Recycling of Electronic Waste II, Proceedings of the Second Symposium
Edited by: Lifeng Zhang and Gregory K. Krumdick
TMS (The Minerals, Metals & Materials Society), 2011

PROSPECTIVE SCENARIO OF E-WASTE RECYCLING IN INDIA

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Keywords: E-waste, Scenario of e-waste, Recycling technology

Abstract

However, India is rich in ores and mineral, but E-waste recycling is necessary due to the report of national and international studies, which cautioned on the generation, treatment and accumulation of e-waste in India. Current data indicate that the total domestic e-waste generation including imports is around 382979 MT, however waste available for recycling and actually recycled are 144143 MT and 19000 MT, respectively. In which recycling by non-formal and formal sector are 95% and 5%, respectively. On the other hand, India has developed expertise in handling verities of metallic wastes in an organized and safe manner. The development of individual process or combined processes for handling the e-waste is underway. Eco- friendly and energy-saving processes are necessary to comply with stringent environmental regulations. The paper includes the recent trend of e-waste generation, recycling process and its future prospects particularly in India.

Introduction

With the development of technology, the lifespan of electrical and electronic equipments (EEE) is decreasing. The life span of computers has decreased from 4.5 to 2 years in the period 1992 to 2005, thus generating large amount of e-waste to the extent of 20-50 million tones/ year in the world [1]. In India alone, 330 thousand tones of e-waste generated in 2007, which is expected to rise 470 thousand tonnes by 2011 [2]. The e-wastes contain valuable, precious and hazardous elements viz. iron, copper, gold, silver, cadmium, mercury etc. In order to meet the environmental norms for hazardous waste disposal and conservation of natural resources around the world, there is a growing concern for the safe recycling of e-waste. Recycling of e-wastes is carried out by the formal and non-formal sectors for the recovery of valuables and disposing of wastes. In India, participation for recycling of e-wastes by non-formal sector is about 95% and that of formal sector is 5%**.** The greater share of unscientific handling of e-waste recycling by non-formal sector causes serious threat to the environment due the emission of dioxine, furan and other harmful gases along with element viz. lead, cadmium, mercury etc. The availability of huge amount of e-wastes and environmental concern attributed development in handling and recycling technology in India and other countries. Some operating or proposed industries for the recycling of e-waste in India are the following companies: Attero Recycling, Delhi, (www.attero.in), Trishyiraya Recycling India Private Limited, (www.ewaste.in), Ecoreco, (www.ecoreco.com), and E-Parisara, (www.ewasteindia.com) These industries are operating e-waste centers in different parts of India viz. Delhi, Meerut, Ferozabad, Chennai, Bangalore and Mumbai. Various R&D work have been proposed for the development of e-waste recycling processes. In this regard few review papers are also appearing in national and international seminars [3]. Various government organization and research centers are trying to achieve an integrated process for the recovery and separation of metals from the e-wastes including pretreatment process like cutting, shredding, grinding, air classification followed by leaching and

solvent extraction process. The processes have also been proposed for the recovery of precious metals such as gold. Researchers and industrialists are integrating together to parleys small scale e-waste recycling industries into large scale industries.

Scenario of E-waste in India

Due to lack of proper technology for the recycling of waste electrical and electronic equipments (WEEE), all around the world, the amount of generation of WEEE is increasing rapidly and comprises about 5% of all the solid waste [4]. In India also demand and supply of EEE increases at a tremendous rate. Fig. 1 shows that there is rapid increase in the number of sales of desktop in the period of 1994 to 2007 and the value reaches up-to 5.52 million [5]. Fig. 2 shows that mobile subscriber in India increases from 90 million to 433 million during the period 2006-11 and expected to touch 900 million in 2015-16 [6].

