

Electronic Waste: Growing issues Practices and Strategies

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ABSTRACT

Majority of the electronic devices life cycle is reduced substantially because of change in technology, attractive designs, marketing trends and compatibility issues. One of the fastest growing problems is E-waste generation across the world. E-waste is an electronic that is outdated, obsolete, broken, denoted, discarded, or at the end of useful life. Among the e-waste generated only 15 -20 % of them is recycled. In last 5 years worldwide e-waste is gradually increased by 21%. E-waste consists of toxic and hazardous materials which have a serious issue on human health and the environment. It is essential to evolve safe and scientific methodologies for disposal and recycling. E-waste management must be given prime importance Population growth, modern life style, advanced technology are the driving factors for generation e-waste. The objectives the paper is to study e-waste and its impact .This paper is basically a secondary research by referring the reports, journal articles , web links etc It provides knowledge about e-waste

Keywords – Health, E-waste, Recycling, Hazardous, Disposal, Management

Date of Submission: 24-01-2021

Date of Acceptance: 08-02-2021

I. INTRODUCTION

Electronic waste, also known as ‘E-waste’ is an electronic item which become obsolete due to : modern technology , design, style, end of their useful life. Over the past twenty years, the usage of electrical and electronic equipment grown exponentially, which needs significant amount of importance. The e-waste has created very dangerous stream of waste. Dangerous chemicals and toxic substances present in e-waste is serious impact on environmental and human health. E-waste is generation is growing exponentially due, millions of computing devices mobiles, TVs and other electronic and electrical are discarded every year.

E-waste contains toxic substances and hazardous materials. These materials have causing several health problems, When these are not disposed in landfills or incinerated improperly The ingredients of e-waste is very diverse and varies among different products and categories. Improper disposal of e-waste release of toxic materials from these materials has adverse effect on human health and environment Therefore e-waste is threat to environment. Therefore the study is done to know the e-waste, various components of e-waste and need of e-waste management. This paper reviews the work done by earlier researches by referring published papers, news paper articles websites.

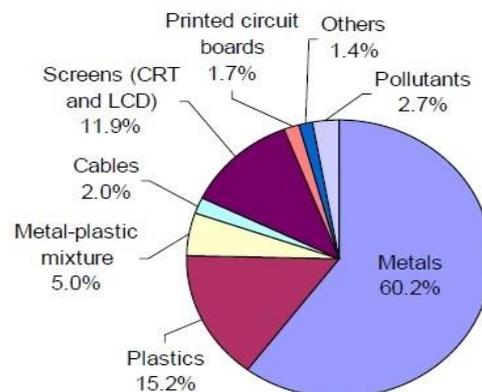


Figure1 : Composition of e-waste

Figure-1 Composition of materials found in electronic waste (courtesy: Swiss Laboratories for Materials Testing and Research.)

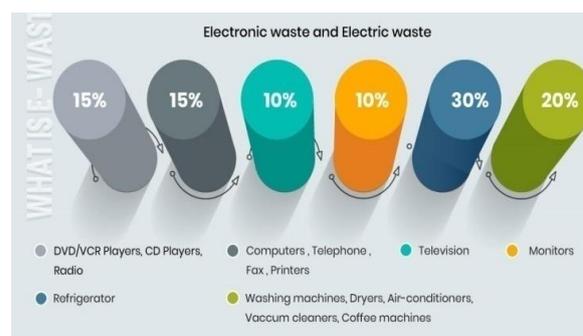


Figure 2: Distribution of E-waste

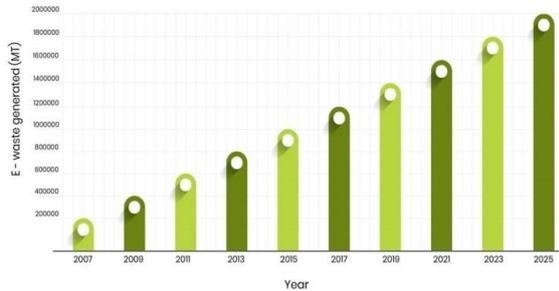


Figure 3: Exponential growth of e-waste

Safe and sustainable disposal of electronic waste is a major issue due to its perilous impact on human life and environment because of hazardous and highly toxic constituents. The purpose of the paper is to provide information about e-waste, its impact on health and recycling process. The paper is organized as follows: Section 1 contains an introduction about e-waste; Section 2 contains E-waste sources and impact; Section 3 contains E-waste recycling; Section 4 contains e-waste disposing methods; Section 5 contains E-waste management; Section 6 gives Conclusion.

