International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 1, Jan-Feb-2021, ISSN (Online): 2395-566X

E-Waste Management

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***Abstract*- Electronic waste, e-waste, e-scrap, or waste Electrical and Electronic Equipment (WEEE) describes discarded electrical devices. There is a lack of consensus as to whether the term should apply to resale, reuse, and refurbishing industries, or only to product that cannot be used for its intended purpose. 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. Some electronic scrap components, Such as CRTs (Cathode Ray Tubes), may contain contaminants such as lead, cadmium, beryllium, or brominated flame retardants. Even in developed countries recycling and disposal of e-waste may involve significant risk to workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaching of material such as heavy metals from landfills and incinerator ashes. Scrap industry and USA EPA (United States Environmental Protection Agency) officials agree that materials should be managed with caution, but many believe that environmental dangers of used electronics have been exaggerated.**

***Keywords*- Electronic waste, Electrical device, metals. Land fill in, recycling, Environment**

I. INTRODUCTION

Rapid changes in technology, changes in media (tapes, software, MP3), falling prices, and planned obsolescence have resulted in a fast-growing surplus of electronic waste around the globe. An estimated 50 million tons of E-waste are produced each year in the world. The USA discards 30 million computers each year and 100 million phones are disposed of in Europe each year. The Environmental Protection Agency estimates that only 15-20% of e-waste is recycled, the rest of these electronics go directly into landfills and incinerators.

"Electronic Waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. This definition includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others define the re-usable (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations.

Because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics. Cathode Ray Tubes (CRT) are considered one of the hardest types to recycle. CRTs have relatively high concentration of lead and phosphors (not phosphorus), both of which are necessary for the display. The United States Environmental Protection Agency (EPA) includes discarded CRT monitors in its category of "hazardous household waste" but considers CRTs that have been set aside for testing to be commodities if they are not discarded, speculatively accumulated, or let unprotected from weather and other damage.Debate continues over the distinction between "commodity" and "waste" electronics definitions. Some exporters are accused of deliberately leaving difficult-to-recycle, obsolete, or non-repairable equipment mixed in loads of working equipment

1. Waste Composition:
The various parts /materials / composition of e-waste may be divided broadly into six categories such as;

- Iron and steel, used for casings and frames
- Non-ferrous metals, especially copper used in cables, and aluminium
- Glass used for screens, windows
- Plastic used as casing, in cables and for circuit boards
- Electronic components
- Others (rubber, wood, ceramic etc.)

II. IMPACTS ON ENVIRONMENT AND HUMAN HEALTH

The Indian information technology industry has a prominent global presence today largelydue to the software sector. More recently, policy changes have led to a tremendous influx of leading multinational companies into India to set up manufacturing facilities, R&D centres and software development facilities. The domestic market is getting revitalized due to buoyant economic growth and changing consumption patterns.This growth has

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significant economic and social impacts. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of electronic waste (e-waste). The increasing obsolescence rates of electronic products added to the huge import of junk electronics from abroad create complex scenario for solid waste management in India.

Hazardous Substances in E-Waste -Environmental and Health Effects:E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidney, bones, reproductive and endocrine systems. Some of them are carcinogenic and neurotoxic.

A study conducted by Greenpeace in 2005 in electronicrecycling yards in Delhi clearly indicates the presence of high levels of hazardous chemicals including dioxins and furans in the areas where this primitive / unauthorized recycling takes place. Disposal of e-wastes is a critical problem faced and poses a threat to both health and vital components of the ecosystem. There are number of channels through which e-waste goes to the environment. E-waste that is land filled 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, leading to contamination of water resources. Incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. Improper recycling and recovery methods can have major impacts on the environment. Crude forms of dismantling can often lead to toxic emissions, which pollute the air and there by also expose the workers to the harmful materials.

The most dangerous form of recycling and recovery from e-waste is the open air burning of circuit boards (made of plastic) in order to recover copper and other metals. Extraction of metals through acid bath method or through mercury amalgamation also contributes to environmental degradation. The toxic materials present in the equipments can be environmental as well as health hazard. Mercury will leach when certain electronic devices, such as circuit breakers are destroyed.

Not only does the leaching of mercury poses problems, the vaporization of metallic mercury and dimethylene mercury is also of concern. The same is true for polychlorinated biphenyls (PCBs) from condensers. When brominated 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 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 rapid growth and faster change in modules of computers, cell phones and consumerelectronics becomes major issue that enhances the amount of e-waste generation.

