprehensive national legal regime. This abstract provides an overview of the legal framework governing e-waste management in India, including key legislation, regulatory authorities, and the concept of Extended Producer Responsibility (EPR). The E-Waste (Management) Rules, 2016, serve as the cornerstone of e-waste management in India, emphasizing the environmentally sound handling and disposal of e-waste. The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) play vital roles in implementing and enforcing e-waste management regulations. The concept of EPR holds producers accountable for the entire lifecycle of their products, encouraging them to adopt sustainable practices. This abstract highlights the importance of the national legal regime in promoting responsible e-waste management, mitigating environmental and health hazards, and fostering a circular economy.

The national legal regime on e-waste management in India demonstrates the country's commitment to addressing the challenges posed by electronic waste. The E-Waste (Management) Rules, 2016, provide a robust framework for the proper handling, disposal, and recycling of e-waste. The concept of Extended Producer Responsibility (EPR) holds producers accountable for the environmental impact of their products, promoting sustainable practices throughout the product lifecycle. The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) play essential roles in enforcing these regulations and ensuring compliance. While there are challenges in effectively managing the growing volume of e-waste, India's legal regime serves as a critical foundation for creating awareness, promoting responsible behavior among stakeholders, and safeguarding the environment and public health. Continued efforts, collaboration, and innovation in e-waste management are essential to achieving a sustainable and circular economy in India.

CONCLUSION

Today most of e-waste is being discarded in the general waste stream. This waste is causing environmental and health concerns. Therefore, this research exhaustively deals with the conceptual framework of e-waste stated in international conventions, legislations, role of international bodies, nongovernmental organizationsetc and has come to the conclusion that definition given in European Union Directive is most suitable. The void in legislative framework and implementation of formal sector of e-waste management adversely affects the effectiveness of E-waste management regime. In addition, dominant presence of informal sector affects the working of formal sector of e-waste management. As informal sector employs environmentally unsustainable practices it adversely affects human health and contaminates ecosystem. Therefore, there is need of proper disposal of e-waste by formalizing the informal sector for sustainable development and protection of human health and environment.

REFERENCES:

[1] C. C. Cantarelli, B. Flybjerg, E. J. E. Molin, and B. van Wee, ‘Cost Overruns in Large-Scale Transport Infrastructure Projects’, *Autom. Constr.*, 2018.

[2] A. Chapuel and J. Reyes, ‘Obtención de una película biodegradable a partir de los almidones de semilla de aguacate (Persea americana Mill) y banano (Musa acuminata AAA) para el recubrimiento de papaya’, *J. Wind Eng. Ind. Aerodyn.*, 2019.

[3] V. Maphosa and M. Maphosa, ‘E-waste management in Sub-Saharan Africa: A systematic literature review’, *Cogent Bus. Manag.*, 2020, doi: 10.1080/23311975.2020.1814503.

[4] M. H. Masud *et al.*, ‘Towards the effective E-waste management in Bangladesh: a review’, *Environmental Science and Pollution Research*. 2019. doi: 10.1007/s11356-018-3626-2.

[5] G. Akon-Yamga, C. U. Daniels, W. Quaye, B. M. Ting, and A. A. Asante, ‘Transformative innovation policy approach to e-waste management in Ghana: Perspectives of actors on transformative changes’, *Science and Public Policy*. 2021. doi: 10.1093/scipol/scab005.

[6] J. Dhillon and V. Sandhu, ‘E-waste management strategy in organizations - A conceptual framework’, *Journal of Critical Reviews*. 2020. doi: 10.31838/jcr.07.01.76.

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E-Waste Management in India: Challenges and Strategies

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ABSTRACT: ***Electronic waste, as known as e-waste, is generated when any electronic or electrical equipment becomes unfit for the intended use or if it has crossed its expiry date. Due to rapid technological advancements and the production of newer electronic equipment, the old ones get easily replaced with new models. It has particularly led to an exponential increase in e-waste in India. People tend to switch to the newer models and trending technologies; also, the lives of products get reduced with time. But the issue is left with e-waste management in India and its challenges.***

KEYWORDS: ***E-Waste, Disposal, Hazardous Substances, Management, Recycling.***

INTRODUCTION

In many developed countries, e-waste management is given high priority. In contrast, in developing countries, it is exacerbated by completely adopting or replicating developed countries' e-waste management and several related problems, including a lack of investment and technically skilled human resources. In addition, there is a lack of infrastructure and the absence of appropriate legislation, specifically dealing with e-waste. Also, there is an inadequate description of stakeholders' and institutions'roles and responsibilities involved in e-waste management, etc. E-waste poses the huge risk to humans, animals, and the environment. E-waste typically consists of plastics, metals, cathode ray tubes (CRTs), printed cables, circuit boards, and so on. The valuable metals like copper, silver, gold, and platinum can be reused from e-wastes once they are scientifically processed. The presence of toxic substances like liquid crystal, lithium, mercury, nickel, selenium, polychlorinated biphenyls (PCBs), arsenic, barium, brominates flame retardants, cadmium, chrome, cobalt, copper, and lead makes it very hazardous, in case e-waste get dismantled and processed in a crude manner with the rudimentary techniques. The computers, mainframes, servers, monitors, printers, scanners, compact discs (CDs), copiers, calculators, battery cells, cellular phones, fax machines, transceivers, TVs, medical apparatus, iPods, refrigerators, washing machines, and air conditioners are examples of e-waste when they become unfit for its use. The presence of highly toxic substances and heavy metals like mercury, lead, beryllium, and cadmium pose a significant threat to an environment even in minute quantities [1], [2].

Challenges for E-waste Management in India

E-waste recycles in India is predominantly an informal sector activity. There are thousands of poor households eking a living from scavenging materials from waste dumps. The common recycling practices for middle-class urban households, particularly for waste paper, plastic, clothing, or metal, is to sell out to small-scale, informal sector buyers often known as 'kabadiwalas,' and they further sort and sell these as an input material to artisanal or industrial processors. E-waste management in India follows a similar pattern. An informal e-waste recycling sector employs thousands of households in urban areas to collect, sort, repair, refurbish, and dismantle disused electrical and electronic products. However, there is a different situation in advanced countries, and there is no concept in India of consumers voluntarily donating the useless electrical and electronic equipment at formal e-waste recycling centers. Also, there is not a concept of consumers paying for disposal of the e-waste they generate. The heavy reliance on an informal sector for e-waste recycling gives rise to these key challenges, as mention below Figure 1:

1. First, the attempt to impose financial penalties on non-compliance or violation of e-waste handling and processing rules is ineffective.
2. Second, broader public knowledge regarding market prices and health safety costs of e-waste recycling is less because less paid workers who do this work do not have proper training.

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3. Third, despite the massive increase in the volume of e-waste generated every year, there is very little investment by large-scale industrial infrastructure for recovery and recycling [3], [4].

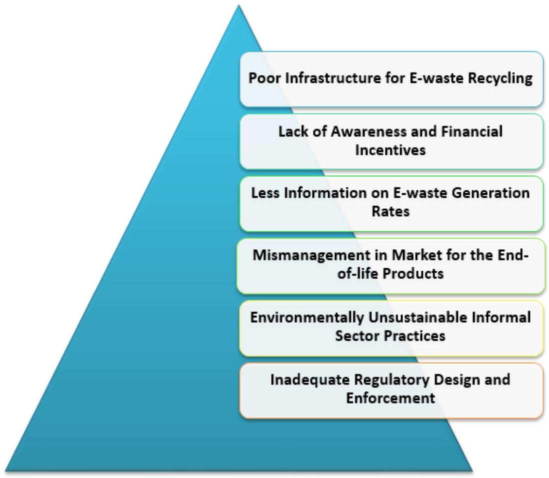

Figure 1: Poor Infrastructure for the Recycling of E-waste.

India has very limited infrastructure capacity for large-scale management of e-waste. There are very few governments approved e-waste recycling centers in the country, which only constitutes about 1/5th of the total amount of e-waste generated each year. The Indian Government offers the co-funded grant scheme that covers between 25% to 50% of the project costs for the e-waste management facilities and building capacity for e-waste businesses. However, the uptake of this scheme has been very limited. In addition, there is also a shortage of formally approved e-waste recycling centers as presently existing centers operate far below their capacity due to poorly organized supply chains between them and the majority of informal sector collectors of e-waste in India.
However, the formal sector recycling is limited to manual sorting and mechanical dismantling of e-waste management in India. At present, there is a lack of industrial e-waste managers with an appropriate environmental control, which are required for large-scale recovery of precious and base metals. A few emerging Indian companies extract metals from e-waste, but they have limited processing capacity. Most of the e-waste processed by a formal sector is exported from other countries with the necessary large-scale infrastructure for metals extraction. In contrast, the informal sector extracts metals using methods such as open-air incineration and acid leaching, which are hazardous and exacerbate environmental pollution and health risks. Although the E-waste guidelines provide several technologies for recycling and processing different types and components of e-waste, both the formal and informal sectors have mainly focused on metal recovery and less on the glass, plastics, and ceramics that comprise the significant proportion of e-waste. The recycling of plastic e-waste is much more complicated due to the presence of flame retardants and other persistent organic pollutants [5], [6].

DISCUSSION

Lack of Awareness and Financial Incentives

There is the lack of public awareness of e-waste hazards in India, and recycling is, therefore, very low. Most consumers do not know or have less knowledge about the hazardous nature of e-waste components or the penalties for improper disposal. They do not know about e-waste management in India is done by urban municipal or state government agencies. Several cities have very few dedicated collection depots or formal recycling centres where consumers can voluntarily drop-off the e-waste. The majority of people and urban household consumers used to sell e-waste or get some discount in exchange when they purchase any new electrical or electronic products from small-scale retail shops. Since consumers lack market information about prices for e-waste and various e-waste components, they have few financial incentives for responsibly disposing of their e-waste.

Less Information on E-waste Generation Rates

It is acknowledged that there is a lack of e-waste inventories and all the responsibility placed on the state-wise e-waste inventories on the respective State Pollution Control Boards (SPCBs). The sales data on electronic products is an important input in the estimation of e-waste quantities. It is often available at a national-level aggregation, which making it challenging to produce inventories at the state levels. In addition to domestic generation, the e-waste is imported from developed countries, often illegally. There is less understanding of a nature and amount of e-waste that gets imported into the country. The systems are required for effective collection, transportation, and processing requires reasonably accurate waste generation knowledge and its composition.

Mismanagement in Market for the End-of-life Products

The inability to reliably source e-waste quantities create economies of scale restricts the entry of private players to set up e-waste management systems in a formal sector. For instance, employing effective recycling technologies for e-waste management in India may require significant upfront capital expenditures, which cannot be justified for private entities in the absence of certainty about sourcing enough quantities of e-waste. Also, these markets suffer from information barriers.

First, the e-waste recycling is a relatively new business; the potential lack of information on cost-effective recycling technologies could be a market barrier. Second, there is low awareness, partly because of the lack of reliable information on e-waste management among consumers, affects markets' functioning. However, the public policy will play a greater role in enabling better markets for e-waste [7], [8].

Environmentally Unsustainable Informal Sector Practices

Despite the formal dismantling and recycling sector's growth, the actual waste processed in the formal sector still very low. Most of these formal facilities are operating below the approved capacities because of inability to source enough waste. The lack of awareness regarding e-waste and the costs of returning the end-of-life equipment to formal collection centres are reducing the willingness of household and institutional consumers to return their waste to the formal sector. Most importantly, through the convenience of household collection and monetary incentives, the informal sector makes this attractive for customers to return their waste, relative to the formal sector, that is yet to invest in robust collection and processing systems. The informal e-waste sector has provided livelihoods to millions of people, often belonging to the most marginalized groups. On contrary, the sector's waste management practices pose serious environmental and health hazards to the workers themselves as well as the larger public. It presents a potential moral dilemma for public policy, and the sustained success of any e-waste management in India will hinge to resolve this dilemma.

Inadequate Regulatory Design and Enforcement

The mandatory take-back system for producers, without accompanying collection targets as no incentives to take responsibility and therefore induced little improvements in e-waste management practices. Certain amendments were proposed, which provided more regulatory certainty by specifying gradual and increasingly stricter collection targets. However, the regulatory design places a significant burden on the already ill-equipped regulatory agencies. The regulators must review the EPR plan submitted by the producers, grant authorization, and enforce the EPR plan's provisions.

The regulations must also specify, elaborate standards and processes for other entities for dismantlers, collectors, recyclers, and bulk consumers and required the agencies to enforce compliance with specific standards. The regulatory authorities must capture benefit from poor enforcement, lack of transparency, unwillingness to publicly share information on compliance and regulatory actions. It has long afflicted environmental regulatory enforcement in India, and e-waste regulations are no exception. It poses the significant public policy challenge to the future of e-waste management in India [9], [10].

Improvement of E-waste Management in India

There are various ways of improving e-waste management in India. However, there are five key components that can be linked together for improving e-waste management in India in a summarised way. It is discussed as below:

Providing Market Information about E-waste Prices

It is a well-established market for e-waste within and between informal and formal sector operators. However, the prices for e-waste & its components are not widely known or publicized among urban consumers. A consolidated price list must be updated on a weekly basis as it would be a powerful market signal for customers who sell the e-waste to local vendors.

The price list has to cover all components of e-waste, starting from bulk e-waste to various glass, metals, plastic, ceramics, and batteries. The information must be presented on dedicated websites by urban municipalities and local newspapers similar to commodity price listings or foreign exchange rates. The price list must reflect the prevailing market demand for e-waste components and enable informal sector collectors to buy and sell e-waste at the fair market prices to private processors or government-approved recycling and dismantling centers.

Incentivizing Formal E-waste Recycling

The Indian Government has introduced a point-based reward system of E-waste Recycling Credits (ERCs) for formal organizations to incentivize them to channel their e-waste through government-approved recycling centers. The E-Waste Rules already classify and code e-waste like laptops, computers, and mobile phones.

These categories have to be correlated at different ERC reward levels. Depending on the type of e-waste supplied, organizations must earn the requisite ERCs that can be used to offset energy utility bills. Such an initiative will also provide a strong incentive for informal sector e-waste businesses to formalize the operations and establish supply chain links with approved recycling centers. The ERCs can be piloted over a 3 to 5 years period to assess the efficacy and to fine-tune for further implementation. The government and industrial sectors in metropolitan cities generate more than 70 % of e-waste. The ERCs can be trialed with a few large industries and government organizations in Mumbai, Delhi, or Bangalore [11].

The Indian government can also expand formal e-waste recycling capacity by co-funding infrastructure upgrades and processing systems at existing government-approved recycling centers. It can provide co-funding incentives to governments for setting up new recycling units through public-private partnerships with large e-waste companies. State governments could also develop grant schemes for incentivizing small-scale, informal e-waste recycling centers to upgrade the facilities so that they comply with them both environmental and occupational health and safety regulations. States can apply for national urban development funding schemes, which can be used to link the well-established informal sector network of decentralized collection and small recycling units with large-scale industrial recycling centers.

Training and Upskilling Informal Sector Players

The majority of an informal e-waste recycling workforce needs upskilling, particularly for handling and dismantling hazardous materials. It must ensure the work's environmental and occupational health and safety and link supply to formal sector processors. It is pursued by the Indian government's National Skill Development Mission. Innovative short courses and training programs can be specially designed for e-waste collectors, handlers, and dismantlers by the Electronics Sector Skill Council's combined expertise, the Green Jobs Sector Skill Council, and regulatory agencies like the Central and State Pollution Control Boards. Training and A concerted, nationwide campaign should accompany up skilling of informal sector workers campaign by central and state governments to increase public awareness about the hazards associated with e-waste. The importance of an informal sector in e-waste collection, e-waste dumping, and the locations of formal e-waste collection depots as approved by the government.

Deploying Readily Available and Mature Recycling Technologies

There is an urgent need for deploying mature recycling technologies alongside existing manual techniques to improve the recycling efficiency of the large volumes of e-waste management in India. India has a very large and mature plastics processing sector which can recycle plastic material from e-waste. The Indian government must promote joint ventures between international and domestic companies for setting up large industrial e-waste recovery plants. These ventures can be funded by a combination of private and public investment.

Developing Innovative Methods & Technologies for Processing New Forms of E-waste

The composition of e-waste is changing rapidly due to the new electronic devices to enter the market. It requires significant investment in research & development for innovative recycling methods and technologies for future-proofing India's e-waste policies and management. For example, smartphones usage has expanded dramatically in India over the past five years, but any e-waste recycling rules do not yet cover the lithium-ion batteries that power the devices. Various new battery and materials technologies are being developed for manufacturing the next generation of electronic devices. Thus, the Indian government must promote and fund research that develops innovative, future-oriented technologies for recycling and transforming new e-waste streams into high-value products. We are constantly evaluating the effectiveness of e-waste regulation and bringing in necessary changes. The government plays an important role in bringing together various stakeholders in a system. We have a few measures that can be considered to move forward.

Figure 2: Illustrate the Create Robust E-waste Management in India.

Strengthen the Informal Sector

The first step can be to more explicitly recognize the informal sector as the stakeholder in any future e-waste regime. Addressing the problem of informal sector e-waste practices requires a greater understanding of the sector itself in terms of its incentives and challenges, as shown in Figure 2. Engagement with informal sector workers and the groups, in a manner that recognizes the right of their livelihoods, builds trust, and develops an understanding of the problems along with potential solutions, can be an initial step. The government must institute a platform that facilitates consultations among various stakeholders like informal sector workers, NGOs working with the informal sector, third parties, private entities, and registered recyclers, and manufacturers. The forums can be constituted under the Ministry of Environment, Forest and Climate Change at a certain level under the State Department.

Policy Instruments under EPR

The government needs to rethink the policy instruments under the EPR approach. In a presence of the informal sector, it requires strengths in collection logistics. A mandatory take back with collection targets cannot be the ideal instrument. Producer responsibility comes in many varieties other than mandatory take-back. The economic instruments like advanced recycling fee or advanced disposal fee on every unit of the product sold in the market will relieve the producers of the physical responsibility of collection, and the revenues generated can be used to develop markets for the end-of-the-life or useless products. The revenues that go into a separate fund can be used in several ways.

Some examples are (a) Subsidize consumers to deposit their e-waste at designated centers, (b) Directly fund recyclers (c) Assist informal sector workers in training or skill development or provide a greater social security net to the workers. These decisions can be made within the consultative forum recommended in an informal sector. The problem with economic instruments will be to determine the right fee. Principles of economics will suggest a fee equivalent to the marginal external cost of the end-of-life equipment. While the external costs assessment is difficult in practice, the fee must be high enough to fund the environmentally safe e-waste processing and disposal.

The sufficient fee can also provide incentives for a design for environmental changes in product design that has been one of the main goals of the EPR approach globally. In a long run, to further incentivize changes, the fee can be based on such factors as the ease of recyclability, dismantling, and environmental impact of materials used in a piece of equipment. The policy framework must also focus on the development of indigenous technologies and/or technology transfer to encourage the widespread application of environment-friendly e-waste recycling technologies.

Regulatory Enforcement

Shifting to the economic instruments such as an ADF can also relieve the regulatory burden since the producers need not be regulated anymore. The long experience with tax collection must make it easy to divert the ADF on electronic products to a separate fund. The State and Central Pollution Control Board will still be required to monitor and enforce compliance with the standards specified for collection centers, dismantlers, recyclers, and PROs. The MoEFCC must make regulatory actions related to e-waste transparent. Regulatory actions like authorizations and their conditions, data on inspections of registered facilities, and inspected facilities' compliance status should all be made publicly available for scrutiny. A few SPCBs already publicly provide some of these documents on their websites, but these practices should be institutionalized as part of the country's regulations. Developing the regularly updated and publicly available inventory of district-wise generation of e-waste quantities by e-waste type (e.g., mobiles, computers, and appliances), waste composition, and flows will also play an important role in enforcement.

E-waste Imports

Under the existing regulations, e-wastes are not allowed to be imported for final disposal but can be imported for reuse and recycling. In an absence of adequate infrastructure in the country for recycling, we must seriously consider banning all kinds of imports. To develop accurate estimates of e-waste, data on imports must be integrated with an e-waste inventory.

Public Awareness for E-waste Management

The current e-waste regulations require the producers to provide, on the websites, information on the impacts of e-waste, appropriate disposal practices, and other issues. There is also a requirement for an awareness campaigns at regular intervals. Many producers have already provided information on the websites, but evidence shows that the overall awareness levels remain low among bulk consumers. Stricter guidelines/regulations to the producers on these awareness campaigns' frequency and mode might improve the situation.

Alternatively, the producers must be mandated to run these campaigns through grassroots-level organizations working in the area of e-waste. On its part, the government must consider integrating e-waste awareness campaigns with other waste streams such as batteries and municipal solid waste. Research on the effective messaging techniques and evaluation of information campaigns could also form a part of the role of the government. These awareness efforts must be geared towards achieving safe handling of e-waste and reducing consumption of electronic products in the long run. Overall, public awareness generation initiatives should be based on partnerships and collaboration among various stakeholders.

Role of Hindrise in E-waste Management System

Increasing information campaigns, capacity building, and awareness are critical to promoting environment-friendly e-waste management programs. Increasing efforts are urgently required on the improvement of the current practices like collection schemes and management practices to reduce any illegal trade of e-waste. Reducing the number of hazardous substances in e-products will also positively affect the specific e-waste streams since it will support the prevention process.

Most of the e-waste is recycled in India in unorganized units, which engage a significant number of manpower. Recovery of metals from PCBs by primitive means is the most hazardous act. Proper education, awareness, and, most importantly, alternative cost-effective technology need to be provided to provide better means to those who earn the livelihood from this. A holistic approach is needed to address the challenges faced by India in e-waste management. The suitable mechanism needs to be evolved to include small units in the unorganized sector and large units in the organized sector into a single value chain. Our approach can be for units in the unorganized sector to concentrate on collecting, dismantling, and segregation, whereas the organized sector could do metal extraction, recycling, and disposal.

CONCLUSION

E-waste management in India is a great challenge for governments of many developing countries. It is becoming a huge public health issue and is exponentially increasing by the day. It has to be collected separately, treated effectively, and disposed of e-waste. It is also a diversion from conventional landfills and open burning. It is essential to integrate an informal sector with the formal sector. The competent authorities in developing countries like India need to establish mechanisms for handling and treating e-waste safely and sustainable manner.

REFERENCES:

[1] S. Arya and S. Kumar, 'E-waste in India at a glance: Current trends, regulations, challenges and management strategies', *Journal of Cleaner Production*. 2020. doi: 10.1016/j.jclepro.2020.122707.

[2] C. P. Garg, 'Modeling the e-waste mitigation strategies using grey-theory and DEMATEL framework', *J. Clean. Prod.*, 2021, doi: 10.1016/j.jclepro.2020.124035.

[3] K. Arulanantham and N. S. Elangovan, 'Environmental issues on electronic wastes and materials handling of e-wastes using e-waste software', *J. Environ. Prot. Ecol.*, 2020.

[4] S. B. Wath, P. S. Dutt, and T. Chakrabarti, 'E-waste scenario in India, its management and implications', *Environ. Monit. Assess.*, 2011, doi: 10.1007/s10661-010-1331-9.

[5] V. Bhagat-Ganguly, *E-waste management: Challenges and opportunities in India*. 2021. doi: 10.4324/9780429285424.

[6] R. Kumar and Karishma, 'Current Scenario of e-waste management in India:issues and strategies', *Int. J. Sci. Res. Publ.*, 2016.

[7] A. Borthakur and P. Singh, 'Electronic Waste Management in India: Identifying the Challenges and Opportunities By Swot and Steepv Analysis', *P.R. China*, 2015.

[8] L. Subramanian, 'Management of Electronic Waste by Bulk Consumers: The Case of India's IT Service Sector', *PQDT - UK Irel.*, 2014.

[9] M. Singh, M. Kaur, and S. John, 'E-waste: Challenges and opportunities in India', in *c2013 IEEE Global Humanitarian Technology Conference: South Asia Satellite, GHTC-SAS 2013*, 2013. doi: 10.1109/GHTC-SAS.2013.6629902.

[10] R. T. Yerramalli and R. G. Burra, 'Optimisation of Electronic Waste Recycling Network and Reverse Logistics-A Literature Review.', *J. Supply Chain Manag. Syst.*, 2014.

[11] V. S. Bammidi, A. Rao, and P. Sharma, 'Zero-gen campuses development in India - A sustainable promise made to the society', in *Society of Petroleum Engineers - International Petroleum Technology Conference 2009, IPTC 2009*, 2009. doi: 10.2523/13914-ms.

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Implementation of Electronic Waste Regulations and Its Legal Challenges in India

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ABSTRACT: ***Human beings have progressed over time and along with it the process of utilizing the resources has also altered. After every use, some residues are generated that are of no value meant to be discarded. Such residues are known as wastes. Initially, in the primitive stages, human beings managed their wastes at the individual level, but as time passed the problem of waste management started gaining global concerns. Similarly, at present, the issue of electronic wastes or e-wastes is gaining serious considerations especially because the rate of generation of such wastes is increasing at an alarming level due to the outcome of technological inventions. The study relating to the ecological significance of e-wastes is important because most of these e-wastes are regarded as hazardous wastes, that possesses the potential to degrade human health as well as the health of the ecosystem. it has now become important to know to what extent do these e-wastes can contribute to environmental degradation and what can be done to reduce such impacts. Further, it is also very important to analyze the validity of the regulatory framework that governs these e-wastes management systems. This paper will thus study the various impacts of wastes in general and e-wastes in particular upon the natural ecosystem. Further, this paper will also try to understand the legal mechanism that is governing the management of these e-wastes both at the international level and at the national level along with the shortcomings if any that exist in these legal mechanisms. At last, this paper will also attempt to provide certain possible suggestions to the challenges, if any against the e-waste management regulations***

KEYWORDS: ***Electronic Waste, Ecological Significance, Health Impacts, Waste Management.***

INTRODUCTION

Everything in this world has its utility but after its use, it more often becomes unusable or incapable of being utilized anymore. In such a situation such useless things become wastes. But these valueless wastes are not without any significance. if thought in an innovative way these wastes might become valuable resources which can even boost up greatest of the great economies and at the same time if not handled in a proper manner the same wastes can become a curse on the entire humanity. Likewise, these wastes also have a huge ecological impact. Wastes can degrade the natural ecosystem thereby causing great harm to the health of all living creatures including human beings. Similarly, due to the advent of the technological revolution, several electronic gadgets have flooded the earth's ecosystem where these electronic gadgets after being used or after losing their utility turn into e-waste or electronic wastes. These electronic wastes also have a huge ecological impact and since the technological innovations are crossing every limit of civilizations, at the same time it is also introducing a whole variety of new wastes which if not handled properly may lead to serious consequences [1], [2].

Conceptual Framework

Meaning of Waste

Waste means matter or material of any type which is unwanted or something that is left after the removal of useful substances or parts from those materials. As an adjective, waste indicates any material, substances, or bi-product that has been estimated or discarded as having no longer utility or is not required after the completion of a process. Wastes are objects or substances that are to be disposed of or are intended to be disposed of. Wastes are not the prime products that have no further use for the generator after his/her purpose of production, transformation, or consumption and which the generator wants to dispose of. Waste is any object that the holder discards or intends to discard or is required to be discarded. From the above definitions, we can drive that waste is something that is of no use and is meant to be disposed of. Waste may be of various types depending upon its nature of difference [3], [4].

Types of Wastes

Wastes can be classified into various classes; however, some of the broadly defined categories of wastes can be listed as follows

a. **Municipal Wastes:** It contains those wastes which are generated from day to day affairs. They include clothes, wires, glasses, remains of foods, etc. they come from schools, factories but mostly from households.
b. **Hazardous Wastes:** Hazardous wastes are those categories of wastes that possess a potential threat to public health and the environment. 8 Hazardous wastes can be of different categories depending on all the three physical aspects of wastes including gaseous, solid, and liquid. Hazardous, such wastes require different ways of treatment since they by nature cannot be disposed of through common means.
c. **Biomedical Wastes:** Biomedical wastes are those wastes which include infectious materials. They are mainly generated by physicians, dentists, medical research facilities, or any other form of health care units. Medical wastes are any wastes generated during testing diagnosis, medical research, or treatment of either animals or human beings.
d. **Solid Wastes:** It includes any garbage, sludge, refuse, etc. from water supply treatment plant, wastewater treatment plant, air pollution treatment plant, etc. and other materials which are discarded including contained gaseous material, liquid, solid resulting from industrial, housing, agriculture, mining, commercial and other community.
e. **Wet Wastes:** They are generally biodegradable wastes which include cooked as well as uncooked fruits, vegetables, other food items, vegetable peels, flower wastes, and all other decomposable wastes.
f. **Gaseous Wastes:** These wastes result from dropping and dissolution activities. These are affluent released in the Earth's atmosphere in the gaseous form. They mostly include oxides of carbon, nitrogen, sculpture, etc.
g. **Electronic Wastes:** Electronic wastes are generally those wastes that are discarded after the utilization of an electronic gadget or product. They are harmful because most of the e-waste like CPUs contains many harmful materials like cadmium, lead, brominated flame, etc. They are even considered as hazardous wastes in most cases like the United Nations Environment Programs Agency considers Cathode Ray Tubes, CRT monitors as hazardous.

Waste management includes those measures that are taken to manage wastes right from their inception to their final disposal. An efficient waste management deals with all kinds of wastes including industrial, households, and so on [5], [6]. Waste management system includes collection, transportation as well as disposal of savage, garbage, and other forms of wastes; it includes all processes and resources for efficient handling of wastes in compliance with the health codes and environmental regulations. Waste management now not only includes merely dumping down the unwanted wastes but also includes a systematic way of handling the wastes with a proper system approach. The waste management system broadly includes three Rs via, Reduce, Reuse and Recycle.

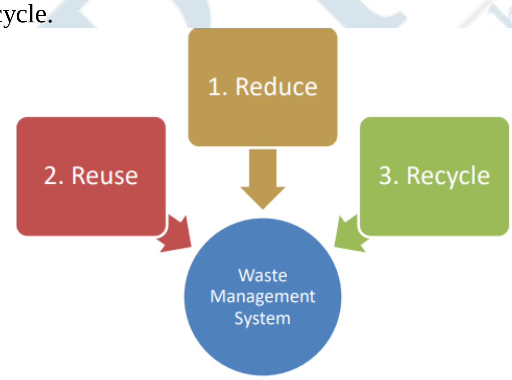

Figure 1: Illustrate the waste management system.

Thus, a waste management system means and includes a system that is for handling the wastes right from its inception to its final disposal in conformity to the health codes and the environmental regulations, as shown in Figure 1. Such management system differs from country to country based on their economic, political and other social aspects.

Ecological Significance of E-Waste

Initially, waste management was dealt with within the individual level where the discarded materials were disposed of in nature. But as human civilization progressed, the amount of wastes and the extent of them being hazardous increased to a level that now nature cannot bear the burden of such an amount of untreated wastes, as a consequence of which, present-day civilization is facing a lot of health crisis as well as ecosystem degradation. Similarly, since the last few decades, a new category of waste known as the Waste Electrical or Electronic Equipment (WEEE) or electronic waste has created huge concerns in both

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developed and developing countries which is at present one of the fastest-growing streams of waste. E-waste has already constituted a huge environmental problem since currently shares 5% of the world's municipal waste which is at a fast growth in the developed countries.

The management of electronic waste (e-waste) is a critical environmental and public health issue in India. To address this growing concern, the Indian government has implemented electronic waste regulations aimed at regulating the generation, collection, transportation, storage, and disposal of e-waste. This detailed description explores the implementation of electronic waste regulations in India and highlights the legal challenges associated with their enforcement [7].

Electronic Waste Regulations in India:

The primary legislation governing e-waste management in India is the E-Waste (Management and Handling) Rules, 2016, enacted under the Environment (Protection) Act, 1986. These rules establish a comprehensive framework for e-waste management and outline the responsibilities of various stakeholders, including manufacturers, consumers, recyclers, and regulatory authorities.

Key provisions of the E-Waste Rules include:

a) **Extended Producer Responsibility (EPR):** Manufacturers are required to establish systems for collecting and environmentally sound disposal of e-waste generated from their products. They must also label their electronic goods to facilitate proper disposal and recycling.
b) **Authorization of E-Waste Recyclers and Dismantlers:** Entities engaged in the recycling or dismantling of e-waste must obtain authorization from the State Pollution Control Boards or Pollution Control Committees.
c) **E-Waste Collection Centers:** The rules mandate the establishment of collection centers for e-waste, making it easier for consumers to dispose of their electronic products responsibly.

