Extraction of Metals From E-Waste: A Review

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Abstract- *E-waste provides with so many valuable metals and rare earth metals. All of these is being wasted by ignorance to the waste produced by consumption. However, recently e-waste is being focused at and viewed as a valuable asset and source for metals and there are various methods which are already implemented for recovery of precious metals. Hydrometallurgical routes, bioleaching, chemicals, enzymes, bacterias used as solvents, catalysts and reactors for obtaining metals, adsorption methods, different chemical polymers used as reactors, bacterial leaching, photocatalysis, electrowinning and electrorefining processes, pyro metallurgical routes are some of the various ways for recovering gold, silver, cadmium, gallium, indium, tin, lead, copper, nickel, platinum, zinc, etc. metals from the electronics which have finished their lifetimes and can't be further reused. These processes are very thoroughly researched and have proven to be practically possible, cost efficient, and also environment friendly.*

Keywords- metal recovery, e-waste.

I. INTRODUCTION

As the technology has advanced, the use of electronic gadgets has increased a lot. Almost every one of us uses a cell phone and has television sets and computers. Many of us look for better cell phone, latest laptop, a new iPad or iPod, etc. The demand for gadgets with new technology is only ever increasing. This is generating a huge amount of e-waste.Electronical devices have become an essential part of our human experience and their productions generates significant electronic waste (e-waste) to meet the growing demand. This e-waste is hazardous, however at the same time provides earth metals. There are various methods for obtaining these metals and hence ultimately reusing the resources ingeniously. [1] [2]

The best way to obtain precious metals from e-waste is to choose selectively from chemical solutions without the need for combustion. It has been reported that adsorbents carrying nitrogen or sulfur provide the required high-volume cohesion. [2]

Adsorbents based on biomaterials, such as polysaccharide gels associated with chemically modified gels, have been studied to obtain precious metals, with high adsorption capabilities of 7.57 and 7.7 mmol/g, respectively. However, most adsorbents are usually tested in pure metal solutions or where there is a limited number of competing metals. However, protocols have little potential to reduce economic or selective savings and are rarely reported for their use in litter or actual waste. [2]

WEEE is now considered one of the world's fastest-growing waste streams. According to figures from the United Nations Environment Program (UNEP), about 50 million tons of electrical waste are produced worldwide each year, of which only 10% are recycled. Waste treatment is the most justified not only because of the impact it can have on the environment in the event of uncontrolled handling, but is also linked to the benefits resulting from the possibility of recovery of valuable components. Thus, without a doubt, the quantitative composition of electronic waste makes this type of waste attractive in terms of the possibility of metal recovery. Printed circuit boards (PCBs), which are part of electronic devices where copper is the most prominent, are the richest of these ingredients. Research into the feasibility of using biological methods to extract metal waste is also being done on biodegradable electricity and electricity (WEEE).[3]

II. MATERIAL AND METHODS

Demand for precious metals, such as metals and rare earths, is constantly increasing in the global market, as many different technological systems use these materials because of their unique properties. Since natural resources are only available in concentrated areas, the most potential interest would be the renewal of metals from Waste Electrical and Electronic Equipment (WEEE). The following are the various processes for extracting different metals.

2.1 Acquisition of gold from the shredder part of the E-waste recycling plant : During e-waste recycling by floating leaching, SLF (Shredder light fraction) is formed. SLF has 0.03% gold in it. The float result showed that 99% of the gold was found there. Gold floated in two processes: (1) the flexibility of Au-containing plastic particles, and (2) the combination of fine Au particles with plastic particles due to paraffin. The plastics in these methods mainly contain sulfonated polystyrene and acrylonitrile butadiene styrene.

Next, these large, heavy particles are unaffected by the blisters and simply sink. Leaching results using ammonium thiosulfate solutions showed that Au extraction increased from 33 to 51% after flotation.[4]

2.2 Thiourea bioleaching recycling gold from e-waste : Leaching of impure gold is done by using thiourea. Thiourea leaching of gold (Au) from e-garbage can be considered as an alternative to the use of highly toxic cyanidation, as long as its use of reagents can be significantly reduced. This TU-bioleaching novel process provides another new way to recycle Au from e-waste and reduce natural hazards.[5]