II. E-WASTE SOURCES AND IMPACT

Main Sources of E-waste

Some of the major sources of E-waste include

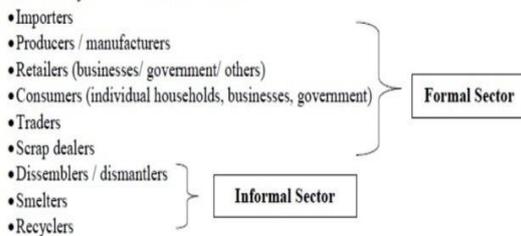


Figure 4: Sources of E-waste

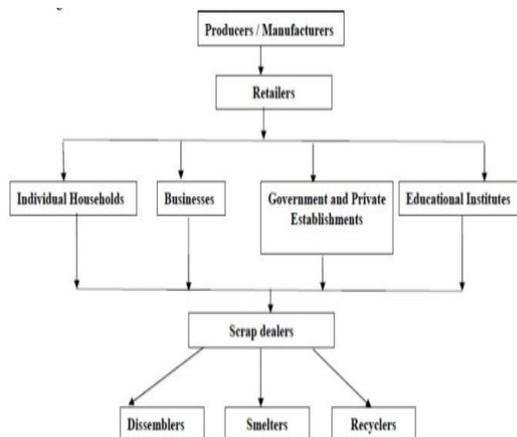


Figure 5: Flow of E-waste across different sectors

Impact of e-waste

The e-waste disposal is a major concern in many regions in the world. E-waste has a harmful impact on nature and its resources and human, animal's health. E-waste is very difficult to recycle as it is a complex and difficult form of waste. E-waste contains deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides, brominated flame retardants, beryllium, antimony and phthalates. People are exposed to toxic chemicals.

E-waste causes respiratory irritation, choking, neuropsychiatric problems, convulsions and chronic ailments such as asthma, skin diseases, eye irritations and stomach disease DNA damage.

a. Human Health

Exposure to the hazardous substances of the e-waste components for a longer duration causes damage to nervous systems, kidney, bones, and the reproductive and endocrine systems. Improper recycling or disposal of e-waste to landfills and incinerators pollutes the water and soil, and contaminates air and causes irreversible damage to the environment. The e-waste includes a substantial amount of hazardous materials such as lead, cadmium, chromium and flame-retardant plastics. Frequent contact with them causes various health problems.

Table 1 E-waste Toxicants effects on health

S.No	Source of e-wastes	Toxic component	Medium of exposures	Health effects
1	PCBs, computer monitors, Television, bulbs	Lead (Pb)	Air, water, soil, dust	Nervous systems, DNA, blood system reproductive health
2	Batteries	Nickel	Air, water, soil, dust, food	Lungs, dysfunction
3	PCBs, Wires	Copper	Air, water, soil, dust	Headache, dizziness, ENT disorders
4	PCBs Monitors Chip devices, phones, connecting components	Cadmium (Cd)	Air, water, soil, dust, food	DNA damage, Reproductive health kidney, liver. Causes neural damage.
5	Memory tapes and disks	Chromium	Air, water, soil, dust,	DNA damage, reproductive health, Lungs dysfunction
6	Relays and switches, printed circuit boards	Mercury (Hg)	Air, water, soil, dust,	Chronic damage to the brain. Respiratory and skin disorders
7	galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr VI)	Air, water, soil, dust,	Asthmatic bronchitis. DNA damage.
8	Cabling and computer housing	Plastics including PVC	Air, water, soil, dust,	Affects reproductive health, Immune systems damage, hormones
9	Plastic housing of equipments and circuit boards.	Brominated flame retardants (BFR)	Air, water, soil, dust,	Disrupts endocrine system function
10	Front panel of CRTs	Barium (Ba)	Air, water, soil, dust,	Muscle weakness; Damage to heart, liver and spleen
11	Motherboard	Beryllium (Be)	Air, water, soil, dust,	lung cancer, berylliosis. Skin diseases such as warts

b. Environment

Our landfills are becoming polluted because of the toxic nature of e-waste, and these toxins are seeping into underwater reservoirs. Improper disposal of e-waste and recycling will have an adverse effect on the environment.

