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Risk Assessment and Environmental Impact of E-Waste Management

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Abstract:
Electronic waste or e-waste is one of the rapidly growing problems of the world. E-waste comprises of a multitude of components, some containing toxic substances that can have an adverse impact on human health and the environment if not handled properly. In India, e-waste management assumes greater significance not only due to the generation of its own e-waste but also because of the dumping of e-waste from developed countries. However certain e-wastes are having their self-life, which cannot be reuse. Hence, it is essential to recycle or disposal of these with suitable precautions. Uncontrolled disposal and recycling activities generate and release high toxic metals such as Hg, Pb, Cd, Cr, Cr(IV), Co, Cu, Ni, and Zn. These also release high concentrations of different types of flame retardants such as PolyBrominated Diphenyl Ethers (PBDEs), Poly-Chlorinated Biphenyls (PCBs) and Organo Chlorine Pesticides (OCPs). In this project, potential environmental health consequences of these toxic metals and organo compounds are described. The selection of this topic is to evaluate electronic waste (e-waste) pollution and the toxic substances present in the e-waste and their threats to human health. Due to technology advancement and development makes new innovative electronic products which are affordable rather repair outdated equipment. It is evident that disposal of electronic products is due to production of new ones. India'scurrent e-waste scenario and their problems in recycling and disposal of e-waste. The tools for e-waste management like life cycle assessment (LCA), material flow analysis (MFA) have been developed to manage e wastes especially in developed countries. By developing eco-design devices and collecting e-waste and safe handling the disposal brings clean environment

1. INTRODUCTION

"E-waste" is a popular, informal name for electronic products nearing the end of their "useful life." Ewastes are considered dangerous, as certain components of some electronic products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, refurbished, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem. This paper highlights the hazards of e-wastes; the need for its appropriate management and options that can be implemented Industrial revolution followed by the advances in information technology during the last century has radically changed people's lifestyle. Although this development has helped the human race, mismanagement has led to new problems of contamination and pollution. The technical prowess acquired during the last century has posed a new challenge in the management of wastes. For example, personal computers (PCs) contain certain components, which are highly toxic, such as chlorinated and brominated substances, toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives. The hazardous content of these materials pose an environmental and health threat. Thus proper management is necessary while disposing or recycling ewastes. These days computer has become most common and widely used gadget in all kinds of activities ranging from schools, residences, offices to manufacturing industries. E-toxic components in computers could be summarized as circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; brominated flame retardants used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) coated copper cables and plastic computer casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc. Basel Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286,700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead can seep into the ground water from landfills thereby contaminating it. If the tube is crushed and burned, it emits toxic fumes into the air.

1.1 E-WASTE

Electronic waste or e-waste is the term used to describe old, end-of-life electronic appliances such as computers, laptops, TVs, DVD players, mobile phones, mp3 players, etc., which have been disposed by their original users'-waste has been categorized into three main categories, i.e., Large Household Appliances, IT and Telecom and Consumer Equipment. Refrigerator and washing machine represent large household appliances; PC, monitor and laptop represent IT and Telecom, while TV represents Consumer Equipment. Each of these e-waste items has been classified with respect to 26 common components found in them. These components form the 'building blocks' of each item and therefore they are readily 'identifiable 'and 'removable.' These components are metal, motor/ compressor, cooling, plastic, insulation, glass, LCD, rubber, wiring/electrical, concrete, transformer, magnetron, textile, circuit board, fluorescent lamp, incandescent lamp, heating element, thermostat, brominated flamed retardant (BFR)-containing plastic, batteries, CFC/HCFC/HFC/HC, external electric cables, refractory ceramic fibers, radioactive substances and electrolyte capacitors (over L/D 25 mm).The composition of WEEE/e-waste is very diverse and differs in products across different categories. It contains more than 1000 different substances, which fall under 'hazardous' and

‘non-hazardous ’categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about50% of the WEEE followed by plastics (21%), non-ferrous metals (13%) and other constituents. Nonferrous metals consist of metals like copper, aluminum and precious metals, e.g. silver, gold, platinum, palladium, etc. The presence of elements like lead, mercury, arsenic, cadmium, selenium and hexavalent chromium and flame retardants beyond threshold quantities in WEEE/e-waste classifies them as hazardous waste. The electronic and electrical goods are largely classified under three major heads, as: ‘white goods, ‘comprising of household appliances like air conditioners, dishwashers, refrigerators and washing machines; ‘brown goods,’ comprising of TVs, camcorders, cameras, etc.; ‘grey goods,’ like computers, printers, fax machines, scanners, etc. The grey goods are comparatively more complex to recycle due to their toxic composition.

