EXTRACTION OF PRECIOUS METALS FROM E-WASTE

A. V. Kavitha*
Lecturer in Computer Science, Govt. College for Women, Guntur.
***Corresponding author: Email: drmuttareddys@gmail.com**

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. Also e-waste contains precious metals like Gold, Silver, Copper, Selenium, mercury etc. Many of these products can be reused, refurbished, or recycled. Recovering precious metals from e-waste can also provide additional income with in the disposal process of end "of life electronics". In this paper few methods of extracting precious metals have been studied.

Key words: stereos, e-waste, mercury

INTRODUCTION

In this era of technology, usage of electronic gadgets has been tremendously increased. Alost every one of us are having cell phones and half of the population have television sets and computers. Many of us are looking for a better cell phone, latest laptop, a new iPad or an iPod. This demand for new technology gadgets is increasing day by day may be because of the shorter span of life of the gadgets. This has resulted in the generation of large quantities of e-waste.

E-waste, which is growing on par with municipal waste is throwing a great challenge for environment and human health. End of use electronic products like Computers, televisions, cell phones, refrigerators, batteries, comes under e-waste. Any electronic product when intact and in use do not create a problem. But, if e-waste is disposed along with other house hold waste, becomes a threat to the environment. E-waste contains many toxic elements like lead, mercury, cadmium, tin, bromide dioxins that leach into the leach into the earth. When dumped in a land fill or thrown into water body, they can cause unimaginable harm to the soil and water resources, thus causing severe ailments like Cancer, Kidney problems, Liver Damage etc., for the mankind.

However along with these hazardous materials e-waste also contains precious metals like Gold (Ace), Silver(Ag), Platinum (Pt), Palladium(pd), Selenium (Se)etc. In this paper, few methods for extraction of precious metals have been studied.

Facts and Figures:

Generation of e-waste:

According to EPA tons and tons of e-waste is being generated every year.

Hazardous Components in e-waste:

Major Hazardous components and materials present in e-waste are shown in the following table.

S.No	Materials and Components	Description
1	Batteries	Heavy metals such as lead, mercury and cadmium are present in batteries
2	Cathode ray tubes (CTRs)	Lead in the cone glass and fluorescent coating cover the inside of panel glass
3	Mercury containing components such as switches	Mercury is used in thermostats, sensors, relays and switches (e.g., on PCBs and in measuring equipment and discharge lamps). It is also used in medical equipment, data transmission, telecommunication, and mobile phones
4	Asbestos waste	Asbestos waste has to be treated selectively
5	Toner cartridges, liquid and pasty, as well as color toner	Toner and toner cartridges have to be removed from any separately collected WEEE
6	PCBs	In PCBs, cadmium occurs in certain components, such as SMD chip resistors, infrared detectors and semiconductors
7	Polychlorinated biphenyl (PCB) containing capacitors	PCB-containing capacitors have to be removed for safe destruction
8	Liquid crystal displays (LCDs)	LCDs of a surface greater than 100 cm2 have to be removed from WEEE
9	Plastics containing halogenated flame retardants	During incineration/combustion of the plastics, halogenated flame retardants can produce toxic components
10	Equipment containing chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs)	CFCs present in foam and refrigerating circuit must be properly extracted and destroyed. HCFCs or CFCs present in foam and refrigerating circuit must be properly extracted and destroyed or recycled
11	Gas discharge lamps	Mercury has to be removed

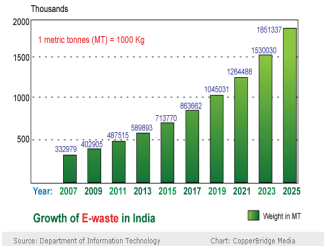
Precious Metals in e-waste:

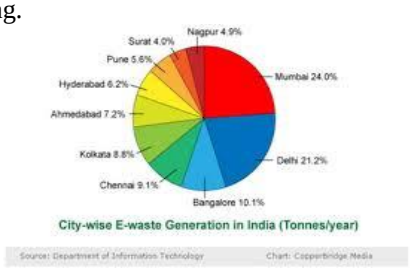
According to the EPA, "Experts estimate that recycling 1 million cell phones can recover about 24 kg (50 lb) of gold, 250 kg (550 lb) of silver, 9 kg (20 lb) of palladium, and more than 9,000 kg (20,000 lb) of copper."

Weight *vs.* value distribution precious metals,[2] 2006.