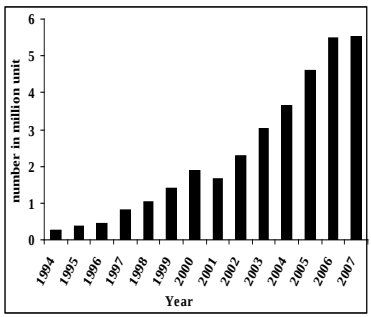

Figure 1. Domestic sales data of electronic devices in India (in million units)

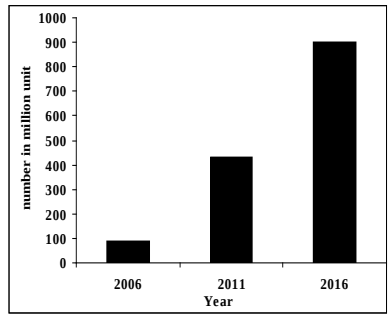

Figure 2. Number of mobile phone subscriber in India (in million units)

Based on the logistic model, it is revealed that around 41-152 million units of computers will become obsolete by the end of 2020 [5]. However, total of 2.5 million tonnes of WEEE comprising of PC, television, washing machine and refrigerators are expected to generate during the period of 2007-11 [7]. These statistics will help the recyclers in building strategy for the recycling of e-wastes.

Composition of e-wastes

The composition of e-wastes widely varies depending on the type of the products and their models as depicted in Table. 1, which shows the presence of metals such as Fe, Cu, Al, Pb, Ni and precious metals like Ag, Au etc. [8]. Older model of the e-scrap found to contain higher value of precious metals. There is wide variation in weight composition of e-scraps and the average content is 40% metals, 30% plastic and 30% refractory as shown in Fig. 3. Among the metals copper, iron, tin, lead, aluminum and nickel are found in significant amount while others metals like gold silver etc. are found in traces [9].

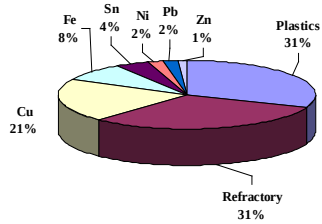

Figure 3. Composition of e-wastes

Table 1. Composition of metals for different e-scrap samples

Electronic waste	Weight (%)					Weight (ppm)		
	Fe	Cu	Al	Pb	Ni	Ag	Au	Pd
TV board scrap	28	10	10	1	0.3	280	20	10
PC board scrap	7	20	5	1.5	1	1000	250	110
Mobile phone scrap	5	13	1	0.3	0.1	1380	350	210
Portable audio scrap	23	21	1	0.14	0.03	150	10	44
DVD player scrap	62	5	2	0.1	0.05	115	15	4
Calculator scrap	4	3	5	0.1	0.5	260	50	5
PC main board scrap	4.5	14.3	2.8	2.2	1.1	639	566	124
Printed circuit boards scrap	12	10	7	1.2	0.85	280	110	NR
TV scrap (CRTs removed)	NR	3.4	1.2	0.2	0.038	20	<10	<10
Electronic scrap	8.3	8.5	0.71	3.15	2.0	29	12	NR
PC scrap	20	7	14	6	0.85	189	16	3
Typical electronic scrap	8	20	2	2	2	2000	1000	50
E-scrap sample 1	37.4	18.2	19	1.6	NR	6	12	NR
E-scrap sample 2	27.3	16.4	11.0	1.4	NR	210	150	20
Printed circuit boards	5.3	26.8	1.9	NR	0.47	3300	80	NR
e-scrap (1972 sample)	26.2	18.6	NR	NR	NR	1800	220	30
E-waste mixture	36	4.1	4.9	0.29	1.0	NR	NR	NR

NR means not reported.

Collection and Recycling of e-wastes in India

Collection of e-wastes

In India, the collection and recycling of e-wastes is largely linked among the manufacturers, distributors, consumers, collectors, traders and recyclers as shown in Fig. 4 [10].