Hazardous substances their occurrences and impact on environment and human health isas follows.

Table 1. Hazardous Substances, their Occurrences and Impacts on Environment and Human Health.

Substance	Occurrence in e-waste	Environmental and Health relevance
Arsenic	Small quantities in the form of gallium arsenide within light emitting diodes	Acutely poisonous and on a long-term perspective injurious to health
Barium	Getters in CRT	May develop explosive gases (hydrogen) if wetted
Beryllium	Power supply boxes which contain silicon controlled rectifiers, beam line components	Harmful if inhaled
Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners	Acutely poisonous and injurious to health on a long-term perspective
Chlorofluorocarbon (CFC)	Cooling unit, insulation foam	Combustion of halogenated substances may cause toxic emissions
Chromium VI	Data tapes, floppy-disks	Acutely poisonous and injurious to health on a long-term perspective causes allergic reactions
Gallium arsenide	Light-emitting diode (LED)	Injurious to health
Lead	CRT screens, batteries, printed wiring boards	Causes damage to the nervous system, circulatory system, kidneys causes learning disabilities in children
Lithium	Li-batteries	May develop explosive gases (hydrogen) if wetted
Mercury	Found in the fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches	Acutely poisonous and injurious to health on a long-term perspective
Nickel	Rechargeable NiCd-batteries or NiMH batteries, electron gun in CRT	May cause allergic reactions
PCB (polychlorinated biphenyls)	Condensers, transformers	Cause cancer, effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. Persistent and bioaccumulation
PVC (polyvinyl chloride)	Cable insulation	High temperature processing of cables may release chlorine, which is converted to dioxins and furans.
Rare Earth Elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)	Irritates skin and eyes
Zinc sulphide		Toxic when inhaled

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III. E-WASTES SEENARIO IN INDIA

The Indian information technology industry has a prominent global presence today largelydue to the software sector. More recently, policy changes have led to a tremendous influx of leading multinational companies into India to set up manufacturing facilities, R&D centres and software development facilities. The domestic market is getting revitalized due to buoyant economic growth and changing consumption patterns.

This growth has significant economic and social impacts. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of electronic waste (e-waste). The increasing obsolescence rates of electronic products added to the huge import of junk electronics from abroad create complex scenario for solid waste management in India.At the consumer end disposal of e-waste or used product is a big issue. In India computers and peripherals are recycled / reused much more than they are in developed countries. Till the last decade affordability of computers was limited to only a socio-economically advantaged section of the population.

In Indian Scenario, electronics industry has emerged as the fastest growing segment both in terms of production and exports. The share of software services in electronics and IT sector has gone up from 38.7% in 1998-99 to 61.8% in 2003-04. A review of the industry statistics show that in 1990-91, hardware accounted for nearly 50% of total revenues while software's share was 22%. The scenario changed by 1994-95, with hardware share falling to 38% and software's share rising to 41%. This shift in the IT industry began with liberalization, and the opening up of Indian markets together with which there was a change in India‟s import policies vis-à-vis hardware leading to substitution of domestically produced hardware by imports.

Since the early 1990s, the software industry has been growing at a compound annual growth rate of over 46% (supply chain management, 1999). Output of computers in value terms, for example, increased by 36.0, 19.7 and 57.6% in 2000-01, 2002-2003, and 2003-04, respectively. Within this segment, the IT industry is prime mover with an annual growth rate of 42.4% between 1995 and 2000. By the end of financial year 2005-06, India had an installed bae of 4.64 million desktops, about 431 thousand notebooks and 89 thousand servers.

According to the estimates made by Manufacturers Association of Information Technology (MAIT) the Indian PC industry is growing at a 25% compounded annual growth rate.The e-waste inventory based on this obsolescence and rate and installed base in India for the year 2005 has been estimated to be 146180-00 tonnes. This is expected to exceed 8,00,000tonnes by 2012. There is a lack of authentic and comprehensive data on e-waste availability for domestic generation of e-waste and the various State Pollution Controls Boards have initiated the exercise to collect data on e-waste generation Sixty-five cities in India generate more than 60% of the total e-waste generated in India. Ten states generate 70% of the total e-waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka,Gujarath, Madya Pradesh and Punjab in the list of e-waste generating states in India.