Weights%	Fe (wt %)	Al (wt %)	Cu (wt. %)	Plastics (wt %)	Ag (ppm)	Au (ppm)	Pd (ppm)
TV-board	28%	10%	10%	28%	280	20	10
PCBs	7%	5%	20%	23%	1000	250	110
Mobile phone	5%	1%	13%	56%	1380	350	210
Portable audio	23%	1%	21%	47%	150	10	4
DVD-player	62%	2%	5%	24%	115	15	4
Calculator	4%	5%	3%	61%	260	50	5
Value-share	**Fe**	**Al**	**Cu**	**Sum PMs**	**Ag**	**Au**	**Pd**
TV-board	4%	11%	42%	43%	8%	27%	8%
PCBs	0%	1%	14%	85%	5%	65%	15%
Mobile phone	0%	0%	7%	93%	5%	67%	21%
Portable audio	3%	1%	77%	19%	4%	13%	2%
DVD-player	13%	4%	36%	47%	5%	37%	5%
Calculator	0%	5%	11%	84%	7%	73%	4%

The following Chart shows that growth of e-waste is alarming.





Processes and procedures

E-waste processing:

e-waste after collection, is dismantled and individual components are teasted and isolated. Here, hazardous materials are separated and are disposed safely without creating any harm to environment. Then precious metals like gold, copper, silver, palladium etc., are extracted from e-waste and can be reused. Some materials like plastic could be recycled.

Procedures for extracting precious metals:

Hydrometallurgical process:

In hydrometallurgical processes, valuable metals contained in e-waste are first leached into acid or alkali solutions, and then concentrated by using various methods like precipitation, cementation and solvent extraction. The methods which could be used for extracting precious metals from e-waste are similar to traditional hydrometallurgical technology used for metals extraction from their primary ores. However, the complex nature of e-waste makes the process complicated compared to natural ores.

The following table shows recovery of precious metals from ewaste as done by few investigators**.**

Investigators	Leaching agent	Process conditions	Recovered metals
Quinet *et al*	H2SO4, chloride, thiourea and cyanide leaching	Leaching & metals recovery by cementation, precipitation, ion exchange and carbon adsorption	Au, Ag, Pd and Cu
Park and Fray	Aqua regia	Ratio of metals to leachant = 1:20 g/mL	Au, Ag and Pd
Sheng and Estell	HNO3 (1st stage), epoxy resin (2nd stage), and aqua regia (3rd stage)	Extraction was carried out in the three stages (self-agitation)	Au
Chielewski *et al*	HNO3 and aqua regia	Roasting of e-waste in the presence of carbon; leaching with HNO3 and aqua regia; and solvent extraction with diethyle malonate	Au

Pyro metallurgical process:

In the pyro metallurgical process, e-waste is melted with several flux components as slag formatives. The molten material containing valuable metals contacts with a molten metal pool into which the valuable metals dissolve and accumulate. The molten metal is called as collector metal. Commonly used collector metals include iron, copper, nickel, lead-copper and nickel matte. And then, the extracted valuable metals must be further treated in order to separate and purity them. Many metals like lead, copper etc., can be extracted through pyro metallurgical process.

Bio Leaching:- This method employs bacterial leaching of metals from e-waste. Microbiological leaching uses a natural ability of microorganisms to transform metals present in the waste in a solid form to a dissolved from Apart from the possibility of bioleaching of metals in alkaline environment (involving cyanegenic bacteria), acidophilus microorganisms and conducting biological process of leaching in an acidic environment play a crucial role in the biohydrometallurgical techniques. Among major groups of bacteria, the most commonly used are: acidophi- lus and chemolithotrophic microbial consortia of: *Acidithiobacillus ferrooxidans*, *Acidithiobacillus thiooxidans*, *Leptospirillum ferrooxidans* and heterotrophs, for example *Sulfolobus* sp. In addition, fungi such as *Penicillium* sp. and *Aspergillus niger* are examples of some eucaryotic microorganisms used in bioleaching during metal recovery from industrial wastes.

Examples of industrial waste treated with bacterial leaching [3].

Waste	Leached metal	Used microorganisms
Electronic scrap	Cu, Ni, Al, Zn	*Acidithiobacillus* ferrooxidans + *Acidithiobacillus* thiooxidans
Lithium batteries	Li, Co	*Acidithiobacillus ferrooxidans*

Discussion: All the methods hydro metallurgical process, pyro metallurgical process and bioleaching have been successfully used to recover precious metals from e-waste. However, recovery of plastics etc. is not possible with pyro metallurgical process. Also, hazardous emissions such as dioxins may be generated during smelling of materials containing halogenated flame retardants. Some elements like cyanide are dangerous lechants and therefore should be used with very high safely standards. When compared with chemical procsses, bioleaching is more eco-friendly as it will not release any dangerous gases or hazardous substances into the environment. But, bioleaching methods at present are not as effective as chemical methods.

Conclusion: As end-of-life electronic products are not only hazardous to health, but also can generate income. This could be a motivated factor for not disposing e-waste along with other house hold waste. Awareness should be created among general public not to throw away e-waste. Also, collection points of e-waste are to be established in every city, town or village. Though recycling units of e-waste are there in India, procedures of collecting and transport are to be improved. e-waste management and handling rules came into existence from 2012, and according to them every manufacturer is responsible for safer disposal and this should be implemented effectively.

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