Management of E-Waste And its future prospective importance

Prof. Mukesh Dhatunde [1] Mr. Vivek Prakash patil [2], Mr. Rushikesh Navnath khade[3], Mr. Pratik Sanjaykumar Kaderkar[4]
[1]Assistant Professor, Dept of Civil Engineering
[2, 3, 4]Dept of Civil Engineering
[1, 2, 3, 4] D Y Patil College of Engineering, Akurdi, Pune

Abstract- *Electronic waste or E waste involves discarded or undesirable electrical or electronic equipment or parts. Increased rapid obsolescence and penetration rate is going to create crises within developing nations as India. Inside India the majority of E-waste is produced wearing metropolitan cities as Mumbai, Kolkata, Delhi, Bangalore, Mumbai and so on. Inside Maharashtra PCMC, the house of various industries particularly in IT industry, figures prominently within the listing of urban areas which yields great E waste found India. The majority of the E waste in PCMC is throwing inside landfill sites or maybe it is incinerated by kabariwallas, while on various other hands formal industry confronting issues because of inadequate availability of E waste-waste model rate is extremely boosts daily particularly a few main products because of switch around technologies, fashion, per capita earnings of people. Generally, there been around 50 % hearted initiatives of PCMC and several businesses handling merely a tiny proportion of the entire E waste created. E waste Management is extremely important undertaking as E-waste turns into a risk to person. Authorities pass a law for E waste control, but don't have political wills it wouldn't be applied accurately.*

Even though the E waste regulations have been applied earlier, there are issue of household E-waste disposal problem as well as recycling where possible continues to be. This particular paper covers the amount of generation and also the condition of E-waste methods by different contributing factors of the device found Indicating absence and PCMC city of wide structure. Electronic e-waste or waste is among the quickly growing issues of the entire world. E-waste is an informal and popular name for electronic products which happen to have completed the useful life of theirs. Discarded pcs, audio equipment, cell phones, electric lamps, fax machines, copiers, stereos, VCRs, televisions, batteries and so on are a handful of instances of e-waste. This particular waste includes non-naturally degradable plastics that possess severe risk to the planet.

Keywords- E-waste, WEEE, E-waste management; environmental challenges; health impacts; E-waste estimation; E-waste prediction; sustainable management; public awareness

I. INTRODUCTION

A. Introduction

The disposed of as well as end-of-life consumer electronics items which range from computer systems, devices utilized in Communication and Information Technology (ICT), household devices, sound & video clip merchandise and every one of the peripherals of theirs are popularly referred to as Electronic waste product (E-waste). The sick negative effects of e waste might be on earth via leaching of dangerous contents from landfills in water tanks to There is, none, without standard format or maybe typically established meaning of e waste inside the globe. Inside the majority of instances, e waste includes the fairly costly & basically long-lasting products employed for information processing, entertainment or telecommunications within individual businesses and households.(Guanabara et al., 2011)

E-waste isn't dangerous in case it's stocked to secure storage or even recycled by medical strategies or even transported from a single place on the other person within parts or even in totality within the semiformal sector. The e-waste may, nonetheless, be looked at dangerous when reused by primitive techniques. E-waste includes many materials like quite heavy metals, plastics, full glass etc., that is usually likely poisonous and also dangerous to human health and the environment, in case not managed within an eco-audio approach. E-waste recycling within the conformal segment by primitive techniques is able to harm the environment. Toxic contamination of streams, other water sources and wells in air flow because of emission of burning and gases of e waste. The recycling where possible procedure, in case not completed correctly, could cause harm to man appearing through inhalation of fumes throughout recycling where possible, communication of your skin of the employees with dangerous things as well as communication during acid therapy utilized in healing procedure.(Luu et al., 2015)

The toxic and hazardous materials seen in e waste consist of lead (Pb) and also cadmium (Cd) in is printed circuit boards (PCBs). Lead is largely present in most electric products/ assembly, cathode ray tubes (CRT) and so on. Cadmium is used in monitor/ CRTs while generally there could be mercury in flat screen monitors and switches. Mercury also is discovered around CFL, relays as well as other certain products and solutions. Aside from the cadmium inside laptop power packs, cadmium is likewise employed for plating metallic enclosures/ metallic components within sub-assemblies. Polychlorinated biphenyls are discovered in transformers and capacitors so when brominated flame retardant on created and printed circuit boards, clear plastic casings, cable as well as polyvinyl chloride (PVC) cable sheathing for PBD/PBDE and insulation wearing clear plastic periods of appliances.(Debnatha et al., 2016)

No highly sought after study has thus far been designed to learn the effect on the e-waste within the ecosystem. Not many NGOs have, nonetheless, discovered that the recycling where possible of e-waste wearing semiformal field is dangerous. These units make use of non-environment-friendly, non-scientific, and primitive methods. As the devices are doing work in unorganized industry, absolutely no information can be obtained to substantiate the point which they're violating the prevailing laws and regulations for work, environmentally friendly safety as well as sector.(Awasthi et al., 2018)

1.2 Definitions of E-waste

Electronic waste (e-waste), is a generic term used to describe all types of old, end-of-life or discarded electrical and electronic equipment, such as household appliances; office information and communications equipment; entertainment and consumer electronic equipment; lighting equipment; electric and electronic tools; toys; and leisure, sports and recreational equipment that are powered by electricity. E-waste contains both valuable and hazardous materials that require special handling and recycling methods.(Appolloni et al., 2021)

1.3 Aim & Objective

1. To analyses and identify the harms and opportunities of E-waste management as it is a very fast emerging threat to environment.
2. To identify variety of regulations and policies related to E-waste management in India.
3. To develop appropriate environmental assessment, implementation and monitoring activities related to different E-waste collection and the respective benefits to improve current E-waste management practices.
4. To develop a methodology regarding E-waste management.

1.4 Global Scenario

The EU legislations restricting the usage of dangerous materials in electronic and electrical equipment (Directive 2002/95/EC) and also encouraging the collection plus recycling of such equipment (Directive 2002/96/EC) have been enforced in February 2003. The legislation offers the development of collection schemes where consumers return their being used e waste at no cost. The goal of these systems is increasing the recycling or re use of such items. Additionally, they need heavy metals like lead, cadmium, mercury, along with hexavalent chromium and flame retardants like polybrominated biphenyls (PBB) or perhaps polybrominated biphenyl ethers (PBDE) to be substituted by safer alternatives.

1.5 E-waste Generation Cycle

E-waste generation traces a path of from equipment acquisition, consumption up until obsolescence. The knowledge of material flow determines the overall flow network of resources or products together with the responsible stakeholders along the equipment life cycle. Figure 2 gives a general product life cycle of electrical and electronic products. Technological obsolescence is the main factor influencing the generation of e-waste amongst domestic and industrial consumers. The phenomenon explains state of non-compatibility of equipment towards its intended functions. Three key drivers that influence obsolescence are:(Xavier, Giese, et al., 2021)

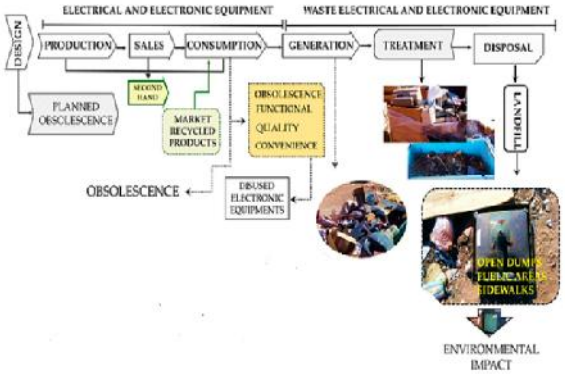


Fig.1 Electrical and Electrical Equipment product life cycle
Source: (Mbohwa, 2019)

1. **Functional obsolescence**: A scenario when a superior product substitutes another of inferior functionalities.
2. **Quality:** A scenario when equipment is declared obsolete due to underperformance.
3. **Convenience**: A case when an equipment although functional and with no better replacement stops being preferred because of mode or style.