2 PROBLEM IDENTIFICATION

Informal processing of electronic waste in developing countries may cause serious **health and pollution problems**, though these countries are also most likely to reuse and repair electronics. Used electronics contain lead, mercury, barium, arsenic etc. none of it good. Some electronic scrap components, such as CRTs, may contain contaminants such as lead, cadmium, beryllium, or brominated flame retardants. Metals like copper, tin, cadmium, mercury and lead, as well as plastics and wood. **Disposing** of them is now a major international problem. E-wastes are not degradable by soil bacteria. Nor can they cannot be destroyed by burning. When they are dumped in landfills, they occupy too much space and leak out dangerous chemicals into the air or soil. If these enter sources of drinking water like rivers or wells, they can cause serious health problems in humans, animals and plants alike.

3. CAUSES OF E- WASTE

The main cause or rather reason for the increasing e waste is the increased number of products (because of development, technology, human mentality and population) because of which disposal problems are caused as excess of anything is not good. The following the major causes

3.1 DEVELOPMENT

As of now, It is estimated that there are over a billion personal computers in the world. In developed countries these have an average life span of only 2 years. In the United States alone there are over 300 million obsolete computers. Not only developed countries the developing countries too have faced a steep rise in sales or moreover wastage in this industry. It is believed that sales of computers and internet usage have gone up by 400% in developing countries as well. As the digital divide narrows we must address the question of disposal of large numbers of "end of life" computers and other IT equipment. We can now also understand that this industry is globalizing at a fast rate or rather an alarming rate. ALL of this is because of development caused by globalization.

3.2 TECHNOLOGY

In this modern era technology is growing at lightning fast speed. This technology results in the coming of newer products and appliances. The major reason for this can be none other than MNC’s (Multinational corporations). MNC's now a days are so powerful that they can influence the whole market system of a country in no time. it is these mnc's that provide better technology The have money more than the bud jet of some countries as well. Moreover they have the power to decide price and quality. However, Its not only that MNC's profit when they start a business. Though some sections may be affected, the middle class have started to prosper because the prices have gone down and quality has increased.

3.3 HUMAN MENTALITY

This has given more money power to the common people (middle class people) and this money power has helped them buy more products and in our case or the case of computers increase e waste by kind of changing their mentality. Because of money power people now a days tend to substitute their older materials with the newer ones and this older materials if electronic related is what is termed as e-waste.

3.4 POPULATION

With the increasing population all these have been triggered even more. It’s simple to understand by one of the most simple theories of unitary method. so if 1 person buys 1 computer so with increasing population the number of computers would also increase with this method. so we can conclude that with increasing population the amount of e waste would also increase because these computers they bought after sometime would be thrown with the introduction of better technology devices which would be bought by the. Moreover all these are interlinked with each other and together contribute to a major environmental concern caused by e waste.

Figure .3.1 E- Waste

4. EFFECTS OF E - WASTE

4.1 EFFECTS OF HUMAN HEALTH

Disposal of e-wastes is a particular problem faced in many regions across the globe. Computer wastes that are landfilled produces contaminated leachates which eventually pollute the groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil. For example, Guiyu, Hong Kong a thriving area of illegal e-waste recycling is facing acute water shortages due to the contamination of water resources. This is due to disposal of recycling wastes such as acids, sludge’s etc. in rivers. Now water is being transported from faraway towns to cater to the demands of the population. Incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. Improperly monitored landfills can cause environmental hazards. Mercury will leach when certain electronic devices, such as circuit breakers are destroyed. The same is true for polychlorinated biphenyls (PCBs) from condensers. When brominates flame retardant plastic or cadmium containing plastics are land filled, both polybrominated diphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. It has been found that significant amounts of

