E –Waste Management in India; Treatment and Opportunities

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Abstract

The historical Industrial Revolution in the 18th century, which brought in a brand-new age for the enormous human race, was the cause of many advances in science and technology. In this 21st century people manage a lot of information's via media and technology as well as personal lives, economies and industries. This in turn has only developed and the different allied systems in people's lives which happen to have the relevance to the large-scale global advancement of the same. However, as is the case with most human inventions, there entails a grey side to this development also which has become to be holistically referred to as e-waste. E-waste (Electronic Waste)is anything electronic and electrical being disposed of, which by every metric poses a potential threat to the same fabric of life i.e., encompassing all forms of lives whether humans, animals, plants, etc. Consequently, the management of e-waste becomes highly imperative to a sustainable healthy living environment. The study bespeaks the condition of electronic trash in India, as well as potential, problems, and methods for managing it. This descriptive article also highlights the harmful health impacts, and the regulatory policies designed to safeguard marginalized citizens from improper e-waste disposal practices.

Keywords: Industrial Revolution, E-waste, Extended Producer Responsibility, Human Race, Sustainable Living Environment

1. Introduction

Asia is one of the world's most populous and rapidly developing areas,. Due to affordable labour, several countries in this region has experienced a fast industrialization, with the support of investment from overseas. The electrical and electronics industry, which has undergone a significant shift as a result of increased technological and commercial advances, is one of the sectors that has profited from this [1]. Although it may appear that the e-waste has little to do with this murky health risk, the truth is that both the production process and end-user consumption have a negative impact on all life on our beautiful earth.the foremost thing in e-waste contribution comes from the exponential production of IT equipment which is undoubtedly a convenience of modern life but the disproportionate production ends up in too much of waste like plastic, polythene, etc. for instance while ,making frames or packaging materials Almost all developed and developing countries like India are bearing the impact of this unbalanced act. Since more the production means more the consumption, the scenario only gives rise to the e-waste disposal by way of bricked electronic gadgets, batteries, ICs, etc. which are ignitable/ inflammable and even toxic, and therefore a huge threat to the several flora and fauna of any localized area.

The abandoned computers, smart phones, other electronic and electrical gadgets have come to represent the information age, with its hopes for gleaming technological advancements and its fears of societal and environmental collapse. A collection of discarded digital items collectively known as "electronic garbage" (or "e-waste") has to be given special attention due to its enormous volume. The huge tech transformation began in 1980 and has continued unabated to this day. The tech transformation brought a variety of items that were not only affordable but also simple to use; as a result, they fully engulfed our homes. Instead of getting them repaired, it is now more practical and easy to replace them [3]. If this trend continues, discarded electronic trash will quadruple globally around 2030 and 2040. As goes with plastic or any other waste, e-waste also imperils the environment in more ways than one. Take a classical example of plastic bags- typical plastic garbage has for ages been known to be non-biodegradable and that ultimately causes an adverse effect on the fertility of the land and in the human lives. The same is the case for worn down vehicles, hospital garbage like discarded drugs, household and commercial disposals that are equally harmful. However electronic waste can prove a great source of profit if it is recycled properly. Since most Indians don't know how to properly dispose of electronic garbage, it is common for individuals to store it in their

homes. Electronics are made of a wide variety of metals, polymers, and glasses, each with its own intricate chemistry [4]. The constantly growing trash is complex in structure and a high source of valuable metals that can be recovered and added back into the manufacturing process. E-Waste commerce and recycler businesses in India offer benefits to a diverse range of individuals. Since 2011, laws governing the management of e-waste have been in effect in India, enabling only licensed wreckers and recycling centres to collect electronic waste [5]. In order to minimise the negative effects on the environment and human health caused by improper recycling and disposal techniques, the proposed research aims to study and evaluate the current policies and practises used by the major e-waste producing countries like India.

Figure 1. Electronic Products Pile of Trash in a Junkyard

1.1.Sources of E-Waste

Electronic waste is made up of broken or out-dated products and devices. It comprises items that are no longer in use. Various sectors of the government, IT companies, institutions, R&D labs (Research and Development Labs), households, and the manufacturing industry all contribute to the production of electronic waste in the world Figure 2 depicts the sources of e-waste.