Technological obsolescence can be considered the major driver of electrical and electronic equipment disposal as it stimulates the need to replace devices or equipment hence a behaviour which directly impact e-waste generation. However, the upgrading of the equipment is as well related to affordability and availability of the market which are factor also related to the economic state of a region.(Lebel, 2012)

1.6 Sources of e-waste

Major sectors responsible for e-waste generation include the industry, universities, business offices, households and government agencies. These sectors incorporate electrical and electronic equipment in their distinct processes hence the e-waste generated is as well distinct to each sector.

Domestic: Households are amongst the major sources of e-waste because they consume a high quantity of electrical and electronic equipment. E-waste from household cover the categories of household appliances and IT and consumer equipment. Household appliances or white goods consist of equipment such as irons, toasters and clocks, oven, refrigerators, stoves and washing machines. IT and consumer equipment or brown goods consist of equipment such as personal computers, televisions and mobile phones.(Mahmud et al., 2020)

Institutions: The sectors that include businesses, institutions, and government agencies exist as e-waste sources because of their high usage and quantities of electronic equipment such as printers, computer and copiers. In these sectors continuous upgrading of equipment is always done to match with the advancing technology hence better efficiency and organizational productivity. For instance, computers are periodically upgraded for compatibility with recent software. I

Industries: Industries range from in activities such as manufacturing, service and processing. They generate e-waste when electrical and electronic equipment are no longer functional or modern with respect to the changing technologies and this is mostly influenced by the need to improve quality in production. Modern industries now incorporate vast electrical and electronics in their processes for instance control systems circuits in manufacturing and process industries can comprise of inductive components like motors, capacitors, resistors, transducers and sensors. Adding to that, industries involved in service also use electrical and electronic equipment such as air-conditioners and heaters for office conditioning, computer, printers and photocopiers for data processing, and devices of importance in communication such as phones. However, it is important to note that manufacturers of electrical and electronic equipment as well generate e-waste when new products are rejected on the production line or fail to meet the quality standard during process. (Sivathanu, 2016)

Imports: Another source of e-waste is imports. In developing countries, e-waste is usually imported from industrialized countries. The used equipment from the industrialized nations will be of attractive prices and still good enough for usage. However, the products will be of shortened lifespan hence they accumulate as e-waste at a faster rate

1.7 Inventory of Electronics Waste

Proper control over the materials used in the manufacturing process is an important way to reduce waste generation. By reducing both the quantity of hazardous materials used in the process and the amount of excess raw materials in stock, the quantity of waste generated can be reduced.(Sivathanu, 2016)

Table 1 Inventory of Electronics Waste

Sr. No.	Items	Weight(MT)
1	Domestic Generation	332979
2	Imports	50000
3	Total	382979
4	WEEE available for recycling	144143
5	WEEE actual recycled	19000
6	Projected quantity of WEEE by 2011 (without including the imports)	467098

Inventory of Electronics Waste: Growth of E waste in India

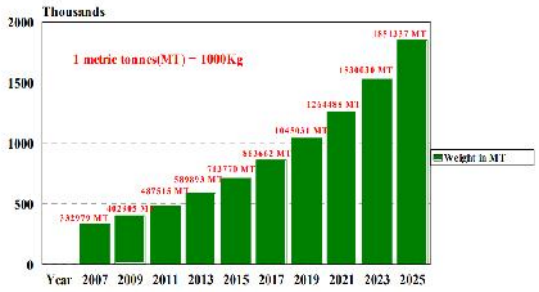


Fig. 2 Growth of E waste in India
Source: (Chatterjee, 2021)

1.7.1 State and City Wise Electronics Waste generation in India

In India, among top ten cities, Mumbai ranks first in creating e waste followed by Delhi, Mumbai, Hyderabad, Ahmadabad, Kolkata, Chennai, Bangalore, Nagpur and Surat. The 65 cities create much more than 60 % of the complete produced e waste, whereas, 10 states create 70 % of the entire e waste. The pie chart at Fig.4 is indicates the state wise generation of e waste whereas Fig. 3 shows the community-wise generation.(Halim & Suharyanti, 2019)

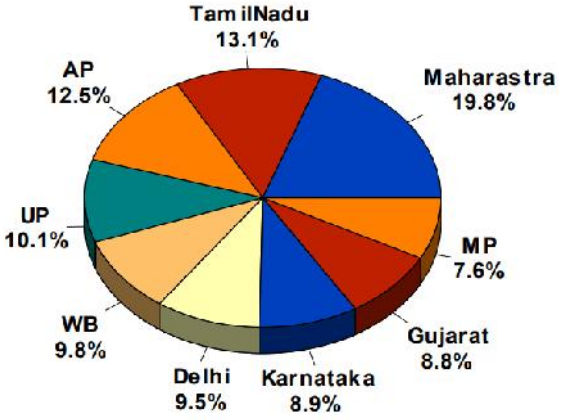


Fig. 3 State and City Wise Electronics Waste generation in India
Source: (Chatterjee, 2016)

Inventory of Electronics Waste

City-wise E-waste Generation in India (Tonnes/year

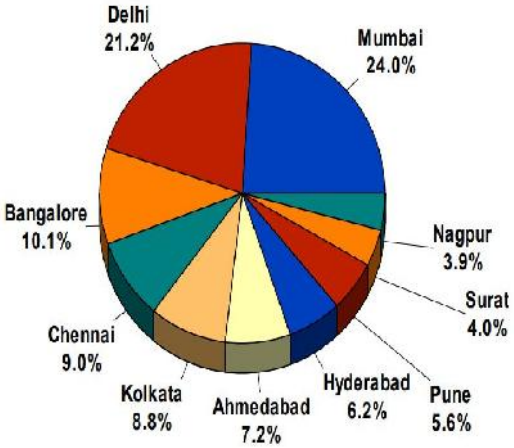


Fig. 4 City wise E-waste Generation in India (Tonnes/year)
Source: (Chatterjee, 2016)

II. LITERATURE REVIEW

Salsabil Shaikh et.al (2020) This paper examines the formation as well as discretion of e waste utilizing an environment framework which invites a crucial evaluation of individuals (e waste workers), company proprietors, customers inside towns and wider policies, to determine the pros and cons belonging in the transactional tasks involving the methods. The analysis relies around Pakistan, and that is the 26th biggest producer of e waste, but is additionally the receiver of e waste from some other exporting nations. Survey final results suggest neighbourhood model of electronic waste product (extrapolated) is certain 281 zillion within terminology of devices or maybe 1790 kilo tonnes (2018 2019). The paper illuminates the usually tough to calculate as well as much less visible' upstream' things to consider, like attitudes and volumes of customers which generate purchasing & disposing choices.(Shaikh, Salsabil, Thomas, Keith and Zuhair, 2020)

Selase Kofi Adanu et.al (2020) The analysis investigated the reason renewable solutions aren't accustomed to gather, dismantle and promote e waste at giving the danger of trauma along with substantial environmentally friendly contamination linked to managing of electronic waste materials. The analysis objectives had been examining the dynamics of technologies followed to handle e-waste, evaluate problems faced within adopting renewable technologies; figure out the missing back links between informal and formal e-waste workers. Investigate concerns were; what's the present degree of technologies followed to handle e waste as well as conflicts restricting the adoption of renewable technologies; as well as what exactly are the lacking back links in between the informal and formal sectors which restrict adoption of renewable e-waste managing methods. Facts collection

integrated utilization of questionnaire to collect information on technologies employed for e waste management, problems faced within utilizing these kinds of technologies as well as exactly what the workers think about as remedies to renewable e waste management. Area observations aided to explain waste managing activities as well as questionnaire responses have been examined with the use of descriptive data.(Adanu et al., 2021)

Camelia Delcea et.al (2020) Because of the expansion on the quantity of electronically and electrical tools waste (e waste), the knowledge of specific consumers' primary choice triggers belongs to a vital reason for enhancing the volume of reused e waste. A number of scientific studies coming from the literature have demonstrated a beneficial connection in between the consumers' attitude, understanding, self-efficacy, community norms, as well as the e-waste recycling intention of theirs, in addition to the good impact in between the intent and also the manifested actions. Extra to the determinants, within the existing analysis, the effect of social networking was examined together with the activities used by nongovernmental organizations and the government, with the objective to add and also to shoot, almost as they can, a top quantity of determinants belonging in the e waste recycling where possible procedure. Nevertheless, the socio-economic or demographic variables, like age range, gender, income, education, quantity of family, etc., have indicated with time to get a contribution to forecasting the consumers' pro recycling behaviour.(CAMELIA DELCEA, 2020)