lead ion are dissolved from broken lead containing glass, such as the cone glass of cathode ray tubes, gets mixed with acid waters and are a common occurrence in landfills. The toxic fall-out from open air burning affects the local environment and broader global air currents, depositing highly toxic byproducts in many places throughout the world. The health effects of certain constituents in e-wastes were summarized in Table. If these electronic items are discarded with other household garbage, the toxics pose a threat to both health and vital components of the ecosystem. In view of the ill-effects of hazardous wastes to both environment and health, several countries exhorted the need for a global agreement to address the problems and challenges posed by hazardous waste. Also, in the late 1980s, a tightening of environmental regulations in industrialized countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to get rid of the wastes, "toxic traders" began shipping hazardous waste to developing countries. International outrage following these irresponsible activities led to the drafting and adoption of strategic plans and regulations at the Basel Convention. The Convention secretariat, in Geneva, Switzerland, facilitates and implementation of the Convention and related agreements. It also provides assistance and guidelines on legal and technical issues, gathers statistical data, and conducts training on the proper management of hazardous waste.

4.1.1 Electronic Waste Substances

Some computer components can be reused in assembling new computer products, while others are reduced to metals that can be reused in applications as varied as construction, flatware, and jewelry.

- ✓ Substances found in large quantities include epoxy resins, fiberglass, PCBs, PVC (polyvinyl chlorides), thermosetting plastics, lead, tin, copper, silicon, beryllium, carbon, iron and aluminium.
- ✓ Elements found in small amounts include cadmium, mercury, and thallium.
- ✓ Elements found in trace amounts include americium, antimony, arsenic, barium, bismuth, boron, cobalt, europium, gallium, germanium, gold, indium, lithium, manganese, nickel, niobium, palladium, platinum, rhodium, ruthenium, selenium, silver, tantalum, terbium, thorium, titanium, vanadium, and yttrium.
- ✓ Almost all electronics contain lead and tin (as solder) and copper (as wire and printed circuit board tracks), though the use of lead-free solder is now spreading rapidly.

4.1.2 Disposal and Toxicity

There are growing concerns that most of the e-waste generated in developed countries is ending up in developing countries that are economically challenged and lack the infrastructure for environmentally sound management of e-waste. This results in adverse socio-economic, public health and environmental impact of toxins in e-waste. A study conducted in soil, air dust and human hair collected from an e-waste recycling site in Bangalore, India, clearly found increased concentrations of trace elements such as lead, zinc, silver, cadmium and copper compared to reference sites.

A further study in China on human scalp hair, assessing the extent of heavy metal exposure to workers and residents in areas with significantly high e-waste recycling operations, found higher levels of cadmium copper and lead confirming the previous findings. A report by *Toxics Link* found that 70% of the e-waste collected at recycling units in New Delhi, India, was actually exported or dumped by developed countries and about 50–80% of the e-waste collected for recycling in the western U.S. is being exported to Asia, about 90% of which techniques in these countries are often crude and do not have the appropriate facilities; the processes include toner sweeping, dismantling of electronic equipment, selling computer monitors to copper recovery operations, plastic chipping and melting, burning wires to recover copper, heating circuit boards over honeycombed coal blocks, andusing acid chemical strippers to recover gold and other metals. In addition, open burning of unwanted e-waste and their open dumping has been found universally. Such unregulated salvaging operations and optional dumping of the e-waste have resulted in severe and complex contamination of the surrounding environment by toxic chemicals such as heavy metals (Cd, Pb, Cu and Hg), as well are stored in certain tissues, leading to intoxication episodes that can be described as acute or long-term intoxications and producing illness when the levels reach critical values.as persistent organic compounds such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These compounds could expose the workers and local residents through inhalation, dermal exposure, and even oral intake (of contaminated food), with the health risk being highest for the workers

4.1.3Other Contaminants

E-waste also contains brominated flame retardants (BFRs) such as polybrominated biphenyls (PBB) and polybrominated diphenylethers (PBDEs) which are used in printed circuit boards, connectors, covers and cables. A recent comprehensive review conducted by A. Sepulveda et al., where scientific data related to concentrations of lead (Pb), PBDEs, polychlorinated dioxins and furans were monitored around e-waste recycling areas in China and India. This highlighted the very high levels of the aforementioned compounds in air, dust, soil and water samples, which at times considerably exceeded the concentration levels found in other industrial urban areas. These findings are further confirmed by studies conducted by Ni et al. where they found high concentrations of above compounds in e-waste recycling sites in China.

