REVIEW OF RESEARCH
IMPACT FACTOR : 5.7631(UIF) ISSN: 2249-894X

VOLUME - 1 | ISSUE - 3 | MARCH - 2019

STRATEGIES FOR EFFECTIVE E-WASTE MANAGEMENT- AN OVERVIEW

P.S. Wakte[1] and N.S. Gaikwad[2]
[1]Department of Microbiology, D.S.M. College, Parbhani, MS, India.
[2]Department of Microbiology, Toshniwal A.C.S. College,SengaonDist.Hingoli,MS, India.
nisugai121@gmail.com

ABSTRACT :

Electronic and electrical equipment rapidly updating their products, for obtaining high quality and efficient processing of equipment in short period, leads to generate large volume of E waste. The management of e waste is a challenge for technology and environment point of view, its rate of generation is higher than the rate of disposal,reuse and recycle. Urgent need to find out the safe and ecofriendly method for recovery of precious metals from E Waste due to its hazardous chemical constituent which effect on health of living organism and environment.Present review emphasis on various strategies such as landfill method ,incineration for disposal of E waste, pyrometallurical method, chemical and Biological use for recovery of precious metals from E Waste. Each method has its own limitation and advantages .Bioleaching of metals from ore has been used many years to recover iron and copper such phenomenon of bioleaching apply for recovery of precious metals from e waste. The research in bioleaching of heavy metals from electronic waste through microorganisms is limited. The review provide insight for e waste management and opening huge area for researcher to developed efficient process for recovery of precious metals from electronic waste without disturbance of environment.

Key words: *Bioleaching, electronic waste, metal extraction,pyrometallurgical.*

INTRODUCTION

Waste electrical and electronic equipment (WEEE) act as a secondary resource for recovery of precious metals, because it contain metals and harmful substances which cause environmental hazardous.(Oguchi, Sakanakura, & Terazono, 2013)Waste Electronic and electrical equipment (E waste)generation is tremendously amount in the world with rate of generation of other waste. E-waste contains both precious and harmful metals which require special handling and recycling methods to reduce environmental contamination and toxic effects on living organisms. (Abdelbasir & Dina, 2018) Europeans produce approximately 20 kilograms of e-waste/person/year.(Patel & Kasture, 2014) The electrical and electronic equipment consist of television, computers, laptops, cell phones, chargers, adaptors, etc. Most important component ofE waste is printed circuit board (PCB). The PCBs consist of precious metals, such as Cu, Zn, Pb, Ni, Cd, Au, Ag, and Sn. The concentration of metals in PCBs depends upon type of E waste product. (Joshi et al., 2017)(Mundada, Kumar, & Shekdar, 2018) .

Printed circuit boards (PCBs) are found in electrical and electronics appliances (televisions, computers,Mobile phones and laptops). PCBs are composed of 40% metals, 30% plastics and 30% ceramics(Cui & Forssberg, 2003) and other major constituents of PCBs that contain polyethylene, polypropylene, epoxies and polyesters. PCBs are converted conductive by coated with base metals (BMs) (tin, silver or copper).PCBs divided in toFR-4 and FR-2, which are used in mobile phones and personal computers. FR-4 types PCBs are made of a multilayer of fiberglass coated with copper used for small electronic equipment and FR-2 types are made of a single layer of fiber glass or cellulose paper or phenolic material that is also coated with a copper layer. FR-2 is used for larger electronic and electrical equipments.(Khaliq, Rhamdhani, Brooks, & Masood, 2014).The extended producer responsibility (EPR) policy design for electrical and electronic equipment is simple for basic idea behind EPR is methods that products and place them on the market should have a responsibility for the end-of-life treatment of those products. Many countries adapt the EPR systems for a broad range of products most notably packaging, vehicles, and electrical and electronic equipment (e-products), but also household hazardous wastes, medications, and various batteries and accumulators.(Akenji, Hotta, Bengtsson, & Hayashi, 2011).