Mrs Anagha katti et.al (2022) The 21st century or maybe "The era of information" is silently and rapidly directing to a big problem relating to sound misuse managing as well as public health and fitness, realized as E- waste product. The "E-waste" or even the "Electronic waste" described as the disposed of radios, mobile phones, TVs, for example, entertainment gadgets, and computers, refrigerators, workplace electronic tools. This comes with the old electronic devices that are made for resale, reuse, recycling, disposal or salvage. Grossly they're loosely thrown away, broken, obsolete, surplus, electronic units. Cathode beam tubes carts are considered probably the most difficult kind to recycle. The electric goods are categorized less than 3 leading heads viz. White-coloured items family members' device apparatuses deep coloured products televisions camcorders digital cameras as well as dark items Pcs printers fax devices scanners therefore forth. As Indians start to be far more expensive as well as spend more and more electric matters & apparatuses, Computer hardware symbolizes basically 70 % of e squander substance and then press transmission gear (12 %), electric hardware (8 %) along with medical hardware (7 %). Additional gear, such as loved one's poor stand for the staying(More et al., 2022)

Abhishek Kumar Awasthi et.al (2018) globally, electronic and electrical tools (EEE) has become a part of regular everyday living. If this gear will become waste product electric as well as electric tools (E-waste or WEEE), nonetheless, it must be correctly dealt with, to be used as a supply of substances for renewable energy and future production, and also to reduce the exploitation of raw substances and also the deleterious influences on both human health and the environment. A sizable amount of e-waste is produced to each China and India, and also each place continues to endure an entrenched casual e waste processing sphere. For that reason, useful substances to come down with e waste are disposed in land that is open, as opposed to remaining adequately extracted for recycling and reuse. Within this document we note the major component of e-waste found India and China is collected through the casual sector as well as cared for with primitive techniques. Furthermore, unlawful changing representatives in addition are involved by mislabelling e waste as well as exporting them to building nations. This information proposes that: the setup of e waste control laws and regulations as well as policies for correct e waste compilation, recycling and treatment, far better instruct customers on the dangers of e waste toxic contamination, limit the unlawful motion of e-waste throughout borders, as well as help support the improvement of the proper, controlled e waste processing market by funding motivator applications producing recycling where possible infrastructure. These steps must boost the recycling where possible capability as well as reduce the quantity of WEEE contaminating the environment as well as endangering man health.(Awasthi et al., 2018)

III. METHODOLOGY

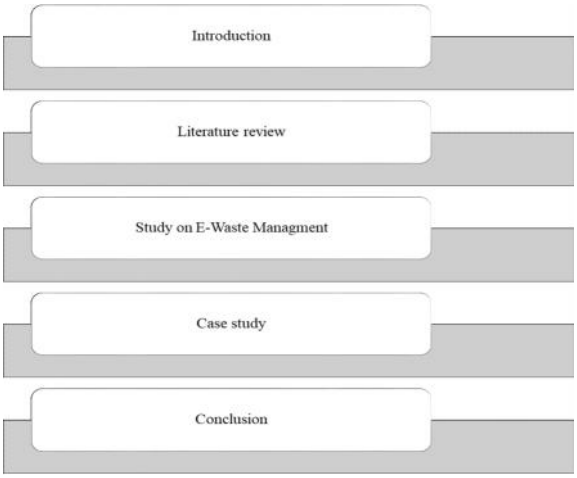


Fig. 5 Flowchart

3.1 Problem statement

In conclusion users as well as customers within budding as well as changing nations, including India, amplify the utilization of their automated as well as wired merchandise, it's apparent the items are learning inside their fingertips location or maybe an element of disposing technique. As a result of this particular compilation, dealing with & treatment methods in a nutshell control of that a part of reliable waste product is a big challenge in front of municipal companies, buyers, and creators. And this also would drive us to contemplate what truly the case with unwanted items is in the event it gets to the kind of waste managing actions.

3.2 Recommendations for management of E-wastes

3.2.1 Inventory Management

Appropriate control over the materials used in the manufacturing process is an imperative way to trim down waste generation. By reducing both the extent of hazardous materials used in the progression and the amount of surplus raw materials in stock, the magnitude of waste generated can be reduced. This can be done in two behaviours i.e. establishing material-procure review and organize procedures and inventory tracking system. Another inventory management procedure for waste diminutions to make sure that only the needed quantity of a material is arrayed.

3.2.2 Volume Reduction

Volume reduction comprises those techniques that confiscate the hazardous fraction of a waste from a non-hazardous portion. These techniques are usually to lessen the volume, and thus the cost of disposing of a waste material. Methods comprise gravity and vacuum filtration, ultra-filtration, reverse osmosis, freeze vaporization etc. For example, an electronic module manufacturer can use compaction equipment to diminish volume of waste cathode ray-tube.

3.2.3 Recovery and Reuse

Waste can be recovered on-site, or at an off-site recuperation facility, or through inter industries was over. A number of physical and chemical techniques are accessible to repossess waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. Sustainable Product Design: Attempts should be made to devise a product with smaller amount of hazardous materials. Renewable materials and energy: Bio-plastics, Bio-based toners, glues and inks etc., should be promoted.

- **An Ideal Model Recycling Procedure**

Recycling activities should inaugurate with the acceptance of e-waste material from diverse locations. The material must be primarily weighed, and separated product-wise (monitors, CPUs, printers, keyboards, etc.) for effortless recovery. The material should be then checked by certified technicians to make certain whether the equipment is working or non-working. If the equipment is in working/ near-working state, then the technicians should try to revamp/ upgrade the equipment to make sure that they become re-saleable. If the equipment is not in a working condition, attempts should be made to retrieve components. Accordingly, the technicians must take apart the equipment into components and aim to retrieve whichever working parts thereof. The lasting components should then exceed for shredding into the twin-shaft shredder which aid to open up‖ sealed components, unravelling metals from plastic. The shredder allow physically dismantled components through a hopper at one end, passes the feed through the shredding chamber where two counter rotating hexagonal shafts suited with circular blades mince the components, and the shredded items are slumped on to a moving conveyor belt. Certain components of the computer such as printed circuit boards (PCBs) include expensive metals such as gold, silver, etc. These PCBs should not be sent for shredding, instead be amassed and used for precious metal extraction. That segment of e-waste which enclose hazardous elements and cannot be recycled must be sent to authorize hazardous waste treatment and dumping facilities for ultimate disposal as per the norms of the Pollution Board.

Recycling of e-waste is not required simply because it is obligatory or environmental prerequisite, but is also crucial to avoid bad exposure when computers and other office automation systems are found in landfill or third world countries, consequently, the industries should move end route for Arche type shift with respect to cost avoidance v/s risk avoidance. Risky substances recovered during the practice of recycling of e-waste are being disposed of through the Common Hazardous Waste Treatment, Storage & Disposal Facility, commonly known as CHWTSDF, sanctioned by the Pollution Control Board in the prearrange manner. Withdrawal of precious metals out of e-waste material is an integral and a very imperative part of the complete e-waste recycling chain.

3.4 Sources of E-waste

Electronic waste principally computer waste is budding exponentially in volume because of increasing demand of information technology and its relevance in the national development. Various government departments, public as well as private sectors are high-speed feeding old

electronic appliances such as computers, telephones, etc., into the squander stream.

In India, two chief sources for e-waste are acknowledged:

- Domestic e-waste.
- Discarding of e-waste from other parts of the world.

Domestic e-waste is engendered from following sectors:

- Individual household and modest business
- Large business, Institutions, government houses and Foreign Embassies
- PC producer and retailers
- Secondary market of old PCs

Out of these sources, individual households have the slightest contribution in the origination of e-product obsolescence. It is the illegitimate dumping of trash computers from other parts of the world that produce the predicament of managing e-waste. Subordinate processing cost, lower labour cost and lack of environmental decree enforcement are the major reasons for increasing unlawful trading of e-waste.