Implementation Challenges:

Despite the existence of e-waste regulations, the implementation and enforcement in India face various challenges, including:

a) **Lack of Awareness and Compliance:** Many individuals and businesses are unaware of e-waste regulations and their responsibilities. As a result, compliance levels remain low, leading to improper disposal and recycling practices.
b) **Informal Sector and Unorganized Recycling:** A significant challenge lies in the presence of an informal e-waste recycling sector that operates without following proper environmental and health safeguards. This sector often employs marginalized communities and uses hazardous methods for extracting valuable materials, putting their health at risk.
c) **Inadequate Infrastructure:** Insufficient infrastructure for the collection, segregation, and recycling of e-waste hampers effective implementation. There is a lack of authorized recycling facilities and collection centers, especially in rural areas, making it difficult for consumers to dispose of e-waste appropriately.
d) **Monitoring and Enforcement:** Ensuring compliance with e-waste regulations requires robust monitoring mechanisms and effective enforcement. However, limited resources and coordination challenges among different regulatory bodies hinder proper oversight and enforcement actions.
e) **Cross-border E-Waste Trade:** India faces the challenge of cross-border e-waste trade, where e-waste is illegally imported, often disguised as second-hand electronic goods. This trade circumvents regulations and contributes to the e-waste burden in the country [8].

Mitigation Strategies:

To address the legal challenges associated with the implementation of e-waste regulations in India, the following strategies can be employed:

a) **Awareness and Education:** Public awareness campaigns can educate individuals, businesses, and local communities about the importance of responsible e-waste management, encouraging compliance with regulations.
b) **Strengthening Infrastructure:** Investments in the development of authorized recycling facilities, collection centers, and e-waste treatment plants are necessary to improve the infrastructure for effective e-waste management.
c) **Capacity Building and Training:** Providing training programs for workers in the e-waste recycling sector, focusing on safe handling practices, occupational health, and environmental protection, can enhance compliance and safety standards.
d) **Collaboration and Stakeholder Engagement:** Cooperation between government agencies, manufacturers, recyclers, NGOs, and international

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partners is crucial for effective e-waste management. Collaboration can lead to shared resources, knowledge exchange, and innovative solutions [9], [10].

The implementation of electronic waste (e-waste) regulations in India has been a significant step towards addressing the environmental and health challenges associated with the improper disposal and management of electronic waste. This detailed description provides an overview of the implementation of e-waste regulations in India, highlighting key aspects, legal challenges, and relevant facts:

E-Waste (Management) Rules, 2016:

The E-Waste (Management) Rules, 2016, serve as the primary legal framework for the management of e-waste in India. These rules outline the responsibilities of various stakeholders, including producers, consumers, bulk consumers, collection centers, dismantlers, recyclers, and the regulatory authorities. Fact: The rules require producers to obtain necessary authorizations and establish mechanisms for collection, recycling, and disposal of e-waste.

Extended Producer Responsibility (EPR):

The concept of Extended Producer Responsibility is a crucial component of e-waste regulations in India. Under EPR, producers are responsible for managing their products throughout their lifecycle, including the post-consumer stage. Fact: Producers are required to implement strategies for collection, channelization, and environmentally sound disposal of e-waste generated from their products.

Collection and Channelization:

The E-Waste (Management) Rules, 2016, emphasize the establishment of collection centers and authorized recyclers to ensure proper channelization of e-waste. These centers act as collection points for consumers and bulk consumers, facilitating the safe disposal and recycling of e-waste. Fact: As of 2020, there were over 3,500 registered e-waste collection centers across India.

Challenges in Implementation:

Despite the progress made in implementing e-waste regulations, there are several challenges that need to be addressed. These include:

a. **Lack of Awareness:** Limited awareness among consumers, producers, and stakeholders about e-waste regulations and the importance of proper disposal hampers effective implementation.

b. **Informal Sector:** The presence of an extensive informal sector engaged in e-waste recycling poses challenges in regulating and monitoring their operations, often leading to unsafe and environmentally damaging practices.

c. **Enforcement and Compliance:** Ensuring strict enforcement of regulations and achieving widespread compliance remains a challenge due to resource constraints, lack of monitoring infrastructure, and coordination between regulatory authorities.

d. **E-Waste Imports:** The illegal import of e-waste from other countries adds to the challenges of effectively managing e-waste in India, requiring stricter border controls and international cooperation.

Legal Challenges:

Implementing e-waste regulations in India has also encountered legal challenges, including:

a. **Jurisdictional Issues:** Clarifying the roles and responsibilities of multiple regulatory bodies at the central and state levels to avoid jurisdictional conflicts and ensure effective implementation.

b. **Capacity Building:** Enhancing the capacity of regulatory authorities, such as the Central Pollution Control Board and State Pollution Control Boards, to enforce regulations, conduct inspections, and monitor compliance.

c. **Penalties and Enforcement:** Strengthening the penalties and enforcement mechanisms to deter non-compliance and illegal activities related to e-waste management.

d. **Stakeholder Participation:** Ensuring active participation and collaboration between stakeholders, including producers, consumers, NGOs, and the informal sector, to create a comprehensive and inclusive e-waste management system.

Facts about E-Waste in India:

1. India generated approximately 2 million metric tons of e-waste in 2020, making it the third-largest generator globally.
2. The average Indian generates around 2.7 kg of e-waste per year.
3. Informal recycling operations in India account for a significant portion of e-waste processing, often leading to health hazards and environmental pollution.

The implementation of e-waste regulations in India has made significant strides in addressing the challenges associated with electronic waste. However, there are ongoing legal challenges and hurdles in effective enforcement, awareness, and coordination among stakeholders. Addressing these challenges and strengthening the implementation of e-waste regulations is crucial to ensuring sustainable and environmentally responsible e-waste management practices in India.

CONCLUSION

We can easily conclude that e-wastes are increasing over time due to the increase in technological innovations. The risk of e-wastes upon human health and the ecosystem is also increasing along with it. The management of these e-wastes has become a serious issue for the present human civilization to deal with. It has also been made clear by several facts that the presence of harmful hazardous substances in the e-wastes like lead, cadmium, and mercury as well as other such chemicals that leads to the contamination of the air, water, and soil due to their accumulation in the ecosystem for a long time without proper treatment. Informal sectors of recycling have also contributed to the health hazards of the workers working there, and several health-related disorders have also been found to be the consequences of improper handling of ewaste. Owing to these reasons several regulations had been provided both at the international level primarily the Basel Convention and at the national level like the E-waste Rules. But unfortunately, UNEP reports demonstrate that still at present several transboundary illegal movements of e-wastes are taking place. Further, the Basel Convention lacks any proper enforcement mechanism for checking such illegal movements. In India too, it has been found that besides having well-drafted laws, yet in the absence of a proper monitoring system and also due to lack of efficient implementation, these laws are failing to achieve their primary goals.

REFERENCES:

[1] J. A. Laub, 'Assessing The Servant Organization; Development Of The Organizational Leadership Assessment (Ola) Model. Dissertation Abstracts International', *Procedia - Soc. Behav. Sci.*, 1999.

[2] C. C. Cantarelli, B. Flybjerg, E. J. E. Molin, And B. Van Wee, 'Cost Overruns In Large-Scale Transport Infrastructure Projects', *Autom. Constr.*, 2018.

[3] L. M. R. Gaspar, C. De T. Inácio, B. R. Quintaes, L. De S. Q. Carvalho, And A. A. De C. Peres, 'Análise Econômico-Financeira Do Gerenciamento Dos Resíduos Sólidos Orgânicos Em Uma Agroindústria De Processamento Mínimo De Hortaliças', *Eng. Sanit. E Ambient.*, 2020, Doi: 10.1590/S1413-4152202020180189.

[4] A. José Sosa-Olivier And R. José Laines-Canepa, 'Refining Of The Solid Fraction Of Sheep Feces Digestates From An Anaerobic Digester', *Ing. E Investig.*, 2020, Doi: 10.15446/Ing.Investig.V40n2.83364.

[5] J. U. Maluf *Et Al.*, 'Optimization Of The Porcine Liver Enzymatic Hydrolysis Conditions', *J. Food Process Eng.*, 2020, Doi: 10.1111/Jfpe.13370.

[6] I. A. Sboeva, L. V Bakulevskaya, E. R. Mikhailova, A. V Stepanov, And Y. V Ivanshchikov, 'The Business Model Of A Plastic Waste Recycling Project In The Context Of The Strategic Integration Of Innovation And Technology Entrepreneurship', *Education Excellence And Innovation Management: A 2025 Vision To Sustain Economic Development During Global Challenges*. 2020.

[7] A. Kumar And M. Holuszko, 'Electronic Waste And Existing Processing Routes: A Canadian Perspective', *Resources*. 2016. Doi: 10.3390/Resources5040035.

[8] K. A. Schumacher And L. Agbemabiese, 'E-Waste Legislation In The Us: An Analysis Of The Disparate Design And Resulting Influence On Collection Rates Across States', *J. Environ. Plan. Manag.*, 2021, Doi: 10.1080/09640568.2020.1802237.

[9] J. Demajorovic, E. E. F. Augusto, And M. T. S. De Souza, 'Reverse Logistics Of E-Waste In Developing Countries: Challenges And Prospects For The Brazilian Model', *Ambient. E Soc.*, 2016, Doi: 10.1590/1809-4422asoc141545v1922016.

[10] J. Alghazo *Et Al.*, 'Potential Of Electronic Waste Recycling In Gulf Cooperation Council States: An Environmental And Economic Analysis', *Environ. Sci. Pollut. Res.*, 2019, Doi: 10.1007/S11356-019-04956-Y.

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E-Waste: Recent Research and the Future about Developing Nations

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ABSTRACT: The emergence of "Waste of Electronic and Electrical Equipment," or "e-waste," is a result of the growth in population and buying power, which is aided by technological advancement. Concern about e-waste is increased by the rising rate of WEEE creation and its dangerous components. This essay outlines the progress of e-waste research and suggests directions for further study. The analysis was based on a review of the literature in open access journals using the term "e-waste." The reliability of the source and the quantity of citations were taken into account while choosing articles. According to the publications we evaluated, China was a major contributor to the research. The management of e-waste, consequences on the environment and human health, and the state of e-waste treatment in a particular area are some of the most researched subjects. Each subject is briefly explained, and suggestions for further study are also offered. Assessment of the e-waste route, economic analysis that takes into account costs, closed-loop management systems, and application of cyber-physical systems to encourage industrial symbiosis are some of the research prospects to enhance e-waste management in Indonesia.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Fast-advancing technology and rising consumer buying power have an impact on the rising usage of electronic products. The increased consumption has an impact on the environment, whether it's via the extraction of raw materials or garbage produced after product use. The term "ewaste" or "Waste of Electronic and Electrical Equipment" refers to all components, subassemblies, and consumables that are still included in the product at the time of disposal. There are several definitions provided by various authorities, however it is important to note that e-waste is any electrically powered equipment that is no longer wanted by the user and may be of any size or function. The phrase "no longer desired" refers to the possibility that e-waste may be produced due to consumer behavior or outdated technology that shortens the lifetime of EEEs as well as the product having outlived its useful life or losing its service function. E-waste may include a variety of goods with differing sizes and components, depending on the definition. An extensive list of electrical and electronic devices is included in Annex II of Directive 2012/19/EU. Figure 1 depicts the categorization and its percentage according to Vats and Singh. The Basel Convention and the "European Union Waste of Electronic and Electrical Equipment Directive" have raised awareness of e-waste since 2002. E-waste is a problem because of its annual volume rise, which is a result of increased consumption and short product lifespans. Only 15% of e-waste gets recycled, making it the garbage that has grown the fastest over the previous ten years. The worry about e-waste is increasing in direct proportion to the volume of e-waste [1], [2].

Three categories of pollutants may be created with these compounds. Heavy metals and halogenated chemicals, which are dangerous components of e-waste, are considered primary pollutants. Secondary pollutants, such as dioxins, polyaromatic hydrocarbons, and poly-halogenated aromatic hydrocarbons, are by-products or residues formed as a result of incorrect recycling processes. Tertiary emissions or pollutants are substances used in recycling that must be handled carefully to prevent problems with the environment and human health, such as aqua regia, the byproduct of the leaching of recycled metals that contains cyanide, hydrochloric acid, nitric acid, thiourea, and bromide.

Contaminated Soil

Dioxin chemicals have been found to pollute the soil at e-waste processing facilities, according to a research conducted in Vietnam. According to WHO regulations, the concentration found was greater than the maximum permissible concentration, mostly as a result of open burning and open storage practices. Vietnam's soil and rivers are contaminated by improper recycling practices, such as open burning and manual disassembly, as shown by the presence of fire retardants in soil and river sediments. A Chinese research examined soil samples from places with rice paddies, open burning pits, e-waste processing facilities, and river sediment samples close to the settlement. Seven metals, including significant concentrations of calcium, copper, molybdenum, lead, nickel, tin, and zinc, were found in soil and sediment samples. A high concentration of those components substantially connected with the processing of e-waste, according to multivariate analysis. In the meanwhile, soil study from open-burning areas revealed Cu buildup, indicating the impact of open burning operations. To prevent soil contamination from chemical elements, adequate treatment procedures and wastewater treatment must be implemented in e-waste recycling facilities.

Air Pollution

In addition to contaminating the land, burning e-waste raises the level of air pollutants, notably particulate matter. In two residential areas and an open-air burning station for e-waste, India researchers found high levels of particulate matter and heavy metals. It was shown that e-waste burning locations had the highest mean concentration of heavy metal and PM10 of all the regions under study. Based on the blood studies, it was also shown that those who live near e-waste burning facilities had the greatest exposure levels. This research demonstrated that the informal garbage sector's use of open burning led to a high degree of air pollution, which had an impact on the inhabitants' high exposure to heavy metals. .A research at two informal e-waste recycling sites in metropolitan Vietnam revealed that the amount of PCBs and BFRs in interior dust was higher than in non-e-waste dwellings, which is consistent with the study in India. According to estimates of human exposure, the majority of BFRs were ingested via the intake of dust, while PCBs were ingested through the intake of air [3], [4].

Water Contamination

Illegal e-waste recycling and open-air burning were the main contributors to the elevated levels of cadmium in the groundwater in Rampur, Shahjehanpur, Moradabad, and Bareilly, four Indian districts. The fact that the cadmium contamination level above the legal limit showed that the groundwater system was experiencing major toxicity issues. A contaminant's presence in surface water will have an impact on the aquatic life and promote biomagnification. In a research conducted in China, samples of water snakes found in a contaminated pond were tested for plasticizers, organophosphorus flame retardants, and PFR metabolites. Biomagnification values. indicate that bio-magnification did not occur, which points to a bio-dilution caused by metabolism.

Evaluation of Human Health

Several research have been done on the exposure to and identification of heavy metals and other compounds in e-waste. A South American study examined the manual collection of metals by low-income children there and the relationship between elevated blood lead levels from lead exposure during the activity. It was discovered that the BLLs of children and adolescents were greater than those predicted by the BLLs. The most often used bioindicators to determine human exposure to e-waste pollutants, in addition to blood tests, are urine and hair samples. Two investigations found exposure in e-waste locations using several metrics. By collecting urine samples from the locals, Zhang et al. studied the exposure to phthalic acid esters, which are prevalent in e-waste recycling locations. Residents in the non-e-waste site served as the reference group for comparison with these samples. The findings demonstrated that inhabitants of the e-waste site had much higher urine concentrations of mPAEs than those of the reference region. In e-waste sites, over 22% of the locals had hazard index values more than 1, which suggest exposure levels that are potentially harmful. The biggest discovery was that 68% of them were between the ages of 0 and 18. Hair and urine samples were used to identify PAH in both employees and individuals who lived close to the e-waste recycling facility.

Residents and ewaste dismantle employees had similar exposure levels, with no discernible difference. One of the carcinogenic metabolites was also discovered in the responders' internal hair. Exposure to heavy metals has both short-term and long-term impacts, including respiratory and reproductive issues, inflammation, cardiovascular illness, and urinary disease. Additionally, human DNA may be impacted by e-waste pollutants exposure. DNA damage and the amount of time spent processing e-waste were shown to be strongly correlated in a research to evaluate possible genomic damages in employees recycling e-waste. An analysis of the health of inhabitants at impromptu e-waste recycling facilities supports this finding. In addition to preterm births, stillbirths, spontaneous abortions, and smaller and lighter babies are all caused by exposure to e-waste. Radioactive materials are present in certain WEEEs, however they make up less than 1% of all electronic trash globally. There is no imminent radiological danger to the locals or employees who work close to the dumpsites, according to a study of radiation exposure at three municipal waste dumpsites and the e-waste dumpsite in Southwest Nigeria. Since not all e-waste contains radioactive materials, the composition of the e-waste in the dumpsites may have an impact on this outcome.

DISCUSSION

Managing Techniques

Situation in Developing Countries Currently

The handling of e-waste is subject to comparable limitations in poor nations. Since e-waste is seen by the locals as a means of subsistence, developing countries often import e-waste from wealthy nations. The informal trash treatment industry thrives close to residential areas since there aren't any official recycling facilities. The backyard procedures at unofficial treatment facilities were carried out manually, without the necessary tools or understanding of the threat to the environment and public health. Some poor nations, like Cambodia and Indonesia, do not have an e-waste management legislation in place. Other restrictions on managing e-waste include a lack of information on the material movement of e-waste and a lack of awareness. The administration of developing nations may be improved by linking local or national rules to EPR projects. The success of the new regulation's implementation will be increased by coupling it with the incentive system. Through the use of system dynamics modeling, a research was able to demonstrate the efficacy of laws. The main element influencing how much e-waste is collected for product recovery is how laws are enforced. While encouraging the EEE producer to concentrate on Extended Producer Responsibility, the government, as one of the stakeholders, must also provide infrastructure for formal e-waste treatment facilities. Collaboration between the official and informal waste sectors may help lessen the detrimental effects of inadequate IWS treatment. For an existing formal recycling facility to enhance the treatment procedures, technical and financial help is required. China serves perhaps the greatest illustration of how the handling of e-waste evolved from crude, artisanal methods into a sophisticated system. Despite the flaws in both processes—pyrometallurgical discharges dangerous compounds, while hydrometallurgical produces more acidic waste streams improving both would lessen the bad effects [5].

Increased Producer Accountability

The term "EPR" refers to the obligation placed on makers and importers to collect and recycle EOL EEE. Although the idea of EPR is commonly understood in industrialized nations, there are two significant obstacles to its implementation in less developed nations. The first difficulty is with identifying the manufacturer due to illegal manufacturing of goods, fake goods, or tiny shop-assembled goods. As a consequence, when EPR is implemented, there will be concealed material flows. Another issue is the potential accuracy of the amount of collected e-waste, which will have an impact on the incentives' payments. The adoption of EPR will encounter several limitations in poor nations that lack a treatment infrastructure, legal framework, and stakeholder knowledge. EPR system has been combined with recycling regulations in industrialized nations like the Republic of Korea, backed by a number of recycling facilities and recycling advocacy.

The use of automation and cyber-physical system automation in the deconstruction of e-waste may increase worker and environmental safety. However, different forms of e-waste pose challenges in the classification and dismantling processes, making the deployment of a fully automated process challenging. The ideal solution is a collaborative robot, which divides the process between human operators and robots. The operator may educate a robot to cut, separate, and do other low-skilled tasks by mixing human and robotized processes. This will address the issues with e-waste identification, categorization, and disassembly. In Japan, a different method employing a cyber-physical system was suggested to lower the cost of e-waste sorting. The metal-rich e-waste is separated from the other particles using a sorting system and coarsely crushed e-waste supplied on a conveyor. By altering the sorting apparatus, it may be operated remotely as a game online or from places where labor is less expensive. Cyber-physical systems may help the e-waste refurbishing industry in a number of key ways, including sorting, disassembling and repairing, pricing, and routing. Implementing CPS improves traceability by allowing control, monitoring, and decision-making for the right processes via RFID tags on the cores. The solution minimizes process inefficiencies and saves up to 664 hours of operating time. .In order to recycle electronic EOL, another research suggested a cooperative web-based platform that links producers, end users, services, and dismantlers, recyclers, or remanufacturers. The decision-making system will assess various reuse scenarios' economic and environmental impacts. The online platform will also promote industrial synergy between businesses in related or unrelated industries. Conclusion: Data sharing, which enables cooperation in the refurbishing system and/or industrial symbiosis, process sharing to enhance efficiency and human health, and remote process to cut costs are all ways that automation and cyber-physical systems improve e-waste management.

Consumer E-waste Behavior

The willingness of customers to engage in e-waste management is influenced by their behavior. Along with attitudes and knowledge, behavior is recognized as one of the key elements that influence whether or not someone is willing to pay extra for e-waste management financing. According to a survey done in Indonesia, 77% of respondents were aware of the concept of e-waste, and 58% and 12% of them indicated that they could be interested in participating in e-waste recycling. Customers combine e-waste with solid garbage and fail to dispose of it in an ecologically acceptable manner, making it impossible for the e-waste management system to be implemented without understanding of disposal practices and participation.

Recycling and Recovery

The wide variety of material value is the greatest obstacle to recycling e-waste. Although 30% of e-waste is made up of polymers with minimal material value, precious and rare metals found in e-waste may be rich sources of raw materials. The ways for recycling metals and plastic are developing, and likewise, research is being done to lessen the drawbacks of the techniques that will be covered in this part.

Metal Recycling and Recovery

Low recovery efficiency and environmental harm are two drawbacks of metal recycling techniques include cremation, manual disassembly, strong acid leaching, and hydraulic shaking bed separation. Volatile organic compounds will become seriously contaminated during incineration. Compared to those handled by the electric heating furnace, blower, soldering iron, and mechanical cutting, the total VOCs produced by the incineration are roughly 40, 139, 180, and 190 times greater. The risk of cancer among employees will rise with excessive VOC exposure. There are a number of methods for recycling metals; some of them offer excellent recovery rates for practically all metals but also have certain economic restrictions because of reagent or investment costs, such as pyrometallurgical and mild extracting technique. Although supercritical technology can recover almost all metals at high rates, it also produces waste oil and gas. Although biometallurgical and vacuum metallurgical processes are thought to be environmentally beneficial, selectivity and industrialisation still need to be improved. By modifying the operating parameters of the technologies or incorporating new technologies or processes into the recycling process, the metal recycling process may be improved. To enhance the sorting procedure, Torihara et al. combined magnetic separation with electrostatic separation. Metal-rich particles were separated using a sorting mechanism after pulverization and physical separation for particles of printed circuit board origin [6].

Recycling Plastic

Given that the plastics component of WEEE is made up of more than 15 distinct kinds of polymers, recycling plastic in it may be challenging. The recycling process is complicated by the presence of brominated flame retardants such polybrominated diphenyl ether and polybrominated biphenyls. There are four different categories for current plastic recycling technology. Primary recycling refers to the mechanical processing of plastic wastes to create a product with characteristics like the original product. The polymer will be transformed into a product with inferior characteristics as a result of subsequent recycling. Chemical components may be recovered from plastic trash through tertiary recycling. Plastic waste energy conversion is categorized as quaternary recycling. Examples of well-known technology that can process plastic from e-waste are CreaSolv and KDV. Since it can turn polymers containing BFR into goods with additional value including Grenew briquettes for steelmaking, super-capacitors, silicon carbide, polymer composites, and 3D printing filaments, new technology, also known as micro-factories, is regarded as the fifth category. .Recycling of Glass

Glass-to-glass recycling and glass-to-lead recycling are two categories of e-waste recycling techniques. First, a lead smelter was used to recover glass. The amount of lead included in CRT glass ranges from 0.5 to 5 kg, and it serves as a shield against X-ray radiation. High throughput is an advantage of this method, but it may lower the value of fine glass. With the latter technique, fresh cathode ray tubes were made

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using the recovered glass as raw material. It lowers costs and increases the furnace's effectiveness in the recycling process. Due of the difficulties in figuring out the precise makeup of the recycled glass, there is a danger [7], [8].

Electronic waste, commonly referred to as e-waste, has become a pressing global issue due to its environmental and health hazards. With the rapid advancement of technology and the increasing consumption of electronic devices, developing nations have emerged as major contributors to the e-waste crisis. This article provides a detailed description of recent research on e-waste in developing nations and discusses the future implications and potential solutions to tackle this growing problem.

Current State of E-waste in Developing Nations:

Developing nations, driven by industrial growth and rising consumerism, face significant challenges in managing e-waste. The improper disposal and recycling of electronic devices lead to adverse environmental and health consequences. Informal recycling practices, such as open burning and dismantling without proper safety measures, are prevalent in many developing countries, releasing toxic substances into the air, soil, and water.

Environmental and Health Impacts:

Recent research highlights the severe environmental and health impacts of e-waste in developing nations. Hazardous chemicals like lead, mercury, cadmium, and brominated flame retardants found in electronic devices pose significant risks to ecosystems and human health. Contamination of soil and water sources affects agriculture and the availability of clean drinking water, leading to long-term health issues like respiratory problems, neurological disorders, and cancer.

E-waste Management Challenges:

Developing nations face several challenges in managing e-waste effectively:

a. Lack of Infrastructure: Inadequate waste management infrastructure, including collection, recycling facilities, and appropriate disposal sites, hinders proper e-waste management.

b. Limited Awareness and Regulations: Insufficient awareness among the public and policymakers about the hazards of e-waste, coupled with weak or nonexistent regulations, contribute to the improper handling and disposal of electronic devices.

c. Informal Sector Dominance: In many developing nations, informal recycling sectors operate without proper regulations or safety measures, exacerbating the environmental and health risks associated with e-waste.

Recent Research Initiatives:

Researchers worldwide have recognized the urgency of addressing e-waste in developing nations and have undertaken various studies to better understand the problem and identify potential solutions:

a. Quantifying E-waste Generation: Researchers have conducted surveys and assessments to quantify the volume of e-waste generated in developing nations, enabling policymakers to formulate effective waste management strategies.

b. Assessing Health and Environmental Impacts: Studies have focused on assessing the specific health and environmental risks associated with e-waste exposure, aiding in the development of targeted interventions and awareness campaigns.

c. Recycling Technologies and Solutions: Researchers have explored innovative recycling technologies and sustainable e-waste management models to reduce the environmental impact and recover valuable resources from electronic devices.

Future Outlook and Potential Solutions:

To address the e-waste crisis in developing nations, several potential solutions have been proposed:

a. Strengthened Legislation and Policy Frameworks: Developing nations need robust legislation and policy frameworks to regulate e-waste management effectively. This includes implementing extended producer responsibility (EPR) programs, promoting environmentally sound recycling practices, and imposing penalties for non-compliance.

b. Building Infrastructure and Capacities: Investments in waste management infrastructure, recycling facilities, and capacity building are crucial to improve e-waste management systems in developing nations.

c. Promoting Circular Economy Models: Encouraging a shift towards a circular economy model, where electronic devices are designed for durability, reparability, and resource recovery, can help reduce e-waste generation.

d. Raising Awareness and Education: Public awareness campaigns and educational programs are essential to educate communities, policymakers, and industry stakeholders about the hazards of e-waste and the importance of responsible disposal.

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CONCLUSION

E-waste poses a significant challenge to developing nations due to its environmental and health implications. Recent research initiatives have shed light on the magnitude of the problem and explored potential solutions. By implementing strengthened regulations, investing in infrastructure, promoting circular economy models, and raising awareness, developing nations can pave the way for a sustainable future by effectively managing e-waste and mitigating its adverse effects. Nearly all nations in the world struggle with the issue of e-waste, but developing nations are particularly affected because of the large amounts of e-waste that are imported into these nations. Therefore, each of us must be dedicated to reducing waste and using, recycling, and reusing all e-waste.

REFERENCES:

[1] J. A. Laub, 'Assessing the servant organization; Development of the Organizational Leadership Assessment (OLA) model. Dissertation Abstracts International', *Procedia - Soc. Behav. Sci.*, 1999.

[2] D. L. Brien, 'Unplanned Educational Obsolescence: Is the "Traditional" PhD Becoming Obsolete?', *M/C J.*, 2009, doi: 10.5204/mcj.160.

[3] M. Ackah, 'Informal E-waste recycling in developing countries: review of metal(loid)s pollution, environmental impacts and transport pathways', *Environmental Science and Pollution Research*. 2017. doi: 10.1007/s11356-017-0273-y.

[4] A. R. K. Gollakota, S. Gautam, and C. M. Shu, 'Inconsistencies of e-waste management in developing nations – Facts and plausible solutions', *Journal of Environmental Management*. 2020. doi: 10.1016/j.jenvman.2020.110234.

[5] O. E. Orisakwe, C. Frazzoli, C. E. Ilo, and B. Oritsemuelebi, 'Public Health Burden of E-waste in Africa', *J. Heal. Pollut.*, 2020, doi: 10.5696/2156-9614-9.22.190610.

[6] S. Herat, 'E-Waste Management in Asia Pacific Region: Review of Issues, Challenges and Solutions', *Nature Environment and Pollution Technology*. 2021. doi: 10.46488/NEPT.2021.V20I01.005.

[7] P. R. Kaushik and S. Herat, 'Current state of e-waste management in India', *Int. J. Environ. Waste Manag.*, 2020, doi: 10.1504/IJEWM.2020.106293.

[8] J. Yu, E. Williams, M. Ju, and Y. Yang, 'Forecasting global generation of obsolete personal computers', *Environ. Sci. Technol.*, 2010, doi: 10.1021/es903350q.

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Ecologically Conscious Options for Management Firm E-Wastes

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ABSTRACT: Electronic items that are reaching the end of their "useful life" are sometimes referred to as "e-waste." E-wastes are harmful because some of its components may contain toxic compounds, depending on their density and condition. These materials' toxic composition endangers both human health and the environment. If discarded incorrectly, outdated electronics such as computers, TVs, VCRs, stereos, copiers, fax machines, electric lights, mobile phones, audio equipment, and batteries may leach lead and other materials into the ground and soil. Many of these things may be recycled, repaired, or reused in an eco-friendly way to make them less damaging to the environment. This essay focuses on the risks associated with e-waste, the need of managing it properly, and possible solutions.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

In the past century, the industrial revolution and subsequent information technology advancements have fundamentally altered people's way of life. The human species has benefited from this progress, but poor management has created additional contamination and pollution issues. The technological advancements made during the last century have created a new obstacle for waste management. Personal computers, for instance, may include parts that are very harmful, such as chemicals that are chlorinated and brominated, poisonous gases, toxic metals, biologically active compounds, acids, plastics, and plastic additives. These materials' toxic composition is dangerous for both the environment and human health. Therefore, adequate management is required for disposing of or recycling electronic trash. Nowadays, computers are the most popular and frequently utilized technology in a variety of settings, including businesses, homes, and industrial facilities. Circuit boards with heavy metals like lead and cadmium, batteries with cadmium, cathode ray tubes with lead oxide and barium, brominated flame retardants used on printed circuit boards, cables, and plastic computer cases, poly vinyl chloride coated copper cables and plastic computer casings that release highly toxic dioxins and furans when burned to recover valuable metals, mercury switches, mercury in flat screens, and poly vinyl chloride could all be categorized as e-toxic components in computers. The 500 million computers in use worldwide, according to Basel Action Network, include 2.87 billion kg of plastic, 716.7 million kg of lead, and 286,700 kg of mercury. A tube used in the typical 14-inch display is thought to contain 2.5 to 4 kg of lead. Landfills may release lead into the groundwater, poisoning it. The tube releases poisonous vapors into the air when it is crushed and burnt [1].

Impacts on Human Health and the Environment

E-waste disposal is an issue that is prevalent in many parts of the world. Landfilling of computer trash results in polluted leachates that ultimately affect groundwater. Acidification of the soil occurs when acids and sludge from melting computer chips are dumped on the ground. As an example, Guiyu, Hong Kong, a major center of illicit e-waste recycling, is experiencing severe water shortages as a result of the tainted water sources.

This is a result of recycling wastes like acids and sludge being dumped in rivers. In order to meet the needs of the people, water is now being carried from far places. E-waste incinerators have the potential to release hazardous gases and pollutants into the air, contaminating it. Landfills that are not adequately inspected may pose environmental risks. When some electrical equipment, such circuit breakers, are broken, mercury will leak. Polychlorinated biphenyls from condensers behave similarly. Both polybrominated dlphenyl ethers and cadmium may leak into the soil and groundwater when plastics that contain brominated flame retardants or that contain cadmium are landfilled. Broken lead-containing glass, like the

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cone glass used in cathode ray tubes, has been discovered to dissolve large quantities of lead ions when it comes into contact with acidic fluids, which happens often in landfills.

In addition to the particular issues associated with mercury leaching, there are additional issues with the vaporization of metallic mercury and dimethylene mercury, both of which are present in waste electrical and electronic equipment. Additionally, landfills may have uncontrolled fires, which may happen often in many nations. Metals and other chemicals, including the highly poisonous dioxins and furans from halogenated flame retardant products and PCB-containing condensers, may be released when exposed to fire. The open-air burning of plastics to recover copper and other metals is the riskiest method of burning electronic trash. The extremely harmful byproducts of open-air burning influence both the local ecosystem and larger global air currents, dispersing them in many locations all over the globe.

the consequences of certain e-waste components on health. If these electronic devices are thrown out with ordinary household trash, the toxics represent a risk to both human health and important ecological components. A number of nations urged the need for a worldwide accord to address the issues and difficulties presented by hazardous waste in light of the negative impact these wastes have on the environment and human health. Additionally, in developed nations, tighter environmental restrictions in the late 1980s resulted in a sharp increase in the price of hazardous waste disposal. Hazardous waste started to be sent to underdeveloped nations by "toxic traders" looking for more affordable methods to dispose of the pollutants. Following these reckless actions, there was widespread indignation, which prompted the Basel Convention to create and enact strategic plans and restrictions. The execution of the Convention and associated agreements is facilitated by the secretariat of the Convention, located in Geneva, Switzerland. Additionally, it collects statistical information, offers advice and training on legal and technical matters, and manages hazardous waste appropriately [2].

