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E-Waste Management with respect to Indian Scenario

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***Abstract*- The electronic industry is the world's largest and fastest growing manufacturing industry in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" of electrical and electronic goods make electrical and electronic waste (e-waste) one of the fastest growing waste streams. E-waste is valuable source for secondary raw material but harmful if treated and discarded improperly as it contains many toxic components such as lead, cadmium, mercury, polychlorinated biphenlys etc.**
Electronic waste or e-waste refers to unwanted, obsolete or unusable electronic and electrical products. Ever increasing usage of electronics and electrical equipments has resulted in piling up of e-waste. The current practices of e-waste management in India encounters many challenges like the difficulty in inventorization, ineffective regulations, pathetic and unsafe conditions of informal recycling, poor awareness of consumers and reluctance on part of the stakeholders to address the issues. In this paper case study of E-Waste management in India and using some efficient methods for E-Waste Management Like "RRR".& E-waste contains a good amount of valuable recyclable materials also and has potential to become lucrative business in the country.

Keywords- E-Waste, Recycling, Electronic, Reuse, Hazardous,Househlod, Landfilling, Equipments, Environmentally Sound Management.

I. INTRODUCTION

E-waste is the popular name for discarded electrical and electronic equipment with all of their peripherals at the end of their life. E-waste comprises of wastes generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. Such wastes encompasses wide range of electrical and electronic devices such as computers, hand held cellular phones, personal stereos, including large household appliances such as refrigerators, air conditioners etc.

The electronic industry is the world's largest and fastest growing manufacturing industry in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" of electrical and electronic goods make electrical and electronic waste (e-waste) one of the fastest growing waste streams. E-waste is valuable source for secondary raw material but harmful if treated and discarded improperly as it contains many toxic components such as lead, cadmium, mercury, polychlorinated biphenlys etc. (Bandyopadhyay, 2010).

The quantity of e-waste generated in developed countries equals 1% of total solid waste on an average and is expected

to grow to 2% by 2010 (UNEP Manual, 2007).In United States alone, 1,30,000 computers and 3,00,000 cell phones are trashed each day (Anderson,
2010).The developed countries use most of the world's electronic products and generate most of the E-waste (Basel Action Network, 2002). Rather than treat e-waste in an environmentally friendly manner, the developed countries are finding an easy way out of the problem by exporting these wastes to developing economies especially, South Asian countries (Basel Action Network, 2002).

The import of e-waste to the developing countries is in violation of the ban imposed by Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, as e-waste come under the definition of hazardous waste (Basel Convention 1992).Following this, our country, a party to the convention, banned the import of hazardous waste including e-waste into the country. But a major source of e-waste in India is illegal imports (Sathish, 2006).

(Fig.1 E-Waste Scenario)

The major portion of the e-waste generated domestically as well as illegally imported are recycled in crude manner leading to pollution of the environment. Lack of legislation in our country at present is aiding this hazardous form of recycling. Therefore there is urgent need to frame and implement rules for regulating this waste and to find

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environmentally sound, economically viable methods for recycling and disposing of this necessary evil.

The necessity of environmentally sound management of e-waste is brought out with the help of a case study of uncontrolled dumping of e-waste.

1.1 E-WASTE-

E-waste is the popular name for discarded electrical and electronic equipment with all of their peripherals at the end of their life. E-waste comprises of wastes generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. Such wastes encompasses wide range of electrical and electronic devices such as computers, hand held cellular phones, personal stereos, including large household appliances such as refrigerators, air conditioners etc.

1.2 MAJOR SOURCES-

Individuals and Small Businesses: The useful span of a computer has come down to about two years due to improved versions being launched about every 18 months. Often, new software is incompatible or insufficient with older hardware so that customers are forced to buy new computers.

Large corporations, Institutions and Government: Large users upgrade employee computers regularly.

Original Equipment Manufacturers (OEMs):OEMs generate e-waste when units coming off the production line do not meet quality standards, and must be disposed off. Some of the computer manufacturers contract with recycling companies to handle their electronic waste, which often is exported.Besides computers, other major e waste source is the cellular phone.

II. INDIAN SCENARIO

According to ASSOCHAM, an industrial body in India the, Compound Annual Growth Rate of electronic waste is 30%. With changing consumer behavior and rapid economic growth, ASSOCHAM estimates that India will generate 5.2 million tonnes of e-waste by 2020.