E-WASTE MANAGEMENT:

Most of developing countries have design proper collection, treatment, disposal systems, laws for disposal and recycling of E waste. The waste management carried for recycling, reuse and recovery of precious metals and nullify the harmful effect on human health and environment. (Jeanmonod, Rebecca, & Suzuki, 2018). The following methods utilized for E waste managements.

1. Landfilling Disposal

General method for disposal of waste electrical and electronic waste through landfilling. E waste bury it. Mining voids or burrow in depth can be used in landfilling, but it create environmental problem by naturally leaching of heavy metals like mercury,nickel and cadmenium consequently landfills may pollute groundwater and its diffusing in to soil, river and streams causes health problem .(Abdelbasir & Dina, 2018) .

2. Incineration

Incineration in a high temperature combustion chamber or burning of waste electrical and electronic equipment (WEEE) into open environment result into release of toxic fumes. WEEE contains BFRs and incineration of WEEE leads to the formation of polybrominateddibenzo-p-dioxins andbenzofurans, these can be every harmful to human health. The processing of WEEE plastic using hot shredder/granulation equipment can also produce dioxins and more dioxins and furans will be form as with decrease in the particle size of WEEE plastic. One of the safest treatment options may be the use of state of the art incinerators with the facility of flue gas cleaning and energy recovery.(Chauhan, Ram, Pant, & Nigam, 2018)

3. Pyrometallurgical Method

The method including incineration, smelting in a plasma arc furnace or blast furnace, drossing, sintering, melting and reactions in a gas phase at high temperatures has becomea traditional method to recover non-ferrous metals as well as precious metals from electronic waste in the past two decades. In the process, the crushed scraps are burned in a furnace or in a molten bath to remove plastics, and the refractory oxides form a slag phase together with some metal oxides.(Chauhan et al., 2018; Cui & Zhang, 2008)

Table 1. Pyrometallumetallurgical methods used for removal of metal from E waste (Cui & Zhang, 2008)

Sr. No.	Methods	Metals recovered
1	Noranda process at Quebec,Canada	Cu,Au,Ag,Pt,Pd,Se,Te,Ni.
2	Boliden RonnskarSmelter,Sweden	Cu,Ag,Au,Pd,Ni,Se,Zn,Pb.
3	Test at Ronnskar smelter	Copper and precious metal
4	Umicores precious metal refining process at Hoboken,Belgium	Base metals, Precious, Platinium groups metals and selenium, Tellurium, Indium
5	Full scale trial at Umicores smelter	Metals in electronic scrap
6	Dunns patent for gold refining	Gold
7	Days patent for refractory ceramic precious scraps	Platinium and palladium
8	Aleksandrovichs Patent for recovery PGM and gold from electronic scraps	PGM And gold

Some limitation of pyromettalurgical process such as recovery of plastic is not possible,iron and aluminium recovery create problem in slag phase as oxide,during extraction process emission of harmful dioxins, halogenated flame retardants. Hence needs to special installation are required for minimize environmental pollution also required large investment for installing recovery plant(Khaliq et al., 2014)

4. Chemical leaching

Chemical leaching techniques for precious metals recovery using acid or alkali ,some ligands, inorganic acids, hydrometallurgical etchings and chemicals such as cyanide leaching ,halide leaching, thiourea leaching and thiosulfate (Abdelbasir & Dina, 2018).

Table no.2 shows the various chemical leaching methods used for recovery of metals from E waste (Pant, Joshi, Upreti, & Kotnala, 2012)

Sr.No.	Types of Chemical leaching	Metals recovered
1	Cyanide leaching	Au, Ag, Pd, Pt.
	Thiourea leaching	Au and Ag
	Halide leaching	Au
	Thiosulphat leaching	Au
2	**Chemical leaching involving Ligands**	
	EDTA	Pd, Cr, Cu, Zn
	DTPA	Cr, Cu, Zn, Pb
	NTA	Cr, Cu, Zn
	Oxalate	Zn
3	**Acid Leaching**	
	Sulphuric acid	Cu, Zn, Ni, Pd, Cd, Cr.
	Hydrochlodic acid	Au, Cu, Ag, Pd.
	Aquq-regia	Au
4	**Hydrometallurgical etchning**	
	$FeCl_3$, $CuCl_2$, HCL	Precious metal
	Organic Solvent.	Fe, Cu, Al, Ni, Au, Ag.

