International Journal of Chemical Studies

P-ISSN 2349–8528
E-ISSN 2321–4902
IJCS 2015; 3(3): 15-21

Received: 19-08-2015
Accepted: 21-09-2015

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Removal of heavy metal from E-Waste: A review

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Abstract
The rapid industrialization has raise the demand for heavy metals, but the reserves of high-grade ores are diminishing. E-waste term refers to electrical and electronic products which has multiple components some are toxic and hazardous that can cause serious health and environmental issues if not handled properly. Multiple components such as 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, refurnished, or recycled. E-waste contains precious materials such as gold, silver, copper, glass and plastics and also contains harmful materials like arsenic, mercury, cadmium and lead, which is affected to environment and human life. This review paper contain the e-waste challenging problems such as handling, transportation, recovery and some key factors which are responsible for E-waste in India, and methods for recovery of metals and other precious materials from E-waste.

Keywords: Electronic waste, recovery of metals from E-waste, E-waste management

Introduction

Advancement of technology and production of electronic and electrical devices, leads to the fastest growing industries in the world. The waste generated after the useful life of product is termed as E-waste which can be extracted by mining operation, metallurgical operation, electronic operation, electroplating and metal finishing operation. E-waste contains both valuable materials as well as hazardous materials which require special handling, dumping and recycling methods. E-waste is hazardous in nature due to presence of toxic substances like Pb, Cr_6, Hg, Cd and flame retardants (polybrominated biphenyls and polybrominated diphenylethers etc). One of the most important components in the e-waste are the PCBs (printed circuit boards) where the precious metals concentrations are ten times higher than in rich precious metals bearing ore. A typical PCB composition is: 30% plastics, 30% refractory oxides and 40% metals. The most abundant metal is copper with a concentration between 10% and 30%. The main components of electronic waste are approximately: 45 % ferrous metals, 10 % non-ferrous metals (mainly Cu and Al), 22% plastics and 9% glass.

E-waste in India

As there is no separate collection of e-waste in India, there is no clear data on the quantity generated and disposed of each year and the resulting extent of environmental risk. According to a report of Confederation of Indian Industries, the total waste generated by obsolete or broken down electronic and electrical equipment in India has been estimated to be 1,46,000 tons per year quantification of e-waste in India is very difficult and, there is no mechanism and policy to check the flow of e-waste in the system. In case of PCs, 22% of the e-waste is generated by households and it is the business sector which accounts for the 78% the e-waste, because 83% of household customers are first time buyers. So business sector is mainly responsible for the waste generation. In addition to this, about 1050 tonnes per year of computer waste comes from retailers and manufacturers. This is important to note that in spite of global agreements, e-waste from developed nations is imported to developing nations like India. Sixty-five cities in India generate more than 60% of the total E-waste generated in India. Ten states generate 70% of the total E-waste generated in India. Maharashtra followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of E-waste generating states in India. Among top ten cities generating E-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur. The Indian government plans to enact new rules that make a producer of electrical and electronic equipment responsible for the collection and appropriate disposal of e-waste generated at the end of life of its products. The management and handling of waste in India is currently governed by legislation such as the Environment (Protection) Act of 1986, and Hazardous Material (Management, Handling and Trans boundary Movement) Rules of 2008.

Processes for the Recycling of WEEE

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

Mechanical Separation

Mechanical processing is an integrated part of this stage where e-waste scrap is shredded into pieces using hammer mills. Metals and non-metals are separated during this stage using techniques similar to that used in the mineral dressing, e.g., screening, magnetic, eddy current and density separation techniques. The final stage in the recycling chain of e-waste is the end processing, where the non-metal and metal fractions of e-waste are further processed.

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. The process description for the term are as follows:-

Incineration is a process that involves the combustion of organic substances contained in waste materials. Incineration of waste materials converts the waste into ash, flue gas, and heat. The ash is mostly formed by the inorganic constituents of the waste, and may take the form of solid lumps or particulates carried by the flue gas. The flue gases must be cleaned of gaseous and particulate pollutants before they are dispersed into the atmosphere.

Smelting is a process which involves extractive metallurgy its main use is to produce a base metal from its ore. This includes production of silver, iron, copper and other base metals from their ores. Smelting makes use of heat and a chemical reducing agent to decompose the ore, driving off other elements as gases or slag and leaving just the metal base behind. The reducing agent is commonly a source of carbon such as coke, charcoal.

