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E-Waste: Recovery of Precious Materials and Minimization of Environmental Impact by Separating Toxic Metals

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Introduction

A relatively recent recognized hazardous waste product comes from discarded electrical and electronic equipment and is categorized as E-waste. E-Waste is chemically and physically distinct from other forms of household wastes. It contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and detrimental effects on human health. The chemical composition of E-waste varies with the development of new technologies. E-waste contains valuable metals (Ag, Au, Cu, Pt, In, Ga, etc.) as well as potential environmental contaminants, especially Pb, Sb, Hg, Cd, Ni, As, polybrominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs). In addition to the discarded electrical and electronic equipment, the other E-waste materials will come from the Photovoltaic Cell (PV) used for the conversion of sunlight into electricity. As of now global installed PV capacity is around 300GW and is expected to further rise to 4,500GW by 2050. At the end of their life these PV will be treated as E-waste.

In the last decade many countries have formulated legislations on E-waste management. It is no longer permissible to dispose E-waste underground or burn it in incinerators without isolating the hazardous materials. Disposing underground, burning in air and acid leaching will deteriorate the environment by spoiling drinking water and releasing toxic gases into the atmosphere. Therefore, recycling of E-waste is crucial from the perspective of minimizing environmental pollution and resource management. As early in 90's some of the developed countries were exporting E-waste to underdeveloped countries years together. This practice after international regulation came in force is no longer allowed.

In order to tackle the issue various scientific groups around the globe are developing new technologies for separation of precious and hazardous materials from the E-waste and conversion of non-metallic parts into useful materials which can be used for road building or otherwise as binder for concrete to be used in construction of buildings. Major practices followed in E-waste management are critically reviewed in this article.

After selection of type of E-waste, first critical step is to convert the waste into powder form using crushers. This step will provide appropriate conditions for further processing which involve the use of chemical reagents and solvents. There are different possible approaches to separate metals from non-metals in E-waste which mainly involve incineration, acid washing or physical separation. Incineration can be used to burn off the non-metallic parts of E-waste and retain the metals from the ashes. However, incineration causes release of hazardous gases such as dioxins and furans which can cause severe harm to the environment. Acid washing/bathing can also be used to react with the non-metallic parts of PCB and recover the metals either from the rich solvent or as precipitates. However, the process of acid washing is very difficult to control especially when including metallic parts of E-waste as it causes release of hazardous vapors and fumes. Electrostatic separation techniques can also be used to separate the metallic and non-metallic parts of E-waste. This technique is safe and has eco-friendly operation. This separation paves the way for more profit from sales of waste plastics/ceramics or for more future conversion of this material into a road/building construction material.

There is a lot of work already in practice for the removal of precious and hazardous materials from the E-waste [1,2]. Metallic parts isolated from waste will be further subjected to the separation of metals having commercial values from metals with potential risk to the environment. Hydrometallurgy is traditional technology for the recovery of precious metals from E-waste. The main steps in hydrometallurgy consist of a series of acid or caustic leaches (cyanide leaching, halide leaching, thiourea leaching, and thiosulfate leaching, etc.) of solid materials. Metallic powder is fed to the leaching tank to extract the metals while subjecting to various leachants [3,4]. The solutions are then subjected to separation and purification procedures such as precipitation of impurities, solvent extraction, adsorption and ion-exchange to isolate and concentrate the metals of interest. Consequently, the solutions are treated by electro refining process, chemical reduction, or crystallization for metal recovery.

The recycling of E-waste is important for resource and waste management. The presence of precious metals in E-waste makes recycling an attractive and viable option both in terms of environment and economics. Effective implementation of E-waste regulation will save the environment so that future generation will live in less polluted environment.

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