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Global Perspective of Disposal, Recycling of E-Waste: Impact on Environment

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ABSTRACT:

"E-waste," short for electronic waste, refers to electronic products that are nearing the end of their useful life or discarded due to the availability of newer and more advanced products in the market. The issue of e-waste has escalated into a significant global problem. The noxious by-products from these discarded electronics combine with untouched soil and air, resulting in detrimental effects on the entire ecosystem, both directly and indirectly. The direct consequences involve the emission of acids and toxic compounds, including heavy metals. Indirect impacts encompass the bioaccumulation of these heavy metals. Numerous private enterprises engage in the collection, disassembly, separation, and exportation of e-waste for recycling purposes. Items such as televisions, copiers, computers, VCRs, stereos, electric lamps, fax machines, audio equipment, cell phones, and batteries, if improperly disposed of in soil and groundwater, pose a serious threat to human health and the environment. Many of these products have the potential to be repaired, recycled, or repurposed in an environmentally responsible manner, thereby minimizing their negative impact on the ecosystem.

Keywords: E-waste, Recycling, Environment, Disposal

1. Introduction

Globally, the electronics industry is the biggest and most creative industry in its category. Huge amounts of electronics are sent across oceans every year, but after their useful lives are up, they decompose into complex waste products that include dangerous heavy metals, acidic chemicals, poisonous substances, and non-biodegradable plastics. Many things are haphazardly thrown out, burned, or exported for recycling. However, about 75% of e-waste has no idea what to do with it; it's either left to wait for decisions on how to use it or look into ways to repurpose it, which includes things like refurbishing, remanufacturing, and using its components again for repairs.

E-waste is a complex mixture of various pollutants. These include base metals like copper and aluminum, refractory oxides like SiO2 and Al2O3, precious metals like gold, silver, and platinum, and heavy metals like lead, cadmium, mercury, barium, arsenic, beryllium, chromium, and selenium. These substances include polyesters containing polychlorinated diphenyl ether (PCDEs) and polybrominated biphenyls (PBBs), as well as chlorinated compounds like polyvinyl chloride (PVC) and polybrominated flame retardants (PBDEs and PBBs). These metals pose a harmful and potentially dangerous risk to human health and the environment when they are found in e-waste.

Because e-waste contains a variety of resources, including metals, glass, and plastics, recycling it is an important way to obtain raw materials. However, because collection and recycling are so difficult, only 17.4% of the world's e-waste is actually collected and recycled. E-waste includes dangerous halogen metals and other metals with diverse physicochemical characteristics, making recycling it a challenging task. Substances that contain these dangerous compounds could endanger the environment if they are not disposed of correctly. Some parts of China, like Guangzhou, continue to have health hazards because of poverty-related behaviors utilizing e-waste, which includes old computers and television sets. Statistics from 2007 showed that China accounted for around 70% of the global e-waste, with the remaining portions going to Africa and India.

Because they have access to cheap labor, these nations have essentially turned into global recipients of e-waste. Remarkably, almost 20% of Ghanaians handle e-waste, frequently restoring this abandoned equipment. The Basel Action Network recorded these observations in 2013. The main cause of poor countries' propensity to take in e-waste from wealthier areas like the USA and Europe is still poverty.

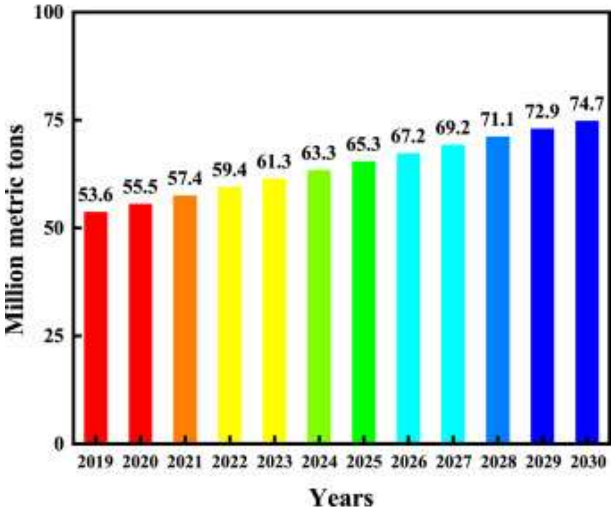

Fig 1**:** Global forecasting of e-waste [3]

2.Literature survey

When we listen modern world first thing come in our mind is electronics devices and advance technology. When there is electronic device then there is electronic waste (e-waste) we all know now what is electronics waste in simple language e-waste is the electronic devices which is no longer used or not working properly. Now a days people change electronics devices so fast as per there requirement and there comfort just like new phone launch after year then people by it and old mobile is no longer used this is the how e-waste generate. E-waste is not only our country problem but it is the global problem.