2.3 E-waste upcycling of gold nanoparticles :E-waste can be a major source of gold nanoparticles, gold nanoparticles can be found in E-waste through other physical and chemical processes. For example, In the first step, the anchors from the microprocessors were separated by synthetic wood, allowing for a gold-plated focus on the metal part. A two-step hydrometallurgical procedure was performed, to obtain a rich Au (III) solution. Such a solution has been used as a second raw material to obtain gold nanoparticles. This case study of the upcycling case shows that e-waste can also use basic materials to obtain the most valuable and useful nanomaterials. These results highlight the potential of urban mining as a continuous and circular path to the development of nanotechnologies.[6]

2.4 Silver extraction from electronics in base-activated persulfate - ammonia system: Silver metal from e-scrap components can leak into the saline system of persulfate and ammonia in a highly alkaline alkaline solution. a solid foundation uses persulfate ion which provides highly efficient oxygen molecules.Oxidized metal then becomes a complex that melts well with ammonia ligands.The kinetic studies of this leaching process are made of pure silver. Potassium persulfate provides significantly (more than 50% silver plates and more than 100% silver powder as provided in the report) increased efficiency of silver dissolution compared to sodium solution or ammonium persulfates. This method is cheaper, less toxic and most importantly does not produce harmful products.[7]

2.5 Replacement of copper, lead and metal from electronic waste with citrate solutions : The report introduces a closed hydrometallurgical process for base metal recovery from electronic waste.Leaching medium sodium citrate solution; In this solution metals are obtained by direct electrification, and the remaining solution is reconstituted for leakage. This leaching-electrowinning cycle is four times higher.The redox properties of the new solution of citrate and leach-containing beverages, were characterized by cyclic voltammetry for the determination of adequate iron reduction conditions.The leaching efficiency of electronic waste, using the same solution after four complete cycles was 71, 83 and 94% copper, iron and lead, respectively, compared to the first leach that had a new citrate solution.[8]

2.6 Extraction of lead from waste CRT funnel glass : Cathode ray tubes (CRTs) have rare earth elements (REEs) at an attractive value.An effective process for detoxification and regeneration of CRT fans' glass was enhanced by the production of lead sulfide precipitate by a melting process containing high temperatures.The main function of the process was to produce lead sulfide, which was then concentrated and separated from the slag. Sodium carbonate and sodium sulfide were used as a reaction agent and reducing agent. Test results showed that lead sulfide recovery rate increased with an increase in factors such as the amount of sodium carbonate and additional sodium sulfide, temperature, and holding time and reached equilibrium. The report states that the maximum lead lead of sulfide was found in about 93%, high sodium carbonate, sodium sulfide level, temperature, and holding time of 25%, 8%, 1200 ° C, and 2 h, respectively.[9]

2.7 Ball milling process for recovery of valuable metals from e-waste scraps : In the study it was found that 99.9% Cu and 95.5% Pd in e-waste particles could be obtained with 0.5 mol / L purified HCl in 15 minutes. Ag focused on leaching residues as AgCl and then obtained 1 mol / L NH_3 solution.During the process of grinding the ball at low temperatures the metals in the raw materials were converted into their oxidation properties and showed XRD and XPD analysis, which means that a solid phase reaction is a reaction mechanism.The e-waste proposal through the ball grinding process was passed based on test results and possible responses were initiated. The metal recovery process has the advantages of a high recovery rate and a leak speed.[10]

2.8 Recovery of valuable metals from electronic scraps by clays and organo-clays: Lanthanum has been chosen as the world's rarest representative while copper is considered to be the most valuable because of its metals. The magic used is montmorilloniticclay and polyamine based organo-clays.It was interesting that cationic exchanges are a method used in the form of pure clay, while both the merging results due to amino groups and cationic exchanges occur in the form of altered clay, respectively responsible for the extraction of copper and lanthanum. In addition, the pH was found to have a significant influence on both the advertising and cleaning conditions.[11]

2.9 Recovery of tin from metal powders of waste printed circuit boards : An effective process is suggested for the special selection of tin and associated metals, to avoid the adverse effects of tin on melting processes. The effects of alkaline pressure and the limits of oxidation leaching on iron conversion were investigated. The results showed that Sn, Pb, Al and small amounts of Zn were extracted from the powders, leaving a residue of copper. Leaching returns of 98.2%, 77.6%, 78.3% and 6.8% of Sn, Pb, Al and Zn, respectively, achieved.Subsequently, more than 99.9% of Pb and Zn in the leaching solution were removed as a combination of PbS-ZnS in the purification process, which could be used as raw material in the extraction of Pb. Approximately 86.2% of Sn was detected, and the purity of the cathode tin was above 99.8%.[12]