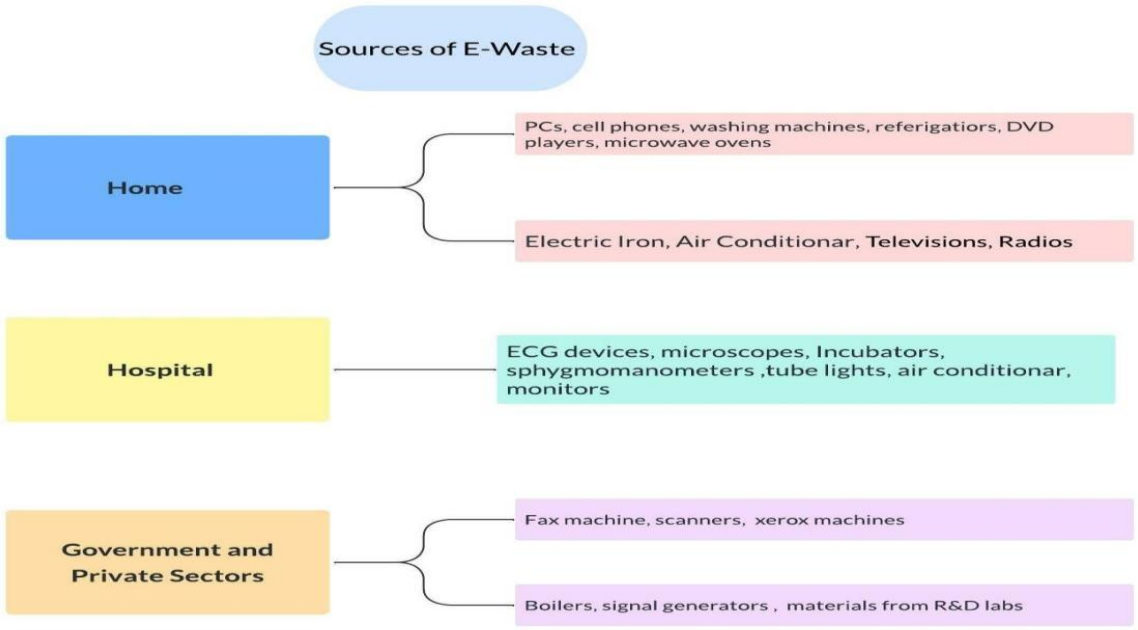

Figure 2. Block Diagram of Sources of E-Waste

The first users of electronic items were large businesses, institutions, and government facilities. Currently, they account for 78% of all PCs that have been installed. As a result, they are India's main producers of out-dated technology. It is estimated that there will be 1.38 million outmoded PCs overall, coming from both commercial and residential sources in the forthcoming years . Information Technology and Telecom Industries are also the contributors to e-waste in India. Mainframe computers, Minicomputers, Personal Computers with input and output devices, cordless telephones, Fax machines, ICs and other components with flaws constitutes this industry’s waste.

Residential customers are also responsible for e-waste, though its contribution is very small in India. Waste from this sector includes defective Television sets, Washing Machines, electric cookers, electric iron and Refrigerators. Biomedical devices such as ECG machines, EMG machines, sphygmomanometers, automatic dispensers and computers etc. become obsolete at faster rate, and hence contribute to e waste. High-speed technological development and modern invention in electrical and electronic fields has accelerated the rate of degradation of these items, resulting in a significant increase in e-waste [6].

1.2.Public Health & Environmental Effects of E-Waste

Due to the increased usage of electronic devices, a huge proportion of electrical and electronic garbage is being generated every day around the world. Use of precious components found in electronic trash, like copper and gold, has led to financial gain, primarily in the informal sector of developing or newly advanced nations. Nevertheless, out-dated methods of usage, like scorching wires to retain the natural copper, risks the seniors and juvenile employees as well as their families to a number of dangerous toxins. Direct contact with toxic substances including lead, cadmium, and chromium, inhalation of toxic gases, as well as chemical build up in land, drinking water, and feed, can all pose health hazards. E-waste also poses threats to the atmosphere. The soil, air, and water components of the atmosphere are affected by the improper disposal of those electronic wastes [7].

Electrical and electronic equipment's are made up of many different parts, some of which include dangerous materials and, if not treated appropriately, can have a detrimental impact on both public health and the ecosystem. These dangers frequently result from inappropriate recycling and disposal practices. The reproductive systems of both male and female humans are impacted, by the lymphocytes and growth retardation, which are some of the major linked health effects. E-Waste contains toxic compounds that can harm the kidneys and liver as well as the central nervous system. Skin cancer, anaemia, carcinogenic tumors, and hormonal issues can all result from routine handling of these materials without protective equipment. In addition, there are psychological issues and hypertension [8]. Table 1 shows some hazardous substances and their ill effects on humans and environment.