Sintering is the process of compacting and forming a solid mass of material by heat and pressure without melting it to the point of liquefaction. Sintering happens naturally in mineral deposits or as a manufacturing process used with metals, ceramics, plastics, and other materials.

Limitations of Pyrometallurgical Processes

Pyrometallurgical routes are generally more economical, eco-efficient and maximize the recovery of PMs, however, they have certain limitations that are summarized here;

- Recovery of plastics is not possible because plastics replace coke as a source of energy.
- Iron and aluminum recovery is not easy as they end up in the slag phase as oxides;
- Special installations are required to hazardous emissions such as dioxins to minimize environmental pollution;
- Instant burning of fine dust of organic materials can occur before reaching the metal bath.
- Ceramic components in feed material can increase the volume of slag generated in the blast furnaces, which thereby increases the risk of losing PMs from BMs;

Hydrometallurgical Treatment

Hydrometallurgical is a process which involves 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 are isolated and concentrated by the processes such as solvent extraction, precipitation, cementation, ion exchange, filtration and distillation. Leaching solvents are mainly H_2SO_4 and H_2O_2, HNO_3, NaOH, HCl etc.

Limitations of Hydrometallurgy Route

Hydrometallurgical routes have been successfully used to recover PMs from e-waste but it has some limitations to:-

- Hydrometallurgical routes are slow and time consuming and impact recycling economy but it has still concerns.
- Cyanide is a dangerous leachant and should therefore be used with high safety standard.
- Halide leaching is difficult to implement due to strong corrosive acids and oxidizing conditions.
- The use of thiourea leachants is limited in gold extraction due to its high cost and consumption.
- The consumption of thiosulfate is comparatively higher and the overall process is slower, which limits its application for gold extraction from ores as well as from e-waste.
- There are risks of PM loss during dissolution and subsequent steps, therefore the overall recovery of metals will be affected.

Electrochemical Treatment

Electrochemical treatment methods are 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 in the Fe-process where copper based scrap is leached in a solution of sulphuric acid in the presence of trivalent iron. The leach solution is the electrolytic ally regenerated.

Literature Review

Concern has been growing over the management practices for waste electrical and electronic equipment (WEEE) and the removal of heavy metals in the developing countries, where these potentially toxic materials are disposed of with municipal solid waste at open dumps and even into surface waters. According to the literature review a personal computer may contain up to 4g of gold and other valuable materials as well as toxic substances such as Pb, Cd, Hg, Cr etc. the following are the literature work done on the removal of heavy metals from E-waste:-

In the year 2005 [2] Kang and Schoenung studied the trends in the amount of e-waste, existing recycling programs, and collection methods and various methods available to recover materials from e-waste. For glass, glass-to-glass recycling and glass-to-lead recycling technologies are involved. For plastics, chemical (feedstock) recycling, mechanical recycling, and thermal recycling methods are analyzed. Recovery processes for copper, lead, and precious metals such as silver, gold, platinum, and palladium were seen. A major challenge for e-waste recycling is the need for a continuous and stable supply of materials to be recycled. Another barrier is the lack of cost-effective technologies for recycling. Also, existing methods are limited in their ability to handle complex products such as CRTs and PCs, which contain a large variety of materials. Finally, to mature the recycling industry it will be necessary to have stable demand for the recycled materials.

Liu *et al*. 2005 studied the cost effectiveness and process for recovery of precious metal by hydrometallurgical process in which electro active polymers are used for the spontaneous reduction. In hydrometallurgical process Nitric Acid Leaching of Ag, Cu, Pb & Ni Precipitation of Sn as Metastannin Acid were used for the process of filtration which separates the Leach Solid Residues Containing Metallic Au & Pd Metastannic Acid Precipitate and liquid Leach Streams Containing Ag, Cu, Pb & Ni Ions. Generation of nitric acid is observed and further filtration process solid and liquid leach streams which gives generation of hydrochloric acid. It has been noticed that the precious metal gold has been recovered and its recycling process technique.