1. **Soil:** e-waste takes hundreds of years to decompose. It has a damaging and long-lasting effect on the environment. Breakdown of electronic components release hazardous toxic chemicals. This will contaminate soil, plants and trees. Lead and lithium will enter into human and animal body through food chain.
2. **Groundwater :** Improperly disposing e-waste can release toxins such as mercury, lead, and cadmium which enters into the groundwater and contaminates water. This will have a hazardous effect on human health risks including reproductive system, cancer, and damages the immune system
3. **Air Pollution :** The e-wastes which are not recycled are burned in incinerators which produce dangerous emission. Such emission causes damage to animals and humans. Due to this ozone depletion and greenhouse gases rate will increase. This contributes to change in earth temperature and climate change
4. **Water Pollution :** Every year millions of tons of garbage including electronic waste enter into the sea/ocean. Electrical and Electronics waste are non-biodegradable. Therefore allowing e-waste to sea/oceans is hazardous to organisms. Due to this biodiversity will be disturbed, and makes the ecosystems imbalance

metallurgical processes. Plastics and other useful materials are also recovered.

The figure- 8 shows the entire E-waste recycling process under controlled conditions:

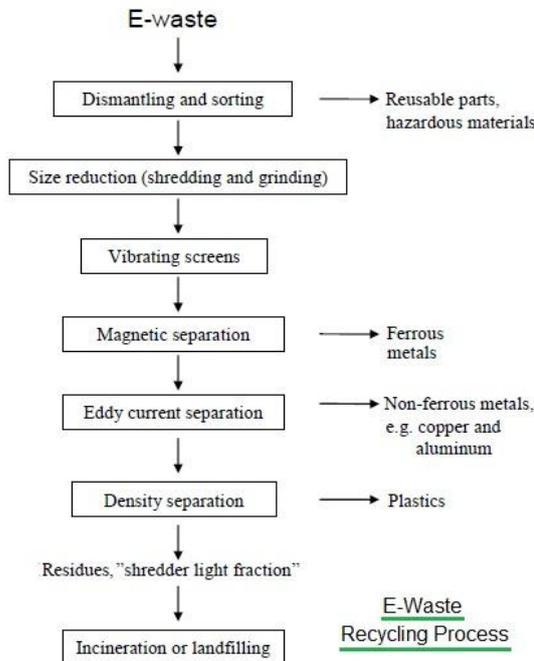


Figure 7 E-waste recycling process

Formal and informal methods are used for e-waste recycling. In Formal e-waste recycling all components are disassembled, separated and categorized by material then items are cleaned. These cleaned items are passed through shredding process mechanically for sorting. At the informal recycling valuable materials are recovered by burning devices to remove non-valuable materials by humans. They are exposed to dangerous materials due to lack of awareness and protective equipments. It results in serious health issues because humans workers come in direct contact and inhale toxic chemicals. Recycling process can be performed under controlled condition

III. E-WASTE RECYCLING

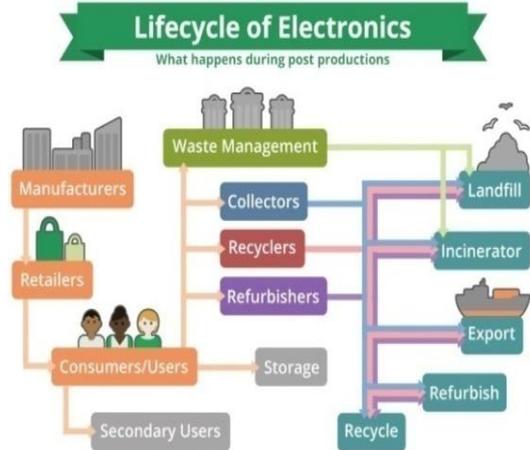


Figure 6: Electronic devices life cycle.