1.3.E-Waste Recycling

As tvaluable products can be retrieved from the waste recycling electronic trash appears to be a good 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. Recycling helps to lessen the atmosphere pollution that is brought on when new device is made using raw resources. Individuals in certain nations are generally aware that various forms of household solid waste can provide benefit. Therefore,

informal traders and official collectors receive payment from consumers of their trash. Subsequently they sell to recyclers, scrap merchants, traders, and refurbishes.

There are two categories of recycling: formal recycling and informal recycling.

1.3.1. Formal Recycling: All businesses labelled as regenerating and are on the list of electronic trash disassembly enterprises and have a repair license, provided by regional environmental safety authorities, are considered formal e-waste recyclers. Because it is governed by state regulation and funding, recycling processes in the formal sector are safer for both employees and the environment. The cost of gathering, transporting, and disposing of hazardous fractions must be borne entirely by professional recyclers

1.3.2. Informal Recycling: E-waste recycling informally is thought of as a technique to salvage profit through broken electronic and electrical devices. Because it operates outside of recognized institutions, the informal sector is unlawful. Rural areas account for the majority of the informal recyclers, who are primarily females and kids. Such kind of regeneration entails cheap labour as well as hazardous hand equipment disassembly. This industry puts recyclers and the environment at risk because it employs subpar procedures and lacks the facilities necessary to protect human wellbeing and the ecosystem [9].

Table 1. Hazardous Substances and their ill Effect

E-Waste Source	E-Waste Component	Environmental Hazard	Effects on Human
CRTs (used in TVs, Monitors, ATM, Video Camera, etc), Batteries, PVC cables, Paints	Lead, barium & other heavy metals	These metals leaching into the ground water and release of toxic phosphor	Anemia, Renal Toxicity, Insomnia
Batteries, Housing & Medical Equipment	Mercury	Air emissions as well as discharge into rivers of glass dust	Renal Toxicity, Muscle tumors, Mental retardation, Cerebral palsy
Plastics from printers, keyboards, monitors, etc	plasticizer bisephenol-A(or BPA), as well DEHP and DBP, plastic compounds known as phthalates	Chlorinated plastics release harmful chemicals into the surrounding soil, which seep into ground water or other surrounding water sources which cause serious harm to the species that drink this water.	Risk in developing heart problems, obesity, reproductive disease
PVC & polymer, Paints, Printing inks, Electrical transformers & capacitors	Polychlorinated Biphenyls (PCBs)	include extreme pollution from production, toxic chemical exposure during use, hazards from fires	Suppression of immune system; Damage to the liver, nervous and reproductive systems

2. Literature Review

An essential part of any research work is its literature review. It assists the investigator in planning and analysing research effort as well as in identifying research needs. To develop suitable research methods, it is also vital to be familiar with prior related investigations [2]**.** A generation, management, government policies and review of prior research and studies in the topic are provided by the evaluation of this literature [10]. This study investigates a very contemporary and novel topic. The latest research covers theoretical ideas on the one hand and real-world examples from Asia and around the globe on the other.

2.1. E-Waste Generation in India

Planning for an effective e-waste monitoring system requires knowledge about e-waste production. Due to ongoing market growth for electronic gadgets and equipment's and their shorter life expectancy, e-waste is being produced at an astounding level throughout the world [11].

India was recognized as the world's fifth-biggest generator of electronic garbage. With an estimated 1.85 million tons of e-waste produced yearly, India was listed among the top 5 countries around the globe in a 2016 research by The Joint Indian Chambers of Commerce and Industry of India and KPMG. An incredible 40–50 million tons are produced each year globally. India generates about 4% of the world's e-waste each year. With 11887.7488 kilograms of electronic trash generated annually, the United States came out on top; China came in second with 6197.88614 kilograms of electronic trash produced yearly.

