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E- Waste Management and Recycling in India

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ABSTRACT: Electronic waste or e-waste is one of the rapidly growing problems of the world. E-waste is a popular and informal name for electronic products which have completed their useful life. Discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipments, batteries etc are some examples of e-waste. This waste also includes non biodegradable plastics which possess serious threat to the environment. Basel Action Network estimates that the 500 million computers in the world contains about 2.87 billions kgs of plastics, 717.67 kgs of lead and 286700 kgs of mercury. A single 14 inch monitor contains about 2.5-4.0 kgs of lead. This may have a drastic effect on the environment, if left untreated. In India, e-waste management assumes greater significance not only due to the generation of its own waste but also due to the dumping of e-wastes by the developed countries. Many of these products can be recycled, reused in an eco-friendly manner. A comprehensive methodology that provides e-wastes regulation, management and proper disposal as well as recycling techniques is the need of the hour. This paper highlights the hazards of e-waste, their effects and the various recycling methods to get rid of them in context of Indian scenario. The proper handling methods of harmful, toxic materials produced from e-waste are also focused in the paper.

KEYWORDS: E Waste, biodegradable, Non biodegradable, recycled.

I. INTRODUCTION

The electrical and electronic waste (E-waste) is one of the fastest growing waste streams in the world. The increasing “market penetration” in developing countries, “replacement market” in developed countries and “high obsolescence rate” make e-waste as one of the fastest growing waste streams. Environmental issues and trade associated with e-waste at local, transboundary and international level has driven many countries to introduce interventions. In accordance with the National Environmental Policy (NEP) and to address sustainable development concerns, there is a need to facilitate the recovery and/or reuse of useful materials from waste generated from a process and/or from the use of any material thereby, reducing the wastes destined for final disposal and to ensure the environmentally sound management of all materials. The NEP also encourages giving legal recognition and strengthening the informal sectors system for collection and recycling of various materials. In particular considering the high recyclable potential of e-waste such wastes should be subject to recycling in an environmentally sound manner. E-waste comprises of wastes generated from used electronic devices and house hold 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. E-wastes contain over 1000 different substances many of which are toxic and potentially hazardous to environment and human health, if these are not handled in an environmentally sound manner. The increasing obsolescence rate of electronic products also adds to the huge import of used electronics products. The e-waste inventory based on this obsolescence rate in India for the year 2005 has been estimated to be 14618 tonnes which is expected to exceed 8,00,000 tonnes by 2016. There is no large scale organized e-waste recycling facility in India and there are two small e-waste dismantling facilities that are functioning in Chennai and Bangalore, while most of the e-waste recycling units are operating in un-organized sector.

II. COMPONENTS OF E-WASTE

The components of e-waste are divided into three categories mainly. They are ---

1) Large household appliances—e.g. refrigerator and washing machine

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- 2) IT and telecom----e.g. personal computer and laptop
- 3) Consumer equipment----e.g. television

III. POSSIBLE HAZARDOUS SUBSTANCES PRESENT IN E-WASTE

The list of all possible hazardous content that can be present in different types of e- waste is shown in table 1.

Table 1 : List of all possible hazardous content that can be presented in different types of e-waste.

SL NO	COMPONENTS	POSSIBLE HAZARDOUS CONTENT
1	Metal	-
2	Motor/Compressor	-
3	Cooling	ODS
4	Plastic	Phthalate plasticize, BFR
5	Insulation	Insulation ODS in foam asbestos, refractory ceramic fibre
6	Glass	-
7	CRT	Lead, Antimony, Mercury, Phosphors
8	LCD	Mercury
9	Rubber	Phthalate plasticizer, BFR
10	Wiring/Electrical	Phthalate plasticizer, Lead, BFR
11	Concrete	-
12	Transformer	-
13	Circuit Board	Lead, Beryllium, Antimony, BFR
14	Fluorescent Lamp	Mercury, Phosphorous, Flame retardants
15	Incandescent Lamp	-
16	Heating Element	-
17	Thermostat	Mercury
18	BFR-containing plastics	BFRs
19	Batteries	Lead, Lithium, Cadmium, Mercury
20	CFC, HCFC, HFC, HC	Ozone depleting substances
21	External electric cables	BFRs, plasticizers
22	Electrolytic capacitors	Glycol and other unknown substances

We can also have an idea about the different compositions of a personal computer, typical television set and a refrigerator by looking at the table 2.