Joseph, 2007 [4] studied the consequences that toxic materials enter the waste stream and resources are wasted when economically valuable materials are dumped or unhealthy conditions are developed during the informal recycling. Environment and human health both had adverse effect by these consequences. It is recommended that the Designer could include the product reducing toxicity, reducing energy use, streamlining product weight and materials, identifying opportunities for easier reuse, and more. Manufacturers have to improve the design by the substitution of hazardous substances such as lead, mercury, cadmium, hexavalent chromium and certain brominated flame retardants and measures to facilitate identification and re-use of components and materials, particularly plastics and promote the use of recycled plastics in new products.

In the year 2007 [5] David studied the process of recovery of metal from amorphous solid waste by leaching process which is the most determinant step of hydrometallurgical process used to extract metals from ores. The samples of amorphous material formed from spent industrial catalysts based on Cu, Ni / γ-Al_2O_3 were physically and chemically characterized by atomic absorption spectrometry (AAS) and chemical analysis was made determine the metals content. Then leaching studies were carried out under room temperature, atmospheric pressure and without gas injection in both sulphuric acid with hydrogen peroxide addition and ammoniacal media for to decide which of them would be the best treatment for this kind of waste materials. Also, the dissolution behaviour of Cu, Ni and Al metals was studied in order to assure the best metal recovery conditions in subsequent processes such as solvent extraction, precipitation or cementation techniques the result noted that addition of hydrogen peroxide to sulphuric acid up to 0.2 enhances leaching of metals. Extraction of metals are found 90% Cu, 85% Ni and 80% Al.

Shelton, 2008 [6] studied the measures that should be followed to improve understanding of electronic waste (e-waste) and the effect on health and the environment on a global scale. This work has included the involvement of examining data and policies of governmental, national, and global organizations in dealing with electronic waste and recycling efforts from 1980 to 2008. Methods of recycling were examined as well as the hazardous composition of electronic components and the result on the environment. This study had suggested the need to increase e-waste recycling. Delving further into how e-waste is processed could provide valuable information. Main focus should be on the fact how items are disassembled, processed, and individual components reclaimed. Attention should be on increasing the amount of e-waste recycled versus exporting or discarding in a landfill

Kamberovic *et al*. 2009 [7] studied the recovery of metal from PCB's by hydrometallurgical process leached with Nitric acid. It has been noted that pouring density, % of magnetic fraction, particle size distribution, metal content and leachability are determined by AAS, XRF and volumetric analysis. The pouring density of total sample and of each fraction was measured using Hall flow meter funnel. Pouring density of total sample was 889 kg/m^3. The sample was subjected to the magnetic separation process using two permanent magnets each weighing 100g. Percentage of magnetic material content was 5.39%. Content of metallic and non-metallic components of entire sample as well as for each fraction was determined by leaching with 50 vol. % HNO3 near to boiling temperature with agitation followed by filtration after cooling. AAS chemical analysis has shown that about 5mm contains high amount of Fe and can be avoided by magnetic separation.

In the year 2009 Chatterjee [8] and Kumar represented an outsourcing model where equal participation of the formal and non-formal sector is ensured to make the e-waste management business a profitable one. The main motivation for non-formal operators is to extract precious metals (gold, silver) from printed circuit board (PCB) using unscientific and unhygienic methods, which are harmful to the workers and the environment. Non-formal operators will concentrate on collection, disassembly, segregation of e-waste, whereas, formal sector will concentrate on processing the PCBs to extract precious metals. The 95-97% of the e-waste by weight contains metal, glass and plastics, which can easily be dissembled and segregated manually without damaging environment; whereas, the rest 3-5% by weight of e-waste actually consists of PCBs/connectors, need environmentally friendly recycling techniques to manage. It has been observed that present inventory suggest that total e-waste has projected as 3, 30, 000,000 Kg. The 95% of the total weight of ewaste (that is, 3, 13,500 000 Kg) can easily be managed by the non-formal units without polluting the environment. The projected volume of the e-waste generation and its associated concerns in the society will be drastically reduced. The rest 5% of the weight (that is, 16, 500,000 Kg) of e-waste actually consists of PCBs/ connectors, which needs environmentally friendly recycling techniques to manage.