Computer equipment as well as mobile phones is recognized as the main electronic trash generators in India by the ASSOCHAM(Associated Chambers of Commerce and Industry of India)-KPMG research, "Electronic trash planning in India." This survey endows that telecommunications devices made up only 12% of the entire electronic trash produced in nation, while on the contrary computers contributed almost 70%. Mumbai came in first place among the Indian cities because it produced an estimated 120,000 metric tons of electronic trash yearly. With 98,000 and 92,000 tons of generated e-waste each, Delhi and Bangalore were finished second and third, respectively. According to a list of states, Maharashtra dominated the ranks for generating electronic trash, pursued by Tamil Nadu and Uttar Pradesh [12].

Twenty-one (21) different types of electrical and electronic devices have been identified for complying EPR (Extended Producer Responsibility) duties under the electronic trash (Managing) standards which were passed in 2016. When these Electrical and Electronic Equipment's reach the end of their useful lives, they become e-waste. The table 2 provides data on national level e-waste creation for the financial years 2017– 18, 2018–19, and 2019–2022.

Table 2. E- Waste Generation (India)

S. No.	**Financial Year**		**Generation (In Tonnes)**
01	2017-2018		7,08,445
02	2018-2019		7,71,215
03	2019-2020		10,14,961.2

The toxic and Other Wastes (Planning and international Movement) standards, 2016 announced by the Ministry, governs the import and export of toxic and other wastes. The government had prohibited the entry of e-waste into the nation by adding it to Schedule VI (Basel No.A1180) of the aforementioned laws. Due to the rise in Electrical and Electronic devices sales in the nation during the past several decades, there has been a tremendous rise in the generation of electronic trash. According to the E-Waste (Planning) guidelines, 2016, the government already has a framework in place to monitor EPR responsibilities relating to PROs. The table 3 shows the current EPR targets:

Table 3. EPR Targets (India)

S. No.	Period	Electronic waste disposal target
01	2017-2018	10% of the waste production amount as stated in the EPR Initiative.
02	2018-2019	20% of the waste production amount as stated in the EPR Initiative.
03	2019-2020	30% of the waste production amount as stated in the EPR Initiative.
04	2020-2021	40% of the waste production amount as stated in the EPR Initiative.
05	2021-2022	50% of the waste production amount as stated in the EPR Initiative.
06	2022-2023	60% of the waste production amount as stated in the EPR Initiative.
07	2023 & Beyond	70% of the waste production amount as stated in the EPR Initiative.

The rules are mandatory for the assessment of EPR of electronic trash via Pollution Control Board, and for the same an online portal has been created, and each producer's or PRO's objective is appropriately assigned based on production statistics of the products mentioned in Schedule-I of the rules. A penalty may be assessed on defaulting producers/PROs in accordance with the terms of the current rules, and the duty must be met even after the assessment of the penalty. In the budget year 2021–2022, the EPR targets were reduced from 50% to 40% in response to the industry feedback and standpoint of covid-19 epidemic [13].

2.2. E-Waste Management

For the sustainable way of electronic wastes, Organizational frameworks such as electronic trash compendium, transmission, purification, preservation, retrieval, and management must be built at national levels. It should be encouraged to establish electronic trash compendium, transfer, and recycling facilities in partnership with business owners and producers. The current methods of managing electronic trash in India have a variety of problems, including difficulties in inventorying, unsafe circumstances for informal recycling, lack of knowledge, and corporate unwillingness to address the important concerns. Despite the numerous laws that exist and safeguard the globally recognized environmental laws inside their boundaries. As already mentioned, the following actions have been done by the government to raise awareness of ecologically responsible electronic waste disposal [14].

1. The EPA (Environmental Protection Agency) offered numerous seminars on the management of electronic trash.

2. The EPA has started taking steps to quickly estimate the amount of electronic trash produced in the nation's largest urban centres.

3. The Department of Information Technology, Bureau of Information and Communication Technology, has prepared and fully disseminated a detailed technical reference on "Department of environment and management for information technology sector in India." [14].

Electronic trash standards were announced by the Department of Environment and Forest in May 2011 and became effective on May 1, 2012. These regulations officially recognize EPR. According to these Regulations, manufacturers are required to establish take-back programmers or collections sites to gather the e-waste produced when their devices is no longer functional. The sale of wastes to registered or approved recyclers or re processors with environmental-friendly facilities is needed. A registered society, a designated agency, a group of people working together, or an association may establish a collection centre under the terms of the rule in order to collect e-waste. These regulations serve as the primary safeguard for ecologically responsible e-waste handling. According to these regulations, 128 Producers located across 11 states have received EPR authorizations. 19 States have established 134 collection centres.