When we listen e-waste then eventually e-waste management comes in our mind for e-waste management there are so many options available like recycle, dispose and many other. There are some laws also form by government for e-waste management. This e-waste management is work but in low performance as we talk in percentages this system is works only 15-20 %. We all know the solution of the problem and we applied it but due to this solution environment faces some serious problem. The methods of recycling and disposal affect environment very badly. In this paper we discuss about the methods of dispose and recycling, and these methods are harmful for environment.

In this paper discussed some current methods of Recycle and disposal method like landfills, Acid baths, Incineration and other and how they are harmful for environment.

3. Methodology

1.Dispose Methods

1.1. Landfilling:

One of the most common ways to dispose of electronic garbage (e-waste) is through landfills, but due to the harmful effects it has on both the environment and human health, this practice is not environmentally sustainable or advised. I can, however, go into great depth about the landfilling method of e-waste disposal.

Gathering: The procedure starts with the gathering of electronic waste from different sources, such as homes, businesses, and governmental organizations. Electronics including outdated PCs, monitors, TVs, mobile phones, and other electronic gadgets may be included in this garbage.

Transportation: E-waste that has been collected is taken to a designated dump. The debris may be divided into reusable or recyclable and non-recyclable components at a collecting facility, but in many instances, it is shipped straight to the landfill without any prior processing.

Landfilling: E-waste is often disposed of in landfills in a way akin to how other solid garbage is. To save space, it is compacted and deposited into predetermined locations. Typically, soil or other materials are used to cover the garbage.

Leachate Management: Through a chemical called leachate, e-waste at landfills has the potential to discharge hazardous substances into the environment. When rainwater or other liquids come into contact with the heavy metals and chemicals in e-waste, leachate is created. Leachate must be collected and treated by landfill operators to keep it from harming groundwater.

Gas collection: As e-waste breaks down, dangerous gases including methane and volatile organic compounds (VOCs) can be released. Some contemporary landfills have mechanisms in place to catch and treat these gases, limiting the emission of those gases into the environment.

Environmental Impact: Improper disposal (landfilling) of heavy electronic equipment containing metals like lead, barium, mercury, and lithium can lead to water pollution. These metals can leach into the soil, eventually reaching groundwater and flowing with rainwater into small ponds or rivers, thereby contaminating these vital water sources. The pollution caused by these toxic elements can harm both plants and animals that rely on these water bodies for sustenance. When people and land creatures consume water contaminated with these pollutants, it can result in various health issues, including liver and kidney damage. This improper disposal of electronic waste is a significant environmental concern, as it not only affects the ecosystems but also poses health risks to humans and wildlife. Proper e-waste management and recycling are essential to mitigate these adverse effects on the environment and public health.

Most E-waste is currently landfilled. Using the Toxicity Characteristic Leaching Procedure (TCLP). E-waste disposal in

modern municipal solid waste landfills is unlikely to result in lead leachate concentrations of regulatory concern. However, most of the research papers demonstrated that the chemical cocktail leached from various consumer electronics using TCLP was toxic to aquatic organisms.

1.2. Acid Bath:

This procedure involves soaking the e-waste in powerful sulfuric, hydrochloric, and nitric acid solutions to dissolve the metal. The salvaged metal is then used to make other things. This method also has downsides, such as the occasional dumping of acid solutions into water supplies, which is harmful to living organisms.

Environment Impact: Acid bath contains many like sulfuric, hydrochloric, etc when metal soak in acid then reaction happened from that reaction many toxic chemicals released which cause air pollution and effect on human who done that process.