Rani *et al*. 2009 [7] heavy metal resistant bacteria were isolated from an electroplating industrial effluent samples that uses copper, cadmium and lead for plating and isolates were characterized to evaluate their applicability for heavy metal removal from industrial wastes. PH, biomass concentration and heavy metal concentration is optimized on biosorption optimization process. The bacterial isolates were inoculated into a series of test tubes containing 5 ml of nutrient broth. The pH was varied from 5 to9 by adjusting the medium amended with 25 mg/L of Cu, Cd and Pb. The biomass concentration was varied from 1 to 5% in the medium containing 25 mg/L of Cu, Cd and Pb. The heavy metal concentration was varied from 20 mg/L to 100 mg/L. This reveals the fact that all the immobilized isolates have a greater potential application for the removal of Cu, Cd and Pb from industrial wastewater than the dead bacterial cells.

Nnorom *et al*. 2010 [10] studied the Evaluation of Heavy Metal Release from the Disposal of Waste Computer Monitors at an Open Dump. The process involves the breaking of cathode ray tubes at open dumps and assessed the total available metals in the cathode ray tube glass; the printed wiring board and plastic components as well as the ability of rainwater to leach and mobilize the metals through batch extraction using weak electrolytes (CaCl2, Ca(NO3)2, and H2O). High Pb concentrations, 1.3-12% of the total lead, were leached by the weak electrolytes and this is between 10-50 times the toxicity characteristic leaching procedure limit. The study provided the valuable information on the leachability mobilization of heavy metals especially Pb from broken computer monitors at waste disposal points. The observation suggest that deionized water extracted as much as 10% of the lead content of the CRT glass indicating the extent storm runoff could mobilize toxins from inappropriately disposed CRTs. The extractable Pb concentrations from the components exceeded the SPLP and TCLP limits.

In the year 2010 Mishra [11] and Rhee studied the recovery of metal from various sulfide minerals or low grade ores by Microbial leaching method. The microbial method is an efficient and cost-effective alternative to chemical and physical methods because of its low demand for energy, material and less generation of waste byproduct. Among the bacteria Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans, Leptospirillum ferrooxidans, and Sulfolobus sp., are well known consortia for the bioleaching activity while Penicillium, and Aspergillus niger are some fungi those help in metal leaching process. It has been observed that most of the abandoned mine sites are recognized by the presence of acidophilic inhabitant which can be isolated and screened in bioleaching of waste materials. These abandoned mine pollution sites contain the microbes those can tolerate very high concentration of heavy metal ions. These cells can be considered as suitable catalyst for industrial application of bioleaching. In future, to improve the yield of metal through bioleaching of solid waste, new strains have to be identified that should be capable of sustaining higher metal concentration..

In the year 2010 Ramahali [12] and Mahlangu studied the removal of heavy metals from platinum industry by the process of biosorption and the advantage of this method. This method has not only provided the removal techniques for removal of effective metals but also high post metal recovery during elution. The paper gels, prepared by chemical modification of waste paper, exhibited remarkable capacity and efficiency for the preconcentration and separation of gold, platinum and palladium from other co-existing metal ions at low to high concentration levels. Their major advantages are that they are usually of very low cost, decrease metal concentrations considerably and are especially useful in waste waters containing low concentrations of metal ions.

In the year 2012 Kumar [15] studied the use of biomaterials for removing of heavy metals from contaminated wastewater fungi as an biosorbent used because of its capability to sequester metal ions from aqueous solution. Cadmium tolerant fungal strain was isolated from the sample using fungal medium (Potato Dextrose Broth). The medium was amended with different concentrations of cadmium (10-100 mgL-1). Serial dilution was carried out to decrease the microbial load in the sample and standard spread plate method was performed. The plates were then incubated at room temperature (30-35 °C) for 48 h. After 48 h incubation fungi from each plate were isolated. It has been noticed that here Aspergillus Sp was isolated for removal of cadmium ions it can tolerate cadmium toxicity up to 100 mg/l study reveals that Aspergillus Sp from E-waste contaminated site has an potential application for removal og cadmium ions.