Table 2: Components of a refrigerator, personal computer, TV sets.

APPLIANCES	REFRIGERATOR	PERSONAL COMPUTERS	TV SETS
Average weight per Kg	48	29.6	36.2
Fe % weight	64.4	53.3	5.3
Non Fe weight	6	8.4	5.4
Glass weight	1.4	15	62
Plastic weight	13	23.3	29.2
Electronic component weight	-	17.3	0.9
Others weight	15.1	0.7	3.4

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IV. HARMFUL EFFECTS OF E-WASTE

- Lead makes up to 6.5% of computers, but the recycling efficiency is only 5%, the remaining 95% goes as waste in the land filling processes. Lead causes hypertension, stroke and premature death to adult and reduced IQ, neurological and biological damage to infants.
- Cadmium, a heavy metal makes up to 0.0094% of a personal computer and has no recycling efficiency. Cadmium accumulation in human body leads to suppression of growth, bone deformation, renal problem and bloodlessness. The disease itai itai is due to the accumulation of cadmium in our body.
- About 22% of the world's mercury consumption is in electrical and electronic equipments namely thermostats, switches, lamps, mobile phones, batteries etc. It causes damage to various organs including the brain and the kidneys as well as the foetus. When inorganic mercury spreads in water, it gets converted into methylated mercury at the bottom of water bodies under anaerobic conditions. The present phytoplankton easily absorbs the resulting methylated mercury, which further enters into the body of fishes through the food chain. By the process of biomagnifications, the level of mercury in the fishes increases to a greater extent than actually absorbed by the phytoplankton. When such fishes are consumed by the humans, it causes a notorious disease called the minamata disease.
- Incomplete burning of plastics gives hydrogen cyanide, carbon monoxide and toxic dioxin. This dioxin formation occurs at 300-325 degree celsius and enters into the atmosphere and disturbs the respiratory system of human beings. Babies can also be exposed to dioxin through breast-feeding.
- Beryllium which is used in plugs and mobile phones causes lung cancer when e-wastes are not properly disposed of by incineration method.

V. MANAGEMENT OF E-WASTE

It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. These electronic junks lie unattended in houses, offices, warehouses etc. and normally mixed with household wastes, which are finally disposed off at landfills. This necessitates implementable management measures.

In industries management of e-waste should begin at the point of generation. This can be done by waste minimization techniques and by sustainable product design. Waste minimization in industries involves adopting:

- inventory management,
- production-process modification,
- volume reduction,
- Recovery and reuse.

Inventory management

Proper control over the materials used in the manufacturing process is an important way to reduce waste generation (Freeman, 1989). By reducing both the quantity of hazardous materials used in the process and the amount of excess raw materials in stock, the quantity of waste generated can be reduced. This can be done in two ways i.e. establishing material-purchase review and control procedures and inventory tracking system.

Production-process modification

Changes can be made in the production process, which will reduce waste generation. This reduction can be accomplished by changing the materials used to make the product or by the more efficient use of input materials in the production process or both. Potential waste minimization techniques can be broken down into three categories:

i) Improved operating and maintenance procedures,

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ii) Material change and

iii) Process-equipment modification

Volume reduction

Volume reduction includes those techniques that remove the hazardous portion of a waste from a non-hazardous portion. These techniques are usually to reduce the volume, and thus the cost of disposing of a waste material. The techniques that can be used to reduce waste-stream volume can be divided into 2 general categories: source segregation and waste concentration.

Recovery and reuse

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.

(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, and Hg is often recycled or disposed of in underground landfill sites.