4.1.4 E- Waste Processing Areas

Guiyu in the Shantou region of China, Delhi and Bangalore in India as well as the Agbogbloshie site near Accra, Ghana have electronic waste processing areas. Uncontrolled burning, disassembly, and disposal causes a variety of environmental problems such as groundwater contamination, atmospheric pollution, or even water pollution either by immediate discharge or due to surface runoff (especially near coastal areas), as well as health problems including occupational safety and health effects among those directly and indirectly involved, due to the methods of processing the waste. Thousands of men, women, and children are employed in highly polluting, primitive recycling technologies, extracting the metals, toners, and plastics from computers and other electronic waste. Recent studies show that 7 out of 10 children in this region have too much lead in their blood.

In this context, three levels of toxic emissions have to be distinguished:

- **Primary emissions:** Hazardous substances that are contained in e-waste (e.g. lead, mercury, arsenic, polychlorinated biphenyls (PCBs), fluorinated cooling fluids etc.).
- **Secondary emissions:** Hazardous reaction products of e-waste substances as a result of improper treatment (e.g.

dioxins or furans formed by incineration/inappropriate smelting of plastics with halogenated flame retardants).

• **Tertiary emissions:** Hazardous substances or reagents that are used during recycling (e.g. cyanide or other leaching agents, mercury for gold amalgamation) and that are released because of inappropriate handling and treatment.

Figure .4.1 human health effects E - Waste

Health and safety risks associated with informal recycling include occupational health risks posed to scavenger/waste pickers and community health risks posed to the related community or general public. These risks can originate from the nature of the waste or the process of collecting, processing, recycling and disposing of it. Informal waste pickers are undoubtedly exposed to increased risks as basic principles of occupational health and safety are disregarded. Scavenging in open dumps is considered to be the most detrimental to health.

Table 4.1 Effects of E-Waste Constituent on Health

SOURCE OF E-WASTES	CONSTITUENT	HEALTH EFFECTS
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (PB)	Damage to central and peripheral nervous systems, blood systems and kidney damage. Affects brain development of Children.
Chip resistor and semi-conductor	Cadmium (CD)	Toxic irreversible effects on human health. Accumulates in kidney and liver. Causes neural damage. Teratogenic.
Relays and switches, printed circuit boards	Mercury (Hg)	Chronic damage to the brain. Respiratory and skin disorders Due to bioaccumulation in fishes. Interfere with regulatory Hormones
Plastic housing of electronic equipment's and circuit boards.	Brominated flame retardants (BFR)	Disrupts endocrine system functions
Front panel of CRTs	Barium (Ba)	Short term exposure causes: Muscle weakness; Damage to heart, liver and spleen.
Motherboard	Beryllium (Be)	Carcinogenic (lung cancer) Inhalation of fumes and dust. Causes chronic beryllium diseaseOr beryllicosis. Skin diseases such as warts.

4.2 EFFECTS OF ENVIRONMENTAL

E-waste or electronic waste are broadly describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices which are at the end of their useful life and need to be disposed or dismantled to recover some valuable components. The problem of e-waste has become an immediate and long term concern as its unregulated and improper accumulation and recycling can lead to major environmental problems endangering not only human and animal health but also environment health due to toxic and other dangerous materials available in them. The countries of the European Union (EU) and other developed countries are adopting scientific methods of recycling and disposal of such waste. The EU defines this e-waste stream as 'Waste Electrical and Electronic Equipment' (WEEE). The main features of the WEEE include definition of 'EEE', its classification into 10 categories and its extent as per voltage rating of 1000 volts for alternating current and 1500 volts for direct current

4.2.1 Effects on air

One of the most common effect of E-waste on air is through air pollution. For example, a British documentary about Lagos and its inhabitants, called Welcome to Lagos, shows a number of landfill scavengers who go through numerous landfills in Lagos looking for improperly disposed electronics which includes wires, blenders, etc., to make some income from the recycling of these wastes. These men were shown to burn wires to get the copper (a very valuable commodity) in them by open air burning which can release hydrocarbons into the air.

Figure .4.2 Effects on air by E – Waste

4.2.2 Effects on water

When electronics containing heavy metals such as lead, barium, mercury, lithium (found in mobile phone and computer batteries), etc., are improperly disposed, these heavy metals leach through the soil to reach groundwater channels

which eventually run to the surface as streams or small ponds of water..