Convention of Basel

The fundamental goals of the Basel Convention are the active promotion of technology transfer and use, as well as the control and reduction of transboundary movements of hazardous and other wastes, including the prevention and minimization of their generation. The Basel Convention has been put into practice according to a draft strategic plan. The Draft Strategic Plan considers current regional plans, programs, or strategies, decisions made by the Conference of the Parties and its subsidiary organizations, project activities now underway, and processes of global environmental governance and sustainable development. To help with the actual implementation of the Basel Declaration, the Draft calls for action at all societal levels, including education, information, communication, methodological tools, capacity building with financial support, transfer of know-how, knowledge, and sound, tested cleaner technologies and processes. It also urges the efficient participation and coordination of all relevant parties as being crucial to achieve the Basel Declaration's objectives within the framework of shared but differentiated responsibility.

DISCUSSION

Enlisting the help of experts in the design of communication tools to raise awareness of the Basel Declaration's goals of environmentally sound management at the highest level and to encourage ratification and implementation of the Basel Convention, its amendments, and protocol, with a focus on immediate actions. enlisting and motivating a group of interested parties to help the secretariat in investigating fund-raising tactics, including project planning and making full use of the expertise in other institutions and non-governmental organizations for collaborative initiatives. to encourage a chosen group of stakeholders to provide additional value to short-term development. to promote and make information on the transfer of know-how widely available through the internet and other electronic and printed resources, particularly via Basel Convention Regional Centers. to conduct regular assessments of your actions in accordance to the agreed-upon indicators;

to work with already-established institutions and programs to enable the transfer of cleaner technology, as well as its methodology, financial tools, and policy, in order to encourage or support the development of capacity for the ecologically sound management of hazardous and other wastes. The transfer of hazardous garbage across borders was halted by the Basel Convention. The treaty has been ratified by India and other nations. However, the United States is not a party to the prohibition and is still in charge of sending hazardous trash, such e-waste, to Asian nations. Developed nations like the US should enact harsher laws inside their own borders to stop this heinous crime. The European Parliament recently enacted laws requiring manufacturers to take back their electronic devices when customers discard them in the European

Union, where it is predicted that in the next 12 years, the amount of electronic trash would quadruple. Extended Producer Responsibility is what this is known as. It also stipulates a timeline for the phase-out of the majority of harmful materials in electronic devices [3], [4].

Control of E-Wastes

According to estimates, 75% of electronic things are stored because there is a lack of management clarity. These electronic trash items are often mingled with domestic debris and left unattended in homes, businesses, warehouses, and other buildings before being dumped at landfills. Implementable management strategies are required as a result. E-waste management in industries has to start at the point of production. Techniques for reducing waste and sustainable product design may help with this. In order to reduce waste, enterprises must adopt:

1. Inventory control.
2. Modification of the production process.
3. Reduces the volume.
4. Recuperation and reusing.

Inventory Control

Reduced waste generation may be achieved in part by exercising proper control over the materials used in production. The amount of waste produced may be decreased by cutting down on both the number of hazardous chemicals utilized in the process and the amount of extra raw materials held in store. Setting up material-purchase review and control processes and an inventory monitoring system are two approaches to do this. The first stage in developing an inventory management program is to develop review processes for every item acquired. All items should be authorized before being purchased, as per procedures. All manufacturing materials are examined throughout the approval process to see if they include any hazardous components and to see if any non-hazardous alternatives are available. Making ensuring that just the necessary amount of an item is ordered is another inventory management strategy for waste reduction. Setting up a stringent inventory management system will be necessary to do this. It is necessary to put in place purchase processes that guarantee that just the quantity required for a given time period is bought, and that resources are only ordered when needed.

Modification of the Production Process

There are modifications that may be made to the manufacturing process to lessen waste output. Changing the product's manufacturing materials, using input materials more effectively throughout the production process, or doing both may achieve this decrease. Three kinds of potential waste reduction approaches may be identified:

Improved Operational and Upkeep Practices,

1. Substantial modification
2. Modification of process-equipment.

Significant waste reduction may be achieved by making improvements to the operation and maintenance of process equipment. This may be done by analyzing the present operating procedures or lack thereof and looking for methods to make the manufacturing process more efficient. Implementing standard operating procedures helps optimize the utilization of raw materials during manufacturing and lower the likelihood that resources will be wasted due to spills and leaks. A tight maintenance schedule that prioritizes corrective repair may lessen the amount of waste produced when equipment fails. Any initiative to reduce waste must include staff training as a crucial component. The right usage of equipment, required maintenance and inspection schedules, suitable process control requirements, and adequate waste management should all be included in training.

Hazardous ingredients may be swapped out for less dangerous or non-hazardous ones in product formulation or manufacturing processes. This method is quite common and works with most industrial processes. Implementing this waste reduction method may just call for a few small process modifications or it may need the purchase of substantial new process equipment. For instance, a maker of circuit boards may switch from solvent-based flux to water-based flux while also switching from solvent-vapor degreaser to detergent parts washer.

Waste generation may be greatly decreased by installing more effective process equipment or by upgrading current equipment to make use of improved production methods. Equipment that has been upgraded or newer may process resources more effectively and produce less waste. The quantity of material that has to be reworked or disposed of is also reduced by increased efficiency by fewer rejected or off-spec products. Reducing waste creation may often be done relatively affordably by modifying existing process equipment. In many instances, the alteration may be as easy as altering how the materials are handled throughout the process to prevent waste. For instance, chemicals are used to remove coating off rejected items so that they may be recoated in various electronic manufacturing processes that require coating a product, such as electroplating or painting. These substances, which may include acids, caustics, cyanides, and other compounds, are often hazardous trash and need to be handled carefully. The amount of waste may be greatly decreased by lowering the number of pieces that need to be modified.

Volume Diminution

Techniques for volume reduction include those that separate a waste's hazardous and non-hazardous components. These methods are often used to decrease waste material volume and, therefore, disposal costs. Source segregation and waste concentration are two broad categories that may be used to categorize the methods that can be utilized to minimize waste-stream volume. In many circumstances, separating debris into different piles is an easy and affordable way to reduce waste. Metal value in the sludge may be recovered by treating wastes containing various kinds of metals separately. A waste stream's concentration can make it more likely that the item can be recycled or utilized again. Methods include reverse osmosis, ultra filtration, gravity and vacuum filtration, freeze vaporization, and more. For instance, to minimize the amount of discarded cathode ray tubes, an electronic component factory may utilize compaction equipment [5], [6].

Recuperation and Reusing

This method might lower the cost of raw materials, eliminate trash disposal fees, and generate cash from a waste that can be sold. On-site, at an off-site facility for waste recovery, or via industry-to-industry trade are all options for waste recovery. There are a variety of physical and chemical processes, such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtering, centrifugation, etc., that may be used to recover waste materials. Electrolytic recovery, for instance, may be used by a maker of printed circuit boards to recover metals from a copper and tin-lead plating bath. Recycling hazardous materials, however, offers little environmental advantage if it just transfers the risks to secondary products that must ultimately be disposed of. Such recycling is a false answer unless the objective is to rebuild the product to employ non-hazardous components.

Designing Sustainable Products

The reduction of hazardous wastes should begin with the product design process, taking the following considerations into account. Rethink the product's design: Make an effort to create a product with less dangerous substance in it. For instance, certain modern computer designs that are flatter, lighter, and more integrated show how attempts to decrease material consumption are being made. Other businesses suggest centralized networks like the telephone network. Utilization of renewable resources: Bio-based plastics are created using chemicals or polymers generated by plants rather than petrochemicals. More commonly, bio-based toners, glues, and inks are employed. There are also solar computers, although they are presently quite costly.
Utilization of less hazardous non-renewable materials: Because many of the materials are non-renewable, designers might make sure the product is made to be reusable, repairable, and/or upgradeable. Some computer makers, like Dell and Gateway, lease out their goods to ensure they may later update and lease them out once again.

The Scenario in Indiana

While the rest of the world is awestruck by the technological revolution, nations like India are in immediate danger. Developed nations, including the US, send their e-waste to India and other Asian nations for disposal. According to a recent inquiry, many gadgets that are sent to be recycled in the United States wind up in Asia where they are either disposed of or recycled with little to no consideration for the environment or the health and safety of the workers. Cheap labor and a lack of occupational and environmental norms in Asia are the main drivers of exports, which causes the hazardous waste of wealthy countries to flow toward the world's poorest countries. These issues' scope has not yet been quantified. However, organizations like Toxic Links India are already hard at work collecting data that could be a start in the right direction in order to restrict this dangerous trade. It is crucial that developing nations, and India in particular, recognize the monopoly of the developed countries and put in place the necessary management mechanisms to stop the dangers and accidents brought on by improper management of e-waste.

Control Options

Given the seriousness of the issue, it is essential that specific management strategies be used to deal with the large amounts of e-waste. The choices for management that have been recommended for the public, businesses, and government are listed below.

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Obligations of the Government

To coordinate and consolidate the regulatory responsibilities of the different government entities for hazardous chemicals, governments should establish regulatory bodies in each district. Governments should be in charge of setting up a sufficient system of regulations, rules, and administrative processes for managing hazardous waste. The e-waste disposal regulations now in place should be examined and updated. It is necessary to have a complete legislation that addresses hazardous waste disposal as well as e-waste management and control. The agency should be given the authority to oversee, manage, and legislate the pertinent operations of government agencies under such a legislation.

To keep an inventory of these items and to gather basic information about them from producers, processors, and importers. The details have to include toxicity and probable negative effects. Determine which compounds are possibly dangerous and demand that the industry test them for negative impacts on human health and the environment. Reduce the dangers associated with the production, handling, distribution, usage, and disposal of electronic waste. Encourage beneficial reuse of "e-waste" and encouraging business activities that use waste". Set up programs so as to promote recycling among citizens and businesses. Educate e-waste generators on reuse/recycling options. Governments must encourage research into the development and standard of hazardous waste management, environmental monitoring and the regulation of hazardous waste-disposal. Governments should enforce strict regulations against dumping e-waste in the country by outsiders. Where the laws are flouted, stringent penalties must be imposed. In particular, custodial sentences should be preferred to paltry fines, which these outsiders / foreign nationals can pay. Governments should enforce strict regulations and heavy fines levied on industries, which do not practice waste prevention and recovery in the production facilities. Polluter pays principle and extended producer responsibility should be adopted. Governments should encourage and support NGOs and other organizations to involve actively in solving the nation's e-waste problems. Uncontrolled dumping is an unsatisfactory method for disposal of hazardous waste and should be phased out. Governments should explore opportunities to partner with manufacturers and retailers to provide recycling services.

Industries' Accountability and Function

Waste producers should be accountable for figuring out the output characteristics of wastes and, if hazardous, offering management choices. Companies may implement their own rules when processing e-wastes, some of which are included below [7], [8]. All workers engaged in handling e-waste in industries, including those at the policy, management, control, and operational levels, should be appropriately qualified and trained.

1. Use label-making supplies to help in recycling.
2. Standardize parts to facilitate disassembly.
3. Reconsider the usage of "cheap products," make the product cycle "cheap," and
4. Does not have any intrinsic worth that would motivate a recycling infrastructure.
5. Produce computer hardware and accessories using biodegradable materials.
6. Make use of technology sharing, especially for production and deproduction.
7. Promote, encourage, or mandate green procurement for corporate purchasers.
8. Consider eco-friendly packaging solutions.

It is a "reverse production" system that designs infrastructure to recover and reuse every material contained within e-wastes, including metals like lead, copper, aluminum and gold, as well as various plastics, glass and wire. Companies can and should adopt waste minimization techniques, which will significantly reduce the amount of e-waste generated and lessen the impact on the environment. Product recycling and disposal should be handled by the manufacturers, distributors, and retailers.

At a minimum, all computer monitors, television sets, and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management. 5. Manufacturers of computer monitors, television sets, and other electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products.

Citizens' Responsibilities

Donating electronics for reuse increases the lifespan of valuable products and keeps them out of the waste management system for a longer period of time, but care should be taken when donating such items, i.e., the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used

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electronics, schools, non-profit organizations, and other institutions can benefit.

In today's technologically advanced world, electronic waste (e-waste) has become a significant concern for organizations due to its environmental impact and potential health risks. To address this issue, management firms need to adopt ecologically conscious options for handling e-wastes. This article provides a detailed description of various environmentally friendly approaches and best practices that can be implemented by firms to effectively manage their e-wastes.

Waste Minimization and Source Reduction:

The first step in ecologically conscious e-waste management is to minimize waste generation at the source. Organizations can achieve this by implementing strategies such as:

a. Procurement Policies: Firms can prioritize the purchase of energy-efficient and environmentally friendly electronic devices. Considering product lifespan, repairability, and recyclability can significantly reduce e-waste generation.

b. Equipment Lifecycle Management: Adopting a structured approach to equipment lifecycle management ensures that electronic devices are used to their fullest potential. Implementing maintenance programs, extending the lifespan of devices, and upgrading instead of replacing equipment can reduce e-waste generation.

c. Inventory Management and Donation: Implementing efficient inventory management systems can prevent overstocking and obsolescence. Firms can donate functional electronic devices to charitable organizations or schools, extending their useful life and reducing waste.

Responsible Recycling and Disposal:

When electronic devices reach the end of their life cycle, it is crucial to ensure responsible recycling and disposal practices. The following approaches can be adopted:

a. E-waste Collection Programs: Management firms can establish collection programs to gather e-wastes from their facilities. These programs can include convenient drop-off points, scheduled pickups, or collaboration with certified e-waste recycling vendors.

b. Certified Recycling Vendors: Partnering with reputable and certified e-waste recycling vendors guarantees that e-wastes are processed using environmentally sound methods. These vendors employ techniques that maximize resource recovery and minimize environmental harm.

c. Data Security and Destruction: Before recycling or disposing of electronic devices, it is essential to securely erase all data to protect sensitive information. Firms should follow industry best practices for data destruction or work with specialized data destruction service providers.

Circular Economy Approaches:

Embracing circular economy principles can significantly contribute to ecologically conscious e-waste management. Some strategies to implement include:

a. Design for Durability and Repairability: Management firms can encourage manufacturers to produce electronic devices with longer lifespans and components that are easily replaceable or repairable. This approach promotes device longevity and reduces the need for frequent replacements.

b. Material Recovery and Recycling: Emphasizing the recovery of valuable materials from e-wastes through recycling processes helps conserve resources. Extracting metals, plastics, and other valuable components from electronic devices reduces the demand for virgin materials.

c. Product Take-Back Initiatives: Implementing product take-back programs allows firms to take responsibility for the proper disposal and recycling of their electronic products. By collaborating with consumers and offering incentives, management firms can ensure the return of used devices for recycling or refurbishment.

Education and Employee Engagement:

Creating awareness among employees about the importance of ecologically conscious e-waste management is vital. Some initiatives include:

a. Training and Education Programs: Organizations can conduct training sessions and workshops to educate employees about e-waste hazards, recycling procedures, and the benefits of environmentally friendly practices.

b. Internal Recycling Programs: Establishing internal recycling programs within the organization encourages employees to dispose of their e-wastes responsibly. Dedicated e-waste collection bins and awareness campaigns can promote participation.

c. Sustainability Committees: Forming sustainability committees or green teams within the organization can drive continuous improvement in e-waste management practices. These committees can monitor progress, suggest new initiatives, and engage employees in sustainability efforts.

CONCLUSION

In conclusion, implementing environmentally friendly practises for handling business e-waste is not only a moral decision but also a must in the modern world. Due to its harmful components and inappropriate disposal methods, electronic trash has grown to be a serious environmental issue as technology has progressed. Management companies may help create a more sustainable future and lessen the harm that e-waste causes to the environment and people's health by using environmentally friendly choices. Implementing efficient recycling programmes is one of the most environmentally responsible alternatives for handling business e-waste. While lowering the requirement for raw material extraction, recycling enables the recovery of valuable materials from electronic gadgets. Management companies must to collaborate with accredited electronic waste recyclers that use best practises when breaking down and processing electronic gadgets. The environment may be protected from dangerous compounds and precious resources can be saved by keeping e-waste out of landfills and guaranteeing efficient recycling. Promoting proper disposal and reuse is another environmentally responsible choice. Management companies may motivate staff and clients to properly dispose of their electronic gadgets by setting up accessible collection sites and conducting awareness programmes. Businesses can also look at ways to repair and reuse electronic equipment to increase its lifespan and decrease the need for new goods. E-waste creation may also be greatly decreased by integrating energy-efficient technology and procedures inside the company's operations. Management companies may optimise their IT infrastructure and reduce the need for frequent updates and replacements by implementing tactics like virtualization, cloud computing, and equipment consolidation. This strategy decreases e-waste while simultaneously saving money and increasing energy effectiveness.

REFERENCES:

[1] H. Abd-Mutalib, C. Z. M. Jamil, R. Mohamed, N. A. Shafai, and S. N. H. J. N. Nor-Ahmad, 'Firm and board characteristics, and e-waste disclosure: A study in the era of digitalisation', *Sustain.*, 2021, doi: 10.3390/su131810417.

[2] R. Heeks, L. Subramanian, and C. Jones, 'Understanding e-Waste Management in Developing Countries: Strategies, Determinants, and Policy Implications in the Indian ICT Sector', *Inf. Technol. Dev.*, 2015, doi: 10.1080/02681102.2014.886547.

[3] M. Sharma, S. Joshi, and A. Kumar, 'Assessing enablers of e-waste management in circular economy using DEMATEL method: An Indian perspective', *Environ. Sci. Pollut. Res.*, 2020, doi: 10.1007/s11356-020-07765-w.

[4] K. Bhaskar and B. Kumar, 'Electronic waste management and sustainable development goals: Is there a business case for linking the two?', *J. Indian Bus. Res.*, 2019, doi: 10.1108/JIBR-01-2018-0051.

[5] S. Sivaramanan, 'E-Waste Management, Disposal and Its Impacts on the Environment', *Univers. J. Environ. Res. Technol. www.environmentaljournal.org*, 2013.

[6] K. S. Khor, T. Ramayah, and H. R. P. Fouladgaran, 'Managing eco-design for reverse logistics', *Int. J. Environ. Waste Manag.*, 2020, doi: 10.1504/IJEWM.2020.108811.

[7] P. Mane and T. T. Niranjan, 'Sustainable value creation through E-waste management: The role of marketing-retailers-operations interface', *Glob. Bus. Rev.*, 2014, doi: 10.1177/0972150914550522.

[8] A. Matarazzo, G. Tuccio, G. Teodoro, F. Failla, and V. A. Giuffrida, 'Mass balance as green economic and sustainable management in WEEE sector', in *Energy Procedia*, 2019. doi: 10.1016/j.egypro.2018.11.302.

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Challenges of Electronic Waste (E-Waste) Management in India

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***ABSTRACT:** Nearly every element of contemporary life has been impacted by information and communications technology (ICT) and organized networking. Even the most isolated regions of the developing nations are seeing a beneficial impact on human existence. Computer power has increased as a result of the information and communications technology's explosive expansion. However, as product lifespans shorten, electrical and electronic trash (ewaste) is growing significantly each year. Most underdeveloped nations, notably in Africa, rely heavily on used or refurbished EEEs that are often imported without functional confirmation testing for the development of information and telecommunications technologies.*

***KEYWORDS:** E-Waste, Disposal, Hazardous Substances, Management, Recycling.*

INTRODUCTION

The life cycle of electronic items has considerably decreased in recent years since the electronic industry is the biggest and fastest expanding industrial sector in the world. The capacity of computers has increased due to the expansion of information technology and telecommunications, but at the same time, product lifespan has reduced. The result of this consumer-focused expansion, quick product obsolescence, and technical advancements is a new environmental challenge: the rising menace of "Electronics Waste" (also known as "e waste"), which consists of outdated electronic gadgets. Given the amount of e-waste management, it is thus both an expanding issue and a growing economic opportunity.

The preferred method for getting rid of outdated electronic devices in India is to get them in exchange from retailers when buying a new item. However, since there is no independent collection of e-waste in India, there is no clear data on the quantity generated and disposed of annually and the resulting extent of environmental risk. According to estimates, 78% of all computers deployed in India are used by business. Business-related obsolete computers are sold at auction. The overall number of outdated personal computers coming out of Indian businesses and families each year is also approximated. Sometimes educational institutions and charity organizations obtain old PCs for repurposing. In the neighborhood of 1.38 million. Based on a Confederation of Indian Industries study. In India, malfunctioning or outdated electronic and electrical equipment is the main source of e-waste [1], [2].

A Discussion of India's E-Waste Management Status

In 2004, there were no particular legislation or standards for electronic trash or computer waste in India, despite the country's extensive environmental regulations. According to the Hazardous Waste Rules (1989), e-waste is not considered hazardous waste unless it can be shown that it has a greater concentration of a particular chemical. There are a few gray areas that need to be handled, even though PCBs and CRTs will always exceed these limits. Due of concerns about mercury, lead, and cadmium, the Basel Convention includes Waste Electronic Assemblies in A1180 and Mirror Entry in B1110. Under List-A and List-B of Schedule-3 of the Hazardous Wastes (Management & Handling) Rules, 1989, as revised in 2000 and 2003, electronic waste is covered. Therefore, the Ministry of Environment and Forests must specifically approve the import of this garbage. The government has taken the following action/steps to improve and promote knowledge about ecologically sound management of electronic trash since the informal sector currently performs the collecting and recycling of electronic waste in the nation.

The Central Pollution Control Board (CPCB) organized a number of workshops on electronic waste management. CPCB has taken steps to quickly analyze the amount of E-Waste produced in the main cities. The National Working Group has been established to develop the EWaste management plan. The

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Department of Information Technology (DIT) and Ministry of Communication and Information Technology have developed and widely disseminated the comprehensive technical reference on "Environmental Management for Information Technology Industry in India." The DIT has also established demonstration projects at Indian Telephone Industries for the recovery of copper from printed circuit boards. The absence of trustworthy data, which makes it difficult for policymakers to develop an e-waste management plan and for the business community to make wise investment choices. Due to the lack of a successful consumer take back program, only a small portion of electronic trash makes it to recyclers. Because the legal sector lacks a secure infrastructure for recycling e-waste, it must rely on the capabilities of the unofficial sector, which poses serious hazards to the environment and people's health. The current mechanisms for recycling e-waste are entirely driven by industry and developed without any help from the government [3], [4].

E-Waste Recycling:

Many abandoned machines include salvageable components that might be merged with other old machinery to create a functional unit. Removing, testing, and inspecting individual components before putting them back together to form fully functional machines takes a lot of effort. For the ecologically sound management of e-wastes, institutional infrastructures comprising e-waste collection, transportation, treatment, storage, recovery, and disposal must be built at national and/or regional levels. The regulatory authorities should authorize these facilities and, if necessary, provide suitable incentives. Establishing e-waste collection, exchange, and recycling facilities in collaboration with governments, NGOs, and manufacturers should be promoted. E-waste recycling that respects the environment calls for advanced equipment and procedures that are not only highly costly but also need specialized knowledge and training to carry out. The ability to identify or ascertain the presence of hazardous or potentially hazardous constituents as well as desirable constituents (i.e., those with recoverable value) is necessary for the proper recycling of complex materials. The company's capabilities and process systems must then be able to be applied to properly recycle both of these streams. For the fugitive and point source emissions, appropriate air pollution control technologies are needed. To recycle E Wastes in an ecologically responsible manner, guidelines must be devised. Once they are confident in the profits, the private sector is stepping forward to invest in e-waste initiatives [5].

Challenges

After analyzing management challenges in China, India and South Africa, it is necessary to consider those that are peculiar to emerging and industrializing nations in WEEE management. The following is a summary of these issues: "Although the amount of domestic e-waste produced per person is still quite low, populous nations like China and India are already enormous e-waste producers in absolute terms; these nations also have the fastest-growing markets for EEE. Some developing and transitional nations import sizeable amounts of e-waste. While some of them are mislabeled, others come as gifts to aid "the poor." The following are only a few of the tremendous obstacles confronting end-of-life treatment of e-waste in underdeveloped nations.

1. The growing amount of illegally imported e-waste entering emerging nations. Rarely is used testing done on used EEE shipped into poor nations. Between 25 and 75 percent of this large amount is thought to be utilized in EEE imports [6], [7].
2. Lack of knowledge on the dangers or toxicity of e-waste. Both the government and the general population are unaware of the possible dangers. The current handling of WEEE in developing nations and its effects on the environment and human health. These two were engaged in the risky practices of recycling crude oil.
3. There is no infrastructure in place to recycle or manage e-waste in accordance with sustainable development/consumption principles. Only South Africa has official e-waste recycling facilities as of 2005.
4. A lack of resources and investments to finance viable e-scrap recycling developments. The crude "backyard" recycling processes result in resource loss, energy waste, and environmental contamination.
5. There is no regulation that addresses e-waste explicitly. Additionally, there are almost no laws or pieces of legislation in place that effectively manage the trans-border movement of recyclables and hazardous trash.
6. Developing nations lack mandatory or efficient voluntary take-back programs (EPR) for end-of-life EEE. The refusal of consumers and businesses to donate their outdated EEE or pay for WEEE recycling is another issue [8], [9].

India, with its fast-growing economy and increasing technological penetration, faces significant challenges in the management of electronic waste (e-waste). The rapid pace of technology advancement, coupled with high consumption rates and inadequate infrastructure, has led to a mounting e-waste crisis. This article provides a detailed description of the challenges faced by India in managing e-waste and highlights the key factors contributing to this complex issue.

Large and Growing E-Waste Generation:

India is one of the largest generators of e-waste globally. The increasing population, rising middle class, and growing digitalization have led to a significant surge in electronic device consumption. The sheer volume of e-waste generated poses a major challenge for effective management and disposal.

Informal Recycling Sector:

One of the primary challenges in e-waste management in India is the dominance of the informal recycling sector. A significant portion of e-waste is processed by informal recyclers, often working in hazardous conditions and without proper safety measures. This leads to environmental pollution and health risks for workers and nearby communities.

Lack of Adequate Infrastructure:

The infrastructure for e-waste management in India is inadequate to handle the growing volume of waste. Insufficient recycling facilities, collection centers, and authorized disposal sites hinder proper disposal and recycling practices. The limited availability of formal recycling facilities forces a large portion of e-waste to be managed through informal channels.

Lack of Awareness and Enforcement:

Awareness about the hazards of e-waste and the importance of responsible disposal is still relatively low among the general public, policymakers, and even some businesses. The lack of awareness contributes to improper disposal practices such as throwing e-waste in regular waste bins or informal recycling. Additionally, enforcement of regulations and guidelines related to e-waste management is often weak, further exacerbating the problem.

Complex Supply Chains:

The supply chains for electronic devices in India are often complex, involving multiple stakeholders such as manufacturers, distributors, retailers, and consumers. Managing e-waste effectively requires coordination among these stakeholders to ensure proper collection, recycling, and disposal. However, the fragmented nature of the supply chains poses a challenge in implementing efficient e-waste management practices.

Limited Resources Recovery:

Electronic devices contain valuable resources such as precious metals and rare earth elements. However, the current e-waste management practices in India often prioritize informal recycling methods that focus on extracting valuable metals, neglecting the safe disposal of hazardous components. This results in the loss of valuable resources and contributes to environmental pollution.

Policy and Regulatory Gaps:

While India has implemented policies and regulations related to e-waste management, there are still gaps in their effective implementation. The absence of a comprehensive regulatory framework and the lack of enforcement mechanisms hinder the establishment of a robust e-waste management system. There is a need for stronger regulations, extended producer responsibility (EPR) programs, and effective monitoring to address these gaps.

India faces multiple challenges in managing e-waste effectively. The large and growing volume of e-waste, dominance of the informal recycling sector, inadequate infrastructure, lack of awareness and enforcement, complex supply chains, limited resource recovery, and policy and regulatory gaps all contribute to the complexity of the issue. Addressing these challenges requires a multi-faceted approach involving improved infrastructure, awareness campaigns, strengthened regulations, collaboration among stakeholders, and promotion of sustainable practices. Efforts towards sustainable e-waste management will be crucial for India to mitigate environmental and health risks while harnessing the potential of a circular economy. The challenges of electronic waste (e-waste) management in India are complex and multifaceted. The country faces a growing e-waste crisis fueled by increasing consumption, the dominance of informal recycling, inadequate infrastructure, lack of awareness and enforcement, complex supply chains, limited resource recovery, and policy and regulatory gaps. These challenges pose significant environmental and health risks, demanding urgent attention and action.

To address these challenges, India must prioritize the development of comprehensive and effective e-waste management strategies. This includes investing in infrastructure for collection, recycling, and disposal, promoting responsible recycling practices, and strengthening regulations and enforcement mechanisms. Creating awareness among the general public, businesses, and policymakers about the hazards of e-waste and the importance of proper disposal is crucial. Additionally, India should foster collaboration among stakeholders, including manufacturers, distributors, retailers, and consumers, to establish efficient and sustainable e-waste management systems. The implementation of extended producer responsibility (EPR) programs can help ensure that manufacturers take responsibility for the entire lifecycle of their products, including proper disposal.

Furthermore, efforts should be made to promote resource recovery from e-waste. By adopting innovative recycling technologies and practices, India can recover valuable materials from discarded electronic devices, reducing the demand for virgin resources and contributing to a circular economy. Addressing the challenges of e-waste management in India requires a coordinated and comprehensive approach involving government initiatives, industry participation, civil society engagement, and public awareness. By prioritizing these efforts, India can mitigate the environmental and health risks associated with e-waste, promote sustainable practices, and pave the way for a more environmentally friendly and resource-efficient future.

CONCLUSION

The many wastes are a result of improper processing and are connected to the primary environmental effects of managing e-waste. Drawing a line between secondary commodities meant for use and trash materials is challenging rather than inherent harmful components. Secondary markets, particularly those for computers, have positive societal effects. They have increased living standards by making things accessible to those with modest incomes. Given that uncontrolled processing in developing nations produces money, there is a significant economic drive supporting the development of an informal sector, which makes it difficult to implement Williams' restrictions from 2005.To separate used electronics from e-scrap intended for material recovery, it is necessary to implement a system for labeling them. This will guarantee that used electronics intended for export are certified and confirmed to operate. The implementation of producer responsibility, the introduction of formal recycling, the adoption of appropriate land fill technology for toxic wastes that will result from these waste management activities are all urgently needed for the effective management of e-waste in developing countries.

REFERENCES:

[1] R. Nivedha and A. I. Sutha, 'The Challenges Of Electronic Waste (E-Waste) Management In India', *Eur. J. Mol. Clin. Med.*, 2020.

[2] R. Nivedha and A. I. Sutha, 'European Journal of Molecular & Clinical Medicine The Challenges Of Electronic Waste (E-Waste) Management In India', *Eur. J. Mol. Clin. Med.*, 2020.

[3] S. Needhidasan, M. Samuel, and R. Chidambaram, 'Electronic waste - An emerging threat to the environment of urban India', *Journal of Environmental Health Science and Engineering*. 2014. doi: 10.1186/2052-336X-12-36.

[4] S. Arya and S. Kumar, 'E-waste in India at a glance: Current trends, regulations, challenges and management strategies', *Journal of Cleaner Production*. 2020. doi: 10.1016/j.jclepro.2020.122707.

[5] A. Borthakur and M. Govind, 'Computer and mobile phone waste in urban India: an analysis from the perspectives of public perception, consumption and disposal behaviour', *J. Environ. Plan. Manag.*, 2019, doi: 10.1080/09640568.2018.1429254.

[6] P. Pathak, R. R. Srivastava, and Ojasvi, 'Assessment of legislation and practices for the sustainable management of waste electrical and electronic equipment in India', *Renewable and Sustainable Energy Reviews*. 2017. doi: 10.1016/j.rser.2017.04.062.

[7] S. B. Wath, P. S. Dutt, and T. Chakrabarti, 'E-waste scenario in India, its management and implications', *Environ. Monit. Assess.*, 2011, doi: 10.1007/s10661-010-1331-9.

[8] U. R. H. Khan Rizvee, 'E-Waste Management in India: Current Practices and Challenges', *Int. J. Res. Appl. Sci. Eng. Technol.*, 2020, doi: 10.22214/ijraset.2020.7049.

[9] M. Sharma, S. Joshi, and A. Kumar, 'Assessing enablers of e-waste management in circular economy using Dematel method: An Indian perspective', *Environ. Sci. Pollut. Res.*, 2020, doi: 10.1007/s11356-020-07765-w.

