E-Waste Problem - Present Status, Challenges faced in its Management and Future: a Study of Gujarat Region

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Abstract:
"E-waste" is a popular, informal name for electronic products nearing the end of their "useful life."E-wastes are considered dangerous, as certain components of some electronic products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, refurbished, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem. This paper highlights the hazards of e-wastes, the need for its appropriate management and options that can be implemented.

Keywords: *Challenges, E-waste, Groundwater, Soil*

1. Introduction

Industrial revolution followed by the advances in information technology during the last century has radically changed people's lifestyle. Although this development has helped the human race, mismanagement has led to new problems of contamination and pollution. The technical prowess acquired during the last century has posed a new challenge in the management of wastes. For example, personal computers (PCs) contain certain components, which are highly toxic, such as chlorinated and brominated substances, toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives. The hazardous content of these materials pose an environmental and health threat. Thus proper management is necessary while disposing or recycling e-wastes.

These days computer has become most common and widely used gadget in all kinds of activities ranging from schools, residences, offices to manufacturing industries. E-toxic components in computers could be summarized as circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; brominated flameretardants used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) coated copper cables and plastic computer casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc.

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.

2. Effects on Environment and Human Health

Disposal of e-wastes is a particular problem faced in many regions across the globe. Computer wastes that are landfilled 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 of water resources.

This is due to disposal of recycling wastes such as acids, sledges etc. in rivers. Now water is being transported from faraway towns to cater to the demands of the population. 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. The same is true for polychlorinated biphenyls (PCBs) from condensers. When brominated flame retardant plastic or cadmium containing plastics are land filled, both polybrominated dlphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. It has been found that significant amounts of lead ion 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.

3. Characteristic of WEEE

In the WEEE Directive, electrical and electronic equipment is defined as being equipment that is dependent on electric current or electromagnetic field to function, and equipment for the generation, transfer or measurement of such currents and fields. The voltage rating to which that applies ranges from 0÷1000 V for AC and 0÷1500 V for DC. The WEEE Directive has ten categories of electrical and electronic equipment and they are categorized as follows:
Large household appliances (e.g. refrigerators
Small household appliances (e.g. coffee machines);
IT and telecommunications equipment (e.g. computers); Consumer
equipment (e.g. radio and TV sets);
Lighting equipment (e.g. fluorescent lamp);
Electrical and electronic tools with the exception of large scale stationary industrial tools (e.g. drills and saws);
Toys, leisure and sports equipment (e.g. video games);
Medical devices with the exception of all implanted and infected products (e.g. X-ray equipment);
Monitoring and control instruments (e.g. smoke detectors); Automatic disperses.

The composition of the WEEE depends strongly on the type and the age of the equipment. For example WEEE from IT and telecommunication systems contain a higher amount of precious metals than scrap from household appliances. In older devices the content of valuable metals is higher but also the content of hazardous substances than in newer devices.

4. Management of E-Wastes

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.

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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.

5. Processes for the Recycling of WEEE

Generally, the following methods for the treatment of electrical and electronic scrap are applied: mechanical separation; thermal treatment; hydrometallurgical treatment; electrochemical treatment.

6. Typical Recycling Process of WEEE

6.1 Mechanical Separation

The different components and devices can be separated in a first mechanical step into various fractions such as metals (iron, copper, aluminum etc.), plastics, ceramics, paper, wood and devices such as capacitors, batteries, picture tubes, LCDs, printed circuit boards etc. These fractions can then be further treated. Plastics are disposed off because of the high halogen content and the metallic fractions are further treated in different metallurgical processes. Printed circuit boards can cause problems because the metallic and non-metallic phases are highly cross linked.

After hand sorting and the removal of the contaminants (mercury switches, PCP containing capacitors etc.) the material undergoes a first size reduction step. Material separation may be based on magnetic, electrostatic, density, visual, or other characteristics. A series of magnets may be used to remove ferrous metals from conveyors. The use of permanent magnets instead of traditional electromagnets can significantly reduce energy consumption. Reprocessing, multiple passes through the shredder and magnets, may increase the ferrous metals recovered. Following the removal of ferrous metals, pieces may be slowly conveyed past pickers to remove large pieces of designated materials such as glass or plastics. Grinders and screens to separate pieces by size often precede nonferrous metal separation processes based on eddy currents, electrostatics, air, float-sink, or centrifugal force. Size reduction may also include subsequent shredding, grinding, or hammer milling processes connected by conveyors. The range of devices in usage depends strongly on the composition of the scrap. The obtained fractions are enriched in certain materials and have to be further processed using other treatment methods such as pyrometallurgy or hydrometallurgy.