5. Biometallurgical process

Bioleaching and biosorption these two techniques are used for removing precious metals from E-waste. Bioleaching is an ability of microbes to transformed solid metallic waste to its soluble and extractable forms. Biosorption means adsorption of metals by means of adsorbents prepared from waste biomass or abundant biomass. (Debnath, Chowdhury, & Ghosh, 2018).Metal recovery by three types of microbes Autotrophic bacteria (e.g. *Thiobacilli sp*.), heterotrophic bacteria (e.g. *Pseudomonas* sp., Bacillus sp.) and heterotrophic fungi (e.g. *Aspergillus sp*., Penicillium spp.)Mainly acidophilic group of bacteria plays an important role in bioleaching of heavy metals from the wastes, for instance, *Acidithiobacillusferrooxidans, Acidithiobacillusthiooxidans, Leptospirillumferrooxidans*, and *Sulfolobus* sp. are the three major groups of microbes involved in bioleaching of metals. Chemolithotrophs of iron- and sulfur-oxidizing nature (which grow autotrophically by fixing CO2 from the atmosphere) are the most important mineral-decomposing microbes. (Chauhan et al., 2018; Pant et al., 2012). Mechanism of metal-removing by a direct and indirect method. The common mechanism of bioleaching is acidolysis,complexolysis,redoxolysis, and bioaccumulation. In direct leaching mechanism, bacterial cell physically contacts with mineral sulfide surface and the oxidation to sulfate tales place via several enzymes. In direct bioleaching involves ferric –ferrous cycle. Generation of ferric ions act as a strong oxidizing agent which oxidizes the minerals. Metal solubilized by Thiosulphate mechanism and polysulfide mechanism. (Pant et al., 2012)

a. Microbial leaching of Electronic Scrap

Joshi et al reported their investigation on the recovery of Cu, Zn, and Pb from cell phone chargers. Three PCBs were used separately for chemical analysis of PCBs with prior acid digestion in aqua regia. It was found that 10.8, 68.0, and 710.9 mg/l of Zn, Pb, and Cu were present in it, respectively. Six PCBs were used for bioleaching experiment with two variations, pulverized and non-pulverized. Though the pulverized sample has shown better leaching than non-pulverized one, former has some disadvantages if overall recycling of e-waste (metallic and nonmetallic fraction) is to be addressed. At the end of leaching experiments, copper was recovered using a simple setup of electrodeposition and 92.85% recovery was attained. (Joshi et al., 2017).

Adhapure et al.investigated that the for bioleaching of metals using large pieces of PCB solve the 'precipitate contamination problem' to get efficient recovery of overall metals .(Adhapure et al., 2014). Arshadi, M., et al. investigated that the simultaneous gold and copper recovery from discarded mobile phone PCBs using *Bacillus megaterium*.(Arshadi, Mousavi, & Rasoulnia, 2016). Bioleaching process has many advantages, eco-friendly, cost-effective, but required more time for recovering of metals present in E-Waste, therefore need to developed a fast and economical process that can be used in large scale for recovery of metals from E-waste scraps.

CONCLUSION

E-waste act as a secondary source for the recovery of precious metals.It is important to process E-waste in proper procedure.Recovery of metals from electronic waste is an essential step to managed E-waste because it contains harmful constituents and precious metals which shows the harmful effect on living organisms. Pyrometallurgical, Chemical and biological methods are used for recovery of metals from E-waste while landfill and incineration are used for disposal of E-waste, but each method has its own limitation and advantages, therefore need to find out the economic, cost-effective and environmentally friendly methods for recovering of E-waste. Due to the complex nature of E-waste, single methods cannot solve all problem regarding recycling or recovery of metals from E-waste. E-waste management and opening huge area for the researcher to a developed efficient process for recovery of precious metals from electronic waste without disturbance of the environment.

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