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A Review of the Recent Development, Challenges, and Opportunities of Electronic Waste

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ABSTRACT: This study provides a review of the recent development, challenges, and opportunities surrounding electronic waste (e-waste). It highlights the increasing magnitude of e-waste generation, the challenges posed by its improper management, and the potential opportunities for sustainable solutions. The study begins by discussing the rapid growth of electronic devices and the consequent rise in e-waste generation globally. It emphasizes the need to address the challenges associated with the disposal and recycling of e-waste due to its hazardous components and environmental impacts. The review delves into the challenges faced in e-waste management, including the lack of proper infrastructure, inadequate regulations, and the presence of informal recycling practices. It explores the environmental and health risks associated with improper e-waste handling, including soil and water contamination, air pollution, and the release of toxic substances. Additionally, the study presents opportunities for addressing the e-waste challenge. It highlights the potential for resource recovery through proper recycling and the establishment of a circular economy model for e-waste management. It discusses the importance of extended producer responsibility (EPR) policies, sustainable product design, and the implementation of efficient collection and recycling systems.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

The study concludes by stressing the importance of international collaboration, public awareness, and policy support to address the complexities of e-waste management. It calls for further research and innovation to develop sustainable and scalable solutions, including advanced recycling technologies, e-waste awareness campaigns, and capacity building programs. By understanding the recent development, challenges, and opportunities of e-waste, stakeholders can work together to promote responsible e-waste management, mitigate environmental and health risks, and harness the potential of e-waste as a valuable resource for a more sustainable future.

While older items are quickly becoming outdated, new information and communications technology products and other e-products are constantly being put into the market. Therefore, every year there is an exponential rise in the quantity of e-waste created. E-waste is generally understood as garbage produced by any components and objects of electronic and electrical equipment that have been thrown away without the aim of being reused. It is also referred to as e-scrap and garbage electrical and electronic equipment in various regions of the globe. E-waste includes a wide range of electronic products, including computers, televisions, lighting equipment, automatic ice makers, medical devices, toys, mobile phones, and computers. It also includes consumer electronics, such as electronic and electrical tools, sports and recreation gear, toys, and mobile phones [1].

The recycling of e-waste may result in the production of by-products such heavy metals, furans, and dioxins via methods like open burning, metal acid stripping, acid baths, and incineration. Even while resource recovery from e-waste might provide jobs and business opportunities, its management may be hampered by insufficient infrastructure and advanced scientific technology. E-waste management is thus seen as one of the largest worldwide concerns of the twenty-first century, offering severe risks to both the environment and human health. The literature on e-waste has been reviewed by many researchers, with some authors concentrating on a particular region. For instance, Andeobu et al. investigated the generation of e-waste and environmental management in Asia Pacific countries while researching the environmental and health effects of disposing of electronic waste in Bangladesh. presented a summary of Malaysia's e-waste creation and handling, in comparison. Some writers who concentrated on e-waste management methods, including Murthy and Ramakrishna, emphasized the world's best practices in e-waste management, highlighting the significance of technical needs, societal awareness, and policy execution to establish a sustainable and circular economy. On the other hand, numerous methods for recycling the most significant metals from the metallic portions of e-waste were studied [2].

The current worldwide trend in e-waste creation, recycling, and the effects on human health before putting up some viable ideas for enhancing e-waste management. The detrimental effects of hazardous elements discovered in e-waste or produced during the recycling process were briefly reviewed by Gupta et al. Pérez-Belis et al. (2015) conducted a study of the literature from 1992 to 2014 with an emphasis on the origins, make-up, management, and disposal of e-waste. The majority of e-waste evaluations in the literature have concentrated on various topics that do not accurately depict e-waste management. As a result, this analysis provided a short overview of e-waste recycling systems, including their collection, pre-treatment, difficulties, and future possibilities. The most current information about e-waste recycling and management has been published in this study, which will assist academics and policymakers in making wise choices.

Electronic Waste Types

Electronic garbage may be divided into categories based on where it came from and what it was used for. There are 10 distinct categories of e-waste that are recognized worldwide. Several variables, including as socioeconomic situations, consumer behaviors, population, and the reliance of companies and homes on electronic and electrical equipment, might affect the average proportion of each kind of e-waste. Legislation, e-waste management infrastructures, economic circumstances, and public awareness all play a major role in how various areas have developed their collecting methods. Most developing nations with little to no e-waste regulation, such those in south-eastern Asia and northern Africa, lack records of their e-waste production. To collect and recycle e-waste, governments in these areas depend on underprivileged and self-employed individuals. These individuals go door-to-door to collect consumer's e-waste, separate the things, and then sell the separated products to municipal merchants who will repair or recycle them. Even though this alternative is the worst owing to its inherent hazards to human health and its poor collection and administration, many untrained people still utilize these sorts of informal collecting operations to make a living and have a simple existence. For instance, it was calculated that Bangladesh collected 0.95 Mt of e-waste annually via informal means. Numerous small-scale recycling facilities in Dhaka were also thought to be able to make up to $3,410.0 every month by employing unofficial means.

Pre-Treatment and Post-Treatment Approaches

E-waste is first pre-treated after collection before being fully processed at treatment facilities. Pre-treatment aims to separate various recyclable components from the majority of the e-waste mixture so that they may be sent to the proper recovery treatment facilities. Three different pre-treatment techniques are possible: human dismantling, mechanical disassembly and separation, and a hybrid of both. Manual disassembly, which may be time-consuming and expensive, often separates dangerous and valuable items such PCBs, casing, monitors, and batteries. Size reduction, shredding, crushing, and metal-and-non-metal separation are all included in mechanical pre-treatment. It is important to note that combining the manual and mechanical pre-treatment methods may save time and money when dealing with complicated mixtures of different pieces of technology. Pre-treatment in industrialized nations often consists of semi-automatic separation followed by metal recovery in cutting-edge facilities.

In underdeveloped nations, manual separation is the most common technique, followed by metals recovery in small workplaces. Non-ferrous metals are separated from non-metals using electric conductivity base separation tools, whereas ferrous metals are often removed from e-waste using low-intensity magnet drums. Sifting and the gravity method employing airflow or water flow tables are two more separation procedures that are often utilized. Metals are moved to the ultimate recovery step after being separated from other materials, where pyrometallurgy and hydrometallurgy are two extensively utilized recovering techniques. High temperatures are used in the pyrometallurgy process to extract and purify metals. The processes of refining, smelting, combustion, and incineration are some examples of pyrometallurgy. Hydrometallurgy, on the other hand, deals with the extraction of metals using aqueous solutions from concentrated mixes or a combination of other materials. In a larger sense, hydrometallurgy is used to recover non-ferrous metals, such as copper, lead, and zinc, whereas pyrometallurgy is often employed to extract ferrous metals from e-waste [3], [4].

Opportunities and Challenges

Regarding e-waste and its handling, there are several possibilities and obstacles. Lack of e-waste laws is one of the major issues. Aside from industrialized countries, the majority of developing nations lack e-waste regulations at this time. 61 nations, or 44% of the world's population, have e-waste laws in place as of 2014. 71% of the world's population was covered by e-waste laws in 78 nations in 2019. Despite the fact that the two most populous nations in Asia, China and India, now have e-waste laws, other large nations, such Pakistan and Bangladesh, do not. Even though there is serious skepticism about the effectiveness of the restriction, Pakistan has prohibited the import of e-waste from other nations. On the other hand, Bangladesh, the eighth-largest nation in the world by population, has just recently sought to examine such a legislation. The Department of Environment of Bangladesh has issued proposed regulations that will limit the use of 15 hazardous compounds in a few certain EEE goods.

Due of its complicated mixture of toxic, priceless, base, and other components, e-waste is still difficult to manage and process even if the essential regulation is in place for its collection and recycling. Electronic trash typically contains 40% metal, 30% plastic polymers, and 30% oxides of various materials. However, owing to an unequal distribution of EEE in the e-waste, these amounts might vary dramatically across nations. Precious materials, base materials, hazardous compounds, halogen materials, as well as plastics, glass, and ceramics, are all found in e-waste.

Recovery of valuable, rare earth, and usable minerals is a special difficulty in managing e-waste while hazardous items are dealt with. Handling dangerous chemicals including CFC fluids, polychlorinated biphenyls, mercury, equipment safety, manual handling of heavy things, electrical safety, cut and abrasion risk, and fire and explosion risk are some of the risks associated with waste management. The limited number of chemical liquids that are permitted to be used in e-waste management, a lack of infrastructure facilities, thermodynamic limits on the ability to separate complex mixtures of materials, which creates a cost-ineffective recovery challenge, financial and policy support, particularly for developing countries, and uneven laws that differ significantly from country to country are additional challenges of e-waste management.

On the other hand, if e-waste is recycled correctly, its potential and chances are crucial. As was already indicated, valuable metals found in e-waste may be recovered via urban mining of e-waste. One metric ton of circuit boards may provide up to 1.5 kg of gold and 210 kg of copper, which is a typical example of urban mining. In comparison to primary mining from ores, there is a much higher concentration of precious metals. For example, typical mining of gold from ore yields 5 g/t of gold and 5.25 kg/t of copper. These figures show that the concentrations of gold and copper in urban mining are 300 and 40 times greater than in ores, respectively. If the right business strategies are used, recovering these precious metals may lead to large profits. It has been calculated that the material worth of e-waste produced globally is three times more than the overall economic value of silver mining and greater than the GDP of several nations.

Environmental and health advantages of e-waste treatment are another possibility. Human health and environmental concerns are now seen as top priorities. However, in underdeveloped nations, e-waste disposal has never been seen as a major problem, leaving the environment and people's health in poor and uncertain condition. However, adopting and putting into practice e-waste management techniques, regulations, and laws may significantly improve these situations [5], [6].

Electronic waste (e-waste) has become a global concern due to its environmental and health impacts. This article provides a detailed review of the recent developments, challenges, and opportunities associated with e-waste management. By examining the current state of e-waste, identifying key challenges, and exploring potential opportunities, this review aims to shed light on the urgent need for effective e-waste management practices.

Recent Development of E-Waste:

a. **Rapid Growth:** The consumption of electronic devices has surged in recent years, driven by technological advancements and increased digitalization. This has led to a significant increase in e-waste generation globally, posing a challenge for sustainable waste management.
b. **Global Generation and Trade:** E-waste is a global issue, with both developed and developing countries contributing to its generation. The trade of e-waste has become a concern, as developed nations often export their e-waste to developing

countries, resulting in improper disposal and adverse environmental and health impacts.

c. **Legislative Initiatives:** Governments and international organizations have taken steps to address e-waste through legislation and regulations. The Basel Convention, for example, aims to control the transboundary movement of hazardous waste, including e-waste, and promote environmentally sound management.

Challenges of E-Waste Management:

a. **Environmental Impact:** E-waste contains hazardous substances, such as lead, mercury, cadmium, and flame retardants, which can contaminate air, soil, and water if not managed properly. This poses significant risks to ecosystems, biodiversity, and human health.
b. **Health Risks:** Improper handling and disposal of e-waste can result in the release of toxic substances, causing respiratory problems, neurological disorders, and other health issues among those involved in recycling activities or residing near disposal sites.
c. **Informal Recycling Sector:** The presence of an informal recycling sector in many countries contributes to inadequate e-waste management. Informal recyclers often lack proper facilities, equipment, and training, leading to unsafe practices and increased environmental and health risks.
d. **Resource Loss:** E-waste contains valuable materials, including precious metals, rare earth elements, and plastics, which could be recovered and reused. However, the lack of efficient recycling practices results in the loss of these resources, perpetuating the reliance on virgin materials.

Opportunities for E-Waste Management:

a. **Circular Economy:** The concept of a circular economy offers opportunities for sustainable e-waste management. By designing electronic devices for durability, repairability, and recycling, the circular economy model aims to minimize waste generation and maximize resource recovery.
b. **Recycling Technologies:** Advancements in recycling technologies provide opportunities for efficient and environmentally friendly e-waste management. Innovations such as hydrometallurgical processes, bioleaching, and urban mining offer promising avenues for resource recovery from e-waste.
c. **Extended Producer Responsibility (EPR):** EPR programs place responsibility on manufacturers for the entire lifecycle of their products, including proper e-waste management. EPR can encourage manufacturers to design products with recyclability in mind and establish take-back programs for responsible disposal.
d. **Public Awareness and Education:** Increasing public awareness about the hazards of e-waste and the importance of responsible disposal is crucial. Education initiatives can empower individuals to make informed choices, promote recycling practices, and support the development of sustainable e-waste management systems.

The recent development of e-waste has highlighted the need for effective management practices to mitigate its environmental and health impacts. Challenges such as environmental contamination, health risks, the presence of informal recycling sectors, and resource loss necessitate immediate action. However, opportunities such as the circular economy model, advancements in recycling technologies, the implementation of EPR programs, and public awareness campaigns offer potential solutions. By addressing these challenges and capitalizing on the opportunities, society can transition towards sustainable e-waste management, conserving resources, minimizing environmental pollution, and safeguarding human health.

CONCLUSION

Metal, plastic polymers, and oxides of other materials are all components of e-waste. The essential phases in recycling and recovering e-waste include collecting, washing, sorting, pre-treatment, and treatment. Large home products, IT and communications, and consumer and small household equipment are the three main forms of e-waste. E-waste includes hazardous chemicals, basic materials, precious materials, other halogens, plastics, glass, and ceramics. At the moment, Europe is the region that collects the most of this garbage, followed by Asia, America, Oceania, and Africa. Among the continents, Asia produces the most electronic garbage. However, compared to Europe, Oceania, and America, Asia produces far less garbage per resident. Unfortunately, 83% of the electronic trash produced worldwide is not recorded, which means that it will either be burned or dumped illegally, posing a major risk to the environment and public health. To manage e-waste, which will be a significant contributor to the circular economy, national and international organizations must work together and raise public awareness.

REFERENCES:

[1] D. B. Johnson, ‘Biomining-biotechnologies for extracting and recovering metals from ores and waste materials’, *Current Opinion in Biotechnology*. 2014. doi: 10.1016/j.copbio.2014.04.008.

[2] P. Ledwaba and N. Sosibo, ‘Cathode ray tube recycling in South Africa’, *Recycling*. 2017. doi: 10.3390/recycling2010004.

[3] X. Wang *et al.*, ‘Application progress of nano copper conductive ink in PCB’, *Huagong Jinzhan/Chemical Ind. Eng. Prog.*, 2021, doi: 10.16085/j.issn.1000-6613.2021-0216.

[4] A. Bazargan, K. F. Lam, and G. McKay, ‘Challenges and opportunities of e-waste management’, in *E-Waste: Management, Types and Challenges*, 2012.

[5] S. Nugraha and Y. Ohara-Hirano, ‘Mental Health Predictor of the Sixth Batch Indonesian Nurse and Certified Care Worker Candidates Migrate to Japan under the Japan–Indonesia Economic Partnership Agreement in Pre-migration Stage’, *J. Heal. Sci.*, 2014.

[6] B. Franklin and C. U. Brancati, ‘Moved to care : the impact of migration on the adult social care workforce’, *Int. Longev. Cent. - UK*, 2015.

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E-Waste and its Negative Effects on the Environment

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ABSTRACT: Electronic waste (e-waste) poses significant negative effects on the environment due to its hazardous components and improper disposal practices. This study highlights the detrimental environmental consequences of e-waste and the challenges it presents. E-waste contains toxic substances such as heavy metals, flame retardants, and harmful chemicals that, when released into the environment, contaminate soil, water, and air. Improper handling and disposal lead to soil degradation, water pollution, and air contamination, with detrimental impacts on ecosystems, agriculture, and human health. Additionally, the extraction of raw materials for electronic devices contributes to resource depletion, habitat destruction, and biodiversity loss. The energy-intensive manufacturing processes and high energy consumption of electronic devices exacerbate climate change. Despite the importance of recycling, e-waste recycling faces challenges such as informal practices, lack of standardized processes, and inadequate infrastructure. These obstacles hinder the efficient and safe recycling of e-waste, perpetuating its negative environmental effects. Addressing the negative impacts of e-waste requires effective regulation, public awareness, and investment in recycling infrastructure. By implementing sustainable e-waste management practices, we can minimize the environmental burden and promote a healthier and more sustainable future.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Electronic waste, also known as e-waste, is any electronic product, or product containing electronic components, that has reached the end of its usable life cycle. Unbeknownst to many consumers, electronics actually contain toxic substances - therefore they must be handled with care when no longer wanted or needed. If a product is outdated, consumers can donate it to someone who might still find it valuable. Many retailers also offer trade-in programs or incentives for people looking to upgrade electronics that require the surrender of an older model; the retailers are able to reuse or repurpose the older models [1], [2]. However, if a product is totally unusable or broken, instead of just being thrown in the garbage, it must be thrown away by a certified e-waste hauler or recycler, or taken to a designated drop-off at a government building, school or organization as e-waste can potentially cause harm to humans, animals and the global environment if disposed of improperly. The consequences of improper e-waste disposal in landfills or other non-dumping sites pose serious threats to current public health and can pollute ecosystems for generations to come. When electronics are improperly disposed and end up in landfills, toxic chemicals are released, impacting the earth's air, soil, water and ultimately, human health [3].

The Negative Effects on Air

Contamination in the air occurs when e-waste is informally disposed by dismantling, shredding or melting the materials, releasing dust particles or toxins, such as dioxins, into the environment that cause air pollution and damage respiratory health. E-waste of little value is often burned, but burning also serves a way to get valuable metal from electronics, like copper. Chronic diseases and cancers are at a higher risk to occur when burning e-waste because it also releases fine particles, which can travel thousands of miles, creating numerous negative health risks to humans and animals. Higher value materials, such as gold and silver, are often removed from highly integrated electronics by using acids, desoldering, and other chemicals, which also release fumes in areas where recycling is not regulated properly. The negative effects on air from informal e-waste recycling are most dangerous for those who handle this waste, but the pollution can extend thousands of miles away from recycling sites

The air pollution caused by e-waste impacts some animal species more than others, which may be endangering these species and the biodiversity of certain regions that are chronically polluted. Over time, air pollution can hurt water quality, soil and plant species, creating irreversible damage in ecosystems. For instance, an informal recycling hub in Guiyu, China that was formed by parties interesting in extracting valuable metals from e-waste, and subsequently has caused the region to have extremely high lead levels in the air, which are inhaled and then ingested when returned to water and soil. This can cause disproportionate neurological damage to larger animals, wildlife and humans in the area [4].

The Negative Effects on Soil

When improper disposal of e-waste in regular landfills or in places where it is dumped illegally, both heavy metals and flame retardants can seep directly from the e-waste into the soil, causing contamination of underlying groundwater or contamination of crops that may be planted near by or in the area in the future. When the soil is contaminated by heavy metals, the crops become vulnerable to absorbing these toxins, which can cause many illnesses and doesn't allow the farmland to be as productive as possible.

When large particles are released from burning, shredding or dismantling e-waste, they quickly re-deposit to the ground and contaminate the soil as well, due to their size and weight. The amount of soil contaminated depends on a range of factors including temperature, soil type, pH levels and soil composition. These pollutants can remain in the soil for a long period of time and can be harmful to microorganisms in the soil and plants. Ultimately, animals and wildlife relying on nature for survival will end up consuming affected plants, causing internal health problems.

The Negative Effects on Water

After soil contamination, heavy metals from e-waste, such as mercury, lithium, lead and barium, then leak through the earth even further to reach groundwater. When these heavy metals reach groundwater, they eventually make their way into ponds, streams, rivers and lakes. Through these pathways, acidification and toxification are created in the water, which is unsafe for animals, plants and communities even if they are miles away from a recycling site. Clean drinking water becomes problematic to find. Acidification can kill marine and freshwater organisms, disturb biodiversity and harm ecosystems. If acidification is present in water supplies, it can damage ecosystems to the point where recovery is questionable, if not impossible [5], [6].

The Negative Effects on Humans

As mentioned, electronic waste contains toxic components that are dangerous to human health, such as mercury, lead, cadmium, polybrominated flame retardants, barium and lithium. The negative health effects of these toxins on humans include brain, heart, liver, kidney and skeletal system damage. It can also considerably affect the nervous and reproductive systems of the human body, leading to disease and birth defects. Improper disposal of e-waste is unbelievably dangerous to the global environment, which is why it is so important to spread awareness on this growing problem and the threatening aftermath. To avoid these toxic effects of e-waste, it is crucial to properly e-cycle, so that items can be recycled, refurbished, resold, or reused. The growing stream of e-waste will only worsen if not educated on the correct measures of disposal.

DISCUSSION

Electronic waste (e-waste) is a growing global concern due to the rapid advancement of technology and the increasing consumption of electronic devices. E-waste encompasses a wide range of discarded electronic products, including computers, mobile phones, televisions, and household appliances. This detailed description explores the negative effects of e-waste on the environment, highlighting the various environmental challenges it poses.

Hazardous Substances and Pollution:

E-waste contains a multitude of hazardous substances, including heavy metals, flame retardants, and toxic chemicals. When improperly handled or disposed of, these substances can have severe environmental consequences, including:

a) **Soil Contamination:** E-waste dumped in landfills can leach toxic chemicals into the soil, contaminating agricultural lands and groundwater. This contamination affects plant growth, soil fertility, and can eventually enter the food chain.
b) **Water Pollution:** E-waste dismantling and improper disposal methods can lead to the release of hazardous substances into water bodies. Heavy metals like lead, mercury, and cadmium can contaminate rivers, lakes, and groundwater, posing a threat to aquatic ecosystems and human health.
c) **Air Pollution:** Open burning of e-waste or incineration without proper pollution control measures releases toxic fumes into the air. This results in the emission of hazardous pollutants,

including dioxins and furans, which contribute to air pollution and pose risks to respiratory health.

d) **Electronic Waste Dumping:** Illegal export of e-waste to developing countries, often through electronic waste dumping, is a significant environmental concern. These activities lead to the accumulation of e-waste in vulnerable regions, causing long-term pollution and environmental degradation.

Resource Depletion and Energy Consumption:

The production and disposal of electronic devices contribute to resource depletion and increased energy consumption:

a) **Extraction of Raw Materials:** Manufacturing electronic devices requires the extraction of valuable and scarce resources, including precious metals like gold, silver, and palladium. Unsustainable mining practices to meet the demand for these materials lead to ecosystem disruption, deforestation, and habitat destruction.

b) **Energy Consumption:** The production, use, and disposal of electronic devices consume vast amounts of energy. The extraction of raw materials, manufacturing processes, transportation, and electricity consumption contribute to greenhouse gas emissions and exacerbate climate change.

Ecosystem Impact:

E-waste negatively affects ecosystems in various ways:

a) **Biodiversity Loss:** The extraction of raw materials for electronic devices often occurs in ecologically sensitive areas, leading to habitat destruction and biodiversity loss. Ecosystems that provide vital services, such as carbon sequestration and water purification, are adversely impacted.

b) **Eutrophication:** Improper disposal of e-waste can result in eutrophication of water bodies. When e-waste components degrade, they release nutrients like phosphorus and nitrogen, leading to excessive algae growth, oxygen depletion, and the disruption of aquatic ecosystems.

c) **Electronic Waste in Wildlife:** Improperly discarded e-waste can pose direct threats to wildlife. Animals may ingest or become entangled in electronic components, leading to injuries or death. Moreover, exposure to hazardous substances affects the reproductive, immune, and neurological systems of wildlife [1], [7].

Recycling Challenges:

While recycling e-waste can help mitigate its environmental impact, several challenges exist:

a) **Informal Recycling Practices:** In many countries, including developing nations, e-waste recycling is often carried out through informal and unregulated practices. These methods are typically inefficient, environmentally harmful, and pose health risks to workers due to the lack of proper safety measures.

b) **Complex Disassembly and Recycling Processes:** Electronic devices are intricate and composed of various materials, making their disassembly and recycling complex. The lack of standardized processes and technology hinders [8].

CONCLUSION

The negative effects of electronic waste (e-waste) on the environment are significant and demand urgent attention. The improper disposal and recycling of e-waste lead to soil contamination, water pollution, air pollution, and biodiversity loss. The presence of hazardous substances in e-waste poses a threat to ecosystems, human health, and wildlife. Resource depletion, energy consumption, and greenhouse gas emissions associated with the production and disposal of electronic devices further contribute to environmental degradation and climate change. Efforts to mitigate the negative effects of e-waste must focus on implementing and enforcing comprehensive regulations, promoting responsible e-waste management practices, and investing in recycling infrastructure. Increased public awareness about the hazards of e-waste and the importance of recycling is crucial for achieving a sustainable solution. Collaboration among governments, manufacturers, consumers, and the recycling industry is necessary to establish efficient recycling systems and improve the recycling rates of e-waste. By adopting a circular economy approach that prioritizes recycling and responsible consumption, we can minimize the environmental impact of e-waste and preserve the health of our planet for future generations.

REFERENCES:

[1] M. P. Van Dijk, 'Can Small Countries Benefit From The E-Waste Global Value Chain?', *Int. J. Waste Resour.*, 2016, Doi: 10.4172/2252-5211.1000e110.

[2] R. Xue, F. Zhang, And F. Tian, 'A System Dynamics Model To Evaluate Effects Of Retailer-Led Recycling Based On Dual Chains Competition: A Case Of E-Waste In China', *Sustain.*, 2018, Doi: 10.3390/Su10103391.

[3] Elytus, 'E-Waste & Its Negative Effects On The Environment', *Elytus Blog*, 2019.

[4] M. Danish, S. Ali, M. A. Ahmad, And H. Zahid, 'The Influencing Factors On Choice Behavior Regarding Green Electronic Products: Based On The Green Perceived Value Model', *Economies*, 2019, Doi: 10.3390/Economies7040099.

[5] D. Rimantho, E. Noor, And H. Effendi, 'Assessment Of Knowledge, Attitude, Practice On Households Related To E-Waste Management: A Case Study In Dki Jakarta', *Bioflux Srl*, 2019.

[6] G. Gök, Ş. Tulun, And O. A. Gürbüz, 'Consumer Behavior And Policy About E-Waste In Aksaray And Niğde Cities, Turkey', *Clean - Soil, Air, Water*, 2017, Doi: 10.1002/Clen.201500733.

[7] S. De Pandit, 'Reverse Supply Chain And E-Waste (Management) Rules, 2016 - A Study On Cellular Phones In India', *Int. J. Manag. It Eng.*, 2018.

[8] K. G. D. Prasad, P. K. Murthy, C. H. Gireesh, M. V. Prasad, And K. D. S. Sravani, 'Prioritization Of E-Waste Management Strategies Towards Green Computing Using Ahp-Qfd Approach', *Proc. Eng. Sci.*, 2021, Doi: 10.24874/Pes03.01.004.

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Electronic Waste Management: A Review

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ABSTRACT: The electronic industry is the world's largest and fastest growing manufacturing industry. It has become leverage to the socio - economic and technological growth of a developing society. The consequence of its consumer-oriented growth combined with rapid product obsolescence and technological advances are a new environmental challenge - the growing menace of "Electronics Waste" or "e waste" that consists of obsolete electronic devices. The current practices of e-waste management in India suffers a number of disadvantages like inadequate legislation, difficulty in inventorisation, health hazards due to informal recycling, poor awareness and reluctance on part of the corporate to address the critical issues. The impacts are intense when toxic materials enter the waste stream with no special precautions, creates adverse effects on the environment and human health and when economically valuable materials are dumped resources are wasted or unhealthy conditions are developed during the informal recycling. Current article gathers the current scenario of E waste generation, data on components and hazardous substances of e-waste that are creating environmental pollution and human exposure to these chemicals, resulting adverse effects due to recycling, incineration and landfill disposal of e-waste.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Discarded electronic waste is the fastest growing stream of waste in industrialized countries. Electronics are changing the lives of people everywhere starting from the way we do business, bring up children, keeping touch with others or personal entertainments. Not surprising, the electronics industry is the fastest growing manufacturing industry. Consumers are drawn to the latest cellular phones, laptops, air conditioners and consumer electronics. The obsolescence of these products leads to a unique mindset where consumers preferred to replace the products rather repair and reuse. The rapid obsolescence is also due to the rapid evolving technology but on the other hand it is clear that the throw away principle yields monetary benefits to corporate. In the wake of this 21st century revolution, this throw away principle is sure to damage the quality of our lives and the generations to come.

The problem of electronic waste, or e-waste, requires global action. Electronic waste, e-waste, e-scrap, or waste electrical and electronic equipment describes discarded electrical or electronic devices. "Electronic waste" may also be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators which are made of sophisticated blends of plastics, metals, and other materials. This definition includes used electronics which are destined for reuse, resale, salvage, recycling and disposal. The European Union defines this new waste stream as Waste Electrical and Electronic Equipment. Since there is no definition of the WEEE in the environmental regulations in India, it is simply called 'Ewaste'. According to Gui et al," WEEE is diverse and complex in terms of materials and components as well as the manufacturing process. Characterization of this waste stream is of paramount importance for developing a cost effective and environmental friendly recycling system". E-waste is categorized by the Government of India under the broad class of hazardous waste. Within e-waste, there are several categories such as large and small household appliances, electrical and electronic toys and sporting equipment, tools, computers and related equipment etc. which contains metallic and nonmetallic elements, alloys and compounds such as Copper, Aluminium, Gold, Silver, Palladium, Platinum, Nickel, Tin, Lead, Iron, Sulphur, Phosphorous, Arsenic etc. The fraction includes over 60% of metals, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70% [1].

DISCUSSION

E-Waste Issues

Based on the outcome of the studies carried out and the consensus arrived at the National Workshop on electronic waste management held in March 2004 and June 2005 organised by CPCB and Ministry of

Environment & Forests, an assessment was made of the existing practice in the e-waste management. The following issues were identified from the assessment.

Increasing amount of E- Waste

Product obsolescence is becoming more rapid since the speed of innovation and the dynamism of product manufacturing / marketing has resulted in a short life span for many computer products. Short product life span coupled with exponential increase at an average 15% per year will result in doubling of the volume of e-waste over the next five to six years.

Toxic Components

E-waste are known to contain certain toxic constituents in their components such as lead, cadmium, mercury, polychlorinated bi-phenyls, etched chemicals, brominated flame retardants etc., which are required to be handled safely. The recycling practices were found inconsistent in informal sectors leading to uncontrolled release of toxic materials into the environment as a result of improper handling of such materials.

Lack of Environmentally Sound Recycling Infrastructure

It has been established that e-waste, in the absence of proper disposal, find their way to scrap dealers, which are further pushed into dismantler's, supply chain. Existing environmentally sound recycling infrastructure in place is not equipped to handle the increasing amounts of e-waste. The major dismantling operations are occurring in unorganized/informal sector in hazardous manner. The potential of increased e-waste generation and lack of adequate recycling facilities have attracted the attention of a number of recyclers globally, expressing interest to start recycling facility in India [2], [3].

Impacts on Environment

E-waste constitutes heavy metals, persistent organic pollutants, flame retardants and other potentially hazardous substances. These pollutants can cause risks to the environment if not managed properly. During recycling and material recovery three main groups of substances are released in to the environment which needs high priority attention as they are highly hazardous in nature. The first group is the original constituents of equipment such as lead and mercury, second group such as cyanide, added during some recovery processes and third group which are formed during recycling processes such as dioxins and furans. If improperly managed, such substances may pose significant human and environmental health risks. The following types of emissions or outputs show the presence of toxic substances in e-waste handling and management. leachates from dumping activities pollute the soil and water resources, coarse and fine particulate matter from dismantling, bottom and fly ashes from burning activities, fumes from mercury amalgamate, desoldering and other burning activities, wastewater from dismantling and shredding facilities and effluents from cyanide leaching and other leaching activities.

Improper breaking or burning of printed circuit boards and switches may lead to the release of mercury, cadmium and beryllium which are highly toxic to human health. Another dangerous process is the recycling of components containing hazardous compounds such as halogenated chlorides and bromides used as flameretardants in plastic, which form persistent dioxins and furans on combustion at low temperatures. A study on burning printed wiring boards in India showed alarming concentrations of dioxins in the surroundings of open burning places reaching 30 times the Swiss guidance level. About 70% of the heavy metals especially mercury and cadmium, in landfills come from electronic waste. Consumer electronics is the root cause for the presence of about 40% of the lead in landfills. These toxins can cause brain damage, allergic reactions and cancer. The highly dispersed recycling units across India, results in problems such as emissions of dioxins and heavy metals like lead, cadmium, mercury in air, indiscriminate dumping of spent fluids and chemicals thus contaminating soils, groundwater contamination through leachate, land filling of non-recyclables and release of BFR.

Occupational health impacts of e-waste

There is little regulation in the informal sector to safeguard the health of those who handle e-waste. Workers are poorly protected in an environment where e-waste from PC monitors, PCBs, CDs, motherboards, cables, toner cartridges are burned in the open and release lead and mercury toxins into the air. Many of these workers complain of eye irritation, breathing problems and constant headaches. Some critical occupational health issues are inadequate working space, poor lighting and ventilation, straining the eyes and breathing polluted air, sitting cramped on the ground for long hours, inhaling toxic fumes, exposure of body parts to fire, acid and other chemicals and unavailability of clean drinking water and toilets. The best example is the town of Guiyu in south-east China.