In the year 2012 Jadhav [14] and Hocheng studied the recovery of heavy metal from E-waste by pyrometallurgical, hydrometallurgical and biometallurgical process. Pyrometallurgical processes have proved to be more efficient for the extraction of metals, such as Ti, Zr, Nb, Ta, Mo, etc. The smelting, roasting, converting and refining are the various pyrometallurgical methods used for metal recovery. This process is fast because the physical form of the scrap is not as important as that required in chemical treatments. Hydrometallurgy is a process in which chemical reactions are carried out in aqueous or organic solutions for the recovery of metals. Three main step of the process namely, leaching, solution concentration and purification, and metal recovery. Reagents used in chemical leaching are nitric acid, mixtures of nitric, hydrochloric and sulphuric acids, sulphuric acid, nitric acid and hydrogen peroxide, aqua-regia, ferric chloride, thiourea, potassium iso-cyanate, potassium iodide and iodine, iodide–nitrite mixture, thiosulphate and cyanides. Metal recovery is the final step in a hydro-metallurgical process. The result found was that biometallurgical process appears to be attractive techniques microbial extraction procedures are more envoirrment friendly were giving extraction yield up to 90%.

In the year 2012 Saini [15] and Taneja studied the management of E-waste in India as it is a developing nation has limited resources to contain and mange E-waste problem. In order to solve this issue proper measure has been taken which includes policy level interventions, implementations and capacity building and to increase public awareness such that it can transform this challenge to a lucrative business also. It has suggested one more measure to E-waste management that it should cover need all round efforts ranging from technological improvement, institutional arrangement, operational plan, protective protocols for workers engaged in such units and at last education of the people at large by introducing it as part of curriculum in higher secondary education.

In the year 2012 Suryan [16] and Ahluwalia studied the method of utilization of low cost sorbent available in abundance for the removal of metals from dilute aqueous solution. The stock solutions containing the 1000 mg l-1 concentration of lead, cadmium, nickel and copper were prepared by dissolving lead nitrate, cadmium iodide, nickel sulphate and copper sulphate respectively in milli Q water. The residual concentration of metals was determined by atomic absorption spectrophotometer using an air-acetylene flame and single element hollow cathode lamp.It has been observed that biosorption technology in which living or dead biomass is used to accumulate heavy metals find a major drawback of cost of growing a sufficient quantity of bacterial fungal or algal biomass. Waste biomass of another industry represent good candidate for the development of inexpensive biosorbent, present study conclude that paper mill waste can be used efficiently in the removal of heavy metal ions (Pb2+, Cu2+, Cd2+ and Ni2+) from aqueous solutions. Though adsorption of metal ions was affected by pH, adsorption was above 70% for all the metal ions covering a range of pH from 2 to 5.

Kumar *et al*. 2012 [15] studied the process of removing toxic cadmium ions by isolated fungal strain from e-waste recycling facility. The use of biomaterials for removing heavy metals from contaminated wastewater and fungi as a biosorbent is used by conventional techniques. Fungi is used because of its capability to sequester metal ions from aqueous solutions. Here the cadmium tolerant fungus, *Aspergillus* sp was isolated from sample of an e-waste recycling facility. The optimal parameters for removal of Cd such as metal concentration, pH, temperature and time were observed. In the controlled conditions it was demonstrated that the maximum of 88% cadmium (100 mgL-1) was removed from aqueous solution by *Aspergillus* sp. at an optimum pH 4 and temperature 30 °C and the biomass of isolated *Aspergillus* sp. has the potential to be used as biosorbent for heavy metal cadmium removal from contaminated wastewater.

Alier *et al*. 2013 studied the recovery of noble metals from PCB's by pyrometallurgical process. PCB's are crushed and passed through various unit operation to separate metal and nonmetal. Metal were introduced in a furnace of temperature 1100-1400 ^{0}C. Metals can be examined by using AAS. Result states that addition of copper slag and NaOH helped in controlling the melting temperature and in separating the metal and nonmetal.

Fornalczyk *et al*. 2013 [18] studied the data concerning the material composition of E-waste with particular attention directed to the precious metal and their possibility of their recovery from PCB's. 71% copper was recovered from circuit boards using, at first stage of leaching, the nitric acid V. Slightly inferior results were obtained for silver (7.42%). Silver has leached into solution. Introduction of aqua regia, as a leaching factor, in the second stage of the process, resulted in a low percentage of Cu and Ag recovery but gold was reached 18%. Recovery of silver and gold could be improved by the use of hot aqua regia and also by the prolonged time of the process and it has been noticed that material complexity of PCB's may complicate the hydrometallurgical process and can reduce the effectiveness of metal recovery.