3.6 E-Waste statistics in India

- India fifth biggest generator of e-waste in 2014.
- 76% of e-waste workers in India suffering from respiratory ailments.
- The total e-waste in India has been anticipated to be 1, 46,180 metric tons per year.
- The e-waste refuse stream is growing at a rate of 5-6 % per year, making it the fastest growing refuse problem in the world.
- The average life expectancy of a new PC is now less than two years.
- Delhi tops the list at present with 11,017 tons followed by Mumbai with 9,730 tons and Bangalore with 4,648 tons. An estimated 30,000 computers become obsolete every year from the IT industry in Bangalore alone. By 2014 India had about 75 million computers and the base is expected to grow to 140 million computers by 2017 end.

3.8 Research Methodology

Systematic methodology was put to use around research work completed for learning the E-waste control.

The study style stipulates the specifics - bolts-of implementation and the nuts. The study design with this analysis involved the following components

1. Designing the exploratory and descriptive par
2. Specifying the sampling progression & size.
3. Defining the info necessary, Scaling procedures and measurement scales.
4. Construction & Pilot tests of questionnaire.
5. Data assortment & data evaluation.

3.8.3 Questionnaire development & Pretesting of Questionnaire

A questionnaire within this study utilized to question variety of concerns to respondent a person to just one foundation to convert the responses of theirs after codification inside a statistical type of info associated with e waste control. The questionnaires utilized here's commercially good as well as a presented inside a lucid approach. The language implemented is easy English therefore the respondent recognizes the crux of the inquiries and so to decrease the standard mistakes takes place during virtually any surveys. It's proved to become effectual method of congregation info more correctly main for great samples which as well from a big geographic region.

Questionnaire tool proved to be helpful for several reasons:

i) Questionnaires have been economical. This was principally recognized as when these massive public is under review researcher needs to concentrate on the monetary constrains of it's to ensure not to boost the research budget of its.
ii) To be able to convert hardcopy day i.e. survey details within the type of questionnaire to soft copy structure to choose additional statistical evaluation it's really required to preserve thoughts free from any kind of bias in addition to as easy as possible.
iii) The survey trough questionnaire technique is individual's maximum and friendly public is conscious of this specific method, which will make respondent incredibly comfy and never concerned or even nervous.
iv) Within this way of main details compilation researcher is a lot less required therefore bias relevant to the subject becomes instantly decreased. This can help within decrease in mistakes throughout analysis step.

3.8.4 Questionnaire Development

For finding out managing of e-waste

Questionnaire Development got site in 2 stages:

i) An evaluation of relevant e waste managing methods round the world, its information and literature coming from suggest contamination management.
ii) A ultimate pretest for computing filtration to arrive at last questionnaire, the very first job was identifying the places within that the conclusion computer users react as well as via the evaluation of literature as well as a result a pilot learn, as well as aspects of employees knowing.

The next job was finding away, the way in which these tasks follow in the organized and unorganized sectors of course, if thus at what accuracy as well as at what fitness level. A little survey was done with 200 conclusion owners while around 185 have been gotten that comprise about 92.5 %. In line with the results coming from the small scale survey, the last questionnaire just for the primary survey was created.

The final questionnaire (refer appendix for Questionnaires) contained the inquiries with regards to conclusion computer user's methods performed & additionally to assess the frequency of these pursuits belonging in the prior 4 yrs. The last questionnaire contained 2 primary parts; Part A includes market based issues whereas component B contains thoughts on legitimate issue below review.

For learning the causes for undertaking e waste management tasks at individual levels and the organization have many explanations viz. getting connected with these businesses and therefore carry tasks within partnering together with the waste management pursuits. It was actually crucial to be aware of the reasons or even the motivating elements behind undertaking as good another degree of employment that is hazardous and dangerous to man nature and health.

IV. THEORETICAL CONTENT AND DATA ANALYSIS

4.1 E-WASTE IS A FAST-GROWING ENVIRONMENTAL HAZARD

E-waste management is a major concern for the environment as the disposal of electronic waste creates harmful effects on the environment. Electronic waste consists of discarded electronic devices that have reached the end of their life span. The improper disposal of electronic waste can lead to environmental pollution and health hazards. With the emergence of new technologies, the amount of electronic waste is increasing at an alarming rate.

- **Harms of E-waste Management:**

Environmental Pollution:

Electronic waste contains a large amount of hazardous materials that can pollute the environment. The improper disposal of electronic waste can lead to soil, air, and water pollution. Electronic waste contains heavy metals such as lead, mercury, cadmium, and arsenic that can seep into the ground, polluting soil and water. When electronic waste is burned, it releases harmful toxins and pollutants into the air, leading to air pollution.

Health Hazards:

The improper handling and disposal of electronic waste can lead to health hazards. Exposure to hazardous materials in electronic waste can cause health problems such as cancer, birth defects, and neurological disorders. Workers who handle electronic waste are at a higher risk of developing health problems.

Landfills:

Electronic waste takes up a significant amount of space in landfills. Landfills are quickly filling up, and electronic waste contributes to the problem. Electronic waste takes up valuable space and can lead to soil pollution and groundwater contamination.

Illegal Export:

Electronic waste is often illegally exported to developing countries. Developing countries do not have the proper infrastructure to handle electronic waste and end up dumping it, causing environmental pollution and health hazards. Illegal export of electronic waste is a major concern and needs to be addressed.

- **Possibilities of E-waste Management:**

Recycling:

Recycling is one of the most effective ways to manage electronic waste. Recycling helps to reduce the amount of electronic waste in landfills and saves valuable resources. Recycling also helps to reduce the amount of hazardous materials that end up in the environment. Recycling of electronic waste can lead to the recovery of valuable materials such as gold, copper, and aluminium.

Reuse:

Electronic devices that are still functioning can be reused. Reuse helps to extend the life of electronic devices and reduces the amount of electronic waste. Electronic devices can

be refurbished and resold, reducing the need for new electronic devices.

Legislation:

Legislation can help to manage electronic waste. Laws can be passed that require manufacturers to take back their products at the end of their life span. This would ensure that electronic devices are disposed of properly and not illegally exported to developing countries. Legislation can also require manufacturers to use environmentally friendly materials in their products.

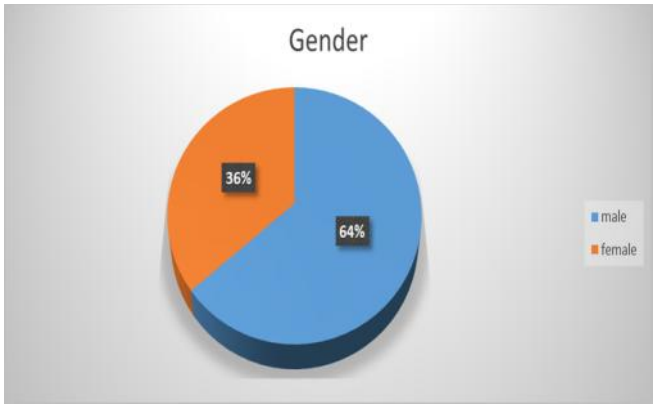
Education:

Education is key to managing electronic waste. Consumers need to be educated on the proper disposal of electronic waste. Consumers need to be informed of the harm that electronic waste can cause and the benefits of proper disposal. Education can help to increase awareness and encourage consumers to recycle and reuse electronic devices.

E-waste management is a major concern for the environment. The improper disposal of electronic waste can lead to environmental pollution and health hazards. However, there are possibilities for managing electronic waste. Recycling, reuse, legislation, and education can help to manage electronic waste effectively. By implementing these possibilities, we can reduce the amount of electronic waste in landfills, protect the environment, and reduce health hazards.