Fig 2: Dissolved copper in the acid bath turned the solution green [2]

1.3. Incineration

Electronic waste (e-waste) items are burned under regulated conditions to create ash and other residues as part of the incineration method of disposal. Although incineration has a number of environmental and health risks, it can be a useful method for reducing the amount of e-waste. Here is a thorough explanation of how to dispose of electronic waste by incineration:

Collection and Sorting: E-waste items are first gathered from a variety of sources, including homes, businesses, and institutions. Next, the materials are sorted. E-waste is frequently separated to distinguish between recyclable and potentially dangerous parts and non-recyclable materials.

Pre-treatment: Some pre-treatment may take place before incineration. This can entail removing dangerous items or substances that aren't good candidates for burning, like plastics and other non-combustible materials. The process of incineration is to be improved, and dangerous substance emissions are to be decreased.

Incineration Process: E-waste is placed into an incinerator, a specialized furnace made to burn garbage at high temperatures, as part of the incineration process. The following steps are commonly included in the incineration process:

a. Combustion: E-waste is heated to high temperatures (typically between 900°C and 1,200°C) while being exposed to oxygen. The organic components combust as a result, releasing heat as the energy.

b. Pollutant Control: To capture and treat emissions, incinerator facilities are fitted with air pollution control equipment. Scrubbers, baghouse filters, and electrostatic precipitators are some of the equipment that can be used to filter out particulate matter, heavy metals, and other pollutants from exhaust gases.

c. Energy Recovery: Some incineration plants are made to produce electricity or heat in order to recover energy from the burning process. This can reduce the energy required for incineration and improve its environmental sustainability.

Residue Management: Ash and non-combustible residues make up the residual components following incineration. Normally, a landfill or a facility for the disposal of hazardous waste receives these remnants.

Environment Impact and Issues Relating to Incineration

Air Emissions: Incineration has the potential to emit harmful compounds like dioxins and furans into the atmosphere. To reduce these emissions, proper pollution control technology and monitoring are crucial.

Health concerns: Communities close to incineration operations may be exposed to health concerns, including respiratory conditions and other health difficulties.

Incomplete Destruction: Incineration may not entirely eliminate all hazardous components of e-waste, which could result in the release of dangerous chemicals into the environment.

Resource Waste: Rare earth elements and precious metals found in e-waste cannot be recovered through incineration.

Many regions have shifted toward alternative e-waste management strategies, such as recycling and responsible disposal, in light of the environmental and health risks involved with burning.

Fig 3. Percentage Disposal of E-Waste In IT Sector [5]

2.Recycling process

Recycling is most beneficial and safe process for e-waste management the most important in this is it takes care of hazardous material and dispose it properly it contains many steps such as

1. Collection: Individuals, companies, and electronic retailers are among the sources from which e-waste is gathered. This process is often facilitated by collection sites, drop-off locations, or recycling initiatives.
2. Sorting: Depending on the kind of materials and equipment used, the gathered e-waste is divided into several categories. This makes it easier to distinguish between parts that can be recycled and those that need to be disposed of specifically.
3. Disassembly: E-waste is broken down into its component pieces, including circuit boards, wires, batteries, polymers, metals, and other materials. There are both automatic and manual techniques for disassembly.
4. Hazardous Material Removal: To avoid contamination, hazardous materials such as lead, mercury, and cadmium are taken out and stored securely. In order to safeguard the environment and the recycling workers, this procedure is essential.
5. Component recovery: Component recovery is the process of separating and preparing valuable parts for reuse or resale, such as capacitors, semiconductors, and connectors. Refurbished parts could be used in other electronic equipment.
6. Shredded and Size Reduction: To make further processing easier, non-reusable parts and materials are shredded and made smaller. Shredded and Size Reduction: To make additional processing easier, non-reusable parts and materials are shredded and made smaller.
7. Metal Recovery: A variety of methods, such as shredding, crushing, and smelting, are used to recover ferrous and non-ferrous metals, such as copper and aluminium, as well as precious metals, such as gold and silver.
8. Plastic Recycling: After processing and recycling, plastic from e-waste is turned into pellets that can be used to create new plastic goods.
9. Recycling Glass: Older TVs and CRT monitor glass is separated and recycled.
10. Processing of Circuit Boards: Precious metals like gold and silver are found on circuit boards. There are several ways to extract these metals, including smelting and chemical stripping.
11. Data Destruction: To safeguard confidential information, data-containing devices such as solid-state drives and hard drives are safely erased or destroyed.
12. Reuse and Refurbishment: Refurbished and resold are some e-waste products that are still usable or repairable. By doing this, the need for new electronics is decreased and the lifespan of existing ones is increased.