Figure 4.3 Effects on water by E – Waste

Local communities often depend on these bodies of water and the groundwater. Apart from these chemicals resulting in the death of some of the plants and animals that exist in the water, intake of the contaminated water by humans and land animals results in lead poisoning. Some of these heavy metals are also carcinogenic

4.2.3 Effects on soil

In this way, toxic heavy metals and chemicals from e-waste enter the "soil-crop-food pathway," one of the most significant routes for heavy metals' exposure to humans. These chemicals are not biodegradable—they persist in the environment for long periods of time, increasing the risk of exposure. These dangers posed by improper disposal on the environment ultimately have impacts on human beings -human cost; the health effects of these toxins on humans include birth defects (irreversible), brain, heart, liver, kidney and skeletal system damage. They also significantly affect the nervous and reproductive systems of the human body. When computer monitors and other electronics are burned, they create cancer-producing dioxins which are released into the air we breathe. If electronics are thrown in landfills, these toxins may leach into groundwater and affect local resources. Thus improper disposal of e-waste not only has effects on the environment, it indirectly and ultimately poses grave dangers to humans and livestock.

Figure 4.4Effects on water by E – Waste

Management of hazardous municipal waste is a challenge in itself. Added to this burden is the management of huge and growing quantities of electrical and electronic waste emerging as one of the most important environmental problems of developing countries, especially India. Approximately 2 lakh tonnes of e-waste was generated in the country in 2007. E-waste has become more of a problem than all other wastes because of the very significant health and environment hazards associated with it.

The e-waste contains a number of toxic components that can cause serious damage to environment and human and animal health if not properly discarded in an environmentally sound manner.

Table.4.2Effects of E-Waste Constituent On Environmental

SOURCE OF E WASTE	PROCESS FOLLOWED	ENVIRONMENTAL HAZARD
Cathode Ray Tubes (CRTs)	Breaking, Removal Of Copper yoke and dumping	Heavy metals like Lead, Barium leach into ground water and release toxic phosphor
Printed Circuit Boards	Desoldering and removing chips	Brominated dioxins , berrylium, cadmium and mercury are emitted in the air
Chips and other gold plated compounds	Chemical stripping using nitric and hydrochloric acids along river banks	Hydrocarbons dischrched directly into water acidifies the river destroying fish and flora
Plastics from computer and peripherals	Shredding and low temperature melting	Emission of brominated dioxins, heavy metals and hydrocarbons in air
Dismantled printed circuit board processing	Open burning of waste boards	Tin and lead contamination of immediate environment

Hexavalent Chromium Compounds: Hexavalent chromium is a toxic form of the element chromium. Hexavalent chromium compounds are man-made and widely used in many different industries. A known carcinogen, these are used in the creation of metal housing which are typical of many electronic products. It can cause lung cancer, irritation or damage to the nose, throat, and lung (respiratory tract), irritation or damage to the eyes and skin etc. Plastic compounds: Poly vinyl chloride (PVC) cabling is used for printed circuit boards, connectors, plastic covers and cables. When burnt or land-filled, these PVCs release dioxins that have harmful effects on human reproductive and immune systems. Hexavalent Chromium Compounds: Hexavalent chromium is a toxic form of the element chromium. Hexavalent chromium compounds are man-made and widely used in many different industries. A known carcinogen, these are used in the creation of metal housing which are typical of many electronic products. It can cause lung cancer, irritation or damage to the nose, throat, and lung (respiratory tract), irritation or damage to the eyes and skin etc. Plastic compounds: Poly vinyl chloride (PVC) cabling is used for printed circuit boards, connectors, plastic covers and cables. When burnt or land-filled, these PVCs release dioxins that have harmful effects on human reproductive and immune systems. Hexavalent Chromium Compounds: Hexavalent chromium is a toxic form of the element chromium. Hexavalent chromium compounds are man-made and widely used in many different industries. A known carcinogen, these are used in the creation of metal housing which are typical of many electronic products. It can cause lung cancer, irritation or damage to the nose, throat, and lung (respiratory tract), irritation or damage to the eyes and skin etc. Plastic compounds: Poly vinyl chloride (PVC) cabling is used for printed circuit boards, connectors, plastic covers and cables. When burnt or land-filled, these PVCs release dioxins that have harmful effects on human reproductive and immune systems. In order to cater to this emerging problem , some authorized recycling companies have come up in India in the last few years like Attero

Recycling Plant – Roorkee , Ash Recyclers – Banglore, E Waste Agency (EWA) – Banglore etc. In such centres, heavy metals are safely extracted in a plant and everything else is recycled. But the irony is the authorized e-waste recycling facilities in India capture only 3% of the total e-waste generated; the rest makes its way to informal recycling yards in major cities like Delhi, Mumbai, and Bangalore. This is because businesses sell their discarded IT and other equipment to informal recyclers for quick money without realizing the hazardous implications it has on health and environment.

