Technology Capacity Building for E-waste Recycling in India: A Comparison between the Technology used by Formal and Informal Sectors

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ABSTRACT

Solid waste management is a gigantic task in India. The phenomenal growth in Information Technology as well exponential increase in use of electronic gadgets in our daily life over the past decade, has resulted in generation of huge quantity of Electronic waste(E-waste). The complex composition of E-waste has further complicated the issue of solid waste management. E-waste contains many types of metallic and non-metallic hazardous chemicals. When electronic waste is dumped in landfills, not only all the energy and material used in making the product is lost, but it also poses high risk of environmental hazards. Their improper disposal may cause severe environmental problems. Electronic junk contains a fair amount of useful components and materials which can be reused or recycled. The major issue of E-waste management in India is the presence of un-organized backyard recyclers who are practicing E-waste recycling by adopting crude methods resulting in inefficient recovery, besides causing health and environmental hazards. Informal sector recycles more than 90 % of the entire E-waste handled .In this paper, a comparative study is made between formal E-waste recycling and informal recycling processes practiced in Delhi. It has been concluded that there is an urgent need of strong investment and regulation mechanism for technological capacity building of unorganized sector.

Keywords: electronic waste, recycling, recovery, resources, treatment, technology, unit operations.

1. INTRODUCTION

The term electronics encompasses a wide range of home and business electronic goods, including televisions, monitors computers, computer peripherals, audio and stereo tapes, VCR's, DVD players, video cameras, telephones, fax and copy machines, cellular phones, wireless devices etc. Discarded electronics -sometimes referred to as end of life of electronic products, electronic wastes, and E-waste or waste electrical and electronic equipment. (WEEE)-are generated, when users or owners of the product decide that they no longer want them .E-waste is popular informal

name of electronic products which are nearing or have reached the end of useful life[1].The necessity of E-waste management arises due to complexity and toxicity of compounds present in computers. E-waste contains over 1000 different substances and chemicals, many of which are toxic and are likely to create serious problems for the environment and human health if not handled properly [2].

The E-waste treatment technology used in formal sector and informal sector

Formal Sector: Environmentally sound E- waste treatment technologies are used at three levels, as under:

a. First level treatment: Inputs: E-waste items like television sets, refrigerators and personal computers
Unit operations:
i. Removal of liquids and gases
ii. Dismantling
iii. Segregation

All three unit operations are dry processes, which do not require the use of water. This is to decontaminate E- waste and render it non-hazardous.
Output: This step gives output of segregated non-hazardous wastes like plastics, printed circuit boards and cables.

b. Second level treatment: Input: Decontaminated E- waste consisting of segregated non–hazardous E-wastes like plastics, cathode ray tube, printed circuit boards (PCBs) and cables.
Unit operations: There are three unit operations of E-waste treatment, which are:

i. Hammering
ii. Shredding
ii. Special treatment processes:
    - CRT (Cathode Ray Tube) treatment consisting of separation of funnels and screen glass
    - Electromagnetic separation
    - Eddy current separation
    - Density separation using air or water. [3]

The major objective of hammering and shredding is size reduction. Electromagnetic separation and eddy current separation utilizes properties like electrical conductivity, magnetic properties and density to separate ferrous and non-ferrous and precious metals.

Output: Ferrous metal scrap, non-ferrous metal scrap mainly copper and aluminum, precious metal scrap mainly silver, gold, palladium, plastic consisting of sorted plastic, plastic with flame retardants and plastic mixture.

c. Third level treatment: Inputs : Sorted plastics, plastic mixture, plastic mixture with frame retardants, CRT, lead Smelting, ferrous metal scrap, non-ferrous metal scrap, precious metals, lead batteries, CFC(chloro floro carbons), oil, capacitors, mercury
Unit operations:

i. Recycling
ii. Smelting
iii. Separation and distillation
iv. Incineration and energy recovery

Plastic recycling: Plastic recycling is done using chemical recycling, mechanical recycling and thermal recycling. The two major plastic resins, which are used in electronics, are thermo sets and thermoplastics. Thermo sets are shredded and recycle and thermoplastics can be re-melted and formed into new products [4].

Metals recycling: Metal recycling has been described in terms of lead recycling, copper recycling and precious metal recycling. After sorting from second level treatment, output materials are sent to the metal recovery facilities. These metal recovery facilities use the following process to recover metals. Lead (Pb) recovery: Reverberatory furnace and blast furnace are used to recover lead from E-waste fraction. Hard lead is recovered from the blast furnace, which contains 75-85 weight % Pb, 15-25 wt. % Sb(Antimony) and its slag contains 1-3% lead. Flue gas emissions from reverberatory furnace are collected by bag house and are fed back into the furnace to recover lead. Slag is disposed on hazardous waste landfill sites. (Cu) Copper recovery: The E-waste fraction containing copper is fed into a blast furnace, which are reduced by scrap iron and plastics to produce black copper. This contains 70-85 wt % copper.