2.10 Acquisition of metal concentrations from printed circuit boards with flexible floatation: Reverse floats used to detect metal discharge from disposable PCBs. Results after analyzing the composition and composition of raw PCB minerals have shown that iron deficiency is reduced as a fraction of the size of PCBs decreases. The major components found in PCBs were Cu, Pb, and Sn, as well as tracking materials were also found in fine PCB particles. Paraffin and terpenic oil were used as pickles and frothers on float floats. Studies show that the highest number of sinks with the highest marks for metal concentrations were 48.72% and 16.86%, 47.96% and 14.61%, 44.36% and 8.81%, with a total concentration of 94.69%, 90.06%, and 75.96% with particles 0.125-0.25 mm, 0.074-0.125 mm, and -0.074 mm PCBs, respectively.[13]

2.11 Recovery of valuable metals from spent lithium-ion batteries : Bioleaching method is done using natural ingredients made by *Aspergillus niger*to dissolve Ni, Mn, Co, Li, Cu and Al from lithium-ion batteries. The reaction method was used to investigate the effects and interactions between the active ingredients of sucrose concentration, initial pH, and inoculum size, to produce organic acid production. The highest refinement of 100% Cu, 100% Li, 77% Mn, and 75% Al occurred at 2% (w v - 1) powder size; Acquisition of 64% Co and 54% Ni occurred at 1% (w v - 1) meat size. This process can be used for major industrial purposes also.[14]

2.12 Recovery of Zn and Mn from used batteries :A similar study of acid and alkaline leaching was performed to obtain Mn and Zn from the alkaline batteries used. Using H2SO4 as a precise and accurate measurement and filter, all residues will be dissolved without carbon .The separation and restoration of these two components is effected by electro deposition which has positive effects on pH values above 4 (current performance above 70% Zn and Mn) performance decreases as pH decreases. Most Zn decomposed alkaline leaching using a 6.5 M NaOH solution, and its recovery was tested by both chemical and chemical processes .However, the formation of pure ZnO failed the formation of ZnO, its formation was highly dependent on the duration of electrodeposition . In a short time, Zn has been a big part of it. Long-term electrodeposit contains synthetic microparticles of ZnO with a small fraction of Zn metal (approximately 3% as measured by X-ray diffraction). Reaction of an oxygen content released from the surface of the anode may aid in its conversion to ZnO.[15]

2.13 Focus of precious metals from printed circuit boards using a high strength division : High power separation has been used to focus on precious metals (e.g., Ag, Au, and Pd) from Cu-Zn alloy PCBs and residual residues. Heat and gravity have been found to have a significant effect on the concentration of precious metals in the alloy and in the residues. At an altitude of 1300 ° C, a gravitational force of 1000, and the separation time of 5min, Ag, Au and Pd in Cu-Zn content increased by 1.65, 2.05, and 1.54 times, respectively, compared to their separation of PCB initially, while the remainder increased by 0.63, 1.02, and 2.62 times, respectively . With the right combination of hydrometallurgical process with high current separation and refining of precious metals, this clean and efficient process provides a new way to recycle precious metals and prevent or avoid the environmental pollution by PCBs. [16]

2.14 Bioleaching of printed circuit boards for various metalworks : Printed circuit boards (PCBs) and metal pickers (SPWL) have received a lot of attention in recent years because of their dangerous effects. A two-step process performed using SPWL as a leaching agent . A series of incorporated bacteria used for bioleaching and the type of virus have been identified as Acidithiobacillusferrooxidans (A. ferrooxidans) by analysis of 16S rDNA respectively. Too large Most of the metal in PCBs is found in two-step lead, such as Cu, Pb, Zn, Sn, Al, Ni. Currently, a large number of iron has been removed from SPWL, which greatly reduces the burden of subsequent treatment. Pulp density and pH are improved to achieve the highest rigidity of copper and iron extraction simultaneously in bioleaching. It turned out that the ideal conditions were pressures of 60g / L and pH of 0.5-1.0. About 100% of the copper was found and 51.94% of the metal was removed under proper conditions.[17]

2.15 Cobalt and lithium extraction from used lithium-ion batteries : Disposal of used lithium-ion batteries contains not only metals such as cobalt and lithium but also impurities such as copper, aluminum and iron. Distribution of metal impurities in the waste of LIBs, as well as their impact on the acid reduction of recycled materials. The results show that the availability of these substances, which do not reduce naturally, pollutants (e.g. Cu, Al, and Fe) can significantly promote the dissolution of raw materials. With the addition of large pieces of Cu and Al, the efficiency of the Co and Li domain increased by more than 99%, leaving leach residues rich in graphite. The use of cost-cutting methods such as hydrogen peroxide or ascorbic acid can be avoided. Most importantly, additional Co and Li associated with Cu and Al electrode materials can also be obtained. This novel approach not only improves the efficiency of LIBs by dumping waste, but also improves the full recovery of Co and Li from LIBs waste.[18]