6.2 Thermal Treatment

Pyrometallurgical processes include incineration, smelting in a plasma arc furnace or blast furnace, drossing, sintering, melting and reactions in a gas phase at high temperatures. Incineration is a common way of getting rid of plastic material and other organics to further concentrate the metals. The crushed scrap can be burned in a furnace or in a molten bath to remove plastics, leaving a molten metallic residue. The plastic burns and the refractory oxides form a slag phase. In smelting reactions a collector metal such as copper or lead can be used. But also impure alloys can be made by smelting the crude metal concentrates. Silver and gold containing scrap materials can be treated in a copper smelter, but silver as well as other noble metals are tied up in a process for a long period. The majority of secondary copper and a main part of the electronic scrap is processed pyrometallurgically in a copper smelter, which include steps as reduction and smelting of the material, blister or raw copper production in the converter, fire fining, electrolytic refining and processing of the anode mud.

In a modern secondary copper smelter, many different kinds of copper containing materials are recycled. Figure illustrates a typical recycling process of waste electrical and electronic equipment containing copper. Besides copper, WEEE materials contain nickel, lead, tin, zinc, iron, arsenic, antimony and precious metals amongst many others. The materials (e.g. electronic scrap) are fed into the process in different steps depending on their purity and physical state. The anode composition and the quality of the dust and slag fluctuate significantly due to the heterogeneity of the input materials. This is also the case with the anode slime which results from electro refining. Another possibility to recover base and noble metals form electronic scrap is the recovery via lead smelting process.
Paralysis is a process where the material is heated up in an inert gas atmosphere. At certain temperatures the organic fractions (plastic, rubber, paper, wood etc.) decompose and form volatile substances which can be used in the chemical industry or for the generation of energy by combustion of the gases or oils. At the present there exists no process which uses this method in industrial scale.

6.4 Hydrometallurgical Treatment

In hydrometallurgical treatment the main steps are acid or caustic leaching of solid material. This process normally requires a small grain size to increase the metal yield. From the solutions the metals of interest are then isolated and concentrated via processes as solvent extraction, precipitation, cementation, ion exchange, filtration and distillation. Leaching solvents are mainly H2SO4 and H2O2, HNO3, NaOH, HCl etc.

6.5 Electrochemical Treatment

Most of the electrochemical treatment methods are usually refining steps and they are carried out in aqueous electrolytes, sometimes in molten salts. Only a few processes can be found
in literature which uses shredder scrap directly in electrolysis. Examples are the iodide electrolysis where an aqueous KI/KOH solution is used to recover gold, silver and palladium from plated or coated metal scrap. Another process is the Fe-Process where copper based scrap is leached in a solution of sulfuric acid in the presence of trivalent iron. The leach solution is the electrolytic ally regenerated.

7. Responsibility and Role of Industries

Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options.

All personnel involved in handling e-waste in industries including those at the policy, management, control and operational levels, should be properly qualified and trained. Companies can adopt their own policies while handling e-wastes. Some are given below:

- Use label materials to assist in recycling (particularly plastics). Standardize components for easy disassembly.
- Re-evaluate 'cheap products' use, make product cycle 'cheap' and so that it has no inherent value that would encourage a recycling infrastructure.
- Create computer components and peripherals of biodegradable materials. Utilize technology sharing particularly for manufacturing and de manufacturing.
- Encourage / promote / require green procurement for corporate buyers. Look at green packaging

options.

- Companies can and should adopt waste minimization techniques, which will make a significant reduction in the quantity of e-waste generated and thereby lessening the impact on the environment. It is a "reverse production" system that designs infrastructure to recover and reuse every material contained within e-wastes metals such as lead, copper, aluminum and gold, and various plastics, glass and wire. Such a "closed loop" manufacturing and recovery system offers a win-win situation for everyone, less of the Earth will be mined for raw materials, and groundwater will be protected, researchers explain.
- Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products. Manufacturers of computer monitors, television sets and other electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products. At minimum, all computer monitors, television sets and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management.

8. Conclusion

Due to the Directive on the Waste from Electrical and Electronic Equipment (WEEE) and the Directive on the Restriction of Hazardous Substances (RoHS), the importance of WEEE recycling has become more evident. Nowadays, the pyrometallurgical treatment in copper smelters is the common process for the recycling of electronic scrap. But the treatment of electronic scrap especially material with high contaminations or amount of plastic needs always a combination of different steps, i.e. mechanical, thermal and hydrometallurgical, whereas the environmental regulations have to be considered. But the costs of sampling and analysis of base and precious metal scrap are quite high and they are often higher than the economics of processing. Furthermore the quantity and composition of the scrap changes continuously and therefore also the market value. Environmental restrictions on processing and disposal of the scrap are to be considered, for example the removal of mercury switches and capacitors. Large metallurgical plants, e.g. copper or lead smelters, may be able to charge high amount of WEEE but due to the decreasing quality and higher amount of plastic it will be more difficult in the future.

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