Willner *et al*. 2013 [18] studied the tests of bacterial leaching of metals from electronic scrap and preliminary results of experimental studies on the copper bioleaching from electronic waste with the participation of acidithiobacillus ferrooxidans bacteria. The biological leaching of electronic material and extraction of copper from waste was higher than in control test. There was no significant difference in the effectiveness of chemical leaching carried out in conditions without corrections and pH adjustment to 2.5.

In the year 2013 Yoheeswaran [19] recommended the scenario, legislation and regulation in national level, e-waste recycling formal and informal sector in national level. In India e-waste generation rate is 20% increase and to cross 805,000 tons. Major amount of e-waste is recycle and recovery by informal sector using basic methods such as open burning and acid stripping method. The both methods are harmful to the human and environmental. Many legislation and regulation available in global and national level, but no legislation is governed in the informal sector. The National Environmental Tribunal Act, 1995, Bio-Medical Wastes (Management and Handling) Rules, 1998, Municipal Solid Wastes (Management and Handling) Rules, 2000 and 2002. It has been seen in order to maintain E-waste awareness should be informal sector and public for disposal of waste. The discarded material collect, separate and transport by the informal sector and recycling, recovery and disposal by the formal sector is the way of reduction of pollution.

Anwesha and Kunal 2013 [20] evaluated the current status of E-waste management practices in India and the domination of informal sector in the E-waste recycling business with all its socio-economic, health and environmental implications and to identify the range of diverse stakeholders in the E-waste management system in India. The stakeholders had significant right from the production of Electrical and Electronic Equipment (EEE) to the final disposal of Ewaste. Problems calculated by the stakeholders were the techniques such as acid-bathing to extract the valuable and reusable components from the E-waste are usually carried out by the urban poor without any health and safety measures and the involvement of women and children in such recycling activities further amplify the problem of E-waste recycling in the country. The key stakeholders identified along the management chain have their respective roles and responsibilities towards sustainable E-waste management in the country. It is high time to consider different policy level initiatives in the form of legislations and other market-based policy initiatives such as Extended Producer Responsibility, Take Back Policies, Advanced Disposal Fee, Advanced Recycling Fee, Tax Credit, Deposit-Refund System, Pay-As-You-Throw etc. in order to address the issues related to E-waste in India.

Dhokpande and Kaware, 2013 [21] studied that recovery of metal by biological method by using low cost materials. Methods involved are adsorption, biological methods, electro coagulation, electro dialysis and various membrane separation techniques among others. In the biosorption method pretreated algal Spirogyra sp and Nostoc biomass were used to remove one of the heavy metal namely selenium. In the activated sludge process chromium, lead and nickel removal efficiency in the fixed activated sludge at concentration of 1 mg/lit was 84%, 75% and 80%, respectively, by increasing concentration of them to 5 mg/lit, the removal percentage increased to 90%,84% and 87%, respectively. They treated the biomass using chemical treatment and noted that 90% percentage of metal like selenium, lead, cadmium, chromium, copper, nickel were removed.

Patil *et al*. 2014 [23] proposed an innovative strategic model for the recovery of valuable metal for the management of e-waste by employing combined technological strategies viz. chemical and biological. Chemical technology involves the leaching of silver from electronic scrap using toxic chemical like cyanide. The complex silver cyanide form is then subjected to biological technology using passive low-cost material. This facts helps to know the strategy to strengthen supply chain elements for efficient management of e-waste.

In the year 2014 Rao studied the potential environmental health consequences of toxic metals and organo compounds. The selection of this topic is to evaluate electronic waste (e-waste) pollution and the toxic substances present in the e-waste and their threats to human health. The main focuses is on overview of India's current e-waste scenario and their problems in recycling and disposal of e-waste. The tools for e-waste management like life cycle assessment (LCA), material flow analysis (MFA) have been developed to manage e -wastes especially in developed countries. It is recommended that Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes. Establishment of E-waste collection, exchange and recycling centers should be encouraged in partnership with private entrepreneurs and manufacturers.