4.4 DATA ANALYSIS

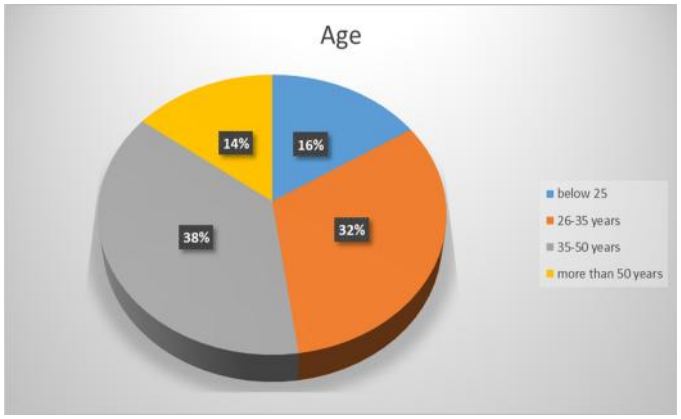
1. Gender



Graph 1 Gender

The graph shows the distribution of respondents by gender, where 246 respondents identified as male and 139 respondents identified as female. The total number of respondents is 385.

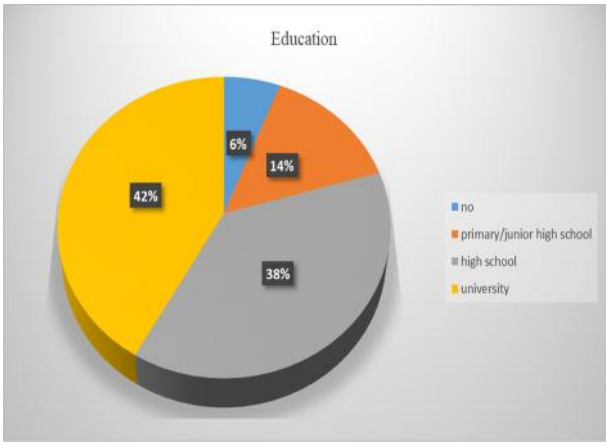
2. Age



Graph 2 Age

The table provides information about the number of individuals in different age groups. The age groups are divided into four categories: below 25, 26-35 years, 35-50 years, and more than 50 years. According to the table, there are a total of 385 individuals. Out of these, 61 individuals are below 25 years of age, 123 individuals are between 26-35 years, 145 individuals are between 35-50 years, and 56 individuals are more than 50 years old. Therefore, the highest number of individuals fall under the age group of 35-50 years (145 individuals), followed by those in the age group of 26-35 years (123 individuals). The lowest number of individuals is in the age group of more than 50 years (56 individuals), followed by those in the age group below 25 years (61 individuals).

3. Education

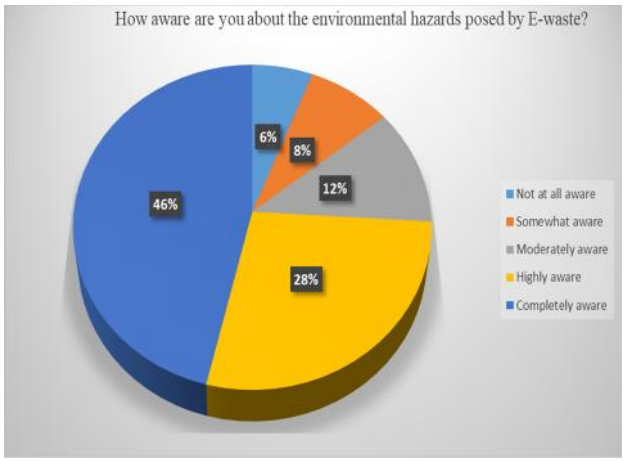


Graph 3 Education

This table shows the distribution of respondents based on their education level. The total number of

respondents is 385. Out of the 385 respondents, 23 did not provide any information about their education level. Among those who did provide information, 56 had a primary or junior high school education, 145 had a high school education, and 161 had a university education. Overall, the majority of the respondents (about 42%) had a university education, followed by those with a high school education (about 38%), and those with a primary or junior high school education (about 15%). The remaining respondents did not provide any information about their education level.

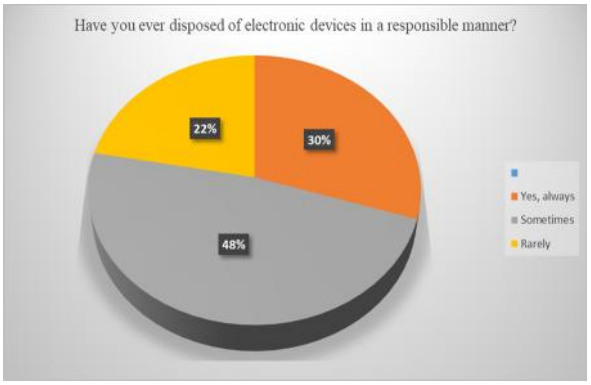
4. How aware are you about the environmental hazards posed by E-waste?



Graph 4 How aware are you about the environmental hazards posed by E-waste?

The table shows the responses of 385 individuals to a survey question about their awareness of environmental hazards posed by e-waste. Out of the total respondents, 23 indicated that they were not at all aware of the hazards, 32 said they were somewhat aware, 45 were moderately aware, 107 were highly aware, and 178 were completely aware. The majority of the respondents, 285 in total, indicated that they were either highly or completely aware of the environmental hazards posed by e-waste. This suggests that people are becoming more informed and conscious about the potential dangers associated with electronic waste disposal. However, the fact that 55 respondents indicated low to moderate awareness indicates that there is still work to be done in educating the public about e-waste and its impact on the environment.

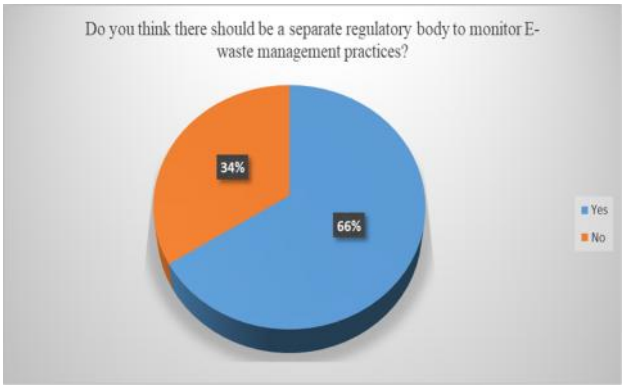
5. Have you ever disposed of electronic devices in a responsible manner?



Graph 5 Have you ever disposed of electronic devices in a responsible manner?

The table shows the responses of a group of individuals who were asked if they have ever disposed of electronic devices in a responsible manner. A total of 385 people were surveyed, and their responses were categorized into four options: Yes, always; Sometimes; Rarely; and Never. Out of the 385 respondents, 91 individuals (approximately 24% of the total) answered that they always dispose of electronic devices in a responsible manner. 146 people (around 38% of the total) stated that they sometimes dispose of electronic devices responsibly, while 67 individuals (about 17% of the total) said they rarely do so. Finally, 81 people (about 21% of the total) admitted that they never dispose of electronic devices in a responsible manner. Overall, the data suggests that a significant proportion of people do not dispose of electronic devices in an environmentally responsible manner, with over one-fifth of respondents admitting that they never do so. However, a majority of people (around 62% of respondents) have at least some level of awareness about responsible electronic waste disposal and dispose of their devices in a responsible manner, either always or sometimes.

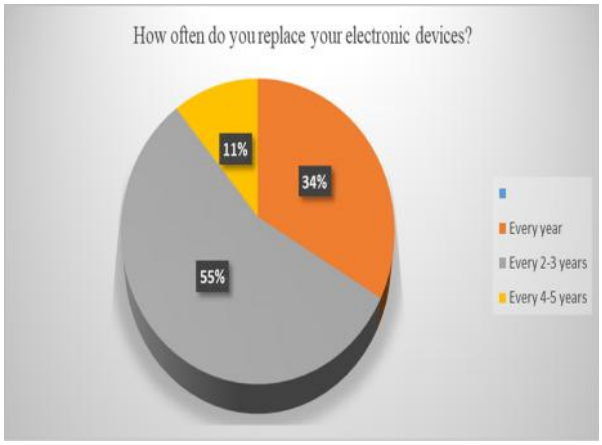
6. Do you think there should be a separate regulatory body to monitor E-waste management practices?



Graph 6 Do you think there should be a separate regulatory body to monitor E-waste management practices?

The table shows the results of a survey question asking whether respondents think there should be a separate regulatory body to monitor E-waste management practices. Out of 385 total respondents, 254 were male and 131 were female. It is not clear from the table whether the respondents' gender has any significant impact on their views on the need for a separate regulatory body. However, it is evident that a majority of the respondents (385) believe that there should be a separate regulatory body to monitor E-waste management practices, although the exact percentage is not provided.