- **Reduced Utilization of Dangerous Chemicals in The Production of Electrical and Electronic Devices and The Parts that Make it:**

a) Each producer of electrical and electronic devices as well as the components, consumables, parts, and spares for such devices mentioned in Schedule I, intend to make sure that fresh electrical and electronic devices as well as the components, consumables, parts, and spares for such equipment, should not comprise lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, levels ranging 0.1% by mass.

b) Sequentially to limit the quantity of electronic trash, manufacturers must ensure that components made by various manufacturers are compatible with one another. Manufacturers must employ technology or procedures that make the finished product recyclable.

c) The expenditure for the sample and screening shall be carried by the manufacture, and the random selection shall be in compliance with the rules established by the Pollution Control Board in this regard. The Pollution Control Board shall conduct random sampling of electrical and electronic devices placed for sale in order to track and confirm, according to the elimination of toxic chemical restrictions.

d) The manufacturer must adopt remedial measures to put the commodity in accordance with the elimination of dangerous chemicals restrictions and remove the item within a reasonable period of time, according to the guidelines established in this respect by the CPCB (Central Pollution Control Board)[15].

- **Standards Regarding Ecologically Robust Management of E-Waste: E-Waste Management Regulations, 2016.**

The 2011 electronic waste (Planning & Handling) standards were announced in 2011 and were effective on May 1, 2012. Each manufacturer, user or wholesale consumer, storage facility, certified technician, and converter of electronic trash engaged in the production, marketing, of electrical and electronic devices specified in list I of these Rules is subject to these rules. The electrical and electronic equipment falls into two groups, namely

a) Telecommunications and IT devices

b) These regulations apply to tech products, including Televisions, freezers, coolers, washers and dryers, and bulbs containing mercury. The enhanced producer responsibility is the primary component of these regulations (EPR). To ensure that producers are using EPR effectively and to boost their involvement in the efficient management of electronic trash. Considering the electronic waste (Management) standards, the CPCB was tasked with developing guidelines for extended producer responsibility, environmentally responsible recycling and dismantling, collection centres, storage, renovation, channelization, and transportation, as well as random sampling for RoHS(Reduction of Hazardous Substances) testing [16].

- **The Following are Some of The Key Elements of The 2018 Electronic Waste (Management) Modification Norms:**

a) The revised electronic trash recovery criteria as per EPR have already been in force from October 1, 2017. The phase-wise recovery goals for electronic trash in volume during 2017–18 shall be 10% of the waste generating quantity as mentioned in the policy, with a 10% rise each year until 2023. The objective has been set at 70% of the amount of trash generated as stated in the EPR policy after 2023.

b) The updated EPR targets must account for the quantity of electronic trash gathered by producers during 1 October 2016 and 30 September 2017 until March 2018.

c) For new producers whose durations of sales activity are smaller than the typical lifespan of their products, additional electronic trash collection goals have been prepared. The typical product lifespan will be determined by the guidelines periodically released by CPCB.

d) Producer Responsibility Organizations must submit for registration with the CPCB in order to carry out the tasks outlined in the Rules.

e) In compliance with the RoHS requirements, the government is responsible for covering the expenditure of selection and screening in order to carry out the RoHS test. The expenditure of the study will be carried by the Producers if the goods don’t comply with Reduction of Hazardous Substances standards [15].

2.3 E-waste Storage Procedures

a) Each supplier, dealer, and converter is permitted to reserve electronic waste for up to 128 days and is required to keep a record of the transactions, exchanges, and depots of electronic trash and make this diary feasible for verification. E-waste collection must be done in accordance with the rules currently in effect, as follows:

b) As long as the electronic trash must to be explicitly saved for the creation of a procedure for its reuse, the environmental protection agency might prolong the aforementioned term up to 364 days [15].

3. Opportunities and Challenges

Regarding e-waste and its handling, there are numerous opportunities and obstacles. The absence of e-waste legislation is one of the major obstacles**.** Aside from industrialised countries, the majority of developing nations lack e-waste regulations at this time [17]**.** It is noteworthy that e-waste policy in India is more than adequate, if followed and implemented in right way the menace faced due to increasing e-waste can be got rid off.