2.16 Indium and tin replacement from waste LCD panels: An environmentally friendly process for the detection of indium (Ku) and tin (Sn) from LCD panel debris has been investigated. Easy-to-use citrate ($C_6H_5O_7^{3-}$), i.e., sodium citrate and citric acid, are used as complex substances. The morphology and morphology present in LCD powder before and after leaching procedures were obtained by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The concentration of In, Sn, and iron (Fe) present in leachate is determined by the atomic absorption spectrometry (AAS). Required thermodynamic conditions for maximum benefit Recovery is developed using MEDUSA software. Appropriate process conditions were determined by experimenting with various initial citrate filters and using sources of reduction or oxidizing agents, respectively hydrazine (N_2H_4) or hydrogen peroxide (H_2O_2).The use of N_2H_4 has been found to be a citrate solution as the reducing agent improves leaching efficiency. However, high levels of In-related Sy and Fe are found in LCD powder. Therefore, treatment procedures begin with the excessive removal of Sn and Fe, which competes with In for the citrate, is included. Infusion with 1M citrate, 0.2M N_2H_4, at pH = 5, using strong sodium hydroxide (NaOH): water ratio (S: L) 20g, L-1 yielded an amazingly large yield of 98.9% after 16.6h.[19]

2.17 The leaking process of lithium and cobalt from lithium-ion batteries used using the benzenesulfonic acid system: Precious metals from used lithium ion batteries (LIBs) are very important when it comes to conserving metal resources and minimizing potential environmental hazards. Therefore, it is necessary to improve the efficiency of the leaching process to obtain cobalt and lithium from the active cathode materials of the used LIBs. Benzenesulfonic acid ($C_6H_5SO_3H$) containingto reduce the agent hydrogen peroxide (H_2O_2) was used in a new way as leaching reagents, and performance variables were madeget high leaching performance. Results show leaked discovery of 99.58% Li and 96.53% Co obtained under it0.75M levels of benzenesulfonic acid, 3vol% H2O2, soluble liquid (S / L) 15g / L, moving speed 500rpm, andLeakage time is 80min at 90 ° C. The apparent apparent potential of Ea for leaching of lithium and cobalt is 41.06 and 35.21kJ / mol,respectively, indicating that the chemical reaction on the face is a measure that controls the ratio during this leaching process.[20]

2.18 Receipt of anode material from used lithium-ion batteries: Reuse of used anode (SAM) materials from Lithium-ion batteries (LIBs) is often very important in terms of recycling and increased resource shortages and environmental problems. The study reported a novel and raw method for reusing lithium, copper and graphite from SAM to treat water leakage. The results showed that 100% graphite was extracted from anode materials and the performance of Lithium leaching was obtained under ideal conditions of 80 ° C, 60 g / L, 300 rpm, and 60 min, respectively. These findings attest to the fact that SAM gained complete independence due to the removal of the binder, which produced a leaching suitable for efficient lithium performance as opposed to acid performance. The SAM extraction method and lithium leaching were introduced based on the results analysis. Graphite was cleaned and recovered after water leaks. In addition, lithium carbonate (Li_2CO_3) was found inside, and a copper filter was found on the sheet. This study aims to improve the economical and natural process of recycling graphite, copper and lithium from SAM. [21]

III. RESULT AND DISCUSSION

The removal of metals from e-waste is very interesting, because the processes are expensive; metals are easily available; and abundance of source (i.e. e-waste) proves the processes to be easy and practically possible. Methods generally used for mining can also be used for this purpose. The methods mentioned above have been verified for successful extraction of metals. Survey for metal recovery from e-waste shows great potential in devising a “modern mining” metallurgy. This area also shows scope for further study and analysis for recovery paths including the conventional ones generally used (or have been in use). 50 tons produced e-waste can be converted to a boon as a potential source for precious metals, rare earth metals, useful metals as well as many difficult to obtain and easily obtainable metals.

IV. ACKNOWLEDGEMENT

The authors are thankful to Department of Applied Sciences and Humanities , Pimpri Chinchwad College of Engineering for providing necessary ICT and Laboratory facilities to carry out the investigations.

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