Among top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chinnai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. There are two small e-waste dismantling facilities are functioning in Chinnai and Bangalore. There is no large scale organized e-waste recycling facility in India and the entire recycling exists in un-organised sector.The Indian information technology industry has a prominent global presence today largely due to the software sector.

More recently, policy changes have led to a tremendous influx of leading multinational companies into India to set up manufacturing facilities, R&D centres and software development facilities. The domestic market is getting revitalized due to buoyant economic growth and changing consumption patterns. This growth has significant economic and social impacts. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of electronic waste (e-waste).

The increasing obsolescence rates of electronic products added to the huge import of junk electronics from abroad create complex scenario for solid waste management in India. At the consumer end disposal of e-waste or used product is a big issue. In Indiacomputers and peripherals are recycled/ reused much more than they are in developed countries. Till the lastdecade affordability of computers was limited to only a socio-economically advantaged section of the population. Resale and reuse of computers continues to be high as does dependency on assembled machines.

No reliable figures are available as yet to quantify the e-waste generation. Increasingly as computers are becoming more affordable and there is greater access to technology, the turnover of machines could definitely be higher.

Apart from the consumer end, another source of more obsolete computers in themarket is from the large software industry where use of cutting edge technology, greater computing speed and efficiency necessarily increase the rate of obsolescence. In the same way as the standard of living is growing high / dealers are providing monthly payment/ instalment facilities / banks are providing loans in a comparatively easy way, affordability of televisions, mobile phones and other house hold appliances are

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enormously increasing.As the consumption pattern increases, e-waste generation also increases. The top ten States and Cities in India generating e-waste are as fallows.

Table 2. E-Waste / WEEE Generation in Top States.

S.No.	States	WEEE (Tonnes)	Percentage (%)
1	Maharashtra	20270.59	18.49
2	Tamil Nadu	13486.24	12.30
3	Andhra Pradesh	12780.33	11.66
4	Uttar Pradesh	10381.11	9.47
5	West Bengal	10059.36	9.18
6	Delhi	9729.15	8.87

IV. E-WASTES RECYCLING

E-waste refers to electronic waste. E-waste recycling is the reuse and reprocessing of electrical and electronic equipment of any type that has been discarded or regarded as obsolete. Some of the common E-wastes include: home appliances such as televisions, air conditioners, electric cookers and heaters, air condoners, fans, DVDs, Radios and microwaves among others; information technology equipment such as computers, mobile phones, laptops, batteries, circuit boards, hard disks, and monitors among others; and other electronic utilities such as leisure, lighting, and sporting equipment.

Recycling of e-waste is a growing trend and was initiated to protect human and environmental health mainly due to the widespread environmental pollution impacts of e-waste.

"Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered e-waste. Informal processing of electronic waste in developing countries may cause serious health andpollution problems, as these countries have limited regulatory oversight of e-waste processing."

1. Step-by Step Process of E-waste Recycling:

The e-waste recycling process is highly labor intensive and goes through several steps. Below is the step-by-step process of how e-waste is recycled,

1.1 Picking Shed: When the e-waste items arrive at the recycling plants, the first step involves sorting all the items manually. Batteries are removed for quality check.

1.2 Disassembly: After sorting by hand, the second step involves a serious labor intensive process of manual dismantling. The e-waste items are taken apart to retrieve all the parts and then categorized into core materials and components. The dismantled items are Tthen separated into various categories into parts that can be re-used or still continue the recycling processes.

1.3 First size reduction process: Here, items that cannot be dismantled efficiently are shredded together with the other dismantled parts to pieces less than 2 inches in diameter. It is done in preparation for further categorization of the finer e-waste pieces.

1.4 Second size reduction process: The finer e-waste particles are then evenly spread out through an automated shaking process on a conveyor belt. The well spread out e-waste pieces are then broken down further. At this stage, any dust is extracted and discarded in a way that does not degrade the environmentally.

1.5 Over-band Magnet: At this step, over-band magnet is used to remove all the magnetic materials including steel and iron from the e-waste debris.

1.6 Non-metallic and metallic components separation: The sixth step is the separation of metals and non-metallic components. Copper, aluminum, and brass are separated from the debris to only leave behind non-metallic materials. The metals are either sold as raw materials or re-used for fresh manufacture.

1.7 Water Separation: As the last step, plastic content is separated from glass by use of water. One separated, all the materials retrieved can then be resold as raw materials for re-use. The products sold include plastic, glass, copper, iron, steel, shredded circuit boards, and valuable metal mix.