VI. E-WASTE RECYCLING AND TREATMENT TECHNOLOGIES IN INDIA

In this context, it is pertinent to assess the e-waste recycling scenario in India, where recycling of e-waste to recover items of economic value is carried out. The assessment of e-waste recycling sector in India indicates that e-waste trade starts from formal dismantling sector and moves to informal recycling sector. E Waste movement from formal to informal sector is driven by trade and can be tracked by trade value chain. This e-waste trade value chain can be mapped based on material flow from formal sector to informal sector.

The three levels of e-waste generation hierarchy give rise to three types of stakeholders involved in e-waste trade as

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described below.

1. 1st Level – Preliminary e-waste Generators.
2. 2nd Level – Secondary e-waste Generators.
3. 3rd Level – Tertiary e-waste Generators.

The input to “Preliminary e-waste Generator” comes from formal organized market like manufacturers, importers, offices and organized markets, where e-waste from domestic consumers comes either in exchange schemes or as a discarded item. Therefore, the major stakeholders are scrap dealers/ dismantlers who purchase e-waste from the first level in bulk quantities. These stakeholders have limited capacity of dismantling and are involved in trading of e-waste with “Secondary e-waste Generators”. The market between first and second level is semi formal i.e. part formal, while the market between second and third level is completely informal. Stakeholders falling under “Secondary e-waste Generators” have limited financial capacity and are involved in item/ component wise dismantling process and segregation ex. dismantling of CRT, PCB, plastic and glass from e-waste. “Tertiary Level Stakeholders” are the major stakeholders between second and third level and are metal extractors, plastic extractors and electronic item extractors. They use extraction process, which are hazardous in nature. The characteristics of emissions from e-waste treatment in semi formal and informal sector in India are as follows:

1. Generation of mixed e-waste fractions along with hazardous waste after dismantling
2. Generation of effluents during metal extraction ex. Acid bath process for copper extraction from printed circuit board
3. Air emissions due to burning of printed circuit board
4. Inefficient secondary raw material generation

The entire e-waste treatment is being carried out in an unregulated environment, where there is no control on emissions. There are two e-waste dismantling facilities in formal sector in India. These facilities are M/s. Trishiraya Recycling facilities, Chennai and M/s E-Parisara, Bangalore.

Environmentally sound E-waste treatment technologies are used at three levels as described below:

1. 1st level treatment
2. 2nd level treatment
3. 3rd level treatment.

Analysis

All the three levels of e-waste treatment are based on material flow. The material flows from 1st level to 3rd level treatment. Each level treatment consists of unit operations, where e-waste is treated and output of 1st level treatment serves as input to 2nd level treatment. After the third level treatment, the residues are disposed of either in TSDF or incinerated. Treatment at different levels is shown in figure 1.

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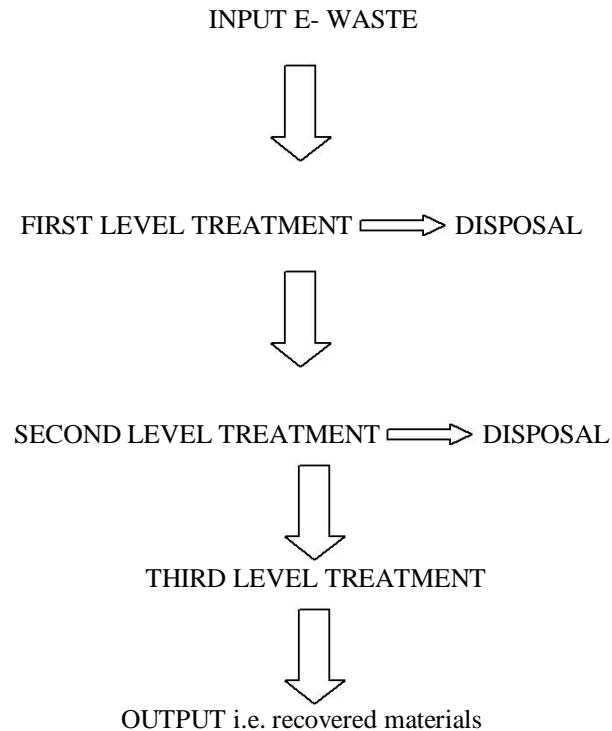


Fig 1: Treatment at different levels

EST for 1st Level Treatment

Input: E-waste items like TV, refrigerator and Personal Computers (PC).

