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E- Waste Management in India and their Over-Coming Strategies

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Abstract:- In India, the quantity of electronic trash has grown to be a significant problem. Eliminating electronic garbage is turning into a significant health and safety emergency because it is the official municipal waste category with the fastest rate of growth at the moment. Similar to hazardous waste, e-waste has grown to be a short- and long-term concern due to the potential for important environmental problems and health risks connected to its uncontrolled accumulation and recycling. E-waste is trash from electrical and electronic appliances that is intended for disposal, recycling, or recovery but has either outlived its useful life or was no longer suitable for the purpose for which it was intended. The public, private, and industrial sectors in India are the primary generators of electronic trash; taken collectively, they make up roughly 70% of all waste produced. The problem is being made worse by the expanding amount of e-waste and the lack of expertise in the field. It has been shown how crucial manufacturer involvement and public awareness have been to the development of the e-waste management system. Governments are also responsible for ensuring adequate funds and for carrying out nationally established environmental regulations that have international consensus. Effective e-waste management and disposal can prevent diseases of the skin, respiratory, digestive, immune, endocrine, and neurological systems as well as cancers, as e-waste is known to include heavy metals, hazardous chemicals, and carcinogens. Therefore, keeping the environment and human health in a state of equilibrium depends on properly managing electronic waste. The purpose of this study is to discuss the causes and effects of environmental e-waste disposal. Specifically, it will cover the advantages and disadvantages of e-waste disposal, strategies for improving e-waste management, and effective ways to use them to promote environmental health.

Keywords:- *Electronic Waste, Disposal, Management, Remediation, India, Toxicity.*

I. INTRODUCTION

Electronic garbage, or "e-waste," has grown to be a significant problem in India. With regard Electronic waste, the fastest-growing portion of the world's formal municipal trash stream, has raised worries about the environment and public health (Dahl 2002). Electrical and electronic waste (WEEE), also referred to as e-waste, is any electrical or electronic equipment that has been discarded, overstocked, out-of-date, or damaged. (CPCB, 2008: Sustainable electronic waste management guidelines.) Most of the discarded electrical equipment in India is stored in residences, because individuals are unaware of the correct disposal methods. This ever-growing waste is also extremely complex, with an abundance of metals, including copper, silver, and gold, that could be extracted and added back into the manufacturing process. E-waste trade and recycling agreements have created jobs for a large number of Indians (Baudl et al., 2001). In Delhi alone, 25,000 workers—including minors—manufacture between 10,000 to 20,000 tonnes of electronic waste by hand every year in outdated dismantling plants. The environment and public health are at risk from improperly dismantled and processed e-waste. (Pandve, undated) To address this growing hazard, it is imperative to assess the public health challenges and policies. The information and communication revolution of the 20th century has fundamentally altered how our institutions, businesses, and economies are structured. A plethora of new problems have also emerged as a result of it, including the enormous volume of trash produced by electric products, particularly hazardous waste, which poses a significant threat to contemporary society and necessitates coordinated effort in order to achieve sustainable development. The scientific and technological breakthroughs of the 18th century led to a new era in human civilization marked by the industrial revolution. Our lifestyles, economies, industries, and organisations are no longer the same after the twentieth-century information and communication revolution. Without a doubt, these amazing modern technological developments have made our lives better. Concurrently, This has led to a variety of problems, such as the quantity of trash produced by waste from other electric products and hazardous waste. The environment and public health are seriously threatened by these and other dangerous contaminants. Therefore, proper waste management is essential for safeguarding the environment, human health, and means of subsistence. It is a serious issue facing contemporary society, and in order to achieve long-term progress, coordinated efforts must be made to find a solution. Moreover, wastes are things that people have to get rid of because they are unhealthy. Numerous different wastes are produced by our routine activities from a variety of sources. On the other hand, home rubbish, or municipal waste, is made up of things like paper, organic waste, metals, and other things. Households, Companies manufacturing plants, and other entities all generate hazardous waste. Pharmaceutical trash, sharps waste, microbiology and biotechnology waste, animal waste, and other biomedical waste are only a few of the several types of

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biomedical waste produced by hospitals and other healthcare facilities. Radioactive waste is defined as any material with a radionuclide content higher than that which is considered safe by national authorities and for which no application is foreseen. Agricultural residues, tyres, automobiles nearing the end of their useful lives, packaging garbage, and various other types of waste are included. These waste compounds are dangerous over time because they are toxic, explosive, combustible, corrosive, reactive, poisonous, or infectious. They thereby represent a significant, even hazardous, risk to public health and environment.