2. E-Cycle Components Re-Use:

1.1 Plastic: All the plastic materials retrieved are sent to recyclers who use them to manufacture items such as fence posts, plastic sleepers, plastic trays, vineyard stakes, and equipment holders or insulators among other plastic products.

1.2 Metal: Scrap metals materials retrieved are sent to recyclers to manufacture new steel and other metallic materials.

1.3 Glass: Glass is retrieved from the Cathode Ray Tubes (CRTs) mostly found in televisions and computer monitors. Extracting glass for recycling from CRTs is a more complicated task since CRTs are composed of several hazardous materials. Lead is the most dangerous and can adversely harm human health and the environment. Tubes in big CRT monitors can contain high levels of lead of up to 4 kilograms. Other toxic metals such as barium and phosphor are also contained in CRT tubes.

To achieve the best environmentally friendly glass extraction, the following steps ensure a specialized CRT recycling:

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- Manual separation of the CRT from the television or monitor body
- Size reduction process where the CRT is shredded into smaller pieces. Dust is eliminated and disposed in an environmentally friendly way.
- All metals are removal through over-band magnets, where ferrous and non-ferrous components are eliminated from the glass materials.
- A washing line is then used to clear oxides and phosphors from the glass
- Glass sorting is the final step whereby leaded glass is separated from non-leaded glass. The extracts can then be used for making new screens.

1.4 **Mercury:** Mercury containing devices are sent to mercury recycling facilities that uses a specialized technology for elimination for use in dental amalgams and metric instruments, and for fluorescent lighting. Other components such as glass and plastics are re-used for manufacture of their respective products.

1.5 **Printed Circuit Board:** Circuit boards are sent to specialized and accredited companies where they are smelted to recover non-renewable resources such as silver, tin, gold, palladium, copper and other valuable metals.

1.6 **Hard Drives:** Hard drives are shredded in whole and processed into aluminum ingots for use in automotive industry.

1.7 **Ink and Toner Cartridges:** Ink and toner cartridges are taken back to respective manufacturing industries for recycling. They are remanufactured while those that can't are separated into metal and plastic for re-use as raw materials.

1.8 **Batteries:** Batteries are taken to specialized recyclers where they are hulled to take out plastic. The metals are smelted is specialized conditions to recover nickel, steel, cadmium and cobalt that are re-used for new battery production and fabrication of stainless steel.

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V. E-WASTE DISPOSAL METHOD

1. Landfilling:
This is the most common methodology of e-waste disposal. Soil is excavated and trenches are made for burying the e-waste in it. An impervious liner is made of clay or plastic with a leachate basin for collection and transferring the e-waste to the treatment plant. However, landfill is not an environmentally sound process for disposing off the e-waste as toxic substances like cadmium, lead and mercury are released inside the soil and ground water.

2. Acid Bath:
Acid bath involves soaking of the electronic circuits in the powerful sulphuric, hydrochloric or nitric acid solutions that free the metals from the electronic pathways. The recovered metal is used in the manufacturing of other products while the hazardous acid waste finds its ways in the local water sources.

3. Incineration:
This is a controlled way of disposing off the e-waste and it involves combustion of electronic waste at high temperature in specially designed incinerators. This e-waste disposal method is quite advantageous as the waste volume is reduced extremely much and the energy obtained is also utilized separately. However, it is also not free from disadvantages with the emission of the harmful gases mercury and cadmium in the environment.

4. Recycling of E-Waste:
Mobile phones, monitors, CPUs, floppy drives, laptops, keyboards, cables and connecting wires can be re-utilized with the help of the recycling process. It involves dismantling of the electronic device, separation of the parts having hazardous substances like CRT, printed circuit boards etc. and then recovery of the precious metals like copper, gold or lead can be done with the help of the efficient a powerful e-waste recycler. The most crucial thing here is choosing the right kind of recycler that does not break laws and handle the e-waste in the eco-friendly manner.

Nowadays, there are many e-waste recycling companies coming up with the pick up facilities collecting obsolete electronic items from your homes. Moreover, they are also running several recycling programs for the users, retailers and manufacturers for the collection of the electronics. Certain agencies such as EPA, Earth 911, E Cycling Center, Call 2 Recycle, Greener Gadgets and Electronic Industries Alliance are the additional resources for helping people in finding the nearby drop off locations.