13. Responsible Disposal: To avoid pollution and harm to human health, any parts or materials that cannot be recycled are disposed of responsibly by adhering to environmental regulations and guidelines.

14. Documentation: Ensuring compliance with environmental and safety regulations throughout the recycling process requires proper documentation and record-keeping.

15. Environmental Compliance: To guarantee that the recycling process is carried out safely and with the least amount of negative impact on the environment, e-waste recyclers are required to abide by environmental laws and regulations in their locality.

Fig 4: Global recycling of e-waste rate [4]

E-waste recycling encourages a more sustainable method of managing electronic products at the end of their lifecycle, helps recover valuable resources, and lessens the environmental impact of disposing of electronic waste. Selecting trustworthy e-waste recycling facilities that adhere to ethical and sustainable standards is crucial.

4. Impact on environment due to e-waste:

Air:

The informal sectors can recover the valuable materials from the e- waste but they will pollute the environment due to informal processing methods such as burning the unsoldering circuit boards over coal-fired grills in open air, melting plastics, burning cables for removing the cop- per, shedding metals by acid bath and dismantling printer cartridges. At last, these extractions may ended-up with the dumping of invaluable materials or throwing residues at the riverbanks (Zhang et al., 2012). For example, fly ash could be produced by burning the PCB in an open facility that has high concentration of tin, copper, lead, bromine and low concentration of zinc and antimony. They may mix up with airborne particles resulting in indirect exposure through contagion of soil, food and surface. Dust particles released into the atmosphere from the e-waste dis- mantling sites has flame retardants and heavy metal particles. These particles can travel longer distances through air and also pollutes the water or soil. Considering the E-waste recycling areas such as Delhi (India) and Guiyu (China) confirms that air, dust, soil and water has very high level of PCDD, PCDF, PBDE and lead content due to the improper disposals (Chakraborty et al., 2021; Xu et al., 2015). At the same time, the organic pollutant like brominated flame retardants were found more in the city like Taizhou (China) which is far away from the waste dump yards (Pascale et al., 2017) and chemicals from informal metal recycling in Guiyu (Kim et al., 2020).

Yet, there is no one reported for direct or immediate harm due to the exposure of e-waste. But the long-term exposure of e-waste by workers may have the few symptoms based on the substances available in the air (Ackah, 2017). In Ha et al. (2009), nearby areas of disposal and recycling process in Bangalore and Chennai has been tested with reference to the United States of America Environmental Protection Agency value to identify the affected rate of air, soil and humans due to e-waste acquaintance. The result seems alarming because the lead in soil, chromium and cadmium in air exceeds the reference value which was suggested by US Environmental Protection Agency (Borthakur and Govind, 2017; Pascale et al., 2017).

Due to improper e-waste disposal in China headed to deposition of toxic metals like lead, mercury and cadmium which make soil contagion leads to affect the irrigation areas especially crops. It will reach the human and livestock through the food chain consumption for long- term makes severe health issues (Fu et al., 2008; Kim et al., 2020). Microbes plays a crucial part in maintaining the biogeochemical cycles in the ecosystem. Due to the toxic landfills, air pollution and water pollution results in diminution of microbial diversity and in turn affects the overall ecosystem (Liu et al., 2015).