1) E-waste recycling Process

The e-waste recycling can be performed by two methods viz. under controlled conditions and under un-controlled conditions. Under controlled conditions process has two types. In the first method e-waste is first dismantled, then mechanically processed to separate/recover the materials. In the second method, metals are recovered from

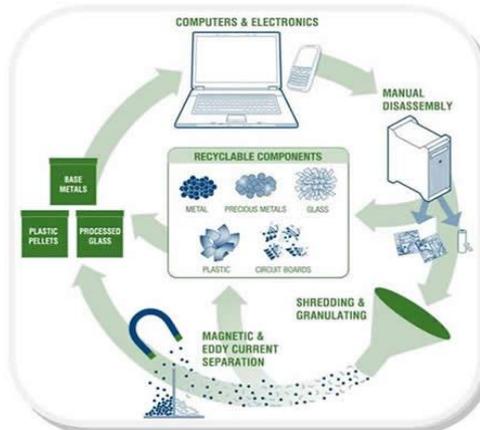


Figure 8: An example of e waste recycling

2) E-waste Recycling Steps

Picking: Old and damaged electrical and electronic devices and accessories are collected from collection bins of electronic take back booths. These accessories are then transported to the recycling plants and facilities

Shredding: It is an initial size reduction process. At the recycling facility electronics items are shredded into 100mm pieces followed by further breaking down the material into smaller fragments. The sorted fragments later go through the separation process where plastic is removed from the metal and internal circuitry. Precious metals – primarily gold, silver and copper are recovered by shredding and smelting operation on circuit boards components are sorted for specialized downstream recycling. All equipment is dismantled to Circuit Board and Component level

Magnetic Removal: A powerful overhead magnet separates steel and iron fragments from the waste, Eddy currents and optical identification and other advanced separation technologies are used to separate metallic items, aluminum, copper, circuit boards and brass for non metallic items such as plastic and glass. In this stage Metallic & Non-Metallic Contents are separated

Separation by Water: After separating metallic and non metallic pieces, plastic and glass fragments are separated using water. Visual inspection and hard sorting are also used to improve the quality of extracted materials.

Preparation for sale: Separated aluminum, brass and copper are prepared for sale as recycled metals. They are used by manufacturer to make new electronic devices and other items. The separated plastic pieces are sorted are sorted by color and sold to plastic recyclers. Then from the separated glass, the glass which contains lead are sent to lead smelters that are further used to make products

Major obstacles to manage the e wastes;

- Non availability of sufficient and suitable data to design e-waste reduction and recycle strategy and non willingness of corporate sectors/company to investment the process
- Small quantity of e waste are used to recycle because of absence of take back scheme for consumers,
- Non availability of healthy and safe working environment for e waste recycling facility in the formal sector.
- The current e waste recycle process, infrastructure and systems are focusing on business point of view

3) New Method of E-waste Pprocessing

Electronics waste becomes a global issue because of exponential growth in use of electronic devices. If e-waste is not handled properly it has an

adverse effect on human health and environmental issues. A new e-waste processing method is shown in the following figures [13]