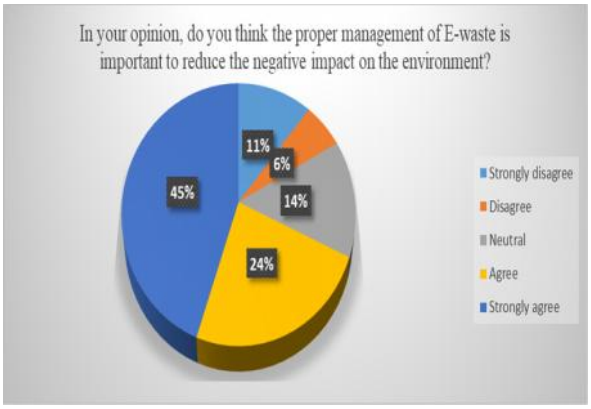
7. How often do you replace your electronic devices?



Graph 7 How often do you replace your electronic devices?

The table shows the responses of a group of people to a question about how often they replace their electronic devices. A total of 385 people responded to the question. Out of the total, 103 people reported that they replace their electronic devices every year, 170 people reported that they replace them every 2-3 years, 34 people replace them every 4-5 years, and 78 people reported that they replace them once in more than 5 years. Based on this data, we can see that the majority of the respondents (170) replace their electronic devices every 2-3 years, while a significant number of people (78) replace them once in more than 5 years. This suggests that people have different habits and preferences when it comes to replacing their electronic devices. The data can be used by manufacturers and retailers to understand consumer behavior and tailor their products and marketing strategies accordingly.

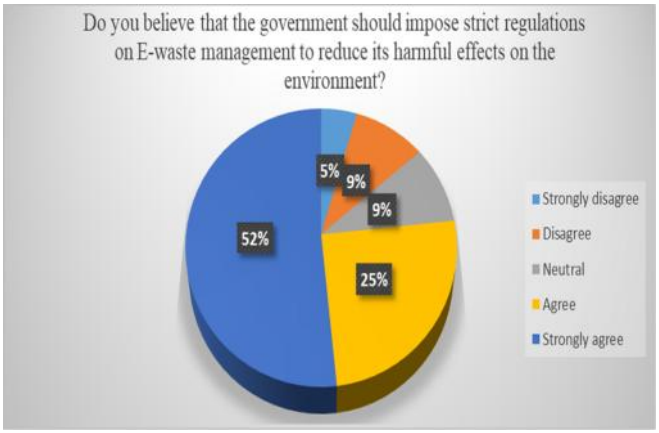
8. In your opinion, do you think the proper management of E-waste is important to reduce the negative impact on the environment?



Graph 8 In your opinion, do you think the proper management of E-waste is important to reduce the negative impact on the environment?

The data shows that out of 385 respondents, the majority of them (178) are completely aware of the importance of proper management of E-waste in reducing the negative impact on the environment. 107 respondents consider themselves highly aware, 45 are moderately aware, and 32 are somewhat aware. On the other hand, 23 respondents are not at all aware of this issue. The results indicate that there is a general understanding among the respondents that proper management of E-waste is crucial to reduce the negative impact on the environment. This is important because E-waste contains hazardous materials that can cause harm to the environment and human health if not disposed of properly. Therefore, it is essential to raise awareness about the importance of proper E-waste management and to encourage individuals and organizations to take action in this regard.

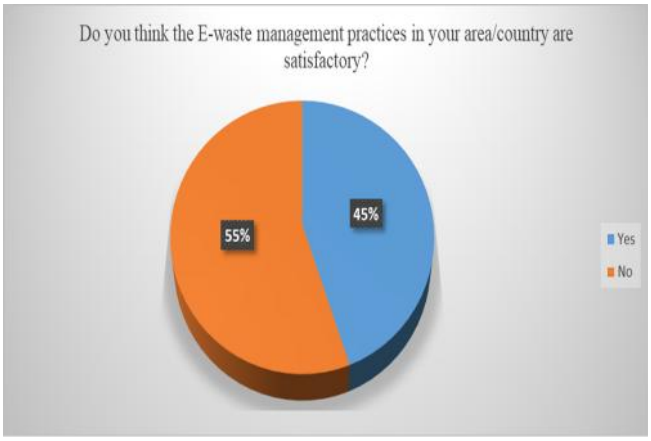
9. Do you believe that the government should impose strict regulations on E-waste management to reduce its harmful effects on the environment?



Graph 9 Do you believe that the government should impose strict regulations on E-waste management to reduce its harmful effects on the environment?

Based on the survey results, it appears that a significant majority of the respondents (295 out of 385) believe that the government should impose strict regulations on E-waste management to reduce its harmful effects on the environment. Of these, 199 strongly agree and 96 agree with this idea. On the other hand, there are 54 respondents who disagree or strongly disagree with the statement, indicating that they do not believe that strict regulations on E-waste management are necessary or desirable. Another 36 respondents were neutral on the issue. Overall, the results suggest that there is a strong support for government intervention in regulating E-waste management, likely driven by concerns over the environmental impact of electronic waste.

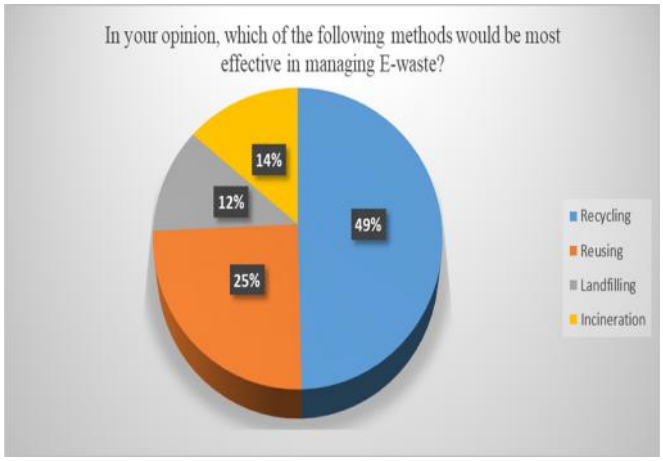
10. Do you think the E-waste management practices in your area/country are satisfactory?



Graph 10 Do you think the E-waste management practices in your area/country are satisfactory?

The data shows that out of 385 respondents who were asked about their opinion on E-waste management practices in their area/country, 172 responded with "Yes" indicating that they are satisfied with the E-waste management practices while 213 responded with "No" indicating that they are not satisfied. Therefore, it can be interpreted that there is a significant number of people who are not satisfied with the current E-waste management practices in their area/country, which suggests that there may be room for improvement in E-waste management practices.

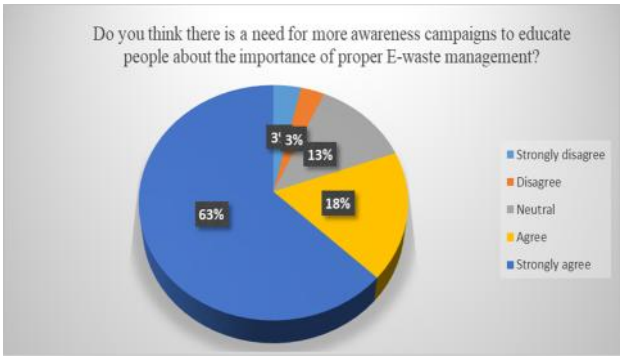
11. In your opinion, which of the following methods would be most effective in managing E-waste?



Graph 11 In your opinion, which of the following methods would be most effective in managing E-waste?

The data shows the responses of a group of individuals who were asked to give their opinion on the most effective method for managing E-waste. Out of the given options, the majority of individuals (191 out of 385) believe that recycling is the most effective method for managing E-waste. This is followed by reusing (95), incineration (54), and landfilling (45). Based on this data, it can be concluded that the majority of individuals believe that recycling is the most effective method for managing E-waste. This is because recycling helps to reduce the amount of electronic waste that ends up in landfills and incinerators, which can have harmful effects on the environment and human health.

12. Do you think there is a need for more awareness campaigns to educate people about the importance of proper E-waste management?