The electronics industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. The share of software services in electronics and IT sector has gone up from 38.7 per cent in 1998-99 to 61.8percent in 2003-04. A review of the industry statistics show that in 1990-91,hardware accounted for nearly 50% of total IT revenues while software's share was 22%. The scenario changed by 1994-95, with hardware share falling to 38%and software 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.

By the end of financial year 2005-06, India had an installed base of 4.64 million desktops, about 431thousand notebooks and 89 thousand servers. According to the estimates made by the 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 rate and installed base in India for the year 2005 has been estimated to be 146180.00 tonne. This is expected to exceed 8,00,000tonne 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 Control 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, Gujarat, Madhya Pradesh and Punjab in the list of e-waste generating states in India.In our country, currently some units have registered with the Ministry of Environment and Forests as possessing environmentally sound management facilities for recycling of e-waste.

(Chart 1 State Wise E-Waste Generation In India)

III. CLASSIFICATION OF E-WASTE

3.1 COMPONENTS 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, (Liquid Crystal Display) LCD, rubber, wiring/ electrical, concrete, transformer, magnetron, textile, circuit board, fluorescent lamp, incandescent lamp, heating element, thermostat, BFR-containing plastic, batteries, fluorocarbons

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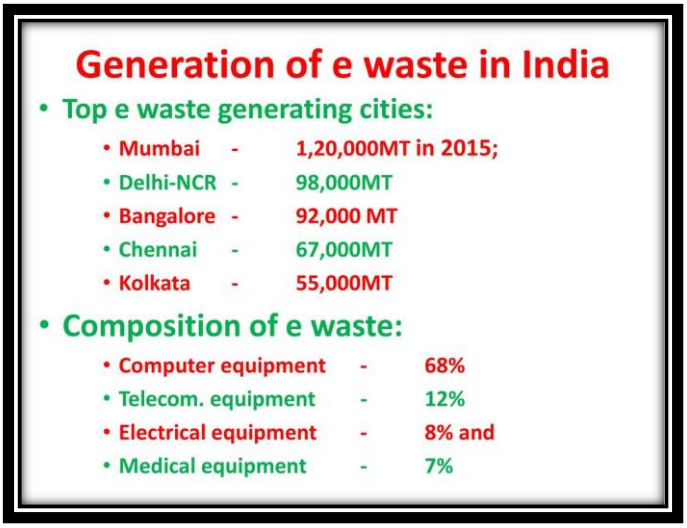
(CFC/HCFC/HFC/HC), external electric cables, refractory ceramic fibers, radioactive substances and electrolyte capacitors. The kinds of components, which are found in refrigerator, washing machine, personal computers (PC) and televisions.

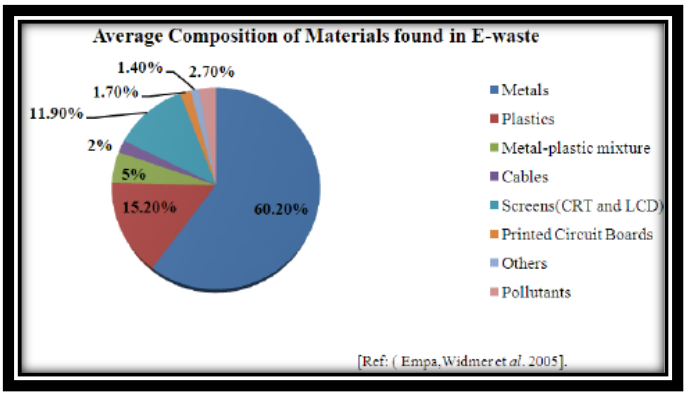
3.2 COMPOSITION OF E-WASTE-

Composition of 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 about50% of the e-waste followed by plastics (21%), non ferrous metals (13%) and other constituents.



(Chart 2 Generation+of+e+waste+in+India)

Non-ferrous metals consist of metals like copper, aluminium 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 e-waste classifies them as hazardous waste.



(Chart 3 Weighted-Percentage-of-Material-in-E-waste)

IV. DATA AND METHODOLOGY OF THE STUDY

METHODOLOGY FOR ENVIRONMENTALLY SOUND MANAGEMENT OF E-WASTE

4.1 E-WASTE COMPOSITION AND RECYCLE POTENTIAL-

The composition of e-waste and its recyclable potential is specific for each appliance. In order to handle this complexity, the parts/materials found in e-waste may be divided broadly into six categories as follows:
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.)