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Since 1995, the traditionally rice-growing community of Guiyu has turned into an intensive informal ewaste recycling centre, probably the largest in the world. Researchers observed many health effects in relation to the rudimentary recycling techniques [4].

Management of E-Waste

In this context, it is pertinent to assess the e-waste recycling scenario in India, where recycling of e-waste to recover items of economic value is carried out. The assessment of e-waste recycling sector in India indicates that e-waste trade starts from formal dismantling sector and moves to informal recycling sector. E-waste movement from formal to informal sector is driven by trade and can be tracked by trade value chain. This ewaste trade value chain can be mapped based on material flow from formal sector to informal sector. This chain was identified considering bottom-up approach with three levels of e-waste generation hierarchy. The three levels of e-waste generation hierarchy give rise to three types of stakeholders involved in ewaste trade as described below.

a) 1st Level – Preliminary e-waste Generators.
b) 2nd Level – Secondary e-waste Generators.
c) 3rd Level – Tertiary e-waste Generators.

The following are the steps involved in an e-waste management facility. In a formal sector the e-waste is segregated into different streams depending on their material composition and recycling potential. After which the hazardous nature is checked to understand its reuse or disposal options.

Recycling, Reuse and Recovery

The composition of e-waste consists of diverse items like ferrous and non-ferrous metals, glass, plastic, electronic components and other items and it is also revealed that e-waste consists of hazardous elements. Therefore, the major approach to treat e-waste is to reduce the concentration of these hazardous chemicals and elements through recycle and recovery. In the process of recycling or recovery, certain ewaste fractions act as secondary raw material for recovery of valuable items. The recycle and recovery includes the following unit operations.

1) **Dismantling:** Removal of parts contains dangerous substances; removal of easily accessible parts containing valuable substances.
2) **Segregation of ferrous metal, non-ferrous metal and plastic:** This separation is normally done in a shredder process.
3) **Refurbishment and reuse:** Refurbishment and reuse of e-waste has potential for those used electrical and electronic equipments which can be easily refurbished to put to its original use.
4) **Recycling/recovery of valuable materials:** Ferrous metals in electrical are furnaces, non-ferrous metals in smelting plants, precious metals in separating works.
5) **Treatment/disposal of dangerous materials and waste:** Shredder light fraction is disposed of in landfill sites or sometimes incinerated, CFCs are treated thermally, PCB is incinerated or disposed of in underground storages, Hg is often recycled or disposed of in underground landfill sites. The value of recovery from the elements would be much higher if appropriate technologies are used.

D. Treatment and Disposal

The presence of hazardous elements in e-waste offers the potential of increasing the intensity of their discharge in environment due to land filling and incineration. The potential treatment disposal options based on the composition are Land filling: The degradation processes of e-waste in landfills are very complicated and run over a wide time span. At present it is not possible to quantify environmental impacts from E-waste in landfills for the following reasons: Landfills contain mixtures of various waste streams; Emission of pollutants from landfills can be delayed for many years; According to climatic conditions and technologies applied in landfills, data on the concentration of substances in leachate and landfill gas from municipal waste landfill sites differs with a factor 2-3. One of the studies on landfills reports that the environmental risks from land filling of e-waste cannot be neglected because the conditions in a landfill site are different from a native soil, particularly concerning the leaching behavior of metals. In addition, it is known that cadmium and mercury are emitted in diffuse form or via the landfill gas combustion plant. Although the risks cannot be quantified and traced back to ewaste, land filling does not appear to be an environmentally sound treatment method for substances, which are volatile and not biologically degradable, persistent or with unknown behaviour in a landfill site. As a consequence of the complex material mixture in e-waste, it is not possible to exclude environmental risks even in secured land filling [5], [6].

Incineration: Advantage of incineration of e-waste is the reduction of waste volume and the utilization of the energy content of combustible materials. Some plants remove iron from the slag for recycling. By incineration some environmentally hazardous organic substances are converted into less hazardous compounds. Disadvantage of incineration are the emissions to air from substances escaping flue gas cleaning and the large amount of residues from gas cleaning and combustion. There is no available research study or comparable data, which indicates the impact of e-waste emissions into the overall performance of municipal waste incineration plants. Waste incineration plants contribute significantly to the annual emissions of cadmium and mercury. In addition, heavy metals not emitted into the atmosphere are transferred to slag and exhaust gas residues and can reenter the environment on disposal. Therefore, e-waste incineration will increase these emissions, so reduction measures like removal of heavy metals are necessary.

E Waste Management Strategies

Policy Level Initiatives

The Policy shall address all issues ranging from production to final disposal, including environmentally sound technology for the recycling of electronic waste. Regulations to control both legal and illegal exports and imports of e-wastes must be clear in the policy. Loop holes in the prevailing legal frame work also to be addressed to prevent or reduce the transboundary movement of e-waste from developed to developing countries. The disposal of e-wastes in municipal landfills must be prohibited in the regulations strictly. Owners and generators of e-wastes should be encouraged to properly recycle their wastes by providing financial incentives. Manufactures of products must be made financially, physically and legally responsible for their products. Policy must emphasis management of restricted substances through awareness among producers and manufactures in the new product development. Environmental hazard labeling of products to create awareness among the general public must also to be covered in the policy. A complete national level inventory, covering all the cities and all the sectors must be initiated. A public-private participatory forum in E-waste management must be developed.

Extended Producer Responsibility

Extended producer responsibility is an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of the product's life cycle, including its final disposal. All vendors of electronic devices shall provide take-back and management services for their products at the end of life of those products. The old electronic product should then be sent for recycling or re-use, either in a separate recycling division at the manufacturing unit or in a common facility. Collection systems are to be established through collection centers to ensure proper collection and transportation directly to the recycling unit. Recyclers that are having authorization for handling, processing, refurbishment, and recycling meeting environmentally sound management guidelines should only be given permission.

The e-waste management in the future depends not only on the effectiveness of policy level initiatives from the government, effectiveness in recycling services, but also on the attitude of buyers. Lack of awareness among the residents to segregate e-waste from municipal waste is increasing the magnitude of e-waste problem in India. Community participation must be initiated in order to understand the key role of manufactures and bulk consumers in e-waste management. Awareness raising programmes and activities on issues related to the environmentally sound management, health and safety aspects of e-wastes may be conducted in order to encourage better management practices among different target groups. Consumers to be educated to buy only necessary products that utilize emerging technologies such as use of lead-free, halogen-free products to be identified through eco-labeling. ESM of e-wastes can be well organized with a help of technical guidelines which emphasis on better collection, recycling and disposal options [7], [8].

CONCLUSION

The current article summarizes the scenario of e-waste generation in India and in other countries. definition, material composition, current disposal methods, hazardous nature of ewaste is also presented to understand the hazardous nature of ewaste in the form of heavy metals and halogenated compounds. Improper handling and management of these waste during recycling and other end-of-life treatment options seems to have potential risks to both human health and the environment. The lack of public awareness regarding the disposal of electronic goods and inadequacy of policies to handle the issues related to E-waste enhance the problem in India. There is no large scale organized E-waste recycling facility in India and most of the recycling exists in unorganized sector. Moreover, the management practices are often poorly designed and have a lot of health and environmental issues. There exists an urgent need for a detailed assessment of the current and future scenario including quantification, characterization, existing disposal practices, environmental impacts and occupational health hazards. e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes.

REFERENCES:

[1] S. Raharjo And A. H. Utomo, 'Comparative Study Of Electronic Waste Management In Developed Countries And Indonesia', *Andalasian Int. J. Appl. Sci. Eng. Technol.*, 2021, Doi: 10.25077/Aijaset.V1i1.4.

[2] M. Xue And Z. Xu, 'Application Of Life Cycle Assessment On Electronic Waste Management: A Review', *Environ. Manage.*, 2017, Doi: 10.1007/S00267-016-0812-1.

[3] G. Ilyassova, A. Nukusheva, L. Arenova, G. Karzhassova, And M. Akimzhanova, 'Prospects Of Legal Regulation In The Field Of Electronic Waste Management In The Context Of A Circular Economy', *Int. Environ. Agreements Polit. Law Econ.*, 2021, Doi: 10.1007/S10784-020-09514-3.

[4] H. Mallawarachchi And G. Karunasena, 'Electronic And Electrical Waste Management In Sri Lanka: Suggestions For National Policy Enhancements', *Resour. Conserv. Recycl.*, 2012, Doi: 10.1016/J.Resconrec.2012.08.003.

[5] D. Ngethe, 'Influence Of Electronic Waste Management Systems In Kenya. A Critical Literature Review.', *J. Environ.*, 2021, Doi: 10.47941/Je.618.

[6] P. Kiddee, R. Naidu, And M. H. Wong, 'Electronic Waste Management Approaches: An Overview', *Waste Manag.*, 2013, Doi: 10.1016/J.Wasman.2013.01.006.

[7] K. Parajuly, C. Fitzpatrick, O. Muldoon, And R. Kuehr, 'Behavioral Change For The Circular Economy: A Review With Focus On Electronic Waste Management In The Eu', *Resources, Conservation And Recycling: X*. 2020. Doi: 10.1016/J.Rcrx.2020.100035.

[8] A. A. Ananno, M. H. Masud, P. Dabnichki, M. Mahjabeen, And S. A. Chowdhury, 'Survey And Analysis Of Consumers' Behaviour For Electronic Waste Management In Bangladesh', *J. Environ. Manage.*, 2021, Doi: 10.1016/J.Jenvman.2021.111943.

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E-Waste Management, Disposal and Its Impacts on the Environment

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ABSTRACT: The global issue of waste electrical and electronic equipment is growing. Its poisonous emissions mix with uncontaminated soil and air and have a negative direct or indirect impact on the whole biota. Acids, poisonous substances, including heavy metals, and chemicals that cause cancer are examples of direct effects. Indirect consequences include biomagnification of heavy metals. E-waste is gathered, disassembled, separated, and exported by several private companies for recyclers. This review is based on information gathered from various journal articles, websites, and the technical note by Greenpeace International; however, strict regulations are currently being followed as on approval of such firms, such as e-steward certification by Basel action network in the US; they also involved in public awareness programs. Additionally, it assesses the development of e-waste management globally today.

KEYWORDS: E-waste, Electronic Garbage, Recycling, Waste Administration.

INTRODUCTION

The biggest and most inventive industry of its type is the electronic one. Tons of electronic goods are sent over the seas every year, but when they are used, they turn into complicated waste materials that include dangerous heavy metals, acids, poisonous compounds, and nondegradable polymers. Numerous are sent to recyclers, burned, or discarded. However, around 75% of wastes are unsure of their purpose or trying to figure out how to utilize them, including refurbishing, remanufacturing, and using their components for repairs, among other things. While others are rubbish that takes up space in businesses, homes, flats, and industries. Leaded glass, circuit boards, and mercury lamps were among the harmful products that the majority of recyclers sent, typically to China, Africa, and India.

Dismantling is a labor-intensive operation that involves more than just unscrewing; it also involves shredding, ripping, and burning [1], [2]. Tonnes of electronic garbage are junked and disassembled in places like China and certain regions of India. The carcinogens and other dangerous substances included in smoke and dust particles cause severe inflammations and lesions, including a variety of respiratory and skin conditions. Circuits are burned in order to search for rich metals like gold, platinum, and cadmium, but their PVC and PCB wire coats might emit sexy smoke, and the carbon particles from toners are carcinogens that could cause lung and skin cancer. According to data collected in 2007, about 70% of the world's e-waste reaches China, with the remaining 40% going to Africa and India. As a result of their cheap labor, these regions have become the world's dumping ground for e-waste. For example, in Ghana, 20% of the population works on e-waste; they use after reconditioning them. The primary driver behind third-world nations' consumption of American and European waste products is poverty [3].

Discussion Point:

E-waste Sources Virtually all outdated electronic devices are categorized as e-waste, including discarded cellphones, cameras, CD players, TVs, radios, drillers, fax machines, photocopiers, printers, toners, ink cartridges, batteries, rechargeable batteries, digital calculators and clocks, CRT monitors, electric solders, computer mother boards, key board, and industrial and household electronic machinery like ovens, fridges, sewing and washing machines, fans, air conditioners, grinders,

Origins and Nature of Particles

PVC, diisononyl phthalate, butylbenzyl phthalate, DIDP, and dibutyl phthalate are phthalates that are used in wire coatings and cables. Polychlorinated biphenyls, or PCBs, are released from transformer oils, printing inks, plasticizers, hydraulic fluids, capacitor dielectrics, and printing fluids. PCBs are also created during the burning of PVC and other chlorinated materials. Chlorobenzenes are employed as solvents, color intermediates, and are also released when PVC is burned. Flame-retardants include of Flame retardant chemicals known as polybrominated diphenyl ethers are often employed in foams and the plastic housings of electronic devices. Triphenyl phosphates (TPP) are chemicals that are employed as plasticizers and flame retardants in copier films as well as hydraulic fluids and lubricants. They are also present in the plastic that covers monitors. Heavy metals include lead, which is used in electrical solder, batteries, and is often alloyed with tin. Lead oxide is also used in cathode ray tubes, glass, and PVC formulation. Contacts, switches, solder connections, rechargeable batteries, stabilizers in the production of PVC, and the inside surface of CRT displays used to provide light all make use of cadmium compounds. Lead acid starting batteries, electronics, polymers with flame retardant additives, and electrical solders all require antimony. Oxides of these heavy metals may be present in the air in the e-waste combustion area. Printed circuit boards, relays, and switches contain mercury. Galvanized steel components employ chromium to prevent corrosion. CRT displays include barium. Circuit mother boards often contain beryllium. Another kind of electronic waste is the free carbon radicles that come from printer toner.

Effects of e-waste Products On Human Health

During the dismantling, shredding, acid baths, and incineration processes, there is a potential of mishaps such cuts and burns. In addition, exposure to the following substances has several long-term impacts. The development of the testicles is impacted by phthalates like DEHP in its monomer form. Butylbenzyl and dibutyl phthalates are particularly harmful to reproduction. Exposure to phthalates during pregnancy also has an adverse effect on the liver and kidneys. Polychlorinated biphenyls (PCB) are among the chlorinated compounds. PCB accumulates in fish and other organisms and goes through bioaccumulation, which results in high value in top-level carnivores like humans. PCB is also absorbable through the skin, inhaled, or ingested and causes neurotoxicity, liver damage, tumors, immunosuppression, and behavioral changes, as well as disorders of the reproductive system and abnormal sperm. Chlorobenzene affects the CNS, liver, and thyroid in animals and has both acute and long-term effects. The kidneys are also impacted by increased chlorination, such as that caused by tetrachlorobenzenes. Hexachlorobenzene is a category 2B carcinogen that affects the immune system as well as the liver, thyroid, kidney, CNS, and neurological system. Additionally, HCB bioaccumulation has been shown. When a fetus is first developing, polybrominated diphenyl ethers, an environmentally persistent substance that has also been linked to bioaccumulation, causes abnormal brain development. It is also linked to effects on learning, memory, behavior, thyroid, and oestrogen hormone systems, as well as the immune system. Burning PBDEs results in the production of equally dangerous brominated dioxins and furans. Human blood contains triphenyl phosphates as a contaminant [4].

Ghana, Africa's E-Waste

From Antwerp and other western cities, Ghana receives over 4 million tons of trash. Even if the government of Ghana has ratified all international agreements, the country's citizens continue enter e-waste because of their inability to acquire new electronics owing to poverty. Additionally, young men and children from slums are employed as collectors and dismantlers as inexpensive labor. E-waste comprises old drills, cameras, laptops, TVs, and other electrical devices. Unusable objects are burnt and disposed of there, while they are sold at a low price with no guarantee of their usefulness. The river has changed into a muddy stream that is now filled with heavy metal pollutants. Fishermen are on the verge of giving up because their catch is contaminated with heavy metals that might have long-term effects on people.

E-Waste's Impact On India

There are 80,000 individuals employed in the recycling industry, and certain towns, like Seelampur, have junk markets where mountains of e-waste are sorted for recycling. After burning the wires, they remove the copper from them. Plastic and PVC emit poisonous smoke that irritates the eyes and leads to respiratory issues. Additionally, acid treatment is used to separate the metals; corrosive acids are also released from old batteries from cell phones and computers, according to Greenpeace scientists. In addition to the low cost of labor, workers spend their time disassembling waste rather than thinking about their own health because recycling computers in India costs just $2 compared to $20 in the US. However, an e-waste recycling facility is now being built in Bengaloore with the potential to process 60,000 tons of e-waste yearly. Mumbai contributed nearly 24% of the country's e-waste, followed by Delhi (21.2%), Bangalore (10.1), and Chennai (9.1%). E-waste

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disposal techniques currently used at the moment, landfills, acid baths, and incineration are employed to get rid of garbage [5].

Landfills

E-waste is said to be a poisonous time bomb that ends up in landfills. After a number of years, they may be released into the environment naturally, and there's a chance that wastes like batteries, which release acids and heavy metals like mercury, nickel, and cadmium, or electronic circuits, which include lead, zinc, nickel, copper, mercury, and cadmium, might also leach. These may mingle with other fresh water sources, like rivers and streams, and reach land, including animals and people. The majority of the e-waste produced in the US and Australia is sold to Asia and Africa, while around half is disposed of in landfills.

Baths in Acid

The circuit board is immersed in sulfuric acid for about 12 hours to dissolve the copper, after which the solution is heated, precipitated copper sulfate is removed, and the residual solution is added with scraped particles. Finally, copper smudges are removed. Lead is also dissolved in acid baths, which are also used to recover gold and silver [6], [7].

Incineration

Pyrolysis is another term for incineration; chemicals produced during incineration are likely to be more harmful than their natural state. Pyrolysis is the process of heating a material without oxygen; no burning takes place here; instead, the heated substance is transformed into fumes, oils, and charcoal. However, just a little amount of air is used in the gasification process to turn the materials into fume, ash, and tar. In China, Africa, India and Pakistan, incineration is a widespread technique of e-waste disposal. The polycylic aromatics, polychlorinated dibenzo-para-dioxins, and polychlorinated dibenzofurans, which are recognized carcinogens, are released when the plastic or PVC circuit board is heated, together with other gases including carbon monoxide, sulfur dioxide, and nitrogen oxides. Antimony, lead, thallium, arsenic, copper, manganese, mercury, and nickel oxides are also found in trace amounts in smoke, however they mostly end up in the ashes.

Safe E-Waste Disposal Techniques and Management Authorities

The safest technique is recycling and reusing materials, including metals, and this involves a system used by the whole industry to collect e-waste. Putting in place appropriate regulations to make the following requirements mandatory: wearing protective masks, gloves, and safety glasses when dismantling; avoiding simple extraction methods like incineration that produce harmful fumes; avoiding dumping and avoiding using acid baths; and putting in place strict regulations against disposing of electronic waste in landfills as it may leach into ground water or may be released over time. strengthening the application of Basel Convention-agreed regulations and enacting strong laws to thwart political intrusions or pressures. creating an appropriate storage system for collected and extracted e-waste till it is utilised as goods. Action must be taken against unlicensed, illegal e-waste collectors and dismantlers; research scientists must be encouraged to find safer substitutes for dangerous chemicals and carcinogens; electronic products that contain such ingredients must be banned; and the movement of e-waste must be closely supervised within state municipal boundaries as well as ports and harbors.

Environmental organizations including NRDC and Basel Action Network developed the e-Stewards certification program after consulting with manufacturers and processors of e-waste. E-steward accreditation ensures recyclers maintain the criteria necessary for the recycling process to be done in a manner that safeguards both the environment and the health of the employees. A list of businesses that are authorized to serve as subscribing e-stewards is kept by BAN, and the first approved standard was released in 2010. And NRDC, BAN, and other campaigners are actively fighting to ensure that the rules on e-waste exporters are vigorously implemented. Additionally, several US states have put in place a system that requires electronic manufacturers to accept responsibility for their goods. As a result, manufacturers are assigned significant duty for gathering and recycling used electronics. Through awareness campaigns, it is also essential to educate the general population on how to handle and dispose of e-waste [8].

CONCLUSION

It has been established that the development of the e-waste management system depends on both increased public awareness and manufacturer participation. Additionally, countries must provide enough funding and ensure that the globally ratified environmental laws are upheld inside their boundaries. The licensing of certifications like estewardship may provide the protection necessary to deter unauthorized e-waste handlers and traffickers. Basel Action Network is now doing its best to restrict or regulate trans-boundary e-waste flows. They are also participating in launching research areas to develop more effective strategies or alternatives and executing public awareness campaigns to educate the global population. E-waste management and disposal must be done properly in order to avoid disorders of the skin, respiratory, digestive, immunological, endocrine, and mental systems, including cancer. E-waste is recognized to be a significant source of heavy metals, toxic compounds, and carcinogens.

REFERENCES:

[1] S. Sangkham, 'Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia', *Case Stud. Chem. Environ. Eng.*, 2020, doi: 10.1016/j.cscee.2020.100052.

[2] A. Panagopoulos, K. J. Haralambous, and M. Loizidou, 'Desalination brine disposal methods and treatment technologies - A review', *Science of the Total Environment*. 2019. doi: 10.1016/j.scitotenv.2019.07.351.

[3] S. Sivaramanan, 'E-Waste Management, Disposal and Its Impacts on the Environment', *Univers. J. Environ. Res. Technol. www.environmentaljournal.org*, 2013.

[4] Ankit *et al.*, 'Electronic waste and their leachates impact on human health and environment: Global ecological threat and management', *Environ. Technol. Innov.*, 2021, doi: 10.1016/j.eti.2021.102049.

[5] S. Needhidasan, M. Samuel, and R. Chidambaram, 'Electronic waste - An emerging threat to the environment of urban India', *Journal of Environmental Health Science and Engineering*. 2014. doi: 10.1186/2052-336X-12-36.

[6] H. T. T. Nguyen, C.-H. Lee, and R.-J. Hung, 'Global Journal of Environmental Science and Management Willingness of end users to pay for e-waste recycling', *Glob. J. Environ. Sci. Manag.*, 2021, doi: 10.22034/gjesm.2021.01.04.

[7] D. Rimantho, E. Noor, and H. Effendi, 'Assessment of knowledge, attitude, practice on households related to e-waste management: a case study in DKI Jakarta', *Bioflux SRL*, 2019.

[8] Y. S. Yong, Y. A. Lim, and I. M. S. K. Ilankoon, 'An analysis of electronic waste management strategies and recycling operations in Malaysia: Challenges and future prospects', *J. Clean. Prod.*, 2019, doi: 10.1016/j.jclepro.2019.03.205.

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E-Waste Management: A Growing Concern for India's Environment and Health

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ABSTRACT: E-waste, often known as electronic garbage, is one of the world's most urgent challenges. E-waste is made up of many different parts, some of which include dangerous materials that, if not treated correctly, might harm both human health and the environment. In India, e-waste management is given more importance owing to both domestic e-waste creation and the importation of e-waste from wealthy nations. In addition, India lacks the necessary infrastructure and protocols for recycling and disposing of waste. E-waste management laws were originally published in 2011 by the Ministry of Environment and Forest (MoEF), placing the responsibility for recycling electronic trash (e-waste) on the manufacturers. In light of activities in India, this review article discusses the related concerns and effects of this rising problem.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Ewaste goods, sometimes referred to as electronic and electrical waste, do not decay or disintegrate. In India, the information and communication technology (ICT) industry has transformed life for everyone over the last twenty years or more, causing an electronic manufacturing industry-wide viral effect that has resulted in extraordinary development in terms of both volume and applications. The new slogan is digital development, and it has left its all-pervasive imprints everywhere. Electronic garbage, often known as e-waste, is a new yet very harmful stream of waste that has been produced by the rising use of electronic and electrical equipment. E-waste disposal is turning into an environmental and health nightmare due to the presence of harmful and dangerous compounds in electronic devices. The fastest rising waste source nowadays is e-waste. Each year, hundreds of thousands of outdated televisions, radios, laptops, and mobile phones are thrown; the majority of these items wind up in landfills or unlicensed recycling facilities. Approximately 80% of that material, according to Basel Action Network executive director Jim Puckett, very quickly finds itself on a container ship heading to a country like China, Nigeria, India Vietnam, or Pakistan where very dirty things happen to it. Recycling companies in the US may not be as honest about what they are doing with your old electronics, he claims. The invasion of e-waste, especially computer garbage, is complicating India's already enormous challenge of managing solid waste. In the guise of free commerce, e-waste from wealthy nations easily finds its way into underdeveloped nations, significantly compounding the issues related to trash management. In light of efforts in India, the article emphasizes the related problems and effects of this rising issue [1].

In many parts of the world, disposing of e-waste is a specific issue. E-waste has an impact on both the environment and human health. E-waste occupies space in the areas it enters and poses serious health risks to both people and animals. It is concerning primarily because some of the chemicals may be poisonous and carcinogenic when treated incorrectly. Due to the millions of parts composed of toxic metals and compounds including lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony, and phthalates that are found in electronic devices, e-waste is far more dangerous than many other municipal trash. Some of these compounds are carcinogenic and neurotoxic, and prolonged exposure to them harms the reproductive, endocrine, and renal systems as well as the neurological and bone systems. Primitive e-waste recycling and disposal in landfills and incinerators contaminates air, water, and soil while also causing irreparable environmental harm. According to a 2005 Greenpeace research of electronic recycling yards in Delhi, the places where this crude recycling occurs include significant concentrations of toxic chemicals, including lethal dioxins and furans. Workers in the e-waste disposal industry are not well protected against the danger.

They disassemble e-waste under abhorrent circumstances, often by hand. In Delhi alone, scrap yards employ over 25,000 people and process 10,000 to 20,000 tons of e-waste annually, with computers making up 25% of that total. There are other e-waste scrapyards in Mumbai, Chennai, Bangalore, Meerut, and Firozabad.1Significant amounts of lead, cadmium, chromium, and flame-retardant polymers are among the dangerous materials discovered in the e-waste. High lead concentration cathode ray tubes and parts are regarded as harmful to health. The brain, neurological system, lungs, kidneys, and reproductive system may all suffer harm by regularly breathing in or handling such toxins, as well as from being in touch with them. Without protective masks and technological know-how, working in inadequately ventilated confined spaces exposes workers to hazardous and slowly poisonous substances. Workers are putting their health and the environment at danger as a result of ignorance. The greatest concentrations of cancer-causing dioxins in the world are found in Guiyu, China, according to scientists who have studied the city (one of the preferred locations for e-waste recycling operations). Seven out of ten children have too much lead in their blood, and pregnant mothers are six times more likely to have a miscarriage. Data on the effects of heavy metal exposure on humans in India are few. Many employees, including young children, are exposed to various e-waste disassembly tasks. No information is provided on the effects of these employees on their health. They can be damaging their life because they lack the necessary information [2].

DISCUSSION

Take-Back Practices of Companies in India: A Snapshot

Prevention, not management, is the key to averting the looming e-waste disaster. The solution lies with the brand owners or manufacturers of electronic products, who need to bear responsibility for financing the treatment of the own-branded e- waste, which is discarded by their customers. Given the toxic nature of e-waste, recycling it is beyond the means of a consumer or local government. The individual producer responsibility (IPR) concept refers to this. The EU, Japan, Korea, Taiwan, and several US states already have laws enforcing producer responsibility for e-waste. Greenpeace wants ethical businesses to provide take-back and recycling services wherever their goods are marketed, not simply in nations where doing so is required by law, and to treat all of their consumers in a consistent manner across the world. Some companies in India have started take-back initiatives, but they are not doing as well as they should. Additionally, brand owners should aim to create a strong infrastructure for e-waste collection and treatment so that it can be gathered and recycled safely. Despite many of these same worldwide companies offering a voluntary take return service in nations like the US, many of these brands have no take back service in India.

The international companies clearly fall short of their promise in India and consider their Indian consumers as inferior customers since they do not have a take-back scheme there, while making lofty statements about producer responsibility. By neglecting to provide a simple and free take return service to enable ethical recycling, these businesses inadvertently contribute to the expansion of the informal recycling industry. Most companies haven't made any noticeable efforts to inform and alert their consumers to the negative effects that e-waste has on the environment and human health, as well as the need for consumers to send back or mail their old electronic items for recycling. Due to their rapidly evolving technology that drastically shortens the lifetime of an electronic device, brands are directly to blame for the enormous amounts of e-waste produced in India. However, they spend millions of rupees on advertising, celebrity endorsements, and marketing efforts to sell their goods [3], [4].

Some E- Waste Management Initiatives in India

The first government-approved environmentally friendly recycling facility that fully utilizes e-waste is called E-Parisaraa. The facility, which is India's first scientific e-waste recycling unit, promises to minimize pollution, landfill trash, and environmentally friendly recover precious metals, plastics, and glass from waste. E Parisaraa is unique in that the sorting process doesn't include melting, unlike backyard management of e-waste. It preserves client privacy and safeguards data from abandoned PCs.

Private Limited by Earth Sense:

The joint venture between the bio-medical waste treatment and management companies M/S. GJ Multiclave India Private Limited and E-Parisaraa Private Limited is called Earth Sense Recycle Private Limited. This business, which recycles all kinds of e-waste, including de-bound assets and other electrical and electronic equipment, was founded in the year 2000.

The Indian business Trishyiraya Recycling India Pvt. Ltd. (TPL) provides secure and dependable e-waste disposal. The business has received certification from both the Pollution Control Board and the Indian Government. It has ongoing security features like CCTV monitors, etc. TPL is pleased with its cutting-edge E-Waste recycling technology. The 'Total Termination Process', which is entirely pollution-free, is a feather in its cap. Neither the water nor the air, not the sound, have been contaminated.

Plugging in for E-Cycling

More chances to donate or recycle or "e-Cycle" unwanted electronics are made available thanks to a cooperation between the Environmental Protection Agency (EPA) and consumer electronics manufacturers, retailers, and service providers. Recycling is a part of e-cycling, where valuable components from outdated electronics are recovered and repurposed to create new goods. It also involves conserving energy and resources by taking less raw materials from the Earth, as well as lowering greenhouse gas emissions, pollution, and waste. Safe electronic recycling benefits others and encourages responsible management of dangerous substances like lead and mercury. E-bins will soon be installed in Bangalore city to enable the secure disposal of electronic trash produced at government facilities. The nongovernmental group (NGO) behind this ground-breaking initiative, Saahas, intends to run campaigns in government buildings to raise awareness of e-waste and the necessity for environmentally friendly and safe disposal of it. For household e-waste pickup and recycling, a toll-free phone number is given. The Manufacturers' Association for Information Technology (MAIT) has established the Electronics Recyclers' Association (ERA) to coordinate the environmentally appropriate treatment of electronic waste (ewaste). ERA will initially include nine members, including three executive members and six e-waste processors [5], [6].

India Legal Actions Concerning Electronic Waste

The Ministry of Environment and Forest (MoEF) has for the first time announced ewaste management laws, placing the responsibility of recycling electronic waste (also known as "ewaste") on the manufacturers. The 2011 e-waste (management and handling) Rules would acknowledge that manufacturers are responsible for e-waste recycling and e-waste reduction in the nation. The regulations will take effect on May 1, 2012. Manufacturers of personal computers, mobile phones, and white goods will have to provide e-waste collecting facilities or implement "take back" programs. "These rules will apply to every producer, consumer, and bulk consumer involved in the manufacture, sale, purchase, or processing of electronic equipment or components," The government is allowing the manufacturers of electrical and electronic devices a one-year grace period to set up their collecting facilities. The Environment Protection Act (EPA) will govern the regulations.

Producers will now be required under the new regulations to inform customers of any potentially dangerous ingredients in their products. Additionally, they must distribute informational pamphlets to discourage the disposal of e-waste in trash cans. However, bulk consumers like businesses and the government would be in charge of recycling the e-waste they produce under the guidelines. The large users must make sure that the e-waste they create is either returned to the manufacturers or directed to approved collection facilities. They must also keep track of the electronic trash they produce and make that information accessible to State Pollution Control Boards or Pollution Control Committees. Electronic waste (e-waste) has emerged as a significant environmental and health concern in India due to the rapid growth of the technology industry and the increasing use of electronic devices. This detailed description explores the various aspects of e-waste management in India, highlighting its environmental and health implications.

E-Waste Generation and Composition:

India has witnessed a staggering rise in e-waste generation, primarily driven by the increasing consumption of electronic devices. E-waste comprises a diverse range of products, including computers, mobile phones, televisions, refrigerators, and more. These products contain valuable materials, such as metals and plastics, but also hazardous substances, including lead, mercury, cadmium, brominated flame retardants, and polyvinyl chloride (PVC).