A. Composition of e-waste

Included are a variety of household products such as air conditioners, refrigerators, LCD/plasma TVs, cell phones, chargers, batteries, compact discs, headphones, and others, along with computer screens, printers, keyboards, and CPUs (Neha Lalchandani 2010). E-waste can be categorised as "hazardous" or "non-hazardous" based on its makeup. Iron and steel comprise around half of the waste, with plastics making up The remaining ingredients are made up of various materials (21%), and non-ferrous metals (13%). In addition to precious metals like silver, gold, platinum, palladium, and others, non-ferrous metals include copper and aluminum (Ibid). Because e-waste contains metals including lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants in excess of threshold levels, it is dangerous for the environment. When disposed of, it greatly pollutes the environment and contains around a thousand different compounds, many of which are toxic (The Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC) 2002). Outdated computers are the biggest source of e-waste and the biggest threat to the environment and public health.

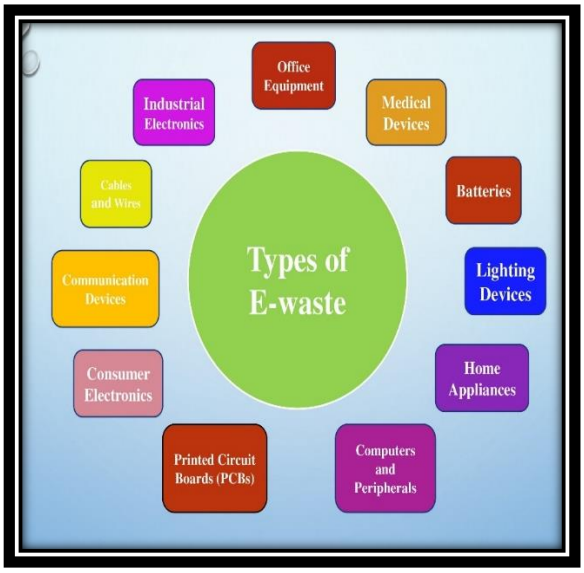

Fig 1 Types of E- waste

B. E-waste disposal technologies currently in use

As of right now, e-waste is disposed of using acid baths, incinerators, and landfills.

➢ *Landfills*

One term for e-waste that finds up in landfills is "poisonous time bomb." Natural processes could eventually release them into the environment, and there's also a chance of waste leaching—batteries, Lead, zinc, nickel, copper, mercury, and cadmium can, for example, leak and combine with acids to form heavy metals, also leak from electrical circuits. These contaminants may find their way into land-based waterways, where they may combine with other freshwater resources, such as rivers and streams, and end up in the food chain for both humans and animals. Most of the electronic garbage produced in the US an Australia is disposed of in landfills (Sivakumaran Sivaramanan 2013).

➢ *Acid baths*

Copper is removed using acid treatments. The copper dissolves after the circuit board has spent about 12 hours immersed in sulfuric acid. The solution is further heated to a boil, the precipitated copper sulphate is extracted, scraped particles are added to the remaining solution, and the copper smudges are eliminated. In addition to extracting gold and silver, acid baths were also employed to dissolve lead (Sivakumaran sivaramanan 2013).

➢ *Incineration*

Pyrolysis is another process that goes along with incineration; with pyrolysis, a material is heated without oxygen, changing it into gases, oils, and charcoal instead of burning it. Compounds created during incineration are probably more hazardous than they are in their natural state. On the other hand, gasification uses a limited sufficient air to cause the chemicals to release fumes, ash, and tar. In Pakistan, India, Africa, and China, incinerating e-waste is a common method of disposal. Smoke contains concentrations of lead, nickel, copper, manganese, mercury, thallium, arsenic, and antimony among other heavy metals; very small amounts are detected in the ashes (Sivakumaran Sivaramanan 2013)

C. E waste management technologies

➢ *Collection and Segregation:*

E-waste Collection Centers where Setting up specific locations to collect e-waste is an essential first step. These locations, which can be automated or manned, allow people and companies to drop off their electronic gadgets for disposal. Automated Sorting Systems such as Robotic arms, conveyor belts, and sensors are some of the technologies used in automated e-waste sorting systems. This facilitates the effective separation of various electronic device kinds.