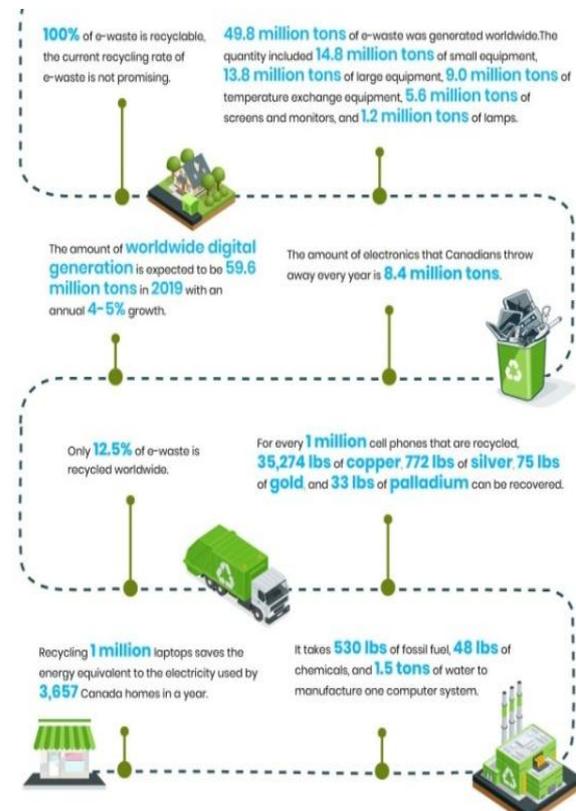


Figure 9 : Global E-waste scenario

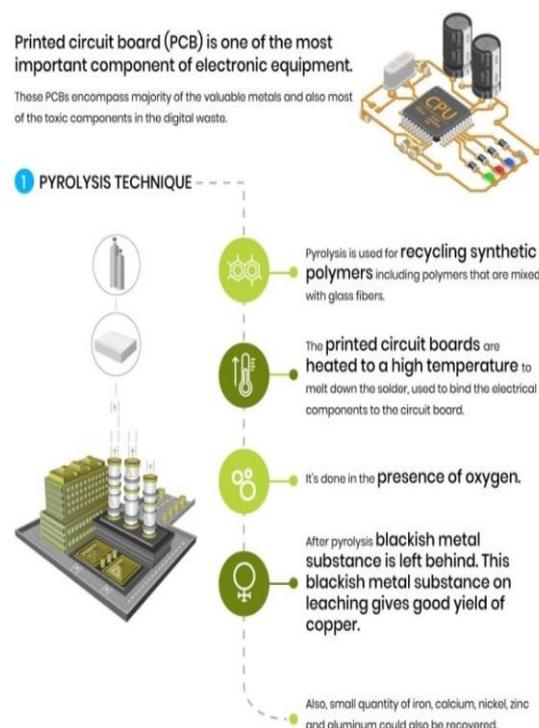


Figure 10 : Pyrolysis Technique

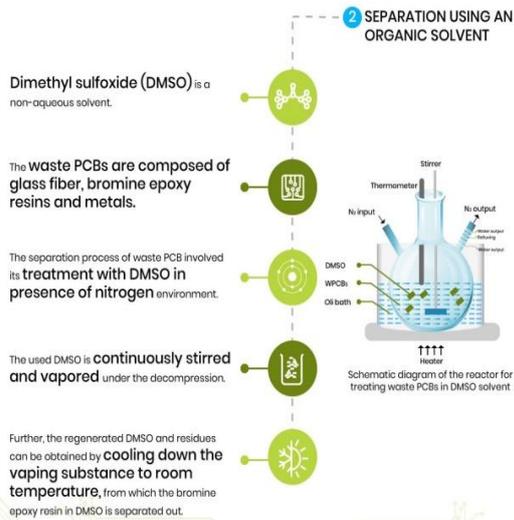


Figure 11: separation using organic solvent

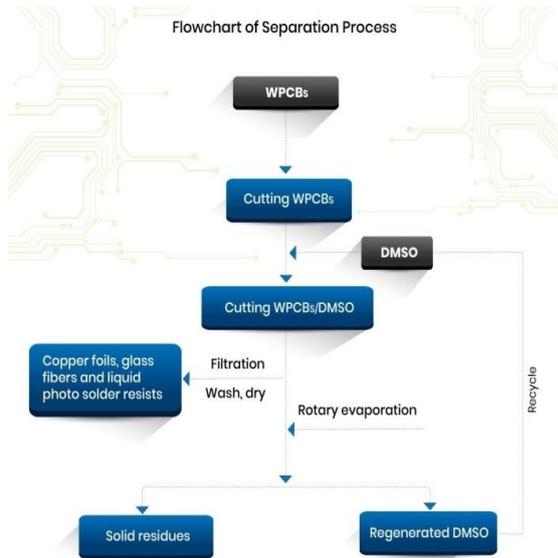


Figure 12: Flow chart of separation process

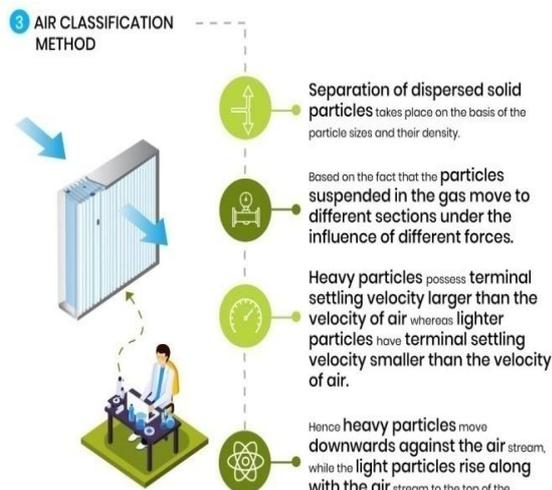


Figure 13: Air Classification Method

Schematic Representation of Air Classification Method

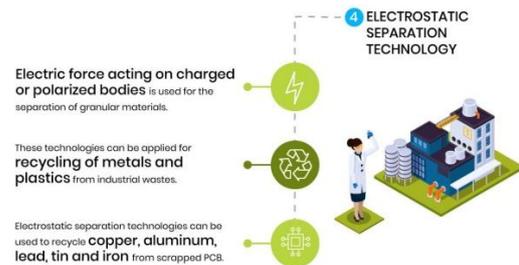
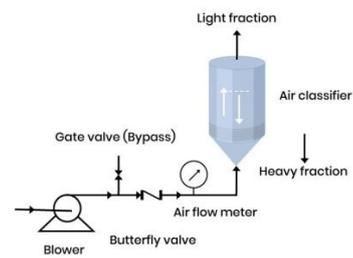


Figure 14: Schematic representation air classification method

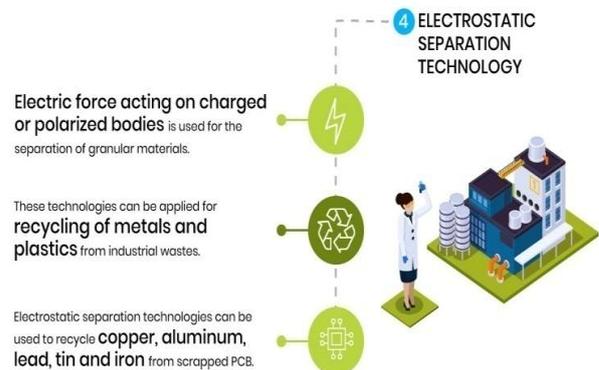


Figure 15: Schematic representation of air classification method

IV. METHODS OF DISPOSING E-WASTE

Electrical and Electronic good are classified as into three major types. 1. *White goods*: comprises of house hold appliances such as air conditioners, dishwashers, washing machines 2. *Brown goods*: comprises of televisions, camcorders, cameras. 3. *Gray Goods*: computers, printers, fax machines, scanners etc. These gray goods are more complex to recycle due to their multilayered configuration and higher toxic composition. Current method used to disposing of e-waste is as follows

Incineration: This is a controlled technique of e-waste disposing. In this process combustion of electronic waste takes place in designed incinerators at very high temperature. This method is has benefit because e-waste volume is reduced to a greater

extent and the energy obtained will be used separately. However this process emits harmful gases such as mercury and cadmium in the environment

Acid Baths: To make the metals free from electronic pathways, the electronic circuits soaked in powerful sulphuric hydrochloric or nitric acid solutions. The metals recovered from this process are used to manufacture other products. During the mean time the hazardous acid waste flows into the local water sources.

Landfills: One of the most commonly used method adopted e-waste disposal is land filling. In this process first soil is removed then trenches are made to bury the e-waste. An impervious liner is made of clay or plastic with a leach at basin for collection and environmentally sound process for disposing off the e-waste as toxic substances like cadmium, lead and mercury will enter inside the soil and ground water.