Graph 12 Do you think there is a need for more awareness campaigns to educate people about the importance of proper E-waste management?

Based on the responses provided, it appears that a majority of respondents (310 out of 385) believe that the government should impose strict regulations on E-waste management to reduce its harmful effects on the environment.

In fact, 242 respondents strongly agree with this statement. On the other hand, there are 26 respondents who disagree or strongly disagree with the idea of government intervention in E-waste management. Regarding the need for more awareness campaigns to educate people about proper E-waste management, the responses are more mixed. While a significant number of respondents (310 out of 385) believe in government intervention, only 117 out of 385 respondents (30%) believe that there is a need for more awareness campaigns. Overall, the results suggest that while there is strong support for government intervention in E-waste management, opinions on the need for more awareness campaigns are more divided.

V. CASE STUDY

Overview of Pimpri Chinchwad:

Pimpri Chinchwad is a rapidly developing city in the Pune district of Maharashtra, India. Pimpri Chinchwad is a rapidly developing city in the Indian state of Maharashtra, with a population of over 1.7 million. Like many urban areas, the city generates a significant amount of electronic waste or e-waste, which includes electronic items like computers, televisions, mobile phones, and other electronic gadgets. It is home to several major industries, including automotive, engineering, and IT. The city's population has been steadily increasing, and so has the amount of e-waste generated. According to a report by the Central Pollution Control Board (CPCB), Maharashtra generates around 1.2 lakh metric tonnes of e-waste annually, and Pune alone generates around 14,000 metric tonnes. The management of e-waste is a critical issue in Pimpri Chinchwad, as improper disposal of e-waste can have adverse effects on human health and the environment. The city administration has implemented several measures to manage e-waste in a sustainable manner. Here are some of the key initiatives taken by the authorities:

- ✓ **E-waste Management in Pimpri Chinchwad:**

E-waste management in Pimpri Chinchwad is primarily handled by the Pimpri Chinchwad Municipal Corporation (PCMC) and the Maharashtra Pollution Control Board (MPCB). The PCMC has established a Solid Waste Management Department that oversees the collection and disposal of e-waste in the city.

Fig 6: As part of the drive, a team of 800 volunteers were stationed at 112 centres, in eight zones of Pimpri-Chinchwad area.

- ✓ **Collection and Segregation:**

The PCMC has set up e-waste collection centers at various locations across the city, where citizens can drop off their e-waste. The collected e-waste is then transported to a central segregation facility, where it is sorted into different categories such as computers, laptops, mobile phones, and other electronic devices.

- ✓ **Recycling and Disposal:**

After segregation, the e-waste is sent to authorized recycling facilities for further processing. The recycling process involves the extraction of valuable metals such as gold, silver, and copper from electronic components. These metals can then be reused in the manufacturing of new electronic products. The remaining non-recyclable waste is disposed of in a safe and environmentally friendly manner.

- ✓ **Awareness Programs:**

To increase public awareness about e-waste management, the PCMC has launched several initiatives. It conducts regular awareness campaigns in schools, colleges, and other public places. The PCMC has also collaborated with several NGOs and private organizations to promote e-waste management.

Fig 7: E-Waste Collection Campaign to Be Implemented in Pimpri-Chinchwad

Source: https://www.punekarnews.in/pune-e-waste-collection-campaign-to-be-implemented-in-pimpri-chinchwad/

Throughout the course of this year, the city of Pimpri-Chinchwad will be conducting a program for the collecting of electronic garbage. The information that hazardous garbage would be collected, recycled, or disposed of scientifically was provided by the Municipal Commissioner Shekhar Singh.

He made these remarks at the Pimpri Chinchwad Municipal Corporation's E-Waste Center in Bhosari, which was celebrating the launch of a pickup van for electronic garbage at the time (PCMC). In attendance were Additional Commissioner Jitendra Wagh, Civil Engineer Sanjay Kulkarni, Head of Information and Public Relations Ravikiran Ghodke, Assistant Commissioner Anna Bodde, Vinita Date of the ECA, Green Scape Head Dr. Rupesh Kadam, and Asha Rao, Natasha Gangal, and Hiraman Bhujbal. Also present was Vinita Date of the ECA.

The task of recycling e-waste and plastic at the cum hobby center was launched with the assistance of PCMC and GreenScape, as well as ECA. Commissioner Singh laid forth the general plan for this undertaking and offered some recommendations. According to what he indicated, a permanent e-waste collection program that runs throughout the year would shortly be adopted across the whole of the city when the first campaign is over.

✓ **Challenges and Roadblocks:**

Despite the PCMC's efforts, there are still some challenges in managing e-waste effectively in Pimpri Chinchwad. One of the main challenges is the lack of awareness among the general public about e-waste management. Many people still dispose of their e-waste in regular trash bins, which can lead to environmental pollution and health hazards. Another challenge is the lack of infrastructure for e-waste management. Although the PCMC has set up e-waste collection centers, they are not enough to cater to the city's growing population. The collection centers also need to be located in more convenient locations to encourage more people to use them.

✓ **Extended Producer Responsibility (EPR):**

The PCMC has also implemented the concept of Extended Producer Responsibility (EPR), which holds manufacturers responsible for the disposal of their products after the end of their useful life. The EPR policy requires manufacturers to collect and dispose of e-waste generated from their products. The PCMC has also imposed a penalty on manufacturers who fail to comply with the EPR policy.

✓ **E-waste Rules and Regulations:**

The Government of India has notified the e-waste (Management and Handling) Rules in 2016 to regulate the management of e-waste in the country. The PCMC has adopted these rules and implemented them effectively in the city. The rules mandate the proper disposal of e-waste, registration of e-waste recyclers, and the establishment of collection centers.

Fig 8: A file photo of e-waste collection in Pradhikaran. Now, residents can have the waste picked up form their doorsteps

It is now possible for people living in Pimpri and Chinchwad to dispose of their electronic garbage by only making a phone call to assistant health officials and requesting that they collect the rubbish from their doorsteps.

To collect the electronic garbage, the Pimpri-Chinchwad Municipal Corporation (PCMC) has sent out different vans, one for each of the city's zonal wards. Residents may use the service by calling the relevant contact numbers that have been supplied to them by the governing body of their individual wards. E-waste was collected from housing societies by scrap sellers, hawkers, and non-governmental organizations up until now since there was no structure in place to handle the collection of it (NGOs).

"The new service may be offered on-call," said Dr. Anil Roy, who is the head of health at the PCMC. In order to make use of the service, residents of housing societies need to phone the numbers that have been posted in their particular wards.

The Pimpri-Chinchwad Municipal Corporation (PCMC) has hired BVG India Ltd and AG Enviro Infra Projects, two private companies, to collect the city's trash on a daily basis. An official from the municipal organization was told that these two organizations have assigned the responsibility of collecting e-waste from doorsteps. Nigdi resident Jaydeep Pawar stated, "It is excellent that the PCMC has launched a separate system for collecting the e-waste. But, I would like to recommend that they could have provided people rewards after dumping their e-waste. " Alternatively, alternatively, they may provide just token concessions on any and all municipal taxes.

Hinjewadi and Talwade parks are both significant centers of the information technology industry that surround Pimpri-Chinchwad. E-waste is becoming a problem in the city as a result of the explosive expansion of the information technology industry here. The PCMC used to dispose of e-waste at the Moshi garbage depot along with the garbage. However, the Maharashtra Pollution Control Board (MPCB) ordered the PCMC not to dispose of e-waste without treatment at the Moshi garbage depot due to incidents of fires and the emission of toxic gas at the Moshi garbage depot. Previously, the PCMC disposed of e-waste at the Moshi garbage depot along with the garbage. There was not a distinct method in place for collecting.

- ✓ **Collaboration with NGOs and Private Players:**

The PCMC has collaborated with NGOs and private players to enhance its e-waste management efforts. The collaboration has helped in creating awareness, promoting recycling, and establishing a robust e-waste management system in the city.