5. STATUS OF E-WASTE MANAGEMENT IN INDIA

5.1 PRESENT E-WASTE STATUS IN INDIA

Despite a wide range of environmental legislation in India there are no specific laws orguidelines for electronic waste or computer waste. As per the Hazardous Waste Rules (1989), e-waste is not treated as hazardous unless proved to have higher concentration of certain substances. Though PCBs and CRTs would always exceed these parameters, there are several grey areas that need to be addressed. Basel Convention has Waste electronic assemblies in A1180 and mirror entry in B1110, mainly on concerns of mercury, lead and cadmium. Electronic waste is included under List-A and List-B of Schedule-3 of the Hazardous Wastes (Management & Handling) Rules, 1989 as amended in 2000 & 2003. The import of this waste therefore requires specific permission of the Ministry of Environment and Forests. As the collection and re-cycling of electronic wastes is being done by the informal sector in the country at present, the Government has taken the following action/steps to enhance awareness about environmentally sound management of electronic waste (CII, 2006)

• Several Workshops on Electronic Waste Management was organised by the Central Pollution Control Board (CPCB) in collaboration with Toxics Link, CII etc.

• Action has been initiated by CPCB for rapid assessment of the E-Waste generated in major cities of the country.

• A National Working Group has been constituted for formulating a strategy for E-Waste management.

• A comprehensive technical guide on "Environmental Management for Information Technology Industry in India" has been published and circulated widely by the Department of Information Technology (DIT), Ministry of Communication and Information Technology.

• Demonstration projects have also been set up by the DIT at the Indian Telephone Industries for recovery of copper from Printed Circuit Boards. Although awareness and readiness for implementing improvements is increasing rapidly, the major obstacles to manage the e wastes safely and effectively remain. These include.

• The lack of reliable data that poses a challenge to policy makers wishing to design an e-waste management strategy and to an industry wishing to make rational investment decisions.

• Only a fraction of the e waste (estimated 10%) finds its way to recyclers due to absence of an efficient take back scheme for consumers, The lack of a safe e waste recycling infrastructure in the formal sector and thus reliance on the capacities of the informal sector pose severe risks to the environment and human health.

5.2 WASTE MANAGEMENT STRATEGIES

The best option for dealing with E wastes is to reduce the volume. Designers should ensure that the product is built for re-use, repair and/or upgradeability. Stress should be laid on use of less toxic, easily recoverable and recyclable materials which can be taken back for refurbishment, remanufacturing, disassembly and reuse. Recycling and reuse of material are the next level of potential options to reduce e-waste. Recovery of metals, plastic, glass and other materials reduces the magnitude of e-waste. These options have a potential to conserve the energy and keep the environment free of toxic material that would otherwise have been released. It is high time the manufactures, consumers, regulators, municipal authorities, state governments, and policy makers take up the matter seriously so that the different critical elements depicted in Figure 1 are addressed in an integrated manner. It is the need of the hour to have an "e waste-policy" and national regulatory frame work for promotion of such activities. An e Waste Policy is best created by those who understand the issues. So it is best for industry to initiate policy formation collectively, but with user involvement. Sustainability of e-waste management systems has to be ensured by improving the effectiveness of collection and recycling systems (e.g., public–private-partnerships in setting up buy-back or drop-off centers) and by designing-in additional funding e.g., advance recycling fees.