V. E-WASTE MANAGEMENT

Global E-waste Monitor reports that in 2019 nearly 53.6 million tons of e-waste was generated, where America generated 13.1 Mt, Europe 12Mt, Asia 24.9 Mt, Africa 2.9 Mt, Oceania 0.7 Mt and only 17% of this was collected and recycled and It also reports that a record 59 tons of e-waste, and predicts a rise to 81 tons by 2030

1. **Build a recycling Centre:** A recycling centre is to be set up for every community needs. It will help the people to meet, socialize, recycle and keep the clean environment
2. **Spread Awareness:** Spread the benefits of recycling which encourages people to adopt move towards recycling. Make banners to explain the advantages, do's and don'ts and put at prominent places in the community to see. This is an active approach for recycling.
3. **Involve local supermarkets:** supermarket can be involved to enhance the recycling activity among the neighborhood community.
4. **Contact the nearby media agencies:** Make use of Information technology to spread the by inviting local newspaper or TV channel. to visit neighborhood community and interview the local authorities and publish articles in news paper about the importance and need of recycling.
5. **Start a campaign:** Take a step to start a recycling campaign. Recycling campaigns will help to increase spreading of recycling awareness.
6. **Arrange a fun fair or carnival:** Involve young minds to inculcate the concept of recycling, Organize community recycling theme fair with games and prizes.

7. **Add Community Drop-Off Locations:** Provide drop off points in community. It is an inexpensive and , easy to use. This will increase recycling rates.
8. **Involve your local arts council:** Contact the local arts peoples and arrange painting show and sculptures made out of E-waste . Organize short plays which should highlight the E-waste benefits of recycling
9. **Get neighborly :** Visit every door with a small group and tell people how not to recycling , make aware how it will affecting their future. Collect funds which can then be used to arrange recycling program

Figure 16 shows the e-waste management Hierarchy

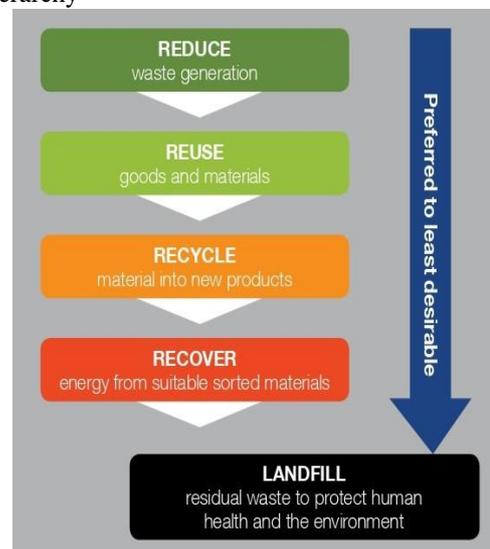


Figure 16 : Waste Management Hierarchy

E-Waste Frame work

A frame work for E-waste management system in India is shown in figure

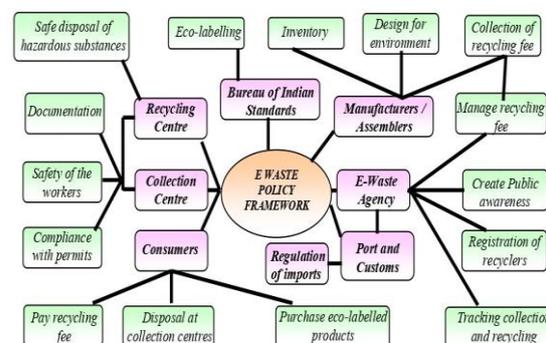


Figure 17 E- waste Management system in India

The best way to deal with E wastes is to reduce the amount of waste generation. Product must

be built for re-use, repair and/or upgradeability. It is essential to use less toxic, easily recoverable and recyclable materials. This will help to take back for refurbishment, remanufacturing, disassembly and reuse. E-waste can be reduced by recycling and reuse of material. Recovery of materials metals, plastics etc by recycling process will minimize the quantity of e-waste. This will help to conserve energy .It prevents the toxic materials to enter into the environment. Therefore it is necessary for the manufactures, consumers, regulators, authorities, governments, and policy maker stake essential steps so as to address various critical elements shown in Figure 16 . It is necessary to frame policy and regulatory frame work to promote e-waste promotion. User involvement is must for sustainability of e-waste systems to improve efficient and recycling of the systems

a. Benefits of E-waste Recycling (courtesy Humming bird international)

Recycling e-waste is turning out to be one of the most attractive and profitable business management E-waste recycling is the process of recovering useful materials, The quantity of the material to be recycled growing exponentially, Currently, major parts of electric and electronic waste (E-waste) is land filled.