Overview of the composition of the appliances in the three categories mentioned earlier is given in table 1.

4.2 Assessment of Hazardousness of E-waste-

The hazardous nature of e-waste is determined by identifying the e-waste category item (identification includes the waste items and year of manufacture), identifying the e-waste composition or its components, identifying possible hazardous content in the e-waste and identifying whether the e-waste component is hazardous or the entire e-waste item is hazardous.

4.3 RECYCLING, REUSE AND RECOVERY OPTIONS-

The composition of e-waste consists of diverse items like ferrous and non-ferrous metals, glass, plastic, electronic components and other items and it is also revealed that e-waste consists of hazardous elements. Therefore, the major approach to treat e-waste is to reduce the concentration of these hazardous chemicals and elements through recycle and recovery. 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.

(i) 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).
(ii) Segregation of ferrous metal, non-ferrous metal and plastic
This separation is normally done in a shredder process.
(iii) Refurbishment and reuse
Refurbishment and reuse of e-waste has potential for those used electrical and electronic equipments which can be easily refurbished to put to its original use.
(iv) Recycling/recovery of valuable materials
Ferrous metals in electrical are furnaces, non-ferrous metals in smelting plants, precious metals in separating works.

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(v) 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.

V. TREATMENT & DISPOSAL OF E-WASTE

The presence of hazardous elements in e-waste offers the potential of increasing the intensity of their discharge in environment due to landfilling and incineration.

The potential treatment & disposal options based on the composition are given below:
1. Incineration
2. Landfilling

5.1 Landfilling-

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. One of the studies 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), persistent (PCB) or with unknown behaviour in a landfill site (brominated flame retardants). As a consequence o fthe complex material mixture in e-waste, it is not possible to exclude environmental (long-term) risks even in secured landfilling.

5.2 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 fluegas 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 reenter the environment on disposal. Therefore, e-waste incineration will increase these emissions, if no reduction measures like removal of heavy metals from are taken.

Table 1 Average Weight and Composition of Selected Appliances (Typical)

Appliances	Average weight (kg)	Fe % weight	Non Fe-metal % weight	Glass % weight	Plastic % weight	Electronic components % weight	Others % weight
Refrigerators and freezers	48 .0	64.4	6 .0	1.4	13 .0	0.2	15.0
Personal computer	29.6	20.0	24	15	23.0	17.3	0.7
TV sets	36.2	5.3	5.4	62	22.9	0.9	3.5

Table 2 Possible Hazardous Substances in Components of E-waste

Component	**Possible hazardous content**
Metal	
Motor/compressor	
Cooling	Ozone Depleting Substances (ODS)
Plastic	Phthalate plasticizer, brominated flame retardants (BFR)
Insulation	Insulation ODS in foam, asbestos, refractory ceramic fiber
Glass	
Cathode Ray Tube	Lead, Antimony, Mercury, Phosphor
Liquid Crystal Display	Mercury
Rubber	Phthalate plasticizer, BFR
Wiring / electrical	Phthalate plasticizer, BFR, Lead
Concrete	
Transformer	

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Circuit Board	Lead, Beryllium, Antimony, BFR
Fluorescent lamp	Mercury, Phosphorous, Flame retardants
Incandescent lamp	
Heating element	
Thermostat	Mercury
BFR-containing plastic	BFRs
Batteries	Lead, Lithium, Cadmium, Mercury
CFC,HCFC,HFC,HC	ODS
External electric cables	BFRs, plasticizers
Electrolyte capacitors	Glycol, other unknown substances

VI. CONCLUSION

The problem of E-waste is growing in alarming proportions in India as also in the world. Although many developed countries have established welldefined E-waste management systems, the systems in India have barriers from socioeconomic, infrastructural, and legal reasons. The E-waste recycling and recovery options practiced in India are very outdated and hazardous, causing severe environmental and occupational hazards

Electronic and electrical equipments cannot be avoided in today's world. So also is the case of waste electronic and electrical equipments. As long as this is a necessary evil, it has to be best managed to minimize its adverse impacts on environment.

Through innovative changes in product design under EPR, use of environmentally friendly substitutes for hazardous substances, these impacts can be mitigated. A legal framework has to be there for enforcing EPR, RoHS for attaining this goal. Adoption of environmentally sound technologies for recycling and reuse of e-waste along with EPR and RoHS offers workable solution for environmentally sound management of e-waste.

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