- ✓ **Micro Steps**

The Pimpri-Chinchwad SME sector, which now disposes of e-waste to scrap dealers, must also be brought into the picture via awareness campaigns and laws. The rule will take effect on May 15, 2012, when the E-waste (Management and Handling) Regulations 2011 take effect. PK Mirashe, MPCB regional officer (Pune), said that the Central Pollution Control Board has merely issued recommendations about e-waste. "Guidelines are not rules; they do not require generators to comply. In the absence of a recycling facility, the MSME sector will sell the waste to the local kabariwallas. If the e-waste regulations are enacted, we will be able to clamp down on industries that do not dispose of e-waste correctly. We can also identify the industries and items responsible for the most pollution," he stated.

- ✓ **E-INITIATIVE**

Officials from the PCMC confirmed that they want to set up a PPP unit to recycle e-waste. It has reached an agreement in principle with Green Enviro, which is part of Pasco Environmental Solutions and gets rid of biomedical waste. "We've found a five-acre plot near the Moshi Kachara Depot, and our goal is to give them land and set up monitoring systems. The whole unit needs a high-tech way to recover metal, glass, and plastic from things like equipment. "It will cost Rs 15 crore," a government worker said in private. "The feasibility report for the project has come," said Asheesh Sharma, a PCMC commissioner. Soon, he will decide whether to go ahead with Green Enviro to build the collection center or to call for new bids. He said, "We want to do a thorough analysis to make sure we can give the job to the current company or ask for new bids." Green Enviro has asked the MPCB for a license to set up the unit, which will start with an investment of Rs 1.5 crore. "We need to understand how things work and spread the word so that a lot of e-waste comes to us. Otherwise, the set-up won't work," said Sunil G. Dandawate, the company's director.

"Our first goal will be to connect with the informal sector, since they need to make a living and are a great place to get rid of e-waste. During the early stages of the dismantling process, we will also work with a facility that is already up and running in Bangalore or Hyderabad. The other thing that makes e-waste is the huge amount of e-waste made at home, which comes from four main things: personal computers, cell phones, refrigerators, and TVs. The SWaCH coordinator for e-waste in PCMC, Maitreyi Shankar, said that this source would be their main focus once the process for getting rid of the waste was made official.

"Our members are people who pick up trash and collect it. They are at the bottom of the chain. But they are the

best way to collect e-waste from people's homes because it will be hard to get the average person to follow the law. On the one hand, we plan to teach our members how to collect e-waste, and on the other, we plan to work with housing societies to set up programs to do the same.

VI. CONCLUSION

E-waste management is a complex and challenging problem in India. The lack of awareness, informal sector involvement, policy implementation, limited infrastructure, and technology challenges are all significant obstacles to effective e-waste management. However, there are a number of potential solutions, including raising awareness, formalizing the informal sector, strengthening policy implementation, developing infrastructure, investing in technology, and encouraging producer responsibility. By implementing these solutions, India can take steps to address the e-waste problem and ensure a more sustainable future.

In conclusion, the proper management of electronic waste is essential to minimize its harmful impact on the environment and human health. The study of the harms and possibilities of e-waste management reveals the urgent need for effective solutions to tackle this emerging threat. The analysis of laws and policies associated with e-waste management in India highlights the government's efforts in regulating the sector. However, there are challenges faced, such as inadequate infrastructure, limited awareness, and poor enforcement of laws. To address these challenges, effective solutions such as public awareness campaigns, innovative recycling technologies, and collaboration between stakeholders are necessary.

The case study of e-waste management in PCMC highlights the pros and cons of the current practices. The pros include the use of advanced recycling technologies and the creation of job opportunities, while the cons include the high cost of implementation and the risk of environmental pollution. The rapid growth in technological advancements has resulted in an increase in the generation of electronic waste, posing significant environmental and health hazards to the community. While the government has introduced various policies and regulations to address the issue, there is still a need for increased awareness and participation from all stakeholders. The effective management of e-waste requires a collaborative effort between the government, manufacturers, consumers, and waste management organizations. The adoption of sustainable practices such as recycling, reuse, and refurbishment of electronic waste can go a long way in reducing the negative impact of e-waste on the environment and society. Therefore, it is crucial to take immediate action and prioritize the proper management of e-waste in PCMC and beyond.

Overall, a comprehensive approach that balances environmental protection and economic development is crucial for effective e-waste management in India. In conclusion, e-waste management is a crucial issue that needs to be addressed in PCMC. The BMC's efforts to manage e-waste are commendable, but more needs to be done to increase public awareness and improve infrastructure for e-waste management. The government, NGOs, and private organizations need to work together to create a sustainable and effective e-waste management system. PCMC has taken several steps to manage e-waste effectively. The city administration has set up collection centres, implemented recycling practices, conducted awareness campaigns, and adopted EPR policies to ensure sustainable e-waste management. However, there is still a long way to go, and continuous efforts are required to improve e-waste management in the city.

REFERENCES

[1] Guanabara, E., Ltda, K., Guanabara, E., & Ltda, K. (2011). *An Operations Perspective on Product Take- Back Legislation for E-Waste: Theory, Practice and Research Needs*. *2004*(2010), 1–28. https://d1wqtxts1xzle7.cloudfront.net/30759473/AV11-libre.pdf

[2] Luu, A., Kim, N., & Lee, J. (2015). *Dear Author , Please , note that changes made to the HTML content will be added to the article before publication , but are not reflected in this PDF . Note also that this file should not be used for submitting NURBS-based isogeometric analysis*. https://re.public.polimi.it/bitstream/11311/978877/4/ViewPageProof_RSER_4546.pdf

[3] Debnatha, B., Roychoudhurib, R., & Sadhan K Ghosh. (2016). *S1878029616301529 @ pdf.sciencedirectassets.com*. https://pdf

[4] Awasthi, A. K., Cucchiella, F., D'Adamo, I., Li, J., Rosa, P., Terzi, S., Wei, G., & Zeng, X. (2018). Modelling the correlations of e-waste quantity with economic increase. *Science of the Total Environment*, *613–614*(August), 46–53. https://doi.org/10.1016/j.scitotenv.2017.08.288

[5] Appolloni, A., D'Adamo, I., Gastaldi, M., Santibanez-Gonzalez, E. D. R., & Settembre-Blundo, D. (2021). Growing e-waste management risk awareness points towards new recycling scenarios: The view of the Big Four's youngest consultants. *Environmental Technology and Innovation*, *23*, 1–14. https://doi.org/10.1016/j.eti.2021.101716

[6] Xavier, L. H., Giese, E. C., Ribeiro-Duthie, A. C., & Lins, F. A. F. (2021). Sustainability and the circular economy: A theoretical approach focused on e-waste urban mining. *Resources Policy*, *74*(August), 101467. https://doi.org/10.1016/j.resourpol.2019.101467

[7] Lebel, S. (2012). Wasting the Future: The Technological Sublime, Communications Technologies, and E-waste. *Communication +1*, *1*(1). https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1003&context=cpo

[8] Mahmud, I., Sultana, S., Rahman, A., Ramayah, T., & Cheng Ling, T. (2020). E-waste recycling intention paradigm of small and medium electronics store managers in Bangladesh: An S–O–R perspective. *Waste Management and Research*, *38*(12), 1438–1449. https://doi.org/10.1177/0734242X20914753

[9] Sivathanu, B. (2016). *User ' s Perspective : Knowledge and Attitude towards*. *11*(2), 413–423. http://www.ripublication.com/ijaes16/ijaesv11n2_06.pdf

[10] Sivathanu, B. (2016). *User ' s Perspective : Knowledge and Attitude towards*. *11*(2), 413–423. http://www.ripublication.com/ijaes16/ijaesv11n2_06.pdf

[11] Halim, L., & Suharyanti, Y. (2019). *Unknown - Unknown - 3214-8007-1-PB*. *1*(2).

[12] Attia, Y., Soori, P. K., & Ghaith, F. (2021). Analysis of households' e-waste awareness, disposal behavior, and estimation of potential waste mobile phones towards an effective e-waste management system in dubai. *Toxics*, *9*(10). https://doi.org/10.3390/toxics9100236

[13] Madkhali, H., Duraib, S., Nguyen, L., Prasad, M., Sharma, M., & Joshi, S. (2023). *A Comprehensive Review on E-Waste Management Strategies and Prediction Methods : A Saudi Arabia Perspective*. 163–179.