India is the fifth largest country for selling the automobiles in 2019 as per the report of India brand equity foundation. The EV are acknowledged as the future technology which reduces the air pollution in transportation sector yet it is limited in developing countries like India due to many challenges such as lack of charging infrastructure, automotive industry landscape and cost benefit. Due to the abovementioned challenges, the purchase of EV is limited. For motivating the EV consumers in India, the government has taken the various steps especially for exempting the income tax and percentage GST reductions to the owner of EV. The Delhi is the capital of India which suffers largely in air pollution. The transition from the fuel/gas-based. Although India have separate legal instruments for handling the battery but the safe recycling of lead-acid battery remains a challenging one. Initiating of the recycling process of battery starts form the consumer end. While purchasing a new battery, consumer gets discount while returning their old battery with authorized retailers. This recycling is carried out both in formal and informal modes. In formal mode, after receiving old battery from the consumer, it reaches to the manufacturer or authorized recycler through the retailer. Informal mode retailer may sell the batteries to the roving collectors who again sell it to the informal smelters through scrap dealers where they will perform the recycling process to remove the lead. Finally, it will reach to the local manufacturer and it may ready for the next selling process. In Gupta and Sahay (2015) , indicated that the informal smelters during the battery re- cycling process may emit the heavy pollutant as equivalent to the value of eight lakhs car running on the leaded petrol. This type of recycling predominately happening at Delhi and also many states in India (Gupta and Sahay, 2015; Gupta, 2020). Under this situation, India should focus on the lithium-ion batteries recycling because India lacks the authorized lithium-ion battery recycling plants for mobility batteries. Lithium-ion batteries are less hazardous as compared to other batteries but should not be dumped with normal waste materials. Suppose, if lithium-ion battery is properly recycled, the useful materials like aluminium, graphite, copper and cobalt may obtained (Media, 2019).

Water:

Mobile phones and batteries have many toxic metals. Suppose, the incorrect disposing of these metals would lead to contamination of soil and water. It is stated that the improper management of e-waste can affect the environment badly. For an example, a single mobile phone battery can pollute 6 lakhs litres of water (Moletsane and Zuva, 2018). Waste mobile phone plastics has mercury, chromium, lead, stibium, and bromine. When it is not handled properly, it may affect the environment and human health (Singh et al., 2020). It is also insisted that the open burning of the waste mobile phone plastics should be avoided to reduce the environmental pollution. Mercury is one of the voluminous noxious compounds in e-waste which can exist in any form such as liquid may create the numerous possibilities to pollute the environment especially the liquid form cannot filter quickly and last longer for even centuries (Needhidasan et al., 2014; Zeller, 2013).

E-waste treatment plant utilizes the hydrometallurgical process to re- move valuable metals like silver, tellurium, and gold from the various categories of e-waste. The nitric acid and cyanide have been used for re- moving the valuable metals through the process but it produces large amount of wastewater (Pollutant water) which contains many toxic compounds. If the wastewater consumed by the consumers directly or indirectly without proper waste water treatment leads to damage the human health adversely (Ackah, 2017). Due to water contamination in Pakistan, around 45% of infants die in every year and it happens because of the lack of water treatment plant in industries. Also, the groundwater in Pakistan has been highly polluted that adversely affects the agriculture sector (Janjua et al., 2021). High persistent and non-degradable metals as in the form of particulate matter can enter the human bodies through either inhalation or eating the food products Consumption of food products is the major pathway for entering these toxic metals into human body as compared with inhalation (Li et al., 2012). For example, micro plastics screening has been examined in several edible fish from the municipal water supply in Nigeria. Around 69.7% fishes have micro plastics in its stomach whereas only 30.3% fishes had no micro plastics. It should be noted that the native people consume more percentage of fishes which comes under this category (Adeogun et al., 2020).

Many people do not have the proper awareness to dispose either the electronic products or the waste from e-products so that the risk of water pollution increases which leads to intensify the reduction in biodiversity and socio-economic development (Kumaraswamy et al., 2020). Manufacturing industries such as battery, automobile, microelectronics and other industries utilize the copper metal which contributes more toxicants into the water bodies (Tabagari et al., 2020). Almost all the countries depend on the ground water in fully or partially for their survival and also utilized for farming, domestic and industrial purposes. But the ground water has been contaminated because of activities like leaching, dumping and e-waste processing entities (Postigo and Barceló, 2015).

Soil:

Soils from a site where acid leaching was used to recover valuable metals, containedupto4250 ng/gPBDEs (Leungetal.,2007). There are elevated concentrations of PCBs, PAHs (Shen et al., 2009a) and PBDEs (Cai and Jiang, 2006) in Chinese agricultural soils proximal to E-waste reprocessing sites. Luo et al. (2009b) reported PBDE concentrations of 191to9156 ng/g (dry weight) infarmlandsoils2 km from an E-waste recycling workshop. Soils from this regional so contain polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), PCBs and PAHs at concentrations up to 100, 330 and 20,000 ng/g, respectively (Shen et al., 2009b).