5. Re-use of Electronic Devices:
This is the most desirable e-waste recycling process where with slight modifications the mobile phones, computers, laptops, printers can be reused or given as second hand product to the other person. The old electronic equipment can also be donated in the various charity programs and thus helping the persons in need. Moreover, there is a better way also by selling the old mobile phones or laptops to the some recycling and refurbishing companies. Several websites are acting as the middleman between recyclers and electronic users. It is a win-win situation for the users as they not only get rid off the old mobile phones but also get paid after reselling it.

6. Management of e-waste:
There is no unique or ideal model for e-waste management in developing countries, each of which has its own specific

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environmental, social, technological, economic and cultural conditions. Environmentally sound management of WEEE recognizes three Rs i.e. reduce, reuse and recycle. The aim would be to reducethe generation of e-waste through smart manufacturing and maintenance, reusetill functioning of electronic equipment by someone else and recyclethose components that cannot be repaired.

A smart e-waste management system for developing countries have to assess the e-waste situation, recognize that e-wastes are a complex mixture of hazardous and non-hazardous substances and materials and need to define the integral e-waste management system taking into conside ration the EEE market penetration, life cycle of ICT equipment, financing mechanisms etc.

The main aspects to be taken into account when framing ICT waste management guidelines for developing countries are:

- Policy and regulations covering import and export of EEE and WEEE in accordance with the rules of each country and with international legislation.
- Defining responsibilities of prime stake holders at the level of government, supply chain, consumers of ICT equipment and entities for disposal of waste.
- Extended producer responsibility (EPR) where the manufacturer's responsibility for its ICT equipment extends throughout the various stages of that equipment's life cycle with internalizing the cost of managing the equipment at end of life.
- Responsible information system to have data on ICT equipment in market, disused EEE management and WEEE management and to have control on the monitoring and future planning.
- Promoting employment and training for the informal sector engaged in recycling and recovery of the materials.

VI. CONCLUSIONS

E waste is a relatively new segment in the global problem of waste removal. It is also the fastest growing segment worldwide in discarded waste. This growing problem in the world is largely ignored or misunderstood. Many people do not understand what it is or how it affects them, the world, or the environment. So the question "What is Ewaste" needs to be addressed before any solutions can be effective.

Ewaste comes from the improper disposal of any number of electronic devices. These devices include computers, televisions, cell phones, or most other electronic equipment. Consumers in developed nations are quick to replace their devices because of continuous technological advances. This upgrading leads to an excess of unused electronic devices. What is done with old computers and phones is what is contributing to the E waste problem. Some people understand the importance of properly disposing of these old units, but many more still throw them in the garbage or incinerators.

Most developed nations in the world have laws and regulations requiring that E waste not be disposed of in landfills or be incinerated. Cities and states have set up programs across the United States where consumers can drop off used electronic devices to be properly disposed of. The best method of disposal is to recycle this equipment. Many people do not understand that the parts in old devices can be reused in new products. There is a popular mantra used by many recycling advocates, "Reduce, Reuse, and Recycle." This slogan has widely been promoted with plastics and glass, but its message is also applicable to the disposal of E waste. Many electronic stores offer services to help customers bring in old electronics or parts so as to dispose of them safely and properly.

Unfortunately, there is another alternative being used for the removal of E waste in the world. Much of the E waste in developing nations is being exported to developing countries. Many developed countries have enacted laws to prevent this from happening, but ewaste is still often being exported. The bulk of the world's E waste is being shipped to Nigeria, Ghana, Pakistan, India, and China, among others. While it seems odd that a country would willingly import another's waste, the waste is imported, sometimes illegally. This practice provides jobs and valuable scraps. Ewaste is a source of valuable metals such as gold, nickel, copper, iron, and silicon. The countries that are receiving this ewaste have lax laws protecting their workers or the environment. Many of the workers are children, or are working countless hours each day. There is also the reality that much of the refuse from electronic devices is hazardous. The dumping of these materials following the harvesting of scrap can lead to contamination of soil or water, damaging an area's environment and potentially their food sources.

The purpose of this webquest was to alert students and make them aware of the problem. Tons and tons of ewasteis dumped each year and the problems continues to grow. The tasks we have assigned are intended to increase awareness of this global situation and encourage students to research not only the problem, but potential solutions. The numbers are mind blowing and awareness is a good way to begin resolving or attending to the problem.

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