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Hazard and Possible Treatment of E-Waste

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Abstract: *Availability of cheap and useful electronics gadgets with limited Product Life Cycle has resulted in lot of electronics junk in household and in the offices. Also the boom in Information Technology Sector has resulted in the additional burden to the existing problem. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of electronic waste. Due to increasing obsolescence rates of electronic products there is heavy import of junk electronic materials from abroad creating complex problems for solid waste management in India.In the present paper the focus is on the factors responsible for generation of e waste, its effects on human health and environment, present day scenario and the forthcoming challenges, followed by the regulations to deal with such a waste has been discussed.*

Keywords: E-waste, Landfill, Incineration, Environment

I. INTRODUCTION

Changed life style, growing income and easily availability of electronics gadgets at lower cost made the human life very colorful. No doubt, every work in office, industry and at home becomes so easy and efficient due to it. Rapid change in technology causes the things to become obsolete faster. Desk top PCs are having life span of 15 plus years but as new software is invented, it cannot be supported by old hardware and hence PC is not having even secondhand market. Same is the case for mobile phones, refrigerators and audio video equipment. When useful lifespan is coming down it creates a problem of disposal and it becomes electronic waste. Electronic waste is fastest growing waste in the world. Currently it equals to 1% of total solid waste generation. This is expected to grow 2% by 2010. In European countries E-waste generation ranges from 5 to 7 million tones per annum.

In India at present annual generation per capita is les than 1 kg , it is growing at an exponential rate. As the electronic industry is the fastest growing segment of Indian industry in terms of production and export. As per country level Waste Electrical and Electronic Equipment (WEEE) assessment study, Mumbai and Pune falls under the top ten cities that are generating maximum quantities and Mumbai alone generates maximum among all the cities of India. Total WEEE waste generation in Maharashtra is 20270.6 tons, out of this Navi Mumbai contributes 646.48 tons, Greater Mumbai 11017.06 tons, Pune 2584.21 tons and Pimpri-Chinchwad 1032.37 tons.

II. CLASSIFICATION OF E-WASTE

E-waste has been categorized into three main categories, Viz. Large Household Appliances, IT and Telecom and Consumer Equipment. Refrigerator and Washing Machine represent large household appliances, Personal Computer, Monitor and Laptop represent IT and Telecom, while Television represents Consumer Equipment. Each of these E-waste items has been classified with respect to twenty six common components, which could be 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, BFR-containing plastic, batteries, CFC/HCFC/HFC/HC, external electric cables, refractory ceramic fibers, radio active substances and electrolyte capacitors .Contribution of some commonly occurring constituents to the equipment as a whole is given in Table No.1.

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TABLE I: PERCENTAGE OF E WASTE CONSTITUENTS IN AN EQUIPMENT

	Component % of total waste						
Equipment	**Motor**	**Metal**	**Glass**	**Wire**	**Plastic**	**CRT**	**PCB with component**
TV		2.33		1.59	14.44	76.80	5.56
Refrigerator	23.10	52.70	1.60	0.20	10.20		
Washing Machine	18.40	47.80	2.60	1.10	1.80	NA	
PC					22.99	60.09	
Toys		2.0			90.0		5.0
Mobile		10			20		40

III. COMPOSITION OF E-WASTE

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 & plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the WEEE followed by plastics (21%), non ferrous metals (13%) and other constituents. 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.

Lead

The typical Pb/Sn solder content in scrap of printed circuit boards ranges between 4-6%, consequently lead represents 2-3% of the weight of the original board. The concerns about lead in circuit appear to relate to the possibility of lead leaching from circuit boards disposed of in landfills.

Mercury

It is estimated that 22% of the yearly world consumption of mercury is used in electrical and electronic equipment (ex. in fluorescent lamps). Its use in EEE has declined significantly in recent years. It has been used in thermostats, (position) sensors, relays and switches (ex. on printed circuit boards and in measuring equipment), batteries and discharge lamps. Furthermore, it is used in medical equipment, data transmission, telecommunications, and mobile phones. The estimated concentration level of mercury in computers is 0.002%.