Liu et al. (2008) reported elevated concentrations of PBDEs and PCBs in soils, plants and snails from the town of Guiyu and the surrounding areas. PBDEs are translocated from soils to plants. Leaves of bracken fern (Pteridium aquilinum L.), spider fern (Pteris multifidi Pori.), sorghum (Sorghum bicolour L.), Japanese dock (Rumexjaponicus Houtt.) and Eastern daisy fleabane (Erigeron annuus L.) contained PBDEs at concentrations of 144, 116, 162, 278 and 326 ng/g (dry matter), respectively, when growing in soil containing 25,479 ng/g PBDE (Yang et al., 2008). Although the bioaccumulation coefficients are small.

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Analysis of rice samples from another E-waste processing town in Eastern China, Taizhou (Zhejiang province) revealed concentrations of Pb and Cd in polished rice to be 2–4 times in excess of 0.2 mg/kg, the maximum allowable concentrations of these elements in food stuffs in China (Fu et al., 2008). In the same town, Liang et al. (2008) measured elevated levels (up to 18 ng/g) of PBDEs in chicken tissues and concluded that these toxins may pose a threat to humans and ecosystems. Rice paddy soils adjacent to E-waste recycling areas in the Zhejiang province were shown to reduce the germination rate of rice (ZhangandMin,2009). Micronuclei as say using Vicia Fabia indicated that the contaminants in these soils also promote DNA damage.

5. Conclusion

Ethical, social, and environmental benefits are the main success criteria for the WEEE. Still, there are still a number of upcoming opportunities and challenges for their management. First, there are worrying signs of finite natural resources due to the massive amount of generation, which could have a impact, either directly or indirectly, on the recycling industry going forward. Nevertheless, the current laws and regulations will reduce pollution levels, but they can't fully address the issue of how informal tourism affects the environment. recycling, the alliance of e-waste recycling can be a constant source of concern for e-waste regulations. formed at a unique regional level. In a similar vein, e-waste in developed nations is subject to recover some items of value and to dispose of metal-containing materials safely. On the other hand, e-waste recovery in developing nations is primarily concentrated on a small number of valuable metals using antiquated methods. Furthermore, more in-depth study of bioleaching potential systems is necessary to identify systematic mechanisms. It is established that the advancement of the e-waste management system depends on manufacturer cooperation and public awareness. Additionally, governments have a duty to provide enough funding and safeguard the international agreements on environmental laws inside their boundaries. licensing for credentials such as e Stewardship could guarantee the safety to stop illegal electronic waste handlers and smugglers. Basisl Right now, Action Network is making every effort to cease or regulate the transboundary movements of e-waste, they additionally engaged in raising public awareness initiatives aimed at educating the global community and launching study areas to discover more effective techniques or substitutes. Given that e-waste is a known major source of carcinogens, hazardous chemicals, and heavy metals, as well as skin-related diseases, intestinal, immunological, endocrine, and cancers of the neurological systems can be avoided through appropriate e-waste management and disposal.

Without a doubt, the solid waste stream with the fastest rate of growth in the world is e-waste. The review article covered the origins of e-waste, the significance of managing e-waste, and the valuable and hazardous metal pollution in electronic waste. Additionally, this article has a critical review the annual growth rate of electronic waste as well as environmental and health consequences of the unofficial recycling and disposal of e-waste. Different e-waste disposal techniques and their benefits have included talked about. Information about recyclers and dismantlers in each state has been provided. This article concentrated on the rules, regulations, and consistent In India, tuition laws are mandatory. Each law's salient features have been delineated. Gave separate cusses. Based on the critical evaluation in a number of areas, India has been given recommendations for the future to enhance the formal e-waste disposal sector and raise consumer awareness of electronic appliances regarding e-waste disposal. The relevant legislation a year-round approach to the collection of municipal solid waste 2000. The work required to separate solid waste cannot be completed by hand. on their own. Additionally, there is an equal obligation to the customers. Because, depending on the kind of waste, they should dispose of it properly. Consequently, it is imperative to have knowledge about how to dispose of e-waste be made with residential customers in mind. Furthermore, the accessibility of local e- waste There should be more and more waste collection facilities available every time to enable customers to easily turn in their electronic waste. Consequently, the manufacturer should properly develop a streamlined process to the customer.

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