3.1 Utilizing E-Waste in Promising and Unique Ways

Computer monitors, motherboards, cell phones, CDs, microphones, screens, coolers, and appliances are common examples of electronic trash. Electronic trash besides of constituting some toxic substances also contains a fair bit of metallic materials. Simply extracting these materials can result in a good junk of profit. Therefore by recycling e-waste, precious metals and other materials can be obtained from electronics while conserving energy, lowering pollution, keeping landfill space, and generating employment. Table 4 shows the elements that can be obtained after recycling electronic trash.

Table 4. Showing Precious Materials that can be Recovered from E-Waste

Material that can be extracted from discarded electronic waste	Name of Substances	Can be used for
Metals	Gold, copper, silver, iron, lead, tin, nickel, niobium, and rare precious metals, Palladium and platinum	Jewellery, electronics, machinery and metallurgy, transportation, light industry, and other fields, lithium batteries, and thick film conductor
Plastic from TVs and computer frames	Polycarbonate, Copolymer of acrylonitrile-butadiene-styrene.	PVC pipes, cables, plastic furniture, toys, and eco-friendly tiles and bricks.
Glass from Cathode Ray Tubes (CRT). computer monitors and TVs		Forite tiles.

Although the majority of these components are present in extremely small quantities in each portable unit, however, due to the enormous number of devices being disposed of, the total amount of waste is actually quite substantial. Three percent of the gold, two percent of the silver, and twelve percent of the palladium mined annually worldwide are used in the production of mobile phones and personal computers. The measurement of actual samples taken on-site has led to a more precise estimation of the electronic waste contents [18].

3.2 Challenges

People and companies must understand how to properly dispose of e-waste. There are numerous electronic waste disposal methods and being aware of the regulations and the repercussions of not following them will make people more environmentally conscious and contribute to the battle against the expanding e-waste problem. The major issues include poor generation rate, in adequate infrastructure, Lack of knowledge and use of out-dated technology.

3.2.1 Inadequate data on e-waste generation rates: It might be challenging to establish inventory at the provincial level as the market information for electronic and electrical

equipment's, a significant factor in calculating the amount of e-waste, is usually accessible at the countrywide level of structure. Electronic trash is not only produced domestically but is also frequently illegally imported from rich economies. The type and volume of electronic garbage coming into the nation are poorly understood. Knowledge about trash formation, composition, and flows must be reasonably accurate in order to design systems for efficient collection, transportation, and processing [19].

3.2.2 Inadequate infrastructure: About 95% of the electronic trash produced in India is recycled illegally and in an improper way. E-waste is collected, transported, separated, dismantled, recycled, and disposed of manually in India by unskilled workers in the informal sector.

3.2.3 Use of out-dated technology: For the extraction of functional pieces like Au, Ag, and Cu, the recycling units of e-waste require unique technological developments. The largest e-waste dismantling area in Delhi is Seelampur. They use wet chemical procedures, employing workers of all ages, and have open incineration and acids pouring on the ground. The personnel in these types of regions require specialised training and knowledge in addition to being concerned about their health and safety.

4. Discussion- (Results and Remedial Measures in Handling E-Waste)

1) In order to save the environment from hazardous e-waste, e-waste need to be handled and managed in more effective manner and all necessary rules should be followed. A better approach for efficient recycling and trash management is to incorporate AI into the operations of trash sorting and disposal.

2) E-waste cannot be disposed of swiftly however certain policies can be implemented between seller and buyer such as a redemption policy that creates a binding agreement between the seller and the buyer, implying that the seller has promised to later purchase the product from the buyer, this way more recycling can be done in more efficient manner.

3) The purchase of products that are not essential are the most frequent source of e-waste. Buy new electronics that the manufacturer can either reuse or waste as little as possible.

A sustainable approach to managing e-waste is to choose durable and recyclable electronics.

4) And furthermore, campaigns may be started to raise awareness of the issue of the alarming amount of garbage currently produced by obsolete electronic and electrical equipment. Since preponderance of electronic garbage is handled by the unauthorized sector in India, from dismantling to burning and disposal in open areas. There is little concern about environmental pollution from dangerous poisons or for one's own personal safety. Young children and women's involvement is especially concerning because of the negative effects on their health, safety, and potential for dynastic injustice. The "Alertness Initiative on Ecological Threat of Digital Garbage" project was launched by the Department of Information & Electronics Technology on March 31, 2015. The Government of India's "Digital India" initiative includes this project. Due to the project's emphasis on e-waste reuse and recycling, which has the potential to save natural resources; it is anticipated to have a major and far-reaching impact on the development of the nation. The project consists of three parts: creation of the content, evaluation of the inventory, and raising awareness among various stakeholders. This initiative support the 2016 E-waste Management Act's successful implementation. Figures below show the results of awareness program launched by Ministry of Electronics and Information Technology. Public education initiatives are necessary when the community is unaware about the issue. The concept of mass awareness via different cinemas highlights the group of people committed to addressing the environmental problem of e-waste, and they volunteer to raise awareness of the problem. Consequently, individuals become more cautious about the secure disposal of E-Waste.