Environmental Impacts of Improper E-Waste Disposal:

Improper e-waste disposal practices have severe environmental consequences:

a) **Soil and Water Pollution:** When e-waste is disposed of in landfills or incinerated, hazardous substances can leach into the soil and contaminate groundwater. This pollution poses a threat to agricultural lands, ecosystems, and water bodies, leading to long-term environmental damage.

b) **Air Pollution:** Open burning of e-waste or inadequate incineration practices release toxic pollutants into the air. These pollutants, including dioxins, furans, and heavy metals, contribute to air pollution and pose respiratory health risks for nearby communities.

c) **Resource Depletion:** E-waste mismanagement results in the loss of valuable resources. Many electronic devices contain precious metals, such as gold, silver, and copper, which could be recovered through proper recycling. Failing to do so leads to resource depletion and the need for further extraction.

Health Impacts on Human Population:

The improper handling and disposal of e-waste also pose significant health risks to the population:

a) **Occupational Health Hazards:** Informal e-waste recycling practices involving manual dismantling and processing expose workers to hazardous substances without proper safety measures. Workers are at risk of respiratory problems, skin disorders, neurological issues, and long-term health complications.

b) **Community Health Risks:** E-waste recycling centers located near residential areas can affect nearby communities. Contamination of air, water, and soil can lead to increased health risks, including respiratory diseases, developmental disorders, and various forms of cancer.

c) **Informal Sector Vulnerability:** The informal sector, consisting of marginalized workers, often engages in hazardous e-waste recycling activities. They lack access to protective gear, training, and health support, further exacerbating the health risks they face [7], [8].

E-Waste Management Initiatives in India:

To address the emerging e-waste challenge, India has implemented various initiatives:

a) **E-Waste Management Rules:** The E-Waste (Management) Rules, 2016, provide a regulatory framework for the environmentally sound management of e-waste. These rules impose extended producer responsibility (EPR) on manufacturers, ensuring their involvement in e-waste collection and safe disposal.

b) **Collection and Recycling Infrastructure:** The government has encouraged the establishment of authorized collection centers, dismantling units, and recycling facilities. These infrastructure developments aim to streamline the collection and recycling process, reducing the reliance on informal recycling practices.

c) **Awareness and Education:** Public awareness campaigns and educational programs have been initiated to promote responsible e-waste disposal practices among individuals, communities, and businesses. These initiatives emphasize the importance of recycling and the potential environmental and health risks associated with e-waste mismanagement.

CONCLUSION

The e-waste is going to become a great challenge for environmentalists and technologists as the rate of growth is much higher than the rate it is disposed, reused or recycled. There is an urgent need for improvement in e-waste management covering technological improvement, operation plan, implementing a protective protocol for the workers working in e-waste disposal and educating public about this emerging issue posing a threat to the environment as well as public health. E-waste management has emerged as a critical environmental and health issue in India. The improper handling and disposal of e-waste pose significant risks to the environment, human health, and sustainable resource.

REFERENCES:

[1] M. N. Lukose, 'A Review On E-Waste Management And Recycling Challenges In India', *Int. J. Sci. Eng. Res.*, 2015.

[2] V. N. Pinto, 'E-Waste Hazard: The Impending Challenge', *Indian Journal Of Occupational And Environmental Medicine*. 2008. Doi: 10.4103/0019-5278.43263.

[3] A. Saoji, 'E-Waste Management : An Emerging Environmental And Health Issue In India Correspondence ':, *Natl. J. Med. Res.*, 2012.

[4] A. Shah, 'An Assessment Of Public Awareness Regarding E- Waste Hazards And Management Strategies An Assessment Of Public Awareness Regarding E-Waste', *Indep. Study Proj. Collect.*, 2014.

[5] R. P. Singh And S. K. Seth, 'India: A Matter Of Electronic Waste; The Government Initiatives', *J. Bus. Manag. Soc. Sci. Res.*, 2013.

[6] M. K. Jhariya, K. P. Sahu, And A. Raj, 'E-Waste, A New Challenge To The Environmentalists', *Nature Environment And Pollution Technology*. 2014.

[7] B. N. Patel And V. Balachandran, 'E Waste Problems - An Analysis', *Int. J. Adv. Res. Manag. Soc. Sci.*, 2015.

[8] R. Marimuthu, M. Shanthi, S. Aramvith, And S. Sivaranjani, 'Smart Waste Management Model For Effective Disposal Of Waste Management Through Technology', In *Eai/Springer Innovations In Communication And Computing*, 2021. Doi: 10.1007/978-3-030-70183-3_9.

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Circular Economy Concepts for Managing Electronic Trash Sustainably: Difficulties and Management

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***ABSTRACT:** Globally, the electronic and electrical industrial sector is expanding at an exponential pace, and sometimes, due to technological improvements, these wastes are being disposed of and thrown at a quicker rate than in the past. Due to the rising use of electronic devices across a variety of industries (IT, healthcare, residential, etc.), there is also an increase in the amount of electronic trash being produced. Compared to underdeveloped nations, affluent countries generate a lot more electronic trash per person. The growth of the global population and the development of technology are mostly to blame for the rise in the amount of e-waste in our environment. E-waste is to blame for environmental hazards since it may include hazardous and dangerous materials like metals that might affect the ecosystem and biodiversity. Additionally, the lifespan and kind of e-waste define its detrimental impacts on the environment, and unscientific disposal methods may increase the degree of hazards as seen in the majority of developing nations like India, Nigeria, Pakistan, and China. Many potential strategies for efficient e-waste management have been considered in the current review article, including recycling, recovering precious metals, embracing the principles of the circular economy, developing pertinent regulations, and using cutting-edge computational tools. On the other hand, it may also provide possible secondary supplies for essential or valuable elements whose original sources face serious supply risks. The monitoring, treatment, and processing of e-wastes may also benefit from the application of machine learning techniques.*

***KEYWORDS:** E-Waste, Disposal, Hazardous Substances, Management, Recycling.*

INTRODUCTION

The adoption of circular economy concepts is crucial for the sustainable management of electronic waste (e-waste). The shift from a linear "take-make-dispose" model to a circular approach aims to maximize resource efficiency, minimize waste generation, and reduce the environmental impact of e-waste. However, implementing circular economy principles in the e-waste management sector faces several difficulties. This article explores the challenges associated with applying circular economy concepts to e-waste management and discusses potential strategies for effective management.

Complex Product Design and Disassembly:

One of the main difficulties in implementing circular economy principles for e-waste is the complex design of electronic products. Many electronic devices are not designed with recycling and disassembly in mind, making it challenging to recover valuable materials and components. Manufacturers need to prioritize product design for disassembly and recyclability, incorporating standardized interfaces and modular components.

Informal E-Waste Recycling Sector:

The existence of an informal e-waste recycling sector poses a significant challenge to implementing circular economy principles. Informal recycling practices often lack proper infrastructure, technology, and safety measures, leading to environmental pollution and health hazards. Engaging and formalizing the informal sector through capacity building, training, and providing incentives can help integrate them into sustainable e-waste management practices.

Lack of Proper Collection Infrastructure:

Establishing an efficient and widespread collection infrastructure for e-waste is critical for implementing circular economy principles. In many regions, there is a lack of accessible collection points and awareness among consumers about proper e-waste disposal. Investing in collection infrastructure, including convenient drop-off points, collection drives, and take-back programs, can enhance e-waste collection rates and promote recycling.

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Technological Advancements and Recycling Processes:

The development and implementation of advanced technologies for e-waste recycling are essential for closing the loop in the circular economy. However, adopting these technologies poses challenges such as high costs, limited scalability, and the need for specialized skills. Continuous research and development, collaboration between industry and academia, and government support can facilitate the adoption of innovative recycling processes and technologies.

Extended Producer Responsibility (EPR):

EPR is a critical policy instrument in circular economy approaches to e-waste management. However, effective implementation of EPR programs can be challenging. Ensuring compliance among manufacturers, creating monitoring mechanisms, and establishing a transparent system for tracking e-waste throughout its lifecycle are necessary for the success of EPR programs.

International E-Waste Trade:

The global nature of e-waste management presents challenges, particularly in addressing the international trade of e-waste. Transboundary movement of e-waste, often disguised as second-hand goods, circumvents regulations and undermines sustainable management efforts. Strengthening international cooperation, enforcing stricter regulations, and promoting responsible trade practices are essential for managing e-waste sustainably on a global scale [1], [2].

E-waste can be defined as unwanted, not working, or at the end of the useful life of any equipment which operates on an electromagnetic field and electrical currents. It conceals wide ranges of electronic devices, varying from hefty domestic appliances to equipment used in ITs and telecom sectors. It also encompasses appliances from the medical, automobile, sports, and toy sectors. Different parts of electric and electronic equipment, like used batteries, electric wires, printed circuit boards, plastic casings, cathode ray tubes, poly. The material design of EEE is very complex, as 69 elements from the periodic table can be found in EEE, including precious metals, Critical Raw Materials, and noncritical metals, such as iron and aluminum. the proportions of different types of metals which are expected to be present in e-wastes, as shown in Figure 1.

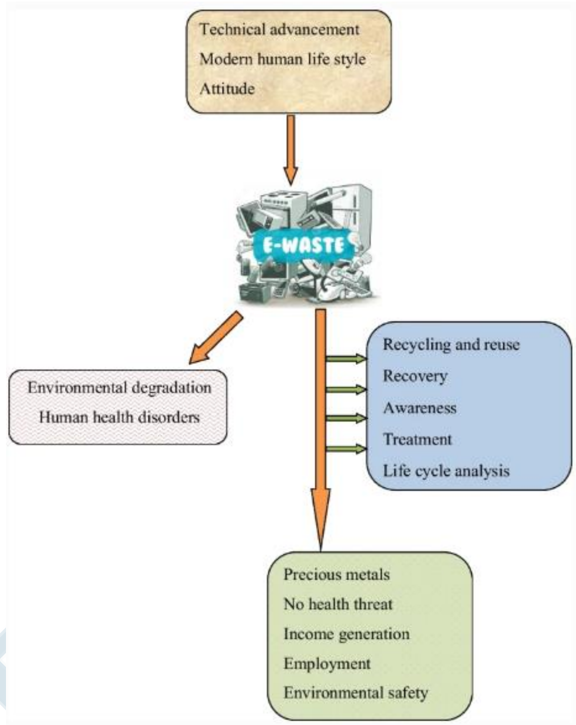

Figure 1: Showing The Management of E Waste.

Types of E-Waste and Potential Sources of Each

The environment is producing several kinds of e-waste. Our houses, the IT industry, the car industry, the medical industry, and other companies that use electrical and electronic components might all be potential producers of e-waste. According to the European regulatory organizations for e-waste disposal, there are ten types of e-wastes. Due to the many dangerous inorganic and/or organic elements they may contain, discarded e-wastes may result in serious issues. Air conditioners, cars, microwave ovens, refrigerators, lights, washing machines, phones, and printers are a few prominent forms of e-waste that include toxic heavy metals that are very dangerous. Persistent organic pollutants, electrolytes, X-ray and radioactive compounds, as well as medical and laboratory equipment, are all utilized in chips, batteries, and other medical and laboratory equipment. These e-wastes may have a number of negative repercussions, and among the factors most to blame for their production include changes in regulation, shorter material lifespans, and technological advancements. Toxic heavy metals including lead, mercury, and chromium as well as persistent organic pollutants may be dangerous materials [3].

DISCUSSION

Effects Of Electronic Waste On Environment And Human Health

If improperly managed, discarded e-wastes may have negative effects on both the environment and human health, such as chronic health problems and environmental damage. In the parts that follow, a particular section relating to issues brought on by e-waste is illustrated.

Environmental Impact

E-waste pollution of the environment, including the soil, water, and other biota, results from improper disposal practices. Heavy metals and particulate particles are reportedly released into the environment by e-waste disposal sites and recycling facilities. Hazardous and non-hazardous materials have been separated from e-waste into two categories. Heavy metals, polycyclic aromatic hydrocarbons, poly dibenzofurans, brominated diphenyl ethers, and polychlorinated dibenzo-p-dioxins are examples of hazardous chemicals. Non-hazardous substances include, among others, the metals Cu, Se, Pt, and Ag. When present in excess of permitted levels, both types of contaminants discharged by e-waste are harmful to the environment and human health. The effects of e-waste vary for the same kind of e-wastes since they rely on the age of the particular e-waste. Pollutants may be reduced or postponed by recycling, but the high volume of e-waste still results in a massive buildup of pollutants in landfills and the environment. E-waste recycling practices in developing nations like India, Nigeria, Pakistan, and China discharge heavy metals and other refractory pollutants into the environment. When these dangerous chemicals are released into the environment, they are quickly linked to several processes, including bioaccumulation, food contamination, and general exposure to ecological processes, which puts everyone at risk.

Affects Air Quality

Several different e-waste pollutants are released into the atmosphere as dust or odors. Humans are mostly exposed by ingestion, inhalation, and skin absorption. Due to their frequent breathing, high risk of in utero exposure, frequent breastfeeding, excessive hand-to-mouth activity, frequent food intake, and poor toxicant clearance rates, children and babies are thought to be the most vulnerable to improper handling of e-waste. The processing and recycling of e-waste at Guiyu, China, A gbogbloshie, Ghana, the National Capital Territory region, India Shershah, Pakistan, Lagos, Nigeria, and Dhaka, Bangladesh produces hazardous primary and secondary e-waste toxicants that are released into the environment. These toxicants include Hg, Pb, Cd, PCBs. However, depending on the sort of work being done in the neighborhood, the amount of toxins in the air may differ. For instance, significant amounts of Pb and Cu are released into the environment from recycling and disposal sites that are often connected with electrical components. Since these toxins may remain in one location for a very long period and can move over enormous distances, the atmosphere serves as a medium for their dispersion. These metals may be bio-accumulated in the life of water, soil, and plants and will have major negative effects on the intake of contaminated food or water since they are suspended in the form of particle matter and also become deposited on the soil surface and open water resources [4], [5].

Affects Water Quality

Numerous studies have also shown that waste effluents are equally to blame for water contamination. Recent years have seen a plethora of research on the removal of various harmful dyes and heavy metals from water. Electrical and electronic equipment disposal companies and other e-waste-related activities use leaching and dissipating processes to release contaminants from e-waste into groundwater and surface water. According to a research by Luo et al., the amount of polybrominated diphenyl ethers in sediment samples taken from the Nanyang River near Guiyu Town has greatly risen, and carp from this river had a high potential for bioaccumulation. Top predators in an aquatic habitat near an e-waste recycling factory ingested 1091 ng/g PBDE and 16,512 ng/g PCBs on a wet weight basis, according to a research on snakes by Wu et al. In the Pearl River Delta, a research on the water flow from downstream locations has shown an increased amount of PBDE and PCBs.

Affects the Soil's Health

Recent decades have seen a dramatic rise in human activity, which releases small quantities of dangerous chemicals into the soil, polluting the soil as a result. Because they discharge metals and other toxins into the environment at greater quantities than other sources, waste recycling facilities are regarded as one of the primary causes of soil pollution. However, one of the most troublesome causes of e-waste contamination of the soil is the handling of e-waste using outdated techniques. A greater concentration of PCBs and PBDEs was observed in the plants, soil, and snails of Guiyu town. According to Luo et al., one of the causes of high levels of metals like Cd, Cu, and Pb in soil is the burning of metallic chips and electrical circuits. A greater value of PBDE was found in agricultural soils within a 2-kilometer radius of an e-waste recycling workshop, according to Luo et al. In a different investigation, soil from the same range was found to contain significant amounts of PCBs, PAHs, and polychlorinated dibenzo-p-dioxins and dibenzofurans. Numerous soil samples examined from the vicinity of the Loni, India e-waste recycling facility revealed very high metal concentrations. Nearly all of the soil samples analyzed were over the allowable limits, with the highest Pb concentration exceeding the recommendations. Additionally, high levels of Cd, Hg, Cr, and Zn have been found in this area. The dangerous toxins, including heavy metals, that are found in the soil may be readily assimilated by plant roots and transferred to the plant's numerous components, such as the stem, leaf, and fruit. Soil polluted by e-waste is one of the main causes of contamination for crops and vegetables.

Influence on Human Health

Human health might be put at danger as a result of improper e-waste management, processing, and recycling practices. Hazardous compounds generated by e-waste may enter a person's body via skin contact, ingestion, or inhalation. Due to a lack of safety precautions, employees who handle or recycle e-waste run a significant risk of direct occupational exposure. Due to the diversity of exposure sources, routes, exposed individuals' characteristics, such as body weight, age, sex, and immunological state, as well as non-identical time periods of exposure, identifying e-waste exposure is particularly difficult. The key factor contributing to the widespread danger connected with e-wastes in people is contaminated water, air, soil, and food. Children who have been exposed to the e-waste in their environment or diet may be at higher risk. Hazardous compounds will be released into the body and retained in fatty tissues when individuals are exposed to e-waste pollutants, posing serious health risks. Humans may consume, inhale, or come into touch with metals on their skin. Oral exposure involves drinking contaminated water and eating contaminated food. It has been discovered that ingesting heavy metals is the major way that humans get exposed to them. From polluted soil, water supplies, or air deposition, heavy metals may potentially bio-accumulate into plant tissues. The rise in heavy metal concentrations in meat-based products is mostly caused by food items cultivated on soil that has been polluted with heavy metals. It has been shown through several studies conducted by numerous researchers throughout the world that heavy metal causes a variety of human illnesses, including those affecting the neurological system, urinary system, cardiovascular system, blood, liver, kidney, learning disability, and urine.

As a result, it is essential for local authorities and governmental entities to carry out a risk and exposure assessment study in the context of e-waste processing and recycling. According to reports, the WHO's suggested upper limit for dioxin levels in people has been exceeded as a result of the e-waste recycling facility in Guiyu, China. Dioxins are entering the human body through water, air, or foodstuffs and creating major health risks. The presence of dioxins over the allowable level has been identified in samples of human milk, hair, and placentas. According to a research by Ha et al., the soil and water in the vicinity of the Guiyu e-waste recycling plant exhibited high levels of heavy metals, which might have major negative consequences on surrounding employees and residents. According to studies on e-waste conducted in Bangalore, India China, and Ghana, inhabitants and employees there were exposed to high levels of heavy metals, polybrominated diphenyl ethers, dioxins, and polychlorinated biphenyls, among other contaminants. It is evident from the explanation above that hazardous chemicals found in e-waste goods have the potential to create very harmful effects [6], [7].

E-waste Recycling Using the Micro Recycling Idea

E-waste offers private businesses an appealing commercial potential for metal recovery, but transporting such rubbish in quantity would be expensive. Smaller places may develop microrecycling plants for material recovery at a low cost. The microrecycling concept involves gathering and sorting e-waste materials from local communities at small-scale factories, which reduces transportation costs, raw material consumption, fossil fuel consumption, and environmental impact while producing recycled materials with added value for use in other applications. These microfactories use a variety of techniques, such as fractional heating to get materials from e-waste and the separation of different metals, polymers, and ceramics. In order to achieve careful separation of important metals and alloys, it is also possible to enable several reactions employing selective thermal transformation. Recently, it has been discovered that valuable materials may be produced from e-waste using unique and basic processes, such as the production of metals, metal nanoparticles, alloys, and nanoceramics. The major goal of this idea is to effectively, securely, and sustainably process and recycle e-waste at a smaller scale so as to be able to deliver value-added materials for the benefit of neighboring companies.

Creation of Efficient E-Waste Management Strategies

In many areas, effective policies have always been a great instrument for success. Take India as an example. Despite being a major center for the manufacture of electronic gadgets, India had ineffective rules when it came to managing its e-waste. The Indian environment ministry has, however, released several recommendations for the efficient treatment of e-waste. Between 1989 and 2016, Indian decision-makers created several waste management policies and recommendations. E-waste management regulations were initially created in 2009, but were combined with plastic waste regulations in 2011. E-waste management-related laws in India need to be seriously revised in order to ensure the safety of the environment and human health. But for the management of e-wastes to be successful, it has to be revised thoroughly. The majority of China's waste management strategies, like those in other countries, are centered on managing municipal solid waste. Following the discussions sparked by the 1989 Basel Convention, the European Union played a significant role in establishing the regulations governing the treatment of e-waste in the early 2000s. The first significant law to set goals for ensuring the recycling, recovery, and treatment of various sorts of trash was the trash Electrical and Electronic Equipment Directive of 2002. In Europe, this directive served as a starting point for the subsequent development of several pieces of law. In nations including Canada, the USA, Japan, and Australia, national law was later developed using this instruction. According to Taneja et al. in the field of waste management, bibliometric research may also aid in the creation of effective policies for a certain topic. Grab et al. and Asokan et al. have made the claim that expanded producer responsibility principles, if included into the formulation of e-waste management policies and put into practice for the recycling and collecting of the e-wastes, might be a superior alternative for e-waste management.

Giving Waste Management Authority Employees Specialized Training

Processing, the use of tools, safety precautions, monitoring, supervision, and other processes are all involved in waste management, making it a multifaceted process. Because these qualified individuals may play important roles in the management of trash, trained people might be a major advantage for waste management authorities. The training for effective waste management may include a variety of stakeholders, such as academic institutions, research organizations, ministries, municipalities, the local public, technical people, etc. For successful e-waste management, a similar hierarchy may be used, which includes governing bodies, governmental and non-governmental organizations, business and society, etc.

Machine Intelligence Methods' Role in Managing E-Waste

E-waste is the broad word used to describe the abandoned electronic gadgets. The improper management of these gadgets has raised severe concerns. Due to the possibility that these leftovers include cadmium, lead, beryllium, zinc, etc., it might be harmful to both human health and the environment. Researchers have already completed a number of studies in the area of e-waste management and disposal, but there are still many obstacles to overcome. The fast expansion of e-waste was explored by Awasthi et al. They discovered that popular e-waste disposal techniques like acid baths and open burning may emit heavy metals like furans and dioxins, which can have negative impacts on the environment. All e-waste-related data has been compiled and uploaded to the cloud server. The acquired sources of e-waste from the current database match those on the cloud server.

On the cloud server, the database category based on the review has already been kept up to date. Based on the categorization, the e-waste product's components have been divided. The components may be categorized using the machine learning-based automatic category adviser. Following the components' filtering, the IoT devices will accept the filtered component, request a name, and send a server-side alert message. It is already connected to the server to meet each component's needs. It is synchronizable with the resources for the received e-waste. The product assignment is assisted by IoT-enabled devices, which set it up in the cloud server with the most recent product list. As a result, the server can automatically respond to any request for these sources. The

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automation, reassignment, and historical learning will all benefit from the use of machine intelligence techniques. In order to automatically enhance the identification of the reusable components. Based on the automated rules of the model, it will be useful in data collecting, filtering, and reusability and boosting product usability [8].

Waste management was examined by Rahman et al. They have suggested a waste management architecture built on the Internet of Things and deep learning. They came up with the idea for a smart garbage can that has many sensors. IoT and Bluetooth technologies have been employed for data monitoring. They succeeded in 91.3% accuracy for the convolutional neural network and 86% usability for the system. The increase of e-waste was researched by Agarwal et al. The topic has been brought up in relation to emerging economies. They have read and examined the literature's projections for artificial intelligence from 2015 to 2020. They discovered that the computational method could aid with e-waste segregation. E-waste collection management may be done intelligently by using clever strategies, according to Kang et al.'s analysis of e-waste management in terms of valuable base metals. Their strategy incorporates the Malaysian-developed automated notification and scheduling of the e-waste management mechanism system. Senthilselvi and colleagues investigated how technology advancement affected e-waste globally. They have brought up the difficulties with electronic equipment disposal. Their goal was to apply machine learning methods to automate the measurement of metal purification.

They employed pyro-metallurgical, hydrometallurgical, eddy current, magnetic separation, and other procedures to separate the metal from the mobile phones. CNN processed the photos of the retrieved metal to remove noise. It aids in the categorization and extraction of features. They utilized and corrected linear units to validate the learnt characteristics. The metal, which may be utilized in any other industrial process, was effectively removed by them. Singh and colleagues investigated e-waste disposal. For managing e-waste, they suggested an IoT-based collecting vendor machine. It was linked to the QR code that included the pertinent data. It has a capacity-based alarm system as well as a safe disposal method. According to Chen et al., e-waste has a significant rise in environmental problems because of the harmful compounds it contains, which have a negative impact on both human health and the environment. For the intelligent examination of potentially dangerous components, they put forward an artificial intelligence approach. The increased need for automated e-waste recycling and management was examined by Abou et al. For managing and classifying e-waste, they used AlexNet layers. Yu et al. spoke on the difficulties with trash disposal. The methods of reducing, reusing, recycling, and recovering have been considered. They have suggested a foundation for automated artificial intelligence.

Their structure was equipped to organize, plan, and obtain precise information. Li et al. used machine learning to the management of e-waste. They monitored urban sub-segments using a gradient-boosting regression tree and neural network. With a 99.1% accuracy rate, the layout was enhanced using machine learning approaches. Islam and others spoke about teleworking. They said that the creation of e-waste has grown as a result of teleworking. They mostly concentrated on the metal collecting. Based on gravity, density, and integrated methods, the recovery was carried out. According to Aswani et al., e-waste is a major issue in the contemporary Indian context. They have proposed using machine learning methods to manage the process of recycling metals from e-waste. An innovative waste management strategy based on long-range protocol and the TensorFlow framework was researched by Ramya et al. LoRa supervised the communication protocol. The TensorFlow framework was used to do out object detection.

It carries out in-the-moment object detection. The structuring of trash data and real-time item identification were both done using the TensorFlow framework. E-waste was also identified using radio-frequency identification. Khan et al. spoke on the use of IoT and machine learning in the collecting of e-waste. They suggested a strategy using machine learning and IoT for efficient e-waste management. They made use of a moisture sensor, an ultrasonic sensor, and an Arduino UNO microprocessor. Their primary goal is to calculate the trash index for dumping grounds. Elangovan and colleagues investigated the rise in e-waste. For the categorization of the metal found in e-waste, deep learning was applied.

Future efforts should concentrate on raising local residents' understanding of the need to alter their behavior in order to quickly resolve any environmental catastrophe, including the management of e-waste. Thus, it would seem that with public involvement, the principles of the circular economy may be considerably secured to the fullest degree possible.

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Knowledge of pertinent technology, economic problems, circular economy concepts, and environmental issues should also be explored together as they may improve the effectiveness of product recycling and reuse. Environmental ethics, regulations, and education have also been shown to greatly increase the public's awareness of environmental protection. Consumers may also be forced to pay certain predetermined amounts of money, albeit this may depend on factors including gender, the specifics of a wedding, how easily recyclable the trash is, and the toxicity of the e-waste. E-waste management in India is a difficult work due to a lack of understanding of environmental preservation and recycling techniques, as well as ineffective legislation, financial concerns, etc. After working with all the stakeholders, public acceptability and economic gain may help with improved e-waste management.

Strict rules and regulations might also be important in the management of e-waste. In a similar vein, there are no legal frameworks for the recycling of e-waste in any African nations. However, they are skilled in recycling electrical or electronic equipment, and their rates are around 2-3 times higher than those of wealthy nations. With the help of government regulatory agencies and companies, Australia has a clear policy for recycling televisions and computers. The only Asian nations with e-waste management policies are China, India Japan, South Korea, and Taiwan. Taiwan, on the other hand, leads the pack with an impressive 82% rate of e-waste recycling, while Japan and South Korea only managed 75%. Policies for recycling and standard development are insufficient in other parts of the globe. Therefore, other nations need to create suitable legislation, especially for the handling of e-waste. The most important benefit of using e-wastes is that they can be used to create jobs by creating business modules and producing fuels through the pyrolysis of precious metals like gold, silver, platinum, copper, and aluminum. These materials are also recyclable and reusable.

They must be dealt with in order of importance if large amounts of e-waste are to be managed effectively and efficiently. Below are a few of the obstacles and practical solutions:

1. Educating people about the harmful effects of e-waste and recycling it.
2. E-waste generation is accurately and continuously measured and quantified.
3. Creating a new structured recycling setup and training a qualified staff to turn a disorganized recycling industry into a well-organized one.
4. Constructing a cutting-edge infrastructure that will allow e-waste to be recycled while posing the fewest risks to the environment and human health.
5. Encouraging the recycling industry by using different economic and financial methods, including tax relaxation, expanded producers' responsibilities, cheap loaning to build recycling infrastructure, and public-private partnerships.
6. Create technology and materials that will enable optimum recovery after recycling.
7. Urban mining is a vital component that may be used to recover resources and energy.
8. Informal and non-scientific procedures need to be examined right away.
9. To minimize any negative effects on the environment, frequent monitoring and strict policies should be implemented.

Recent incidents have shown how unheard-of and unconcerning scenarios like the COVID-19 pandemic epidemic have had a significant negative impact on the organized and unorganized sectors associated to managing e-waste. Therefore, these issues should be taken into account while creating policies. Additionally, the viability of advanced computational tools may be investigated specifically for the management of e-waste in order to benefit the environment and the general population. A proper cost-benefit analysis of the various e-waste treatment strategies should be conducted in order to better guide future research. Large volumes of electronic garbage are created globally as a consequence of ostensible upgrading initiatives. Along with certain valuable and recyclable materials, these e-wastes could also include some hazardous substances. Because of this, the environment and biosphere may also be harmed by their irresponsible management and open disposal methods.

CONCLUSION

E-waste is typically handled improperly since the general public is unaware of its significance and the severity of its threats. E-waste may also include radioactive chemicals, which may harm plant tissues and eventually stop plant development. Radioactive substances in the soil may reduce a plant's ability to absorb nutrients. Aside from knowledge, main obstacles to efficient e-waste treatment include a lack of infrastructure, irresponsible consumption, the financial crisis, and others. However, certain beneficial practices, such as societal motivation, behavioural change, the availability of sufficient finances or incentives, the right availability of e-waste treatment facilities, and adoption of green practices, may lower the levels of these difficulties. Artificial intelligence and machine learning are two methods that may be used to improve e-waste management processes. The deployment of modern computational tools is also playing key roles in many fields. By using such strategies, economic viability may also be preserved. Along with realizing the principles of a circular economy, it will also assist in the partial or full realization of many other sustainable development objectives. While circular economy concepts offer a promising framework for sustainable e-waste management, several difficulties must be addressed for effective implementation. Overcoming challenges related to product design, the informal sector, collection infrastructure, recycling technologies, EPR implementation, and international trade requires a multi-stakeholder approach involving government, manufacturers, consumers, and recycling industries. Collaborative efforts, innovation, and policy interventions are crucial for managing electronic waste sustainably and moving towards a circular economy for e-waste.

REFERENCES:

[1] M. Chen And O. A. Ogunseitan, 'Zero E-Waste: Regulatory Impediments And Blockchain Imperatives', *Front. Environ. Sci. Eng.*, 2021, Doi: 10.1007/S11783-021-1402-X.

[2] K. Parajuly, C. Fitzpatrick, O. Muldoon, And R. Kuehr, 'Behavioral Change For The Circular Economy: A Review With Focus On Electronic Waste Management In The Eu', *Resources, Conservation And Recycling: X*. 2020. Doi: 10.1016/J.Rcrx.2020.100035.

[3] A. Chakrabarty And S. Nandi, 'Electronic Waste Vulnerability: Circular Economy As A Strategic Solution', *Clean Technol. Environ. Policy*, 2021, Doi: 10.1007/S10098-020-01976-Y.

[4] S. Galparoli, A. Caielli, P. Rosa, And S. Terzi, 'Semi-Automated Pcb Disassembly Station', In *Springerbriefs In Applied Sciences And Technology*, 2021. Doi: 10.1007/978-3-030-74886-9_4.

[5] G. Ziritt Trejo, R. Taboada Hernandez, Z. Moreno, And M. Isabel Castellano, 'Public Management And Sustainable Development: Expression Of Social Responsibility', *Innov. Manag. Educ. Excell. Through Vis. 2020, Vols I -Xi*, 2018.

[6] C. C. Cantarelli, B. Flybjerg, E. J. E. Molin, And B. Van Wee, 'Cost Overruns In Large-Scale Transport Infrastructure Projects', *Autom. Constr.*, 2018.

[7] P. P. Biancone, S. Secinaro, And V. Brescia, 'A Planning And Control System Based On Social Welfare Indicators Useful Way To Guide The Governance For Sustainable Healthcare Mobility', In *Research Advancements In National And Global Business Theory And Practice*, 2018.

[8] A. P. M. Velenturf And P. Purnell, 'Principles For A Sustainable Circular Economy', *Sustainable Production And Consumption*. 2021. Doi: 10.1016/J.Spc.2021.02.018.

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Overview of Electronic Waste Recycling and Disposal

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ABSTRACT: The fastest-growing kind of hazardous trash in the world is reportedly electronic garbage, or e-waste. Hazardous chemicals, potentially valuable materials that may be recycled, and other inputs are all included in e-waste. In both developed and underdeveloped nation settings, e-waste takes a variety of paths following disposal, including official and informal recycling, storage, and dumping. Over the last ten years, there have been substantial changes in how e-waste is handled and regulated both globally as a hazardous waste stream and as a source of secondary raw materials. Extended producer responsibility regulations, which require electronics makers to pay for safe recycling and disposal of electronics, are being enacted by an increasing number of nations. As the possibility of recovering valuable materials has expanded, the e-waste recycling sector is becoming more structured. However, a number of recent studies have indicated that e-waste recycling continues to involve a variety of occupational health and environmental dangers.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

A very diverse source of hazardous trash is electronic waste, sometimes known as e-waste or waste electrical and electronic equipment. Any electronic device that a consumer or corporation plans to discard or that is no longer functional for its intended use belongs to this waste stream. Due to a number of interrelated factors, such as the exponential increase in e-waste production, the potential value of recycling the waste in order to recover precious metals and other elements, and the environmental and health risks connected with improperly storing, disposing of, and recycling e-waste, e-waste has attracted a lot of public and political interest. The creation of producer "take-back" legislation, technological advancements in recycling procedures, and the establishment of partnerships to facilitate the transfer of e-waste between the informal and formal recycling sectors are just a few of the major responses to the growing generation of e-waste.