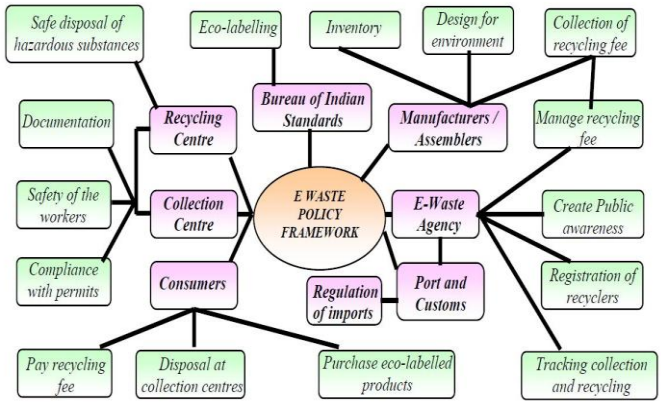

Figure 5.1 Elements of e-waste management system for India

5.3 E-WASTE CONCERNS AND CHALLENGES

1. Accurate figures not available for rapidly increasing e-waste volumes— generated domestically and by imports.
2. Low level of awareness among manufacturers and consumers of the hazards of incorrect e- waste disposal.
3. No accurate estimates of the quantity of e-waste generated and recycled available in India.
4. Major portion of e-waste is processed by the informal (unorganized)sector using rudimentary
5. Techniques such as acid leaching and open-air burning, which results in severe environmental damage.
6. E-waste workers have little or no knowledge of toxins in e-waste and are exposed to health hazards.
7. Cherry-picking by recyclers who recover precious metals (gold, platinum, silver, copper, etc) and improperly dispose of the rest, posing environmental hazards.
8. No specific legislation for dealing.
9. High-risk backyard recycling operations impact vulnerable social groups like women, children and immigrant labourers.
10. Inefficient recycling processes result in substantial losses of material value and resources.

6. MANAGEMENT OPTIONS TO SEVERITY OF THE PROBLEM

Considering the severity of the problem, it is imperative that certain management options be adopted to handle the bulk e-wastes. Following are some of the management options suggested for the government, industries and the public.

6.1 RESPONSIBILITIES OF THE GOVERNMENT

- Governments should set up regulatory agencies in each district, which are vested with the responsibility of co-ordinations and consolidating the regulatory functions of the various government authorities regarding hazardous substances.
- Governments should be responsible for providing an adequate system of laws, controls and administrative procedures for hazardous waste management. Existing laws concerning e-waste disposal be reviewed and revamped.
- A comprehensive law that provides e-waste regulation and management and proper disposal of hazardous wastes is required. Such a law should empower the agency to control, supervise and regulate the relevant activities of government departments. Under this law, the agency concerned should provided.

6.2 RESPONSIBILITY AND ROLE OF INDUSTRIES

Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options. All personnel involved in handling e-waste in industries including those at the policy, management, control and operational levels, should be properly qualified and trained. Companies can adopt their own policies while handling e-wastes. Some are given below:

- Use label materials to assist in recycling (particularly plastics).
- Standardize components for easy disassembly.
- Re-evaluate 'cheap products' use, make product cycle 'cheap' and so that it has no inherent value that would encourage a recycling infrastructure.
- Create computer components and peripherals of biodegradable materials.
- Utilize technology sharing particularly for manufacturing and de manufacturing.
- Encourage / promote / require green procurement for corporate buyers.
- Look at green packaging options.

Companies can and should adopt waste minimization techniques, which will make a significant reduction in the quantity of e-waste generated and thereby lessening the impact on the environment. It is a “reverse production" system that designs infrastructure to recover and reuse every material contained within e-wastes metals such as lead, copper, aluminum and gold, and various plastics, glass and wire. Such a "closed loop" manufacturing and recovery system offers a win-win situation for everyone, less of the Earth will be mined for raw materials, and groundwater will be protected. At minimum, all computer monitors, television sets and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management.

6.3 RESPONSIBILITIES OF THE CITIZEN

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford. E-wastes should never be disposed with garbage another household wastes. This should be segregated at the site and sold or donated to various organizations.

While buying electronic products opt for those that:

- Are made with fewer toxic constituents
- Use recycled content
- Are energy efficient
- Are designed for easy upgrading or disassembly
- Utilize minimal packaging

Offer leasing or take back options have been certified by regulatory authorities. Customers should opt for upgrading their computers or other electronic items to the latest versions rather than buying new equipments.