➢ *Reuse and Renovation:*

- *Facilities for Refurbishment and Donation Programs:*

A portion of e-waste can be fixed and repurposed. Electronic equipment malfunctions are found and fixed by refurbishment centers, prolonging the gadgets' useful lives. E-waste can be decreased by promoting the donation of working electronics to people or charities that are in need.

➢ *Techniques for Recycling:*

D. Mechanical Shredding

Electronic garbage can be cut into tiny pieces using a machine. This makes it easier to separate various materials so that they can be recycled, like glass, plastic, and metal.

➢ *Hydrometallurgical Processes*

These entail the extraction of valuable metals from electronic trash using chemical solutions. Recovering precious metals like gold, silver, and palladium is especially helpful in this regard.

➢ *Pyrolysis*

This technique heats e-waste without oxygen, causing materials to break down into liquids, solids, and gases. The end products can be utilized as chemical feed stocks or as fuel.

➢ *Biotechnological Processes:*

Research is being conducted on the use of microbes to extract valuable metals from electronic trash, which may be an environmentally beneficial method.

➢ *Secure Data Destruction:*

- *Data Wiping Software*

It's important to make sure that sensitive data is permanently deleted before recycling or discarding electronic equipment. Software designed to wipe data can erase storage media in order to prohibit data recovery.

- *Shredding and Degaussing*

To guarantee data security and irrevocably erase storage media, physical destruction techniques like shredding and degaussing can be used.

➢ *Programs for Extended Producer Responsibility (EPR):*

Manufacturers are encouraged by EPR initiatives to assume accountability for the full life cycle of their products, which includes recycling and appropriate disposal. Partnerships with recycling facilities can help with this.

➢ *Blockchain Technology:*

This technology can be utilized to manage e-waste in a transparent and traceable manner. It ensures accountability by tracking electronic gadgets' whole life cycle, from manufacture to disposal.

➢ *Public Education and Awareness:*

A crucial component of e-waste management is raising consumer knowledge of the effects that e-waste has on the environment and the significance of disposing of it responsibly.

E. E-waste disposal methods that are safe and e-waste management authority

The safest method comprises reusing and recycling materials, including metals, and entails setting up an industry-wide infrastructure for e-waste collection. Putting in place appropriate regulations to make the following requirements for disassembly: donning safety glasses, masks, and gloves; avoiding quick extraction methods like burning, which emits toxic emissions; preventing acid baths and dumping; and maintaining strict laws against the disposal of e-waste in landfills due to the possibility of leakage or release of the material into groundwater. establishing stringent restrictions to fend off political pressures and incursions, supporting the Basel convention's agreed-upon legislation, and putting in place an appropriate system for holding onto gathered and separated e-waste till it is needed to make goods. Prohibit the sale of electronic goods that include hazardous materials; bring legal action against unauthorized collectors and dismantlers of electronic waste; provide funding for research initiatives to find safer alternatives to chemicals that cause cancer and other harmful substances; and monitor the flow of e-waste through state municipal borders, ports, and harbors. The e-Stewards accreditation scheme was developed by environmental organizations including the Basel Action Network (BAN) and the Natural Resources Defence Council (NRDC) following discussions with manufacturers and e-waste processors. By becoming certified as E-stewards, recyclers may demonstrate that they follow tight regulations that protect both the environment and workers during the recycling process. Furthermore, as noted by the NRDC (2012), the BAN maintains a registry of organisations authorised to act as subscribed e-stewards; the first recognised standard originated in 2010. Advocates such as BAN and NRDC are currently campaigning to make sure that exporters of e-waste are prohibited from exporting their products under any circumstances (NRDC 2012). In addition, a number of US states have put in place legislation requiring electronic product producers to accept liability for their creations. Therefore, after products are used, a large portion of the responsibility for collecting and recycling them is placed on electronic makers. Public awareness programs are crucial in educating the public about the handling and disposal of e-waste.