E-waste is a very complicated waste stream since it includes a variety of products and because the precise makeup of many electronic components is regarded as a trade secret, which means it is the manufacturer's private knowledge. In general, "up to 60 distinct elements may be found in contemporary electronics, many of which are beneficial, some of which are dangerous, and some of which are both. The printed wiring boards often include the most intricate mixture of materials. Mobile phones, for instance, are made of "over 40 elements in the periodic table, including base metals like copper and tin, special metals like cobalt, indium, and antimony, and precious metals like silver, gold, and palladium," to provide one particular example.

The official recycling sector has been recycling electronics that had been employed in commercial or industrial purposes, such as medical equipment, for more than 40 years. These huge commodities are usually imported from industrialized nations in the OECD and transported there to be processed in order to recover secondary raw materials from specialist facilities. Due to the limited amount of recoverable valuable elements in consumer electronic trash from smaller devices like mobile phones and TVs, recycling has traditionally not been financially viable in nations with higher labor expenses. As a result, these items have typically been discarded, kept in consumers' homes, or exported to less developed nations like China, India Ghana, and Nigeria, where they are recycled by unauthorized recyclers using low-tech techniques like manual dismantling, open burning, and acid leaching to recover gold, copper, and other valuable metals. Due of the harmful compounds that are also included in consumer electronics, these approaches not only result in serious risks to human health and the environment but also provide employees with subsistence incomes. This chapter will examine these traditional recycling initiatives and the manner in which they are changing as a result of advancements in technology and the world economy [1], [2].

The recycling of electronic waste typically involves five fundamental steps: collection, toxics removal, preprocessing, end processing, and disposal. The way these steps are handled around the globe varies greatly. E-waste may be collected legally via producer "take-back" programs that are either voluntary or required, or it may be collected informally by "waste pickers" for a large portion of the world's waste stream. Consumer electronics recycling rates have traditionally been far higher in areas where e-waste is picked up by unofficial collectors than in areas where garbage is dropped off via official channels. Once at the recycling facility, hazardous parts that need special handling are taken out. The units are then divided based on material into more homogeneous groupings. This may be carried out automatically, manually, or by combining both methods. Mechanical disassembly may entail conveyor belts, enormous shredders, and magnets, while manual dismantling uses instruments like screwdrivers, hammers, and labeled containers.

More homogeneous groupings of material are subsequently processed via a refining process, which may be carried out chemically, with heat, or with metallurgical processes, after the separation and dismantling stages. A massive smelter in Antwerp, Belgium, or an acid stripping operation in a backyard in Guiyu, China, are two examples of this stage's technological sophistication. According to research, there is often a "race to the bottom" practice of lowering standards and environmental protection as locations compete for the garbage by providing low-cost methods. All of the parts that cannot be sold or utilized as secondary raw materials are then disposed of using techniques like landfill or incineration.

The procedure used, particularly during the stages of separation and dismantling, determines the amount of efficiency attained via e-waste recycling. The finest secondary raw materials may frequently be accessed during the breakdown of electronics considerably more easily manually than mechanically. The E.U.'s automated take-back initiatives are ineffective compared to the labor-intensive e-waste collection rates prevalent in several African nations. Additionally, manual dismantling is preferred to machine shredding, which mutilates and incompletely separates various materials. For instance, whereas 90% of the gold in used mobile phones may be recovered by human disassembly, mechanical shredding only recovers 26% of the gold. However, unless labor costs are really low, these more labor-intensive choices are not economically viable [3], [4].

DISCUSSION

Electronic waste (e-waste) recycling and disposal are vital processes aimed at managing the growing volume of discarded electronic devices responsibly. This overview provides a comprehensive understanding of e-waste recycling and disposal, highlighting the importance of proper handling, the recycling process, and the potential environmental and health impacts of improper disposal.

Importance of E-Waste Recycling:

E-waste recycling is essential for several reasons:

a) **Resource Conservation:** Electronic devices contain valuable resources such as precious metals, rare earth elements, and plastics. Recycling e-waste allows for the recovery and reuse of these materials, reducing the need for new resource extraction.
b) **Environmental Protection:** Proper recycling prevents e-waste from ending up in landfills or being incinerated, which can release hazardous substances into the environment. Recycling minimizes soil and water contamination, air pollution, and the depletion of natural resources.
c) **Energy Savings:** Recycling e-waste requires less energy compared to extracting and processing raw materials. Energy savings contribute to the reduction of greenhouse gas emissions and mitigate the environmental impact of electronic device production.

E-Waste Recycling Process:

The e-waste recycling process typically involves the following steps:

a) **Collection:** E-waste collection can occur through various channels, including designated drop-off points, collection events, and take-back programs offered by manufacturers or retailers. Proper collection ensures that e-waste is directed to authorized recycling facilities.
b) **Sorting and Dismantling:** Upon arrival at a recycling facility, e-waste is sorted into different categories based on device types and materials. Dismantling involves the removal of batteries, cables, circuit boards, and other components for separate processing [5], [6].
c) **Hazardous Substance Removal:** Hazardous substances, such as mercury, lead, cadmium, and flame retardants, are safely extracted from the e-

waste during the recycling process. Specialized techniques and equipment are employed to minimize environmental and health risks.

d) **Material Recovery:** After hazardous substances are removed, the e-waste is further processed to recover valuable materials. This includes shredding, separation of metals and plastics, and refining processes to extract reusable resources.

e) **Proper Disposal of Residuals:** Any remaining waste or non-recyclable materials are disposed of in an environmentally responsible manner, adhering to local regulations and guidelines.

Environmental and Health Impacts of Improper Disposal:

Improper disposal of e-waste has significant environmental and health consequences:

a) **Soil and Water Contamination:** When e-waste is dumped in landfills or improperly disposed of, toxic substances can leach into the soil and contaminate groundwater, leading to the pollution of ecosystems and agricultural lands.

b) **Air Pollution:** Open burning of e-waste releases harmful pollutants into the air, including toxic gases and particulate matter. Inhalation of these pollutants can have adverse effects on human health and contribute to air pollution.

c) **Health Risks:** Improper handling of e-waste exposes workers and nearby communities to hazardous substances. Long-term exposure to toxic chemicals found in e-waste can lead to respiratory problems, neurological disorders, reproductive issues, and various forms of cancer.

Regulatory Framework and Best Practices:

To address e-waste management, many countries have implemented regulations and established best practices. These include:

a) **Extended Producer Responsibility (EPR):** EPR holds manufacturers accountable for the entire lifecycle of their products, including their proper disposal and recycling.

b) **International Standards:** International standards, such as the Basel Convention, regulate the transboundary movement of e-waste and promote environmentally sound recycling practices.

c) **Certification and Auditing:** Certifications such as Responsible Recycling (R2) and e-Stewards ensure that recycling facilities adhere to strict environmental and health standards.

Extended producer responsibility and its impact on e-waste recycling

The amount of electronic garbage thought to be produced worldwide each year varies greatly. These estimations are based on the volume and number of different electronic devices that are bought in a given year, taking into account the expected lifespan of that specific item. It is crucial to remember that a sizeable amount of consumer e-waste is either retained in customers' homes or is mixed up with ordinary household rubbish and disposed of into landfills. Surveys of recyclers on the number of electronics collected may also be taken into consideration. In certain cases, such as in those locations where makers are required to "take-back" customers' unwanted devices, information on the quantity of e-waste collected for recycling is accessible. Such requirements have their roots in the idea of extended producer responsibility, which contends that producers of goods containing hazardous materials should be accountable for handling the logistics and costs associated with recycling or properly disposing of such goods.

Manufacturers originally resisted EPR legislation, but as interest in the strategic value and possible profitability of the secondary raw materials found in e-waste has grown, so too has support for it. Around the world, different EPR "takeback" laws have been implemented, notably in a number of U.S. states, the European Union, and other nations in Asia, Africa, and Latin America. These rules suggest a possible change away from the informal sector's dominance in electronics recycling and toward the development of a structured e-waste recycling industry.

Pilot projects and public-private partnerships to collect and recycle electronics in ways that are effective and economical have grown in number as a result of the increasing number of EPR laws requiring manufacturers to take extended responsibility for the environmentally sound recycling of their products. Some of these programs, which come under the Basel Convention on the Control of the Transboundary Movements of Hazardous Wastes and Their Disposal, include moving electronic garbage across international borders. Technical recommendations for the processing and disposal of e-waste have been developed as a consequence of pilot projects and technical working groups that The Basel Convention has held over the years [7], [8].

Additional pilot projects are being developed under the auspices of the United Nations University to support a globalized e-waste recycling chain that

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involves labor-intensive dismantling and preprocessing in nations with lower labor costs and high-tech end-processing in nations with more up-to-date facilities. Major recycling companies, electronics producers, and government representatives are of the opinion that such alliances will guarantee a higher volume of input for big, high-tech smelters and give access to secondary raw materials that were previously "dumped" or otherwise held within the global South countries where informal recycling is currently practiced.

CONCLUSION

Electronics are created, manufactured, sold, and used on a worldwide scale. The environment and human health are at risk during these early phases of an electronics' life cycle. Similar to this, moving hazardous items across international boundaries is often required for the destruction and recycling of electronics. Growing government and industry interest in recovering secondary raw materials from e-waste, such as rare earth elements, is encouraging the creation of formal, automated processes for recycling e-waste at the end-processing stage as well as strategies to increase recycling rates. This has sometimes required the creation of enabling legislation, as EPR "take-back" laws, and in other instances it has resulted in pilot initiatives that support collaborations between recyclers in the official and informal sectors. Progress has been achieved, but there are still many more things that can be done to make sure that trash receivers are appropriately equipped to handle and recycle them in an ecologically friendly way. Regulation and control will be crucial in reducing the many threats that recycling e-waste poses to human health and the environment as these changes take place.

REFERENCES:

[1] C. A. Lucier and B. J. Gareau, ‘Electronic Waste Recycling and Disposal: An Overview’, in *Assessment and Management of Radioactive and Electronic Wastes*, 2020. doi: 10.5772/intechopen.85983.

[2] S. Needhidasan, M. Samuel, and R. Chidambaram, ‘Electronic waste - An emerging threat to the environment of urban India’, *Journal of Environmental Health Science and Engineering*. 2014. doi: 10.1186/2052-336X-12-36.

[3] Anuja Prabhakar, Romi Nayyar, and PK Sharma, ‘Environmental and Health Impacts of Electronic Waste: A Global Concern!!’, *Int. Healthc. Res. J.*, 2021, doi: 10.26440/ihrj/0505.08445.

[4] M. Heacock *et al.*, ‘E-waste and harm to vulnerable populations: A growing global problem’, *Environmental Health Perspectives*. 2016. doi: 10.1289/ehp.1509699.

[5] S. Jaibee *et al.*, ‘Review on Current Status of Waste Electric and Electronic Product in Malaysia’, *Appl. Mech. Mater.*, 2015, doi: 10.4028/www.scientific.net/amm.773-774.898.

[6] M. S. Chowdhury *et al.*, ‘An overview of solar photovoltaic panels’ end-of-life material recycling’, *Energy Strategy Reviews*. 2020. doi: 10.1016/j.esr.2019.100431.

[7] A. R. Köhler, L. M. Hilty, and C. Bakker, ‘Prospective Impacts of Electronic Textiles on Recycling and Disposal’, *J. Ind. Ecol.*, 2011, doi: 10.1111/j.1530-9290.2011.00358.x.

[8] A. Kush and A. Arora, ‘Proposed Solution of e-Waste Management’, *Int. J. Futur. Comput. Commun.*, 2013, doi: 10.7763/ijfcc.2013.v2.212.

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E-Waste Management as a Global Challenge

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ABSTRACT: E-waste management has emerged as a global challenge due to the escalating volume of electronic waste generated worldwide. The study also emphasizes the need for international cooperation and the implementation of effective regulatory frameworks to address this challenge. The exponential growth in electronic devices consumption has resulted in an alarming increase in e-waste generation globally. The improper management of e-waste poses significant environmental risks, including soil and water pollution, air contamination, and resource depletion. Moreover, the hazardous substances present in e-waste pose severe health threats to workers involved in informal recycling practices and local communities residing near e-waste disposal sites. To mitigate the global e-waste challenge, various regulatory frameworks have been implemented, such as extended producer responsibility (EPR) and the Basel Convention. EPR policies hold manufacturers accountable for the entire lifecycle of their products, encouraging responsible end-of-life management. The Basel Convention regulates the transboundary movement of hazardous waste, including e-waste, to prevent illegal dumping and promote environmentally sound practices. Addressing the global e-waste challenge requires international cooperation, technology transfer, and capacity building. Collaboration among countries, knowledge sharing of best practices, and the establishment of effective e-waste management systems are crucial. By adopting sustainable practices and implementing robust regulations, stakeholders can work together to mitigate the environmental and health impacts of e-waste and promote a circular economy approach to its management.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

With worldwide links between developed, developing, and transitional nations, waste management of electrical and electronic equipment (E-waste or WEEE) is a critical problem in the solid waste management industry. In high- and middle-income nations, where the population consumes a lot of EEE items (electrical and electronic equipment), which quickly turn into e-waste, a consumption culture and a dependence on technology rule everyday life. Due of its potential for harm to the environment and human health, this percentage is a rapidly expanding waste stream that requires specific handling and control. However, valuable elements found in e-waste may be recovered (such as precious metals and copper), reused, and recycled (such as metals and plastics) by a variety of sectors, helping to reduce the use of natural resources.

To change the perception of e-waste from a harmful source of pollution to a useful resource in the context of sustainable development is the current challenge for e-waste management systems. The 3R (reduce, reuse, recycle) strategy and waste hierarchy concept are given more attention than landfills. The Waste Framework Directive's ("Waste Framework Directive") "end of waste" criteria define the conditions under which a certain kind of trash ceases to be a waste and acquires the status of a product (or secondary raw material). The circular economy, in which wastes are seen as resources and set up the paths toward a recycling society, is promoted by EU policy. E-waste is a unique waste stream that is governed by appropriate laws [1].

Management of e-waste in Wealthy Nations

Different methods are used across the globe to handle WEEE. The EU directive is the most comprehensive national regulatory framework since it covers an EEE's whole life cycle, from the design stage through end-of-life management. The most recent update (2012) included additional recycling and take-back collection objectives. For example, the "one-to-zero" option for collecting tiny WEEE requires distributors to accept a used product without purchasing a new one. A legislative structure comparable to the EU's has been formed in Japan, and there are many other similarities between the two. In the US, where there isn't a single federal law governing e-waste disposal, a different legislative strategy is used: each state has established its own system with certain organizations and aims. The so-called "National Strategy on Electronics Stewardship," which intends to highlight government activities to improve the design of electronic devices and the management of old or discarded electronics, was announced in 2011 as one attempt at a unifying strategy. Despite the inability to establish a universally applicable legal standard, WEEE management systems have similarities and variances depending on the chosen legislative strategy. The EU law is mainly founded on the EPR principle, which states that manufacturers must use both collective and individual take-back systems to manage all stages of the product's life cycle, including the post-consumer stage. In Japan, the take-back system for EEE must be organized by producers and importers, in accordance with the EPR concept. The EPR concept has recently been used in Canada to establish new WEEE regulations.

The adoption strategy being advocated in the US mostly focuses on the design stage. Various incentives and targeted programs have been designed to assist manufacturers in creating more environmentally friendly electronic devices with the intention of preventing and reducing these waste flows. The two tactics that are most often used for WEEE are eco-design strategies and lengthening product lifespans. Prevention typically represents the most effective strategy to mitigate environmental and social problems deriving from wastes. The Electronic Product Environmental Assessment Tool (EPEAT), which establishes performance standards for developing greener electronic devices, is one example from the first group. Additionally, it is used as a procurement technique designed to aid institutional buyers in the public and commercial sectors as they assess, contrast, and choose desktop computers, laptops, and monitors based on their environmental characteristics [2].

Due to the fast spread of electronic devices and the ensuing rise in the creation of electronic garbage (e-waste), e-waste management has become a worldwide concern. This thorough analysis analyzes the many facets of managing e-waste as a worldwide concern, including the scope of the issue, effects on the environment and human health, legislative frameworks, and the need for international collaboration.

Dimensions of the Issue:

The amount of electronic garbage produced worldwide is mind-boggling. Approximately 53.6 million metric tons of e-waste were produced globally in 2019, and this amount is anticipated to climb, according to the Global E-waste Monitor 2020. The expanding e-waste problem is a result of the rising demand for electronic gadgets, short product lifecycles, and quick technical improvements.

Environmental and Health Impacts:

Improper e-waste management has severe environmental and health consequences:

a) **Environmental Impacts:** E-waste contains hazardous substances such as lead, mercury, cadmium, brominated flame retardants, and polychlorinated biphenyls (PCBs). When e-waste is improperly disposed of or recycled, these toxic substances can leach into soil, contaminate water sources, and pollute the air. This contamination harms ecosystems, biodiversity, and natural resources [3], [4].

b) **Health Impacts:** Improper handling of e-waste poses health risks to both workers involved in informal recycling practices and local communities residing near e-waste disposal sites. Exposure to hazardous substances can lead to respiratory problems, reproductive disorders, neurological damage, and an increased risk of cancer.

Regulatory Frameworks:

To address the global e-waste challenge, countries have implemented various regulatory frameworks:

a) **Extended Producer Responsibility (EPR):** EPR policies hold manufacturers responsible for the entire lifecycle of their products, including proper disposal and recycling. This approach encourages manufacturers to design products with recyclability in mind and provides financial incentives for responsible end-of-life management.

b) **Basel Convention:** The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal regulates the international movement of e-waste, aiming to prevent illegal dumping and promote environmentally sound management.

c) **National Legislation:** Many countries have enacted specific legislation and regulations for e-waste management, setting targets for collection, recycling, and safe disposal. These regulations often include provisions for proper handling of hazardous substances, licensing of recycling facilities, and awareness campaigns.

Need for International Cooperation:

Managing e-waste effectively requires international cooperation and collaboration:

a) **Transboundary Movement:** E-waste is frequently traded across borders, with developed countries exporting e-waste to developing countries. Close cooperation and strict enforcement of regulations are necessary to prevent the illegal dumping of e-waste and ensure that it is managed responsibly.

b) **Technology Transfer and Capacity Building:** Developing countries often lack the infrastructure, technology, and expertise to manage e-waste sustainably. International cooperation can facilitate technology transfer, capacity building, and financial support to enhance e-waste management practices in these regions.

c) **Knowledge Sharing and Best Practices:** Sharing experiences, knowledge, and best practices among countries can foster innovation, improve recycling technologies, and establish effective e-waste management systems globally [5].

In our rapidly advancing technological era, electronic devices have become an integral part of our lives. However, the proliferation of electronic waste, or e-waste, has emerged as a significant global challenge. E-waste refers to discarded electronic devices, including computers, smartphones, televisions, refrigerators, and other electronic appliances. The improper disposal and management of e-waste pose serious environmental and health risks. This article delves into the details of e-waste management as a pressing global challenge, exploring its impact, challenges, and potential solutions.

Growth and Impact of E-Waste:

The growth of e-waste is staggering. With the continuous development of technology and increasing consumer demand, the quantity of discarded electronic devices is skyrocketing globally. E-waste contains hazardous substances such as lead, mercury, cadmium, and flame retardants. When improperly handled or disposed of, these toxic materials can contaminate air, soil, and water, posing severe health risks to both humans and the environment. The impact of e-waste includes environmental pollution, soil degradation, water contamination, and the release of greenhouse gases.

Challenges in E-Waste Management:

Several challenges contribute to the complexity of managing e-waste on a global scale:

a) **Lack of Awareness:** Many people are unaware of the hazards associated with e-waste or the importance of proper disposal. Insufficient awareness leads to the disposal of electronic devices in regular waste streams, exacerbating the problem.

b) **Inadequate Infrastructure:** Many countries lack the necessary infrastructure and facilities to handle e-waste effectively. Insufficient recycling facilities, collection systems, and recycling technologies hinder proper disposal and recovery of valuable materials.

c) **Informal Recycling Sector:** In some regions, e-waste ends up in the informal recycling sector, where workers, often without proper safety measures, extract valuable components through crude methods. This informal sector contributes to health risks and environmental pollution.

d) **International Trade and Dumping:** E-waste is often exported to developing countries with lax regulations, leading to illegal dumping and improper handling of electronic waste. This practice perpetuates environmental injustice and exacerbates the global e-waste problem.

Potential Solutions for E-Waste Management:

Addressing the e-waste challenge requires a comprehensive approach involving various stakeholders, including governments, manufacturers, consumers, and the recycling industry. Here are some potential solutions:

a) **Awareness and Education:** Raising awareness among consumers about the hazards of e-waste and the importance of responsible disposal is crucial. Educational campaigns and initiatives can help inform the public about proper e-waste management practices.

b) **Extended Producer Responsibility (EPR):** Governments can enforce EPR policies, making manufacturers responsible for the entire lifecycle of their products. This includes designing devices with easier recyclability, establishing collection systems, and ensuring safe recycling of e-waste.

c) **Improved Recycling Infrastructure:** Governments and organizations should invest in the development of recycling infrastructure, including collection centers, processing facilities, and advanced recycling technologies. This will enable the safe and efficient recycling of e-waste, minimizing environmental impact.

d) **International Collaboration:** Global cooperation is essential to address the transboundary movement of e-waste. Strengthening regulations and enforcement, discouraging illegal trade, and promoting responsible recycling practices can mitigate the dumping of e-waste in developing countries.

e) **Circular Economy Approach:** Encouraging the transition to a circular economy, where electronic devices are designed for durability, repairability, and resource efficiency, can reduce the generation of e-waste and promote sustainable consumption.

E-waste management is a critical global challenge requiring urgent attention. By adopting effective strategies, raising awareness, improving recycling infrastructure, and promoting responsible practices, we can mitigate the environmental and health risks associated with e-waste. The rapid advancement of technology and the increasing consumption of electronic devices have led to a significant global challenge known as e-waste management. E-waste, comprised of discarded electronic devices, poses substantial environmental and health risks due to its hazardous components. This study provides a detailed description of e-waste management as a global challenge. It explores the growth and impact of e-waste, highlighting the challenges involved in its management, such as lack of awareness, inadequate infrastructure, the presence of informal recycling sectors, and international trade and dumping. The study also presents potential solutions to address this issue, including awareness and education campaigns, extended producer responsibility (EPR), improved recycling infrastructure, international collaboration, and the adoption of a circular economy approach. By implementing these solutions, it is possible to mitigate the detrimental effects of e-waste, promote responsible disposal, and work towards a sustainable future.

CONCLUSION

The e-waste management sector is in a full transitional stage at global scale. Despite the major disparities between high-income, transition and developing countries the e-waste management is a global environmental concern. Governments and local authorities across the globe face serious challenges in order to collect, treat, recycle and dispose this fast-growing waste stream in a safety manner for the environment and human health. The global interconnections between developed and developing countries, national and regional analyses are further revealed. E-waste management is a pressing global challenge that requires concerted efforts from governments, manufacturers, consumers, and the recycling industry. The magnitude of e-waste generation, along with its environmental and health impacts, necessitates the implementation of robust regulatory frameworks, including EPR policies and international agreements such as the Basel Convention. Collaboration among countries, technology transfer, and capacity building are vital for addressing the global e-waste challenge and moving towards a more sustainable and circular economy approach to e-waste management.

REFERENCES:

[1] F.-C. Mihai and M.-G. Gnoni, 'E-waste Management as a Global Challenge (Introductory Chapter)', in *E-Waste in Transition - From Pollution to Resource*, 2016. doi: 10.5772/64596.

[2] H. Ghimire and P. A. Ariya, 'E-Wastes: Bridging the Knowledge Gaps in Global Production Budgets, Composition, Recycling and Sustainability Implications', *Sustain. Chem.*, 2020, doi: 10.3390/suschem1020012.

[3] Q. Song, J. Li, and X. Zeng, 'Minimizing the increasing solid waste through zero waste strategy', *J. Clean. Prod.*, 2015, doi: 10.1016/j.jclepro.2014.08.027.

[4] L. Andeobu, S. Wibowo, and S. Grandhi, 'An assessment of e-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review', *Science of the Total Environment*. 2021. doi: 10.1016/j.scitotenv.2021.148078.

[5] O. Osibanjo and I. C. Nnorom, 'The challenge of electronic waste (e-waste) management in developing countries', *Waste Manag. Res.*, 2007, doi: 10.1177/0734242X07082028.

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E-Waste Management in Different Countries: Strategies, Impacts, and Determinants

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ABSTRACT: Over the last two decades, the electronic equipment has increased dramatically around the world, which causes increasing in e-waste as well. This increasing has affected the environment badly. E-waste disposal has become one of the most critical issues and concerns have raised of it because most of these products do not biodegrade easily and they are toxic. Different strategies have been followed in many countries in order to solve the e-waste problem. Understanding these strategies can help to plan better for e-waste management correctly. Awareness of people about the e-waste impacts is crucial, because it can ensure people participation in managing the e waste process. This research has carried out in order to introduce to the e-waste impacts on environment and human health, and the importance of people awareness about these impacts. In addition, it shows many strategies that have been used in different countries to manage the e-waste, choosing the successful one to focus in order to benefit from it. Furthermore, a surveying has been carried out to exam people awareness in Iraq about the e-waste impacts. Finally, recommendations to manage e-waste successfully have been added.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

E-waste is an unofficial but well-known phrase. Any electrical or electronic device nearing the end of its useful life is included. The markets for electrical and electronic equipment have expanded significantly on a global scale. Even though these goods' useful lives have decreased, they nonetheless wind up in landfills or recycling facilities. Around the globe, worries about the negative impacts of e-waste have increased. E-waste is produced on a yearly basis in the range of 20 to 50 percent of the world's population. It now poses a serious hazard to both the environment and human health. The short lifetime of electronic devices, population increase, economic progress, and shifting consumer habits are the main causes of the rising volume of e-waste. Many nations have used various strategies to address the e-waste problem. Some of these tactics were revealed by this investigation, and the most fruitful one has been selected to be the emphasis. Additionally, a study was conducted to assess public knowledge of the impacts of e-waste on human health and the environment. Additionally, suggestions for effectively managing e-waste have been provided [1].

Effects of E-Waste

E-waste may be categorized based on its physical and chemical components. E-waste is made up of a variety of materials, such as metals, plastics, metal-plastic blends, cables, screens, PCBs, pollutants, wood, refractory materials, and oxides, among others.

Three categories of pollutants in e-waste exist:

a) Primary pollutants such halogenated substances and heavy metals.
b) Secondary pollutants include substances such poly aromatic hydrocarbons, dioxins, and poly halogenated aromatic hydrocarbons that are formed by goods or residues as a consequence of incorrect recycling processes.
c) Tertiary emissions or pollutants are substances that are recycled. These substances, which include aquaregia, nitric acid, cyanide, hydrochloric acid, thiourea, and bromide in the metal recycling leaching process, must be handled carefully in order to prevent negative environmental and health effects.

The improper recycling of e-waste, such as manual disassembly and open burning, pollutes rivers and land. In Vietnam, fire retardants were found in soil and river sediments, which led to the discovery of this. Near the e-waste recycling facility in China, there was also evidence of soil pollution. By measuring the amount of heavy metals in the air, it was discovered that e-waste open burning sites had greater amounts of these metals and more air pollution. Additionally, it was shown that indoor dust in e waste areas included greater amounts of PCBs and BFRs than dust in non-e-waste areas. Additionally, it was shown that burning e-waste outside while it is being illegally dismantled has a negative influence on both groundwater and surface water.

According to a number of studies, e-waste is harmful to human health. By analyzing the blood, hair, and urine, it was shown that residents who live close to e-waste facilities had higher urine concentrations than those who don't. Additionally, the inside hair of the responders contained carcinogenic compounds. Additionally, exposure to heavy metals has led to immediate and long-term impacts such respiratory, reproductive, cardiovascular, and irritability issues. Studies have demonstrated that there is a link between DNA damage and the amount of time that electronic trash is processed in unofficial e-waste recycling facilities. E-waste also contributes to spontaneous abortions, preterm births, and shorter gestational periods [1], [2].

DISCUSSION

Recycling e-Waste

As long as valuable products can be retrieved from it, recycling electronic trash seems to be a viable answer in many nations. E-waste recycling is crucial for both economic recovery and environmental sustainability. Many nations have cited the effective recycling of electronic waste as a key concern. Recycling is the most crucial factor in e-waste reduction. It provides advantages for the environment at every step of the life cycle of electronic items, from the resources used to make them to the techniques used to dispose of them. Recycling helps to lessen the water and air pollution that is brought on when new equipment is made from raw materials. People in certain nations are generally aware that various forms of household solid waste may provide value. Therefore, informal traders and official collectors get payment from customers for their garbage. Then they sell to recyclers, scrap merchants, brokers, and refurbishers [3], [4].

There are two categories of recycling: official recycling and informal recycling.

Unofficial Recycling

E-waste recycling informally is thought of as a technique to salvage value from broken electrical and electronic equipment. Because it operates outside of recognized institutions, the informal sector is unlawful. The bulk of the unofficial recyclers are women and children from rural regions. This kind of recycling entails labor-intensive and hazardous manual equipment disassembly. Simple tools like chisels, hammers, and screwdrivers are used in this kind of recycling to quickly separate the various elements. This industry puts recyclers and the environment at risk because it employs subpar procedures and lacks the facilities necessary to protect human health and the environment.

1. Systems for managing e-waste in various nations
2. The world is classified into developed and developing nations.

In the European Union, the finest e-waste management can be found. For instance, Switzerland and the Netherlands have the finest e-waste management systems. A legislation in the European Union requires businesses and manufacturers to set up particular systems for disposing of e-waste. Certain dangerous compounds can no longer be used in electronic and electrical devices. They also passed legislation requiring WEEE businesses to build up mechanisms for WEEE treatment and producers. This system must be accountable for its products throughout their entire existence, from conception to disposal. Otherwise known as EPR, it is described as "the producer's responsibility for a product is extended to the postconsumer stage of a product's life cycle [5]."

E-waste is mostly the same with minor differences in other wealthy nations. Strict guidelines have been established in Germany to control e-waste. Without any fees from customers for e-waste disposal, the e-waste is collected directly from individual residences, and the number of collection stations depends on the local circumstances and population density. Collection informally is not permitted. E-waste is handed back to the producers after the collecting stage. E-waste is then divided into five distinct containers. They separated into five groups based on the criteria listed in the Act. In the US, e-waste is disposed of in poorer nations, which has negative effects on the ecology and health in these areas [6], [7]. The Basic Law was passed in Japan by the Ministries of the Environment, Economy, Industry, and Trade to encourage recycling and resource conservation in order to address difficulties with landfill capacity and resource shortages. This law's primary goals are to create a society based on recycling, reduce the production of electronic trash, and increase the use of secondary resources. Electronic waste Technologies for gathering, logistics, and reprocessing are included in infrastructure management. Collecting EoL goods from homes and delivering them to regional aggregation stations is the duty of merchants. Additionally, there are several organizations that have been designated by the government to collect electric household appliances. The end-user concept mandates that consumers bear the cost of goods and services. Customers may purchase a recycling ticket to provide to the pickup agent when they dispose of their e-waste. For instance, a customer should get in touch with the manufacturer or take their computer to the post office if they wish to get rid of it. It is then sent to the manufacturer's recycling plant to be recycled [8].

E-waste management is not covered by any particular laws in developing nations. Developing nations lack the technological capabilities and infrastructure needed to remove trash in safe ways, which has led to health issues in these nations such neurological and respiratory illnesses, cancer, and birth abnormalities. Therefore, it is essential to stop the unlawful importation of WEEE. In certain circumstances, particularly in nations with severe environmental restrictions, the expense of recycling outweighs the money that is recovered from materials. Therefore, the last stages of e-waste are dumped in nations with poor or nonexistent environmental norms, such as West Africa and Asia. Since 1992, the Basel Convention, an international agreement, has prohibited the export of hazardous waste to developing nations. As long as the exporting of reusable items is permitted, the exports of what they dubbed "second-hand goods" is ongoing. However, according to estimates from the EU Commission, approximately 75% of used items are defective and cannot be repaired, or they simply have a limited second life. E-waste importation from wealthy nations is common in underdeveloped nations because locals see it as a source of income. Lack of legal recycling causes e-waste and informal trash treatment to flourish close to residential areas in developing nations. In certain poor nations like Indonesia and Cambodia that lack specific laws to handle e-waste, informal recycling operations and treatment are carried out without understanding of the dangers they pose to the environment and human health. E-waste management in underdeveloped nations has been impacted by a lack of information about the volume of e-waste material flow and a lack of awareness. Most poor and underdeveloped nations are unable to handle e-waste in a manner that doesn't harm the environment and people's health due to political, technical, and financial obstacles [9].