7. E- WASTE TREATMENTS AND DISPOSAL

Because of the complex composition of valuable and hazardous substances, specialized, often "high-tech" methods are required to process e-waste in ways that maximize resource recovery and minimize potential harm to humans or the environment. Unfortunately, the use of these specialized methods is rare, with much of the world's e-waste traveling great distances, mostly to developing countries, where crude techniques are often used to extract precious materials or recycle parts for further use. This also leads to localized pollution of environment and is health hazards for advanced life forms. It is widely used methods for disposal of e-waste. In this method, trenches are made on the flat surfaces by removing soil from the trenches and waste material is buried in it, which is covered by a thick layer of soil. Secure landfill is made using modern technique.

Figure 7.1 E- Waste Treatments and Disposal

7.1 LAND FILLING

The degradation processes in landfills are very complicated and run over a wide time span and can be many years.

Figure7.2 Land Filling E –Waste

7.2 RECOVERY

The e-waste management system recovery is the important one because so, many hazards of e-wastes materials. Recovery is good for human health and environment in this controlled and complete combustion process, the waste material is burned in specially designed incinerators at a high temperature (900-1000^{o}C). Advantage of incineration of e-waste is the reduction of waste volume and the Utilization of the energy content of combustible materials. In this method some environmentally hazardous organic substances are converted into less hazardous compounds.

7.3 RECYCLE

Fridge, Washing machines, TVs, Monitors & CRT, keyboards, laptops, modems, telephones, hard drives, floppy drives, Compact disks, mobiles, fax machines, printers, CPUs, memory chips, connecting wires & cables can be recycled. .

Figure7.3 Recycle the E – Waste

Recycling involves dismantling i.e. removal of different parts of e-waste containing dangerous substances like PCB, Hg, separation of plastic, removal of CRT, segregation of ferrous and nonferrous metals and printed circuit boards. Strong acids are used to remove precious metals such as copper, gold, palladium. The value of recycling from the element could be much higher if appropriate technologies are used.

7.4 REUSE

It constitutes direct second hand use or use after slight modifications to the original functioning equipment. It is commonly used for electronic equipment like computers, cell phones etc. Inkjet cartridge is also used after refilling. Old working computers can be donated to schools or organization working in the field of education. Computers beyond repairs can be returned back to the manufacturers. This method also reduces the volume of e-waste generation. The better option is to avoid its generation. To achieve this, buy back of old electronic equipment shall be made mandatory. This can considerably reduce the volume of e- waste generation.

7.5 REDUCE

The very important and impact factor e - waste management is reduce the e - Waste material. The manufacturing of these devices and the use of rare materials that go into their production represent a huge source of embodied energy. Minimizing e-waste helps to conserve resources and reduces the amount of energy we take from the earth.Reusing the precious metals and plastics in old cell phones alone instead of making or mining more of them would save as much energy as flipping off the power to 24,000 US homes for an entire year. The typical American household has 24 electronic devices and in 2009 the EPA estimated that there are 2.37 million tons worth of electronics ready to be disposed of. This would fill almost five football stadiums!

Re-evaluate. Do you really need that extra gadget? Try finding one device with multiple functions.

Extend the life of your electronics. Buy a case, keep your device clean, and avoid overcharging the battery.

Buy environmentally friendly electronics. Look for products labeled Energy Star or certified by the Electronic Product Environmental Assessment Tool (EPEAT).

Donate used electronics to social programs—and help victims of domestic violence, children safety initiatives, environmental causes, and more. Ask your student REP for a postage paid mailer for your cell phone or ink cartridge. For each item received, the World Wildlife Fund will receive one dollar.

Reuse large electronics. Post to **Harvard's Reuse List**

Recycle electronics and batteries in e-waste recycling bins located around campus. Large electronics can go in the larger bins found in your building

8. CONCLUSION

The above mentioned threats from the ever growing e-waste stream can only be minimized by producing less of it through application of concepts such as green chemistry and design for environment where alternatives to toxic materials can be found. Good examples of this include the development substitution of toxic raw materials with less toxic materials as in the case of Pb-free soldering and the development of halogen-free BFRs in electronics manufacture. Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes. Establishment of ewaste collection, exchange and recycling centers should be encouraged in partnership with private entrepreneurs and manufacturers. An effective take-back program providing incentives for producers to design products that are less wasteful, contain fewer toxic components, and are easier to disassemble, reuse, and recycle may help in reducing the wastes. Hence creating awareness among the e-waste generating sectors is the important task now.

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