F. Measures to be undertaken to manage electronic waste

➢ ***Rapid Technological innovation:*** The output of electronic devices has increased significantly as a result of the unrelenting speed of technological innovation. Because of this, many electronic items now have shorter lifespans, which adds to the growing issue of e-waste.
➢ ***Environmental Impact:*** There are serious environmental concerns associated with improper e-waste disposal. Lead, mercury, and cadmium are among the hazardous materials found in electronic equipment that can contaminate soil and water, damaging ecosystems and posing a health risk to people.
➢ ***Depletion of materials:*** In order to manufacture electrical gadgets, precious and frequently finite materials must be extracted and used. With so many of these materials having potential for recycling and reuse, e-waste represents a lost opportunity for resource recovery.
➢ ***International Trade of E-Waste:*** This problem is made worse by the international trade of e-waste, which frequently goes to developing nations with laxer environmental laws. For those engaged in informal

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recycling, this may result in health problems as well as further environmental damage.

- ***Potential for Responsible Recycling:*** Recovering valuable resources and safely disposing of hazardous materials are only two examples of the responsible recycling techniques that must be adopted in order to manage e-waste effectively. It is essential to support the creation and application of sustainable e-waste recycling techniques.
- ***Consumer Awareness:*** Increasing consumer knowledge of how electronics affect the environment and encouraging appropriate disposal methods are crucial first steps in solving the e-waste issue. Promoting the purchasing of robust and readily recyclable goods will help lower the amount of e-waste produced.
- **Regulatory Measures:** To regulate the manufacture, disposal, and recycling of electronic gadgets, governments and international organizations are essential in putting regulations into place and enforcing them. Tight enforcement can deter illicit dumping and encourage ethical e-waste disposal.
- ***Industry Responsibilities:*** Electronics producers have a big say in how their products are used throughout their lives. In order to address the issue of e-waste, companies must embrace sustainable design, use recyclable materials, and assume accountability for the end-of-life management of their goods.

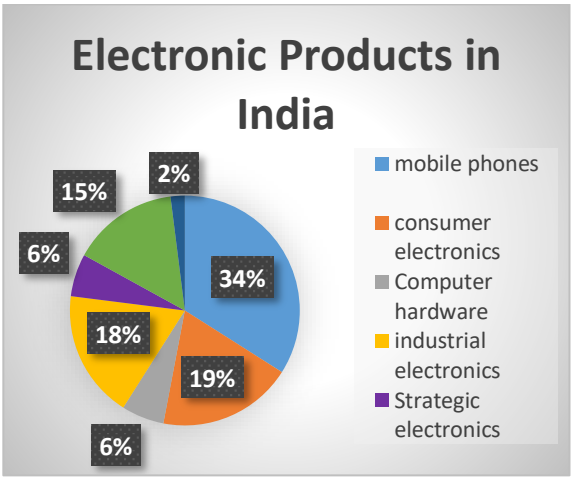

Fig 1. Electronic products in India

G. Recycling of electronic trash.

The first two stages of recycling e-waste are manual collecting, sorting, separating, and disassembly; mechanical processing, which involves shredding, grinding, and other techniques, comes next. The right facilities receive the recovered materials so they can undergo additional processing and resource recovery. E-waste recycling is a broad phrase with many different stakeholders. Ensuring long-term e-waste management is the obligation of every link in the value chain. Manufacturers must shift from creating products with obsolescence in mind to ones with reuse in mind. Stakeholders must be informed by authorities of the possible dangers connected to e-waste. Customers need to start delivering their electronic waste to recycling and disassembly centres that employ eco-friendly techniques to handle the waste (Siddharth Ghanshyam Singh, 2020).

H. E-Waste Management: Where Are We Now?

With so few organised e-waste recycling facilities, India's e-waste recycling largely relies on the unorganised industry. The majority of the nation's urban slums handle and process over 95% of the nation's e-waste, where inexperienced workers carry out hazardous tasks without wearing personal protective equipment, endangering both their health and the environment. Facilities for recycling and treatment need hefty upfront costs, particularly those with extremely complicated machinery and procedures. Hicks and associates (2005) Only one computer component disassembly results in payment for these labourers. For such a little amount, workers' lives are destroyed (2009, Silicon India News Bureau). These backyard recyclers lack access to personal protective equipment, exhaust-waste gas treatment, and wastewater treatment facilities (Roman and Puckett, 2002). According to Williams (2005), the problem appears to be getting worse even with a lot of media coverage and the introduction of several national-level trade restrictions (mostly from China and India). For this reason, health risk assessments are particularly important in poor nations to look into the consequences of improper handling of electronic trash that has reached the end of its useful life (Yanez et al., 2002).