The following can be recovered from re cycling of e-waste: Lead, Tin, Copper, glass, Aluminium, Irons Silicon, nickel & cadmium, Lithium, Zinc, Gold, Mercury, Sulphur, Carbon:.

1. Saving 160,000m³ of landfill space
2. Saves 23,000 tons of greenhouse gases
3. Recycling can create 2.3 million jobs by 2030
4. Potential savings of 520 mega liters of water
5. Cost saving,waste reduction by 22 million dollar
6. Building strong economy by tax revenue generation of 12.9 billion dollars
7. Recycling of metals can save 74% of the energy used to make them.
8. Get financial reward by selling obsolete cell phones to recycling cell plants
9. Recycling a tones of aluminum can offer average household electricity for the next 10 years
10. Copper, gold, silver, palladium. These can be recovered which provide great amount of economical incentive

b. Market Snapshot

E-waste is growing at an immense rate in the world due to the rising usage of electrical appliances and electronic gadgets. Improper handling and unsafe disposal of e-waste can result in threats to the environment and humans. Electronics

waste is global issue, it needs to be handles by proper recycling systems. E-waste recycling is nothing but the recycling of electrical and electronic devices such as TVs, air conditioners, computers, mobile phones, laptops, DVDs, oven, microwave, fans, heaters, toasters, in order to safely extract raw materials such as metals, plastic, glass, and mercury, and reuse these materials and devices. As governments across various countries develop policies for e-waste recycling management, the market is expected to grow at a significant rate in the coming years. Devices such as smartphones, laptops, routers, PCs, gaming devices, and other electronic accessories are frequently exchanged or upgraded by individuals resulting in large volumes of e-waste. Hence, increasing electronic waste around the globe is one of the major factors responsible for the growth of the market. Another factor is rise in employment opportunities in developing countries. The electronic waste recycling market at global level is expected to increase at 13.03% CAGR to reach a market value of 39,498.81 Million in 2024

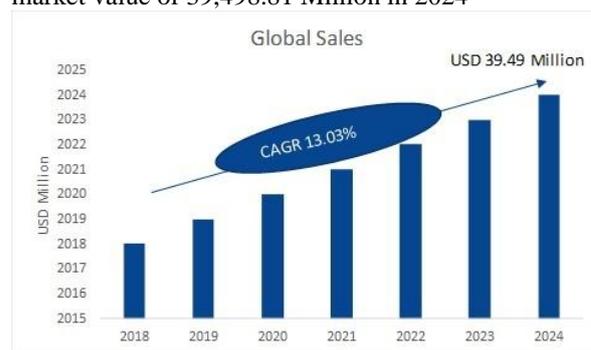


Figure 18: e-waste market (source: MRFR Analysis)

c. Challenges of E-waste

- Lack of awareness hazards of incorrect e-waste disposal.
- Non availability of proper data related to amount of e-waste produced and recycled
- Most of e-waste is processed by the informal (unorganised), which causes irreversible environmental damage.
- Workers are exposed to health hazards as they don't have knowledge of toxins in e-waste.
- Substantial losses of material value and resources due to inefficient recycling processes
- Picking up of gold, platinum, silver, copper, etc by recyclers and improper disposal of other material, causes environmental damage.
- No specific legislation for dealing with e-waste management.

VI. CONCLUSION

The e-waste is a major challenge to environmentalists and technologists because of the e-waste generation rate are much higher than e-waste disposed or recycled. Therefore we need improved e-waste management system which should cover advancement in technology, new operation plan, improved and safe environment and protocol for the workers who are involved in e-waste disposal and recycling operation and peoples must be made aware environment threat and issues to public health and the environment . There is no one-and-only solution for e-waste recycling systems

Banning of transboundary movements of e-waste is not a solution to the e-waste problem. It is necessary to find the solution in local and regional level and the social implications of the issue. Effective regulations are to be combined with incentives for recyclers Informal sectors are currently lacking with safe, economic and easier methods

E-waste problem can be resolved by making both peoples and consumers aware about e – waste. It is essential to integrate both the informal sector with the formal. Avoid the practices that have that are hazardous and harmful to both human health and the environment. We need to develop a more stringent integrated and strategic waste prevention framework to effectively address e-waste related issues.

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