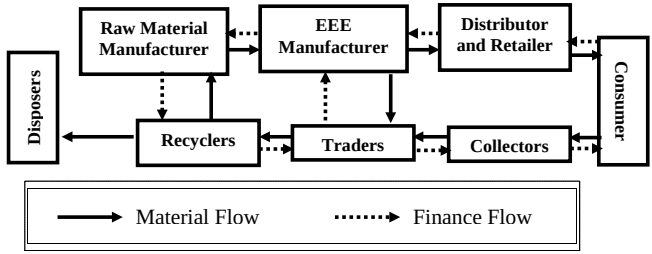

Figure 4. Flow of e-wastes collection for recycling in India

The unorganized sectors are largely involved in the collecting, trading and recycling works. Unlike developed countries, waste pickers pay price to consumers for their discarded products and there is no concept of Advance Recycling Fee (ARF) which are paid by the consumers to the retailers, retailers to manufacturers and manufacturers to the recyclers.

Recycling of e-wastes

The recycling of e-wastes in India is mainly practiced in unorganized sectors while some industries are also recycling these materials in their plants. In order to develop suitable recycling methods, R & D institutions are also developing processes to recover the valuables to conserve the resources without affecting the environment. The collaborative research in association with foreign research institutions is also being made. These details are discussed below.

a. Industrial approach of Recycling: As mentioned above, the main constituents of e-wastes are plastic, glass and metals. The recovery of metallic constituents is tedious due to presence of various valuable, precious and hazardous metals.

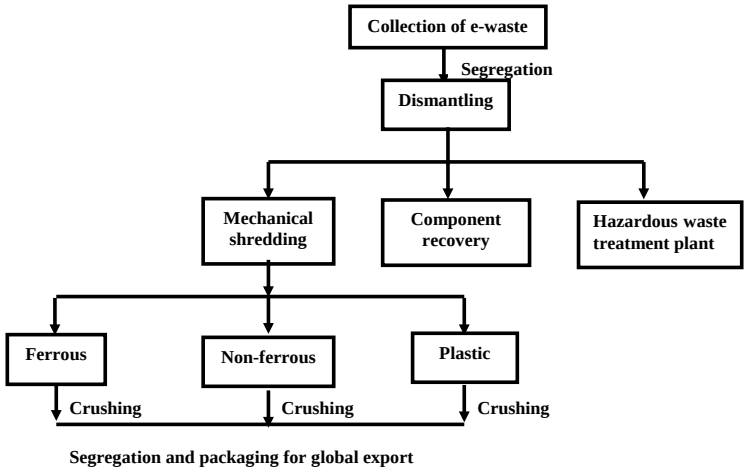

Figure 5. Schematic flow diagram for the recycling of e-wastes in Indian industry

Some of the industries like Attero, TPL, Ecoreco etc. are involved in the recycling and management of the e-wastes. Fig. 5. depicts typical flow process for recycling of e-scraps in Indian recycling plant. For the better recovery of elements, initially collected e-wastes are segregated according to their parent products followed by dismantling. Components like solder, battery, cables etc. obtained from the dismantling of e-wastes. These components are recycled for the recovery of elements like tin, lead, nickel, lithium etc. The hazardous substances that cannot be recycled are exported to hazardous waste treatment plant. Rest of the part of e-waste viz. plastic, PCBs etc obtained after component recovery undergoes for the mechanical shredding

followed by the separation of ferrous, non-ferrous and plastic material. After crushing and segregation of obtained class, these are packed for the global export. Apart from the recycling of valuable and hazardous elements, the segregated constituents are also exported for the recycling of precious metals like gold and silver.

b. R&D studies for recycling of e-wastes: The studies are being made in different R&D institutions. Among them National Metallurgical Laboratory (NML), Jamshedpur is pioneer in developing processes for e-waste recycling, in India. The studies are basically concentrated on physical processing for the segregation and concentration of materials followed by their recovery by hydro/pyro-metallurgical techniques to develop eco-friendly processes. The results of salient processes are described below.

Physical processing of e-wastes: E-wastes are heterogeneous in nature and present in different physical shapes and composition. Different authors made different attempts to classify the e-waste into metallic and non-metallic form by physical processing methods. At NML, physical separation technique has been employed for the beneficiation of metals and other useable components from e-wastes as presented in Fig. 6 [9]. E-wastes after dismantling, segregation and shredding are pulverized to a size fraction of 1 to 0.5mm to dislodge the bounded part for downstream process.