Beryllium

Copper beryllium alloys are used in electronic connectors where a capability for repeated connection and disconnection is desired, and thus where solder is not used to make a permanent joint. Such connectors are often gold plated, so that copper oxide is not created on their surfaces, and does not form a non-electrically conductive barrier between the two connectors. A second use of beryllium in the electronics industry is as beryllium oxide, or beryllia. Beryllia transmits heat very efficiently, and is used in heat sinks. These sinks project heat-generating devices by rapidly distributing their heat to a much larger volume and surface area, where it can be further safely discharged into a moving air stream. Beryllia heat sinks have been used in specific designed parts, which are attached to a heat source, and have also been built into specific microelectronic devices as integral parts of the substrates of those devices. Beryllium oxide (BeO) or beryllia is found in some power transistors, transistor and valve bases, and some resistors.

IV. EFFECTS OF E WASTE ON ENVIRONMENT AND HEALTH

Computer wastes that are 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. For example, Guiyu, Hong Kong a thriving area of illegal e-waste recycling is facing acute water shortages due to the contamination

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of water resources. 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. Not only does the leaching of mercury poses specific problems, the vaporization of metallic mercury and dim ethylene mercury, both part of Waste Electrical and Electronic Equipment (WEEE) is also of concern. In addition, uncontrolled fires may arise at landfills and this could be a frequent occurrence in many countries. Summary of effects of e waste on health is given in Table 2.

TABLE III: 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 resistors and semiconductors	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.
Corrosion protection of untreated and galvanized steel plates, decorator or hardner for steel housings	Hexavalent chromium (Cr) VI	Asthmatic bronchitis. DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes Reproductive and developmental problems; Immune system damage; Interfere with regulatory hormones
Plastic housing of electronic equipments 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 disease or beryllicosis. Skin diseases such as warts.

V. ELECTRONIC WASTE MANAGEMENT

E-waste generation cycle is important is in its management (Fig -1). E-waste treatment involves complex treatment technologies, which may be located at different locations. In the European Union where the annual quantity of electronic waste is likely to double in the next 12 years, the European Parliament recently passed legislation that will require manufacturers to take back their electronic products when consumers discard them. This is called Extended Producer Responsibility. It also mandates a timetable for phasing out most toxic substances in electronic products.

Waste minimization in industries involves adopting:

- Inventory management,
- Production-process modification,
- Volume reduction,
- Recovery and reuse.

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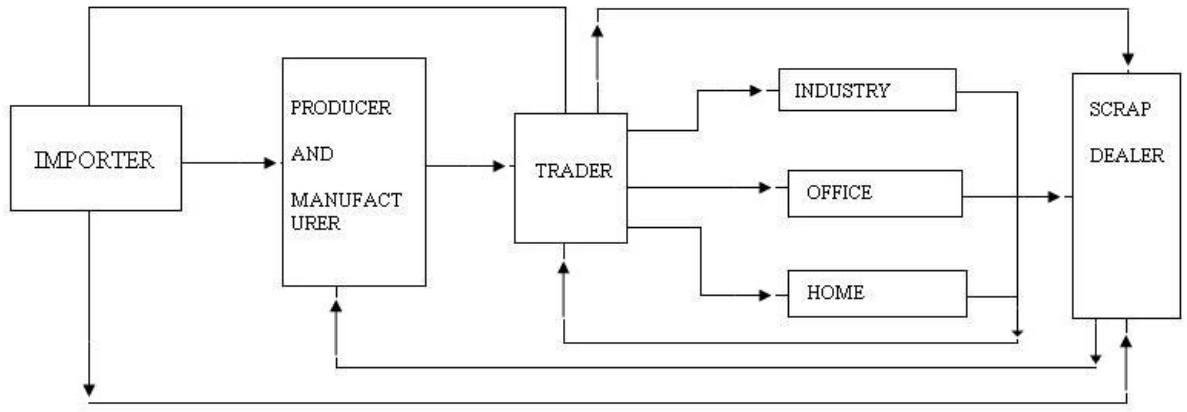

Fig.1 E waste generation cycle.