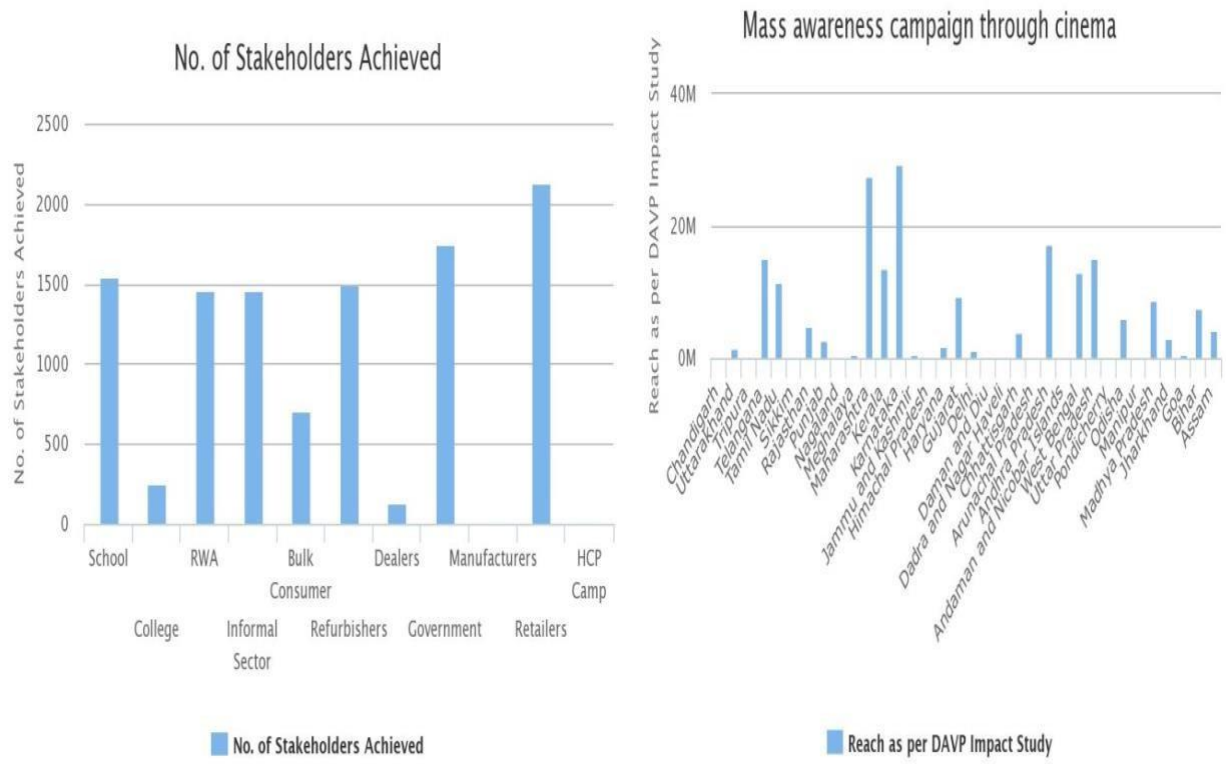

Figure 3. Showing Mass Awareness about E –Waste

5. Conclusion and Future Scope

The subtitle regarding the unfortunate onset of e-waste may be seen as an overboard one, however, mankind has to find a way around it, or lest it may cause other major disaster on the humanity. One of the coherent ways to tackle the problem is by making management in the mega IT companies/corporations accountable by mandating them to the effective recycling/disposal of e-waste, besides minimal use of plastics, etc.

The other focuses on the end-user directly The user should be aware of the importance of complete e-waste disposal, which can be carried out at their home or business by safely disposing of the equipment or even recycling by using and reusing in other areas that are practical. Furthermore, in order to control the future increase in e-waste, it is mandatory to raise public understanding of the problem and effectively implement the law. Let us hope that the world gets freed from the clutches of the increasingly rampant e-waste.

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