I. Remedial measures for e-waste:

- *Rduce, Reuse, and Recycle:*

- ***Reduce:*** Promote the creation of electronic gadgets with minimal environmental effect, longer lifespans, and upgradeable components.
- **Reuse:** To increase the longevity of functional electronic gadgets, encourage their refurbishment and reuse.
- **Recycle:** To extract useful elements from e-waste, set up effective recycling processes.

- *Gathering and Sorting:*

Put in place suitable collection methods to make sure e-waste doesn't end up in conventional trash streams. Sort e-waste according to the materials it contains to make recycling and handling it simpler.

- *Safe Handling and Elimination:*

Create and put into practice eco-friendly techniques for disposing of non-recyclable electronic waste.Make certain that dangerous substances are appropriately removed and handled in order to avoid contaminating the environment.

- *Eco-friendly Technologies:*

Investigate and finance the development of novel and sustainable e-waste recycling technologies, such as bioremediation and ecologically friendly extraction techniques.

- *Rules and Legislation:*

Stricter enforcement of laws governing the recycling and disposal of e-waste. Put in place programs for extended producer responsibility (EPR), which make producers responsible for the management of their products' end-of-life.

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- *Public Education and Awareness:*

Raise public awareness of the harm that incorrect disposal of e-waste causes to the environment. Inform customers about appropriate disposal and recycling procedures as well as responsible e-waste management methods.

- *Global Collaboration:*

Encourage international cooperation in addressing the broad scope of e-waste problems. Disseminate technology and best practices for managing e-waste globally.

- *Research and Innovation:*

Encourage research and development initiatives to find fresh approaches to e-waste cleanup that are both more effective and efficient. Promote creativity in electronics design to make recycling simpler and use fewer dangerous materials.

II. DISCUSSION

Trash produced by electronic devices, such as computers and cell phones, that have reached the end of their useful lives is known as "e-waste," or electronic waste. This is the kind of waste that is growing at the fastest rate on the planet. Global e-waste generation is expected to exceed 50 million tonnes by 2020 (Balde et al., 2017). With an estimated 2 million tonnes of e-waste created annually, India is among the top five countries in the world. Similar to many other developing nations, the unorganized sector—which is thought to handle more than 90% of the waste—handles the majority of India's e-waste. Numerous valuable metals, rare earth metals, ferrous and non-ferrous metals, plastic, wood, and glass products can all be found in e-waste. Unproven e-waste processing techniques have been linked to several negative consequences on human and environmental health (Toxic connections 2014). In the last few decades, many developed and developing countries have implemented laws in response to these concerns. Different legal organizations have different definitions for the word "e-waste". E-waste, or waste electrical and electronic equipment, is defined by the European Union (EU) as any electrical or electronic equipment that is disposed of, including any and all parts, subassemblies, and consumables that are still linked to the product after it is finished, according to Anon (2013). The main characteristic that sets e-waste apart is that it must be disposed of since it is no longer fit for its intended purpose. Everything that is considered end-of-life that we want to get rid of for recycling and disassembly is referred to as "e-waste". If any equipment is maintained in a home, repository, or warehouse and is not disposed of, it will not be called e-waste. There are many different sources of e-waste, including homes, big clients like government agencies and businesses, producers, and merchants. The majority of e-waste that we observe being collected or recycled is most likely from ten years ago and has reached the end of its useful life; with the right care, the remaining parts can be repaired or utilized once more. E-waste includes appliances like computers, air conditioners, washing machines, refrigerators, televisions, and vacuum cleaners. Glass waste is predicted to account for 37% of all e-waste, followed by metallic debris at 33% and plastic waste at 30%, according to Anon (2018). E-waste has been dubbed the world's trash stream that is expanding the fastest because some types of e-trash are increasing exponentially (Balde et al., 2017). The United Nations has labelled this sharp rise in e-waste a "tsunami". A World Economic Forum report suggests that although e-waste is a contributing factor to the issue, it may also be a major force in fostering a circular economy and offering a solution. It is simple for producers, manufacturers, and retailers to categorise e-waste as a post-consumer issue. But making such an assumption won't result in a workable solution. Stakeholders such as designers, manufacturers, producers, investors, traders, miners, producers of raw materials, consumers, legislators, and other stakeholders like refurbishers, dismantlers, collection centers, and recyclers all play crucial roles in ensuring a closed loop, reducing waste, and maintaining value for products through repair, reuse, and recycling. When an item of equipment reaches the end of its useful life, its manufacturer is in charge of handling and disposing of it, together with any consumables and replacement parts. The E-waste Management Rules, 2016 in India contain this information. For its kind, the electronic industry is the largest and most creative in the world. Tonnes of electronic equipment are transported across the oceans each year, but after they are used, they release a complicated waste product that contains many hazardous heavy metals, acids, poisonous compounds, and non-biodegradable polymers. When it comes to utilising e-waste for purposes like refurbishment, remanufacturing, and part reuse for repair, among other things, more than 75% of it is unclear of its intended application. Others are trash that clogs up precious space in offices, warehouses, and commercial buildings. Most electronic recyclers shipped dangerous goods to China, Africa, and India, including circuit boards, mercury lamps, and leaded glass 2013 saw the upload of Basel Action. Dismantling is a labor-intensive process that includes unscrewing, tearing, shredding, and burning; in places like China and parts of India, tons of e-waste are burned for disposal. In addition to a range of respiratory and skin conditions, smoke and dust particles include carcinogens and other dangerous compounds that can result in serious inflammations and blisters. Although PVC and PCB used in their wire coverings might cause skin cancer, circuits are burned to extract precious metals such as gold, platinum, and cadmium (Kevin et al., 2008). Data from 2007 indicates that China receives more than 70% of the world's produced e-waste, with the remaining portion going to Africa and India. Their low labor costs have allowed them to grow into the largest e-waste dumping site in the world, with around 20% of Ghana's workforce to process and then use reconditioned electronics (Basel Action uploaded on 2013). Because of their poverty, third-world nations use e-waste from Europe and the US.