Unit Operations: There are three units operations at first level of e-waste treatment. They are:-

1. Decontamination: Removal of all liquids and Gases
2. Dismantling : Manual/mechanized breaking
3. Segregation

All the three unit operations are dry processes, which do not require usage of water.

1. Decontamination

The first treatment step is to decontaminate e-waste and render it non-hazardous. This involves removal of all types of liquids and gases (if any) under negative pressure, their recovery and storage.

2. Dismantling

The decontaminated e-waste or the e-waste requiring no decontamination

The decontaminated e-waste is dismantled to remove the components from the used equipments. The dismantling process could be manual or mechanized requiring adequate safety measures to be followed in the operations.

3. Segregation

After dismantling the components are segregated into hazardous and nonhazardous components of e-waste fractions to be sent for 3rd level treatment.

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Output:

1. Segregated hazardous wastes like CFC, Hg Switches, batteries and capacitors
2. Decontaminated e-waste consisting of segregated non-hazardous E-waste like plastic, CRT, circuit board and cables

EST for 2nd Level Treatment

Input: Decontaminated E-waste consisting segregated non hazardous e-waste like plastic, CRT, circuit board and cables.

Unit Operations: There are three unit operations at second level of E-waste treatment

1. Hammering
2. Shredding
3. Special treatment Processes – It comprises of
 - (i) CRT treatment consisting of separation of funnels and screen glass.
 - (ii) Electromagnetic separation
 - (iii) Eddy current separation
 - (iv) Density separation using water

The two major unit operations are hammering and shredding. The major objective of these two unit operations is size reduction. The third unit operation consists of special treatment processes. Electromagnetic and eddy current separation utilizes properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, non ferrous metal and precious metal fractions. Plastic fractions consisting of sorted plastic after 1st level treatment, plastic mixture and plastic with flame retardants after second level treatment, glass and lead are separated during this treatment. The efficiency of this treatment determines the recovery rate of metal and segregated

CRT treatment technology

The salient features of CRT treatment technology are given below.

1. CRT is manually removed from plastic/ wooden casing.
2. Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted to facilitate internal phosphor coating.
3. Internal phosphor coating is removed by using an abrasive wire brush and a strong vacuum system to clean the inside and recover the coating. The extracted air is cleaned through an air filter system to collect the phosphor dust.

EST for 3rd Level E-waste Treatment

The 3rd level E-waste treatment is carried out mainly to recover ferrous, nonferrous metals, plastics and other items of economic value. The major recovery operations are focused on ferrous and non ferrous metal recovery, which is either geographically carried out at different places or at one place in an integrated facility. The following sections describe the unit operations, processes, available technology and environmental implications.

Input-sorted plastic, plastic mixture, lead smelting, CFC, oil, capacitor, mercury.

Unit operation- recycling, incineration, separation and distillation, secondary lead smelter, Au/Ag separation.

Output---plastic product, energy recovery, lead, iron, copper/aluminium, glass cullet.

Plastic Recycling

There are three different types of plastic recycling options i.e. chemical recycling, mechanical recycling and thermal recycling. In chemical recycling process, waste plastics are used as raw materials for petrochemical processes or as reductant in a metal smelter. In mechanical recycling process, shredding and identification process is used to make new plastic product. In thermal recycling process, plastics are used as alternative fuel. The two major types of plastic resins,

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which are used in electronics, are “thermosets” and “thermoplastics”. Thermosets are shredded and recycled because they cannot be re-melted and formed into new products, while thermoplastics can be re-melted and formed into new products.

VII. CONCLUSION

The problem of e-waste can be thus seen as a big danger to the society. Basically for the e-waste management technique, 4 R's are recommended to tackle waste generation. They are reduce, reuse, recycle and refuse. By this 4 R's waste can be minimized to some extent by which life forms can survive without much electronic waste, i.e. in a much safe environment

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