Okwu and Onyeje, 2014 focuses on the good site extraction of valuable substances by means of recycling. The processes involved in e-waste recycling are: collection, dismantling, pre-processing, end processing and final metal recovery collection mechanism of e-waste is very important because it is the determinant of the quantity of waste that is available for recovery through recycling and the amount that is lost in the process of storage. Dis mantling is the removal of some functioning or valuable components such as copper cables, memories, drives, batteries, capacitors and so on for re-use. It has been noticed that E-waste process contains collection, dismantling, pre-processing, end processing and final metal recovery.

In the year 2014 Raval studied the hazard of E-waste the need for its appropriate management and options that can be implemented. The importance of WEEE recycling has become more evident the pyrometallurgical process treatment in copper smelter is the common for the recycling of electronic scrap. But treatment of electronic scrap with high contaminants and amount of plastic needs always a combination of different step

i.e. mechanical, thermal, hydrometallurgical. But the cost of sampling analysis of base and precious metal scrap are high.
In the year 2014 Patel [23] and Kasture provides the study of the impacts and possible management of E-waste using biological systems using microorganisms, earthworms and plants are valuable alternatives to traditional methods. Microremediation is defined as the use of the microorganisms to eliminate, contain or transform the contaminants to nonhazardous or less-hazardous form in the environment through the metabolisms of microorganisms. There are 6 major mechanisms in microremediation of toxic metals are Bioleachin, Biosorption, Bioaccumulation, Biotransformation, Biomineralization, Microbiallyenhanced chemisorption of metals. Physical incineration and chemical process using strong acids are hazardous as well as expensive.
Willner *et al*. 2014 studied the bacterial leaching of metals from various polymetallic waste and the removal of metals by the process of biohydrometallurgical method. These wastes are the carriers of valuable metals: base metals, precious and platinum group metals. It has been seen that biological leaching has been conducted in the presence of variety microorganisms and in a wide range of waste-carrying base, special and precious metals. In many cases promising results of metals extraction were obtained. Problems associated with metal toxicity towards microorganisms have been solved by their adaptation to high concentration of heavy metals. Although many problems associated with the selection of the optimum process parameters still remain to be resolved, increased efficiencies of bacterial leaching operations, make these processes more competitive in relation to conventional methods.
In the year 2014 Kavitha studied the extraction of precious metal from E-waste by hydrometallurgical, pyrometallurgical and bioleaching process firstly e-waste is collected, dismantled and individual components are tested and isolated.. 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. In the pyro metallurgical process, e-waste is melted with several flux components as slag formatives. Microbiological leaching uses a natural ability of microorganisms to transform metals present in the waste in a solid form to a dissolved from. 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. 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.
Sivakumar *et al*. 2015 studied the E-waste composition, categorization, Global and Indian E-waste scenarios, prospects of recoverable, recyclable, and hazardous materials found in the E-waste, Best Available Practices, recycling, and recovery processes followed, and their environmental and occupational hazards. It is recommended that an effective take-back program providing incentives for producers to design products that are less wasteful, contain fewer toxic components, and are easier to disassemble, reuse, and recycle may help in reducing the wastes. Hence creating awareness among the e-waste generating sectors is the important task now. Technical audit and Life cycle analysis are also recommended before releasing the electronic consumer product.
In the year 2015 Tsamis studied the current level of technology development for the recovery of rare earths from electronic waste and examines the elements that affect its development at the industrial scale and the opportunities arising for high tech SMEs and the existing policy framework and provides a set of recommendations for improved implementation of existing actions and new policy measures. Rare earth metals are a group of 17 elements consisting of the 15 lanthanoids plus Scandium (Sc) and Yttrium (Y). Rare earths (REEs) tend to be analysed as a single group due to their generally similar properties. It ha been suggested that the existing recovery technologies of REEs from WEEE has been significant level of research, very few of them have moved to industrial scale. Generally, metallurgical extraction chemistry is well known, the challenge usually lies with dealing with the impurities that accompany the typical recyclates. To this point, the recovery of REEs from lamp phosphors is the most mature in terms of industrial scale application.

Conclusion
A systematic approach is required to treat and pollution load from this sector. Much emphasis should be given to collection point that should be located in the society. The transportation and processing of waste needs optimization. All the methods should be evaluated from techno economical point and their feasibility should be accessed. A single method will not be capable of treating the pollution load but the combination of the methods in step is required to recycle, recover and reduction of pollution load.

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