The black copper is oxidized to produce blister copper 95 wt. % purity. Black copper and blister copper are reduced by coke, wood or waste plastic in an anode furnace. Other less noble metals and sulphur are removed and anode copper is produced which is dissolved in sulphuric acid electrolyte with other elements such as Zn, Ni and Fe. The pure copper 99.99 wt. % is deposited on the cathodes. The byproducts of copper recovery process and slag are reused for roof shingles, ballasts for railroads. The entire secondary recovery of copper uses only one sixth of the energy that would be required to produce copper from the ore [5]. Developed countries like USA, Europe and Japan have already adopted fully automated high cost technology for E-waste recycling [6].

In India, due to non-availability of highly sophisticated technology with the informal E-waste handlers (backyard practitioners). almost 95% of the E-waste is handled manually by unskilled workers. This emphasizes the importance of E-waste handling in informal recycling operators.

E-waste treatment technology and methods in practice by the informal recycling sector

The recycling and recovery of materials from computers and other E-waste is complex and requires specialized techniques, whereas the methods adopted by all the recyclers are highly unsophisticated, rudimentary and dangerous. Disassembly is done by manual dismantling of all parts of computers using a hammer and a chisel. Monitors are of great interest for scrap dealers as they contain good quantities of copper besides circuit boards and picture tubes.

The steps in monitor recycling involve physical removal of plastic casing, picture tube, copper yokes and plates. The intact and functional CRT is resold for regunning. These recharged tubes are used for manufacturing of color and black and white local brand televisions. Copper recovered from yokes is sold to copper smelters. Copper from wires is extracted by stripping with hands or open burning of wires in open land or drums. The printed circuit boards contain heavy metals such as antimony, gold, silver, chromium, zinc, lead, tin and copper [7]

The recycling of PCBs drawn from monitors, discs, printers, etc., involves a number of steps. Gold plated pins are manually removed. The core of each motherboard has a flat laminated gold plate. The laminated parts are cut and sold to goldsmiths for gold recovery. ICs (integrated circuits), condensers, bearings and other small parts are removed by heating the motherboard on a stove to loosen the bond between solder and plastic.

The resalable items are plucked out from preheated plates. These circuit boards are taken by other dealers to recover soldering material and copper. The solder material is removed by heating it on a kerosene gas kit and allowing molten lead to flow into a water tub. The circuit boards are manually scraped off with iron strips before extracting copper from them. Motherboards are openly burnt in pits.

Copper is sent to another unit for purification. Mother boards are also treated in open acid drums to extract copper from them. In an overall view, it is seen that after getting E-waste from various sources, small traders dismantle each component and through channelizing each component by various groups of recyclers, local traders earn about Rs. 2000-2500 per PC.A number of hazards arise due to the improper recycling and disposal process used. Table 1compiles the potential environmental and health hazards due to informal ways of recycling of e-waste.

Table 1: Environment and health hazards

E-Waste Component	Process	Potential environmental hazards	Potential occupational hazards	Source
Cathode ray tubes	Breaking, removal of copper yoke and dumping	Lead, barium and other heavymetals leaching into ground water and release of toxic phosphorous	Silicosis, Cuts from CRT glass Short term exposure of barium can cause vomiting, abdominal cramps, diarrhea and muscle weakness. Inhalation or contact with phosphor containing cadmium or other metals	[8], [9]
Printed circuit boards	Desoldering and removing computer chips	Air emission of the same substances	Tin and lead inhalation Slightly increased lead absorptionresults in decrease of hemoglobin and psychological dysfunction Possible brominated dioxin, beryllium, cadmium and mercury inhalation	[10]
Chips and other gold-plated components	Chemical stripping using nitric and hydrochloric acid along riverbanks	Hydrocarbons, heavy metals, brominated substances etc. discharged directly into river and banks. Acidifies the river destroying fish and flora	Acid contact with eyes, skin may result in permanent injury Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases can cause respiratory irritation – leading to severe effects, including pulmonary edema, circulatory failure and death	[8]
Plastics from Computerandperipherals	Shredding and low temperature melting	Emission of brominated dioxins and heavy metals and hydrocarbons	Probable hydrocarbon, brominated dioxin and PAH exposure to workers living in the burning works area Polyaromatic compounds can cause response like chlorance and related dermal lesions	[10]
Secondary steel or copper	Furnace recovers steel or copper from waste	Emission of dioxins and heavy metals	Exposure to dioxins and heavy metals Presence of heavy metals like mercury in living organisms causes	[11]

and precious metal smelting			cancer and birth defects.	
Wires	Open burning to recover copper	Hydrocarbon and ashes, including PAHs discharged into air, water and soil	Brominated and chlorinated dioxin and PAH exposure to workers living in the burning works area Several PBDE's affect thyroid function	[12]

2. CONCLUSION

Developed countries have been practicing fully automated recycling technology, which involves a high cost where as in India and especially in Delhi E-waste recovery and recycling is mainly done in unorganized manner and mostly manually by untrained workers. We have a bright possibility of recovering the maximum from electronic junk. However it is not possible without the support and efforts of consumer who should bear the primary responsibility of making E- waste reach the organized handlers .E- waste is actually not a waste it is E- wealth from secondary resource for metals and non-metals. Resource recovery can be carried out without harming ecology and environment if formal recycling units with sound technology come up in Delhi also. If a judicial combination of trained manual labor and technical support is involved in handling the E- waste in Delhi our heaps of electronic junk can be the source of resources of wealth generation. It is concluded that there is an urgent need of strong investment and regulation mechanism for technological capacity building of unorganized sector.

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