III. CONCLUSION

The fact that e-waste is dangerous is one of the environmental issues facing the world that is expanding the fastest. The problem is getting worse due to an increase in e-waste and a lack of knowledge and experience in relevant industries. Numerous workers in India risk their health by forcefully disassembling these electrical devices for a living. Therefore, there is an immediate need for a plan to shield these employees from the health hazards related to managing e-waste. These staff members ought to receive the necessary instruction on how to safeguard oneself and properly dispose of e-waste. There are a lot of technical solutions available for managing e-waste, but in order to be included in the management system, they need to satisfy certain criteria including labour, logistics, collecting systems, and laws. It is likely that assessment studies and operational research will be necessary. The unorganized sector in India Its broad reach and capacity to access waste from both urban and rural locations have made it essential to the management of e-waste. It's critical to acknowledge that India possesses unique capabilities for gathering and combining data, which it may use to improve urban poor people's quality of life and the environment. The challenge lies in establishing a meaningful connection between the law and the unorganised sector, something that can only be achieved if the law recognizes the unorganised sector's existence and involvement. The current regulation should be revised by the Ministry of Environment, Food, and Climate Change (MoEFCC) to more clearly recognize the informal sector's contribution to the disposal of e-waste. Additionally, the government sectors can work to increase public awareness, which has the potential to be a strong driver for changing consumer behaviour. One possible model for the campaign might be the Swachh Bharat Mission, which strives to make India cleaner.

Consequently, we can state with confidence that India is capable of handling its own e-waste and ensuring that it is done so in a way that is sustainable for the environment. It has been demonstrated that public awareness and manufacturer participation are crucial to the development of the e-waste management system. In addition, governments have to provide the necessary funding and uphold domestically the internationally agreed-upon environmental regulations. By stopping unauthorised e-waste handlers and traffickers, licencing certifications like e-stewardship may boost security. Cross-border flows of e-waste are currently being actively prevented or controlled by the Basel Action Network. In addition, they are engaged in building research facilities to discover better solutions or substitutes, as well as public awareness campaigns aimed at educating people worldwide. E-waste can lead to cancer as well as illnesses of the skin, respiratory, digestive, immune system, endocrine system, and nervous system because it is a known source of carcinogens, hazardous chemicals, and heavy metals. In conclusion, solving the e-waste issue calls for a thorough and cooperative strategy including people, companies, governments, and international organizations. We may endeavor to lessen the negative effects that electronic waste has on the environment and society by spreading awareness, putting responsible practices into place, and supporting sensible legislation.

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