E-waste Composition and Recycle Potential

The consumption of E-waste and its recyclable potential is specific for each appliance. In order to handle this complexity, the parts/materials found in WEEE have been divided into six categories.

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

Treatment Options

The composition of E-waste described in above section shows that it consists of diverse items like ferrous and non ferrous metals, glass, plastic, electronic components and other items. The contents described in Chapter 2 also revealed that E-waste consists of hazardous elements. The potential treatment options based on this composition are given below.

- Land filling or incineration of WEEE together with municipal waste
- Recycling/recovery processes
- Disposal of residues from recycling/recovery processes

Land filling

The literature review reveals that degradation processes in landfills are very complicated and run over a wide time span. At present it is not possible to quantify environmental impacts from E-waste in landfills for the following reasons:
Landfills contain mixtures of various waste streams;
Emission of pollutants from landfills can be delayed for many years;
According to climatic conditions and technologies applied in landfills (e.g. leachate collection and treatment, impermeable bottom layers, gas collection).
One of the study on landfills reports that the environmental risks from landfilling of E-waste cannot be neglected because the conditions in a landfill site are different from a native soil, particularly concerning the leaching behavior of metals. In addition it is known that cadmium and mercury are emitted in diffuse form or via the landfill gas combustion plant. Although the risks cannot be quantified and traced back to E-waste, landfilling does not appear to be an environmentally sound treatment method for substances, which are volatile and not biologically degradable (Cd, Hg, CFC).

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Incineration

Advantage of incineration of E-waste is the reduction of waste volume and the utilization of the energy content of combustible materials. Some plants remove iron from the slag for recycling. By incineration some environmentally hazardous organic substances are converted into less hazardous compounds. Disadvantage of incineration are the emission to air of substances escaping flue gas cleaning and the large amount of residues from gas cleaning and combustion.

There is no available research study or comparable data, which indicates the impact of E-waste emissions into the overall performance of municipal waste incineration plants. Waste incineration plants contribute significantly to the annual emissions of cadmium and mercury. In addition, heavy metals not emitted into the atmosphere are transferred to slag and exhaust gas residues and can re-enter the environment on disposal. Therefore, E-waste incineration will increase these emissions, if no reduction measures like removal of heavy metals from are taken.

Recycling and Recovery

The presence of hazardous chemicals and elements in E-waste offers the potential of increasing the intensity of their discharge in environment due to landfilling and incineration. Therefore, the major approach to treat E-waste is to reduce the concentration of these hazardous chemicals and elements through recycle and recovery and finally dispose E-waste fractions through either incineration or landfilling or a combination of both. In the process of recycling or recovery, certain E-waste fractions act as secondary raw material for recovery of valuable items. The recycle and recovery includes the following unit operations.

Dismantling: Removal of parts containing dangerous substances (CFCs, Hg switches, PCB); removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts). Segregation of ferrous metal, non-ferrous metal and plastic: This separation is normally done in a shredder process. Recycling/recovery of valuable materials: Ferrous metals in electrical are furnaces, non-ferrous metals in smelting plants, precious metals in separating works. Treatment/disposal of dangerous materials and waste: Shredder light fraction is disposed of in landfill sites or sometimes incinerated (expensive), CFCs are treated thermally, PCB is incinerated or disposed of in underground storages, Hg is often recycled or disposed of in underground landfill sites.

VI. CONCLUSION

From above discussion it can be concluded that E waste is one of the fastest growing waste in the world. It is one of the troubles we are facing as we are using new technologies. To find out solution for the reduction and treatment of E waste the things which to be followed are

1. Proper inventory management
2. Product modification
3. Recycle and reuse
4. Use of EST
4. Government responsibilities
5. Industries responsibilities.
6. Citizens responsibilities

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