As the global challenge of e-waste management continues to grow, different countries have implemented various strategies to address this pressing issue. E-waste management involves the collection, recycling, and disposal of electronic devices to minimize environmental and health risks associated with their improper handling. This article provides a detailed description of e-waste management in different countries, focusing on the strategies employed, their impacts, and the determinants influencing their approaches.

Strategies for E-Waste Management:

Countries around the world have adopted diverse strategies to tackle e-waste management based on their specific circumstances and priorities. Some common strategies include:

a) **Legislation and Policy Frameworks:** Many countries have enacted legislation and established policy frameworks to regulate e-waste management. These frameworks often include Extended Producer Responsibility (EPR), which holds manufacturers responsible for the entire lifecycle of their products, from production to disposal.

b) **Collection Systems:** Effective collection systems are crucial for proper e-waste management. Countries have implemented various approaches, such as establishing dedicated collection centers, organizing periodic collection drives, or integrating e-waste collection with existing waste management systems.

c) **Recycling Infrastructure:** Developing robust recycling infrastructure is essential for efficient e-waste management. Countries have invested in recycling facilities, both centralized and decentralized, equipped with advanced technologies to recover valuable materials and minimize environmental impact.

d) **Public Awareness and Education:** Raising public awareness about the hazards of e-waste and promoting responsible disposal practices is key. Countries have conducted educational campaigns, implemented labeling systems on electronic products, and provided guidelines for consumers on proper e-waste disposal.

Impacts of E-Waste Management Strategies:

The strategies implemented by countries for e-waste management have significant impacts on various aspects, including:

a) **Environmental Protection:** Effective e-waste management strategies contribute to environmental protection by reducing pollution and preventing the release of hazardous substances into the ecosystem. Proper recycling and disposal help minimize soil, water, and air contamination.

b) **Resource Recovery:** E-waste contains valuable resources such as precious metals, rare earth elements, and plastics. Efficient e-waste management strategies allow for the recovery of these materials, reducing the need for virgin resources and promoting a circular economy

c) **Health and Safety:** Proper e-waste management protects the health and safety of both workers involved in recycling operations and the general population. Implementing safe practices and reducing exposure to hazardous substances ensures a healthier environment for all.

Determinants Influencing E-Waste Management Approaches:

Several determinants shape the e-waste management approaches adopted by different countries:

a) **Economic Factors:** The economic capacity of a country influences its ability to invest in e-waste management infrastructure and technologies. Wealthier nations often have more resources to allocate to efficient recycling and disposal systems.

b) **Technological Advancements:** Countries with advanced technological capabilities may be better equipped to handle e-waste management, including the development of innovative recycling methods and resource recovery techniques.

c) **Legislative Frameworks:** The presence of strong legislation and supportive policy frameworks facilitates effective e-waste management. Countries with well-established regulations and enforcement mechanisms tend to have more structured and efficient systems in place.

d) **Public Awareness and Attitudes:** The level of public awareness and attitudes towards e-waste play a significant role in shaping management approaches. Countries with proactive public engagement and responsible consumer behavior are more likely to adopt comprehensive e-waste management strategies.

E-waste management strategies vary across different countries, reflecting their unique circumstances and priorities. The impacts of these strategies range from environmental protection and resource recovery to safeguarding health and safety. Determinants such as economic factors, technological advancements, legislative frameworks, and public awareness influence the approaches taken. By understanding these strategies, impacts, and determinants, countries can learn from each other's experiences and work towards more effective and sustainable e-waste management practices on a global scale.

CONCLUSION

E-waste is an issue that requires a worldwide solution and is growing alarmingly each year. Consequently, measures must be implemented to reduce unlawful dumping. The majority of industrialized nations have created laws and policy directives to limit the use of dangerous chemicals in these items and to handle e-waste after disposal. The European Union has been successful in putting into place a unified legal framework for the management of e-waste. Germany and Japan were the next countries to implement an effective and systematic e-waste management system after Switzerland. As far as emerging nations go, there are several laws present there, but they are not consistently enforced. The majority of developing nations lack equivalent legislation, especially when it comes to their enforcement. Additionally, there are no facilities to extract valuable metals from e-waste, nor are there any specialized centers for processing e-waste. A crucial component of an e-waste management system is precise data on e-waste flows, which is currently lacking. The management of e-waste may be improved in developing nations by linking local and national rules. E-waste management is influenced by human behavior. One of the key elements that has an impact on the financing for e-waste management is behavior. Consumer participation in the e-waste management process may be ensured by raising consumer awareness. Therefore, the technique for this study concentrated on raising people's awareness of e-waste. Government must inform citizens of their responsibilities and educate them on the effects that improper e-waste disposal has on human health and the environment. Lack of awareness results in ineffective product usage, lack of participation from consumers, and lack of reusing and recycling. If handled properly, e-waste has the potential to be a fantastic source of energy.

REFERENCES:

[1] J. A. Laub, ‘Assessing the servant organization; Development of the Organizational Leadership Assessment (OLA) model. Dissertation Abstracts International’, *Procedia - Soc. Behav. Sci.*, 1999.

[2] Y. Isnaeni and N. M. Farda, ‘Analisis Penurunan Muka Tanah Sebagian Kota Semarang Tahun 2017-2019 Menggunakan Citra Sentinel-1A dan Teknik Different Interferometry Synthetic Apertare Radar (D’, *J. Bumi Indones.*, 2020.

[3] S. Ahmad, S. Jha, A. E. M. Eljialy, and S. Khan, ‘A Systematic Review on e-Wastage Frameworks’, *Int. J. Adv. Comput. Sci. Appl.*, 2021, doi: 10.14569/IJACSA.2021.0121287.

[4] N. W. M. Wong, ‘Electronic waste governance under “one country, two systems”: Hong kong and mainland china’, *Int. J. Environ. Res. Public Health*, 2018, doi: 10.3390/ijerph15112347.

[5] L. H. Xavier, M. Ottoni, and J. Lepawsky, 'Circular economy and e-waste management in the Americas: Brazilian and Canadian frameworks', *J. Clean. Prod.*, 2021, doi: 10.1016/j.jclepro.2021.126570.

[6] A. S. Ouedraogo, R. S. Frazier, and A. Kumar, 'Comparative life cycle assessment of gasification and landfilling for disposal of municipal solid wastes', *Energies*, 2021, doi: 10.3390/en14217032.

[7] S. Cheval, C. M. Adamescu, T. Georgiadis, M. Herrnegger, A. Piticar, and D. R. Legates, 'Observed and potential impacts of the covid-19 pandemic on the environment', *International Journal of Environmental Research and Public Health*. 2020. doi: 10.3390/ijerph17114140.

[8] S. Abalansa, B. El Mahrad, J. Icely, and A. Newton, 'Electronic waste, an environmental problem exported to developing countries: The good, the bad and the ugly', *Sustain.*, 2021, doi: 10.3390/su13095302.

[9] D. Purchase *et al.*, 'Global occurrence, chemical properties, and ecological impacts of e-wastes (IUPAC Technical Report)', *Pure Appl. Chem.*, 2020, doi: 10.1515/pac-2019-0502.

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Policy Concerns for Developing Nations' Effective Handling of E-Waste

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ABSTRACT: Efficient management of electronic waste (e-waste) poses significant policy challenges in developing countries due to limited resources, inadequate infrastructure, and rapid technological advancements. This study focuses on the policy issues that need to be addressed to ensure effective e-waste management in developing countries. It highlights the importance of regulatory frameworks, extended producer responsibility (EPR), integration of the informal sector, capacity building, and international cooperation. Developing countries face the challenge of formulating and enforcing comprehensive regulations for e-waste management. Robust regulatory frameworks are essential to guide collection, recycling, and disposal practices. Implementing EPR policies, which hold producers accountable for the lifecycle of their products, encourages responsible end-of-life management and promotes eco-design principles. Integrating the informal sector into the formal e-waste management system is crucial to address environmental pollution and health hazards. Capacity building programs are needed to enhance skills and awareness among policymakers, waste management professionals, and informal recyclers. International cooperation plays a vital role in providing technology transfer, financial aid, and expertise to strengthen e-waste management infrastructure and practices. Efficient e-waste management in developing countries requires comprehensive policies, including regulatory frameworks, EPR implementation, and integration of the informal sector, capacity building, and international cooperation. Addressing these policy issues will lead to more sustainable e-waste management practices, reducing environmental impacts and protecting public health.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

Developing nations face unique policy concerns in effectively handling electronic waste (e-waste) due to their specific socio-economic and infrastructural challenges. This study focuses on the key policy concerns that need to be addressed to facilitate the efficient management of e-waste in developing nations. It highlights the need for comprehensive regulatory frameworks, capacity building, sustainable financing mechanisms, technological support, and international cooperation. Developing nations often lack comprehensive and enforceable regulations for e-waste management [1], [2]. Effective policy frameworks should encompass e-waste collection, recycling, disposal, and the prevention of illegal trade. These regulations need to be tailored to the specific context of each nation while aligning with international guidelines and best practices. Capacity building initiatives are crucial to equip developing nations with the necessary skills, knowledge, and resources for e-waste management. These programs should target policymakers, waste management professionals, and informal sector workers, focusing on safe handling, recycling techniques, and awareness of the environmental and health impacts of improper e-waste management. Sustainable financing mechanisms are essential to support e-waste management initiatives in developing nations. Governments can explore options such as green taxes, extended producer responsibility (EPR) programs, and public-private partnerships to fund collection, recycling, and disposal infrastructure.

Technological support plays a significant role in efficient e-waste management. Developing nations should leverage appropriate technologies for e-waste processing, including safe dismantling, sorting, and recycling methods. Access to affordable and environmentally friendly technologies is crucial for developing nations to manage e-waste effectively. International cooperation is vital for developing nations to address e-waste challenges. Collaborative efforts can involve technology transfer, capacity building support, knowledge sharing, and financial assistance from developed nations and international organizations. Strengthening cooperation can foster innovation, promote best practices, and ensure the responsible management of e-waste in developing nations [3], [4].

Management of e-waste Electrical and electronic equipment trash is often considered to include electronic waste as well. The European Commission defines the term "end-of-life commodity/gadgets that have been used for generating, measuring, and transferring the electrical or magnetic current, and/or functioned by supplying the current during their service life" as the most prominent definition of "e-waste/WEEE." Discarded electronic products, electrical appliances, and power storage batteries are only a few examples of what is included in the term "E-waste" in this context. E-waste is also defined as a diverse collection of ferrous, nonferrous, ceramic, and plastic materials by the Association of Plastics Manufacturers in Europe. A significant amount of EoL materials are being produced that have been contained inside the E-waste border as a result of fast evolving technology and its unparalleled usage in everyday life. E-waste is the kind of garbage that is rising the fastest globally, with an annual growth rate of more than 4%. Although the superior technology and management systems of the wealthy countries have shielded them from the E-waste enemies, emerging and undeveloped nations are still unable to get adequate guidance for the efficient management of E-waste. A significant amount of e-waste in those nations, particularly those in the low- and middle-income bracket, is either dumped in landfills or supplied to the unregulated recycling industry. To separate metal and polymer materials, it is normal practice to burn obsolete cables and printed circuit boards. To recover the valuable metals from e-waste, rudimentary techniques including hand-picking and disassembling, nitrate/aqua-regia leaching, and dumping the residual and effluent streams in an open area are also used. Lack of environmental and public health protection due to improper resource recycling efficiency [5], [6].

DISCUSSION

Current e-Waste Management Techniques

The collection, handling, processing, and ultimate disposal are acknowledged as the key aspects in the worldwide framework for a successful management of e-waste. On the other hand, the main problems cited for developing nations include hazards from poor treatment of increased volume by informal recycling with weak/absent E-waste regulation. However, it is impossible to dismiss the importance of the informal economy in low- and middle-income nations. The current methods of managing e-waste, which include collecting it from consumers, homes, businesses, and the public sector after passing the EoL. Below, it is more pertinently explored how the increased handling of the resulting E-waste volume in developing nations.

Comparing the Policies of Rich and Developing Nations

The developing nations are now using EEE more quickly than the industrialized nations, despite their slower pace of technical development. As a result, they also create more electronic garbage, maybe twice as much as industrialized nations, as shown in Figure 1. For instance, it is predicted that by 2030, developing and industrialized nations would have wasted 400 700 million and 200 300 million units of outdated computers, respectively. However, because of the absence of appropriate norms and regulations, emerging nations face far more difficulties than industrialized nations. Their contrast is thus interesting to talk about.

Figure 1: Illustrate the e waste management policy.

Due to issues including few resources, poor infrastructure, and quick technology improvements, developing nations confront particular difficulties in the proper handling of electronic waste (e-waste). In order to encourage effective e-waste management in developing nations, this section outlines important policy concerns that must be resolved, including legislative frameworks, extended producer responsibility (EPR), integration of the informal sector, capacity development, and international collaboration.

Regulatory Frameworks: Comprehensive and enforceable legislation for the handling of e-waste are sometimes lacking in developing nations. Strong regulatory frameworks must be put in place in order to create standards for collection, recycling, and disposal procedures. E-waste creation, import and export restrictions, ecologically sound recycling requirements, and appropriate disposal techniques should all be covered by effective legislation. To keep up with changes in consumption habits and technological breakthroughs, these restrictions need be modified on a regular basis.

Extended Producer Responsibility (EPR): Under EPR regulations, producers are now responsible for handling e-waste instead of the government. The full lifespan of a product, including its safe disposal and recycling, is the responsibility of the manufacturer. EPR implementation supports eco-design principles, incentivizes producers to design goods with recyclability in mind, and offers financial rewards for responsible end-of-life management. To guarantee that manufacturers are accountable for the e-waste they make, developing nations must enact and enforce EPR regulations [7], [8].

Integration of the Informal Sector: In developing nations, the management of e-waste is heavily influenced by the informal sector. Informal recyclers often work under uncontrolled circumstances, posing risks to human health and the environment. It is crucial to include the unofficial sector into the established e-waste management framework. This may be accomplished by enhancing their abilities and ensuring adherence to safety and environmental requirements via capacity development, training, and providing technical and financial assistance.

Building Capacity: To improve their e-waste management capacities, developing nations must engage in building capacity projects. This involves giving legislators, regulators, waste management experts, and unofficial recyclers instruction and technical support. Programs to improve capacity should include encouraging best practices in e-waste collection, disassembly, recycling, and disposal while also raising awareness of the threats incorrect e-waste management poses to the environment and human health.

International help and collaboration: Addressing the difficulties of managing e-waste in underdeveloped nations calls for international help and collaboration. Developed nations may help by transferring technology, offering funding, and offering their knowledge to enhance the infrastructure and procedures for managing e-waste. Collaboration between countries may promote information exchange, the investigation and creation of novel technologies, and the creation of universal guidelines for the management of e-waste, as shown in Figure 2.

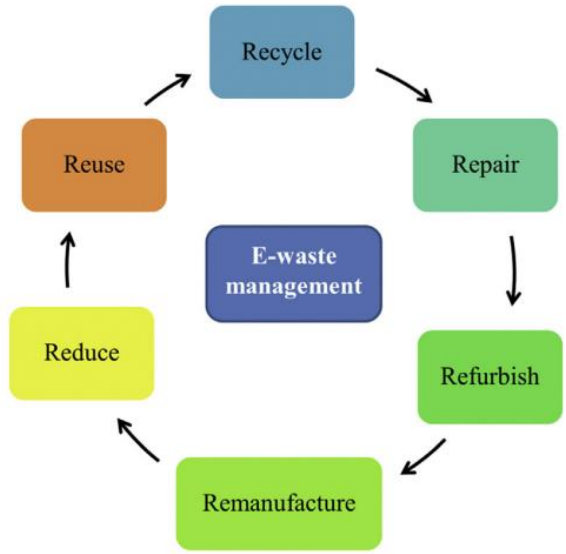

Figure 2: E-waste circular economy.

Researchers have discovered a volatile market for elements recovered through the recycling of E-waste. With this in mind, it is advised that the informal sector, particularly rag pickers, receive advanced training for collection, dismantlers, and refurbishers, provide incentives and financial support to attract private sector participation, impose strict regulations for E-waste imports, monitor and enforce existing regulations, collaborate internationally, and implement decentralized E-waste repair and refurbish initiatives. This program may be the answer to creating a sustainable E-waste paradigm [9], [10].

CONCLUSION

E-waste poses a bigger challenge to developing nations' sustainability since they get the majority of these dangers from rich nations. It is imperative that developing nations adopt the legal frameworks of industrialized nations in order to implement regulations specifically aimed at managing e-waste and make an effort to solve this global issue. Because developing nations produce more domestic E-waste than developed nations, there is an urgent need to regulate the flow of E-waste, mostly under the name of UEEE. This issue is especially significant in nations like China, India Pakistan, Nigeria, Brazil, and Argentina since a sizable portion of their economies are dependent on the illegal E-waste industry. The highlighted incidents and present situation of these nations' e-waste management systems and regulations reveal that there is, if slowly, a rising awareness in this area. Only a small number of developing nations have yet to create their own E-waste policies. Despite the fact that a number of methods for the sustainable treatment of e-waste have been provided, the present environment makes it impossible to ignore the informal sector. It has been determined that the only way to achieve a major decrease in the disposal of E-waste in the near future is for the formal and informal sectors to collaborate in order to perform integrative recycling, which may advance the circular economy. Addressing important policy concerns is necessary for effective e-waste management in emerging nations. Strong regulatory frameworks are essential, and they should include EPR policies, thorough and enforced laws, and inclusion of the unorganized sector. Enhancing e-waste management practices, promoting sustainable recycling technologies, and reducing the threats to the environment and public health posed by e-waste depend on capacity development programs and international collaboration. Developing nations may progress toward a more sustainable and responsible method of managing e-waste by enacting these legislative measures, which will be advantageous to the environment and public health.

REFERENCES:

[1] S. M. Abdelbasir, S. S. M. Hassan, A. H. Kamel, and R. S. El-Nasr, 'Status of electronic waste recycling techniques: a review', *Environmental Science and Pollution Research*. 2018. doi: 10.1007/s11356-018-2136-6.

[2] K. J. Miner, I. T. Rampedi, A. P. Ifegbesan, and F. Machete, 'Survey on household awareness and willingness to participate in e-waste management in jos, plateau state, Nigeria', *Sustain.*, 2020, doi: 10.3390/su12031047.

[3] S. Murugavelh, B. Anand, K. Midhun Prasad, R. Nagarajan, and S. Azariah Pravin Kumar, 'Exergy analysis and kinetic study of tomato waste drying in a mixed mode solar tunnel dryer', *Energy Sources, Part A Recover. Util. Environ. Eff.*, 2019, doi: 10.1080/15567036.2019.1679289.

[4] J. O. Babayemi, M. B. Ogundiran, and O. Osibanjo, 'Current Levels and Management of Solid Wastes in Nigeria', *Environ. Qual. Manag.*, 2017, doi: 10.1002/tqem.21498.

[5] A. Borthakur and M. Govind, 'Emerging trends in consumers' E-waste disposal behaviour and awareness: A worldwide overview with special focus on India', *Resources, Conservation and Recycling*. 2017. doi: 10.1016/j.resconrec.2016.11.011.

[6] A. Shamim and A. M. K, 'E-Waste Trading Impact on Public Health and Ecosystem Services in Developing Countries', *Int. J. Waste Resour.*, 2015, doi: 10.4172/2252-5211.1000188.

[7] M. S. Hossain, N. A. Nik Norulaini, A. A. Banana, A. R. Mohd Zulkhairi, A. Y. Ahmad Naim, and A. K. Mohd Omar, 'Modeling the supercritical carbon dioxide inactivation of Staphylococcus aureus, Escherichia coli and Bacillus subtilis in human body fluids clinical waste', *Chem. Eng. J.*, 2016, doi: 10.1016/j.cej.2016.03.120.

[8] M. Vijarania, S. Gupta, and A. Gambhir, 'Challenges and strategies for E-waste management in developing countries', *IJ Sci. Eng.*, 2017.

[9] A. H. A. Azeem, H. Mallawarachi, and D. Geekiyanage, 'Building organisational capacities for effective e-waste management: A conceptual framework', in *World Construction Symposium*, 2019. doi: 10.31705/WCS.2019.16.

[10] F. H. A. Shibly and S. S. Thelijjagoda, 'Development of a Web Based Electronic Waste Management System: A Study with Special Reference to Recycling Companies in Sri Lanka', *Proc. Int. For. Environ. Symp.*, 2015, doi: 10.31357/fesympo.v20i0.2562.

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A Theoretical Review of Organizational Capabilities and E-Waste Management

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ABSTRACT: Organizational capabilities play a crucial role in effective e-waste management. This study provides a theoretical review of the relationship between organizational capabilities and e-waste management, highlighting the key factors and mechanisms that contribute to successful e-waste management practices within organizations. The study begins by emphasizing the growing concern over the environmental and social impacts of e-waste and the need for organizations to adopt sustainable practices. It then explores the concept of organizational capabilities and their significance in addressing the complexities of e-waste management. Theoretical frameworks and models are discussed to understand how various organizational capabilities, such as technological, managerial, and collaborative capabilities, influence e-waste management outcomes. Technological capabilities encompass the ability to handle, process, and recycle e-waste effectively. Managerial capabilities involve strategic planning, resource allocation, and monitoring to ensure compliance with regulations and environmental standards. Collaborative capabilities emphasize partnerships and collaborations with stakeholders, including suppliers, customers, and government agencies, to enhance e-waste management practices.

KEYWORDS: E-Waste, Disposal, Hazardous Substances, Management, Recycling.

INTRODUCTION

The worldwide market for manufacturing and consuming electrical and electronic equipment is expanding at an accelerating rate. Over 40,000,000 tonnes of e-waste are generated globally each year, and this is attributed to the increased market penetration of electrical and electronic equipment in developing nations, the expansion of a substitute market in developed nations, and a high rate of product obsolescence. Since these things are purposefully made to last for a limited time, they are commonly thrown away. E-waste often travels from industrialized nations to underdeveloped nations with struggling economies. According to Kalra, a number of gulf nations commonly serve as hubs for the transhipment of e-waste between developed and poor nations. According to Green Peace International, even though the Basel Convention forbids the international transportation of dangerous wastes, hazardous wastes are still being transported illegally to China from industrialized nations including the United States, Japan, and Canada. This issue is becoming worse not because there aren't any rules or laws, but rather because they aren't being followed. Before the end of 2009, India produced 4,340,000 tonnes of electronic garbage. Despite the fact that India has several environmental protection regulations, no particular legislation has been passed to address e-waste. According to Toxics Link, e-waste routinely enters developing nations under the pretense of free commerce, aggravating the issue of e-waste management there. Only 15% of trashed products are recycled; the rest are dumped in landfills. Stakeholders in the e-waste disposal process have distinct financial and infrastructural responsibilities to maintain. The majority of nations in the world have ratified a number of international environmental accords, including the Basel Convention, Bamako Convention, Nairobi Convention, Stockholm Convention, and Rotterdam Convention, in an effort to combat hazardous waste. Therefore, the purpose of this study was to determine how organizational capacities affected the management of electronic waste [1], [2].

The study highlights the importance of organizational learning and knowledge sharing in building and strengthening e-waste management capabilities. It also examines the role of organizational culture, leadership, and employee engagement in driving sustainable e-waste management practices. The theoretical review emphasizes the need for organizations to develop comprehensive capabilities that integrate technological, managerial, and collaborative dimensions. These capabilities enable organizations to adapt to evolving e-waste management challenges, improve operational

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efficiency, and enhance environmental performance. The study concludes by calling for further empirical research to validate and refine the theoretical frameworks discussed. By understanding the relationship between organizational capabilities and e-waste management, organizations can develop effective strategies to address e-waste challenges and contribute to a more sustainable future.

Definition of the Issue

Institutional initiatives to improve service delivery, increase competitiveness, and increase exposure in international research provide the foundation for the exponential expansion of ICT globally. There is concern about the effects of these expanding e-waste flows on the environment. Although gadgets often pose little hazard to users, it is generally recognized that improper e-waste disposal may disturb sensitive ecosystems, degrade the environment, and therefore have unfavorable effects on human health. Lead, cadmium, mercury, and lithium are only a few of the toxic substances found in electronic trash from inactive rudiments. These dangerous materials may escape through poor disposal and inadequate recycling processes, endangering the ecosystem. Researchers and academics have connected e-waste to negative impacts on human health, including cardiovascular illness, DNA damage, and perhaps cancer of different types, in addition to its detrimental effects on the environment. Due to the lack of understanding about the whole spectrum of e-waste management as well as how to appropriately handle and dispose of garbage in an environmentally responsible way, there is a major knowledge gap. Therefore, by studying the organizational skills of E-Waste Management, this research aimed to contribute to the sparse body of literature presently available on the subject [1], [3].

DISCUSSION

Technology-Organization-Environment

Organizational variables in research on the adoption of technology, according to Tornatzky and Fleischer, include the attitude toward creativity, financial capacity, organizational size, institutional knowledge, the sharing of information, the capacity to learn, and the support of the highest levels of management. The environmental context, organizational context, and technical context are the three components that make up the Technology-Organization-Environment Framework developed by Tornatzky and Fleischer. The five steps of the adoption process for innovations, according to Rogers, are knowledge, persuasion, decision, implementation, and confirmation. In order to estimate the adoption rate, Rogers proposed five perceptual qualities of innovation: relative benefit, compatibility, complexity, trialability, and observability. The diffusion of innovations theory has been extensively used in recent years in the area of information technology relevance research, such as web site adoption, along with the TOE framework.

The Capability Theory

A competitive advantage is mostly based on capabilities, while capabilities themselves rely on resources, according to Grant's capability theory. The author continues by saying that a firm's ability to remain competitive requires the use of both resources and capabilities. The significance of capabilities also implies that businesses may achieve trustworthy management from their own resources by employing their own capabilities consistently when they carry out fundamental business operations [2], [4].

Management of E-Waste

Consumer and commercial gadgets that are nearing the end of their useful life are considered e-waste. E-waste is defined by European Union laws as equipment that needs power to operate properly, as well as equipment that generates, transfers, and measures electric currents and fields. StEP noted the difficulties handling e-waste presents for poorer nations. They claim that if handled properly, e-waste has the potential to be profitable. Who are the primary recipients of e-waste, nevertheless face significant challenges in building efficient e-waste management systems. The necessity for different governments throughout the globe to recognise the challenge of managing e-waste is shown by the needs for education, innovation, collaboration, and a legislative framework. different countries are urged to perform academic research to solve the issue. Luther studied the connections between product design, construction, and usage, as well as how these elements affect the physical recycling process, including material separation. In their analysis, Kellenberg and Levinson discuss how much effort is wasted, the market's potential size and development, as well as the procedures involved in recycling e-waste in respect to both developed and developing nations.

Available Resources to an Organization

The three Rs, or reduce, reuse, and recycle, are the cornerstones of effective organizational e-waste management. Management would decrease the production of electronic waste by improving

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manufacturing and maintenance efficiency; reuse electronic equipment by offering to sell or donate any working devices to others; and recycle any broken or damaged components. Hewlett-Packard, the Global Digital Solidarity Fund, and the Swiss Federal Laboratories for Materials Testing and Research all reported in 2014 that the private sector, which is also the largest producer of e-waste globally, owns the majority of computers, including outdated computers. 2.5 Empirical Analysis In order to identify the gaps in the literature that the present research will fill in order to advance knowledge on the study's issues, this part analyzes the results of prior studies and compares them with the variables of the conceptual framework [5], [6].

The Impact of Human Resource Skills On the Management of Electronic Waste

Skilled human resources and effective management processes are required for a company to achieve its goals. As a result, businesses cannot achieve their goals without properly motivating and maintaining a skilled staff with the necessary intellectual capital. Akroush makes this argument on the challenging task of carrying out a strategic strategy. Recent management research, such those by Wright et al., have supported the idea that organizational competencies directly affect performance. According to the findings of these research, organizational competencies must be relevant and well targeted in order to have a positive impact on e-waste management—not that the better they are, the better they would perform. Organizational management is impacted by human resource capabilities. Organizational effectiveness served as the yardstick for measuring management. The research by Chuang et al. examined how human resource skills relate to managerial effectiveness while focusing on how these relationships relate to organizational effectiveness. They came to the conclusion that improving organizational core competencies, in particular the competency of human resources, is the key to business success. It is thus suggested that expanding the use of human resource skills in creating and putting plans into action would boost the efficacy of e-waste management. Therefore, the purpose of the research was to determine how human resource skills and e-waste management techniques relate to one another. Cooper and Molla present evidence that the likelihood that the company would effectively adopt recycling of e-waste, among other sustainability measures, increases with the capacity of stakeholders to generate knowledge about sustainable use of information technology. Because it has a considerable impact on organizational management, human resource management affects an organization's capacity for knowledge generation [7].

Impact of the policy framework on the management of e-waste

Due to the pervasive practice of disposing of hazardous wastes in Africa and other developing regions, the Basel Convention was created in 1989. Eastern Europe, as well as other developing nations where there was less environmental concern and stringent rules were nonexistent, became the target zone for dumping as manufacturers and transporters sought less expensive alternatives to the newly illegal African dumping areas. The handling of e-waste has been one of the literature's primary foci. The literature research has also discussed the use of used electrical and electronic equipment as "ores" for precious metals and replacement components. It has also been thought about the notion that the waste producer is responsible for the product for the whole of its useful life. For an inclusive waste electrical and electronic equipment treatment system, strategy-oriented studies have recommended for formalizing informal recycling by giving it access to formal recycling facilities via legislative, institutional, or economic activities. The literature on waste electrical and electronic equipment emphasizes the differences between informal and formal recyclers of e-waste, particularly by focusing on differences in their internal and external characteristics, specifically in technological, human resource capabilities, economic factors, and policy framework criteria. However, regardless of the characteristics of the person recycling it, there may not be effective management of e-waste in the actual process.

Technological Prowess

Different knowledge gaps, e-waste management technologies, funding, e-waste collection, e-waste disposal, e-waste legislation, and cooperation were all found. According to the survey, there are no well-defined technological techniques for handling e-waste. The numerous technological policies in place around the world do not provide a strong enough framework to handle the problem of e-waste management.

Policy Structure

There is a vacuum in municipal policies since none specifically deal with the issue of e-waste; instead, the majority of rules deal with garbage in general or solid waste in particular. In terms of e-waste and associated garbage, there is a gap in the enforcement of local and international law. Despite the fact that the majority of nations have ratified international policies, the country does not have a clear local policy on the importation of e-waste; it is up to the individual countries to carry out the convention's implementation. The majority of nations do not have legislation governing the methods of putting international treaties into effect and enforcing them [8].

CONCLUSION

In summary, investments in enhancing human resource competencies will enable the organization to successfully achieve its aims and objectives in the management of e-waste. The degree of human resource participation and the creation and application of e-waste management seem to have a significant beneficial link. The research found that there is a continuing need to comprehend organizational adoption of technological innovation, its dimensions, and qualities due to the ongoing growth of new technology and methods of adopting it.

REFERENCES:

[1] S. J. K. D. M. Nzuki, 'Organizational Capabilities and E-Waste Management: A Theoretical Review', *Int. J. Sci. Res.*, 2018.

[2] J. A. Laub, 'Assessing the servant organization; Development of the Organizational Leadership Assessment (OLA) model. Dissertation Abstracts International', *Procedia - Soc. Behav. Sci.*, 1999.

[3] M. Strebler, 'Training and developing employees', *Appl. Hum. Resoruce Manag.*, 2009.

[4] N. Kumar and A. Chatterjee, 'Reverse Supply Chain: Completing the Supply Chain Loop', *Int. J. Prod. Econ.*, 2009.

[5] G. Ziritt Trejo, R. Taboada Hernandez, Z. Moreno, and M. Isabel Castellano, 'Public Management and Sustainable Development: Expression of Social Responsibility', *Innov. Manag. Educ. Excell. Through Vis. 2020, Vols I -Xi*, 2018.

[6] F. Löser, 'Strategic Information Systems Management for Environmental Sustainability Enhancing Firm Competitiveness with Green IS', *Universitätsverlag der TU Berlin*, 2015.

[7] V. Maphosa and M. Maphosa, 'E-waste management in Sub-Saharan Africa: A systematic literature review', *Cogent Bus. Manag.*, 2020, doi: 10.1080/23311975.2020.1814503.

[8] H. Ismail and M. M. Hanafiah, 'Evaluation of e-waste management systems in Malaysia using life cycle assessment and material flow analysis', *J. Clean. Prod.*, 2021, doi: 10.1016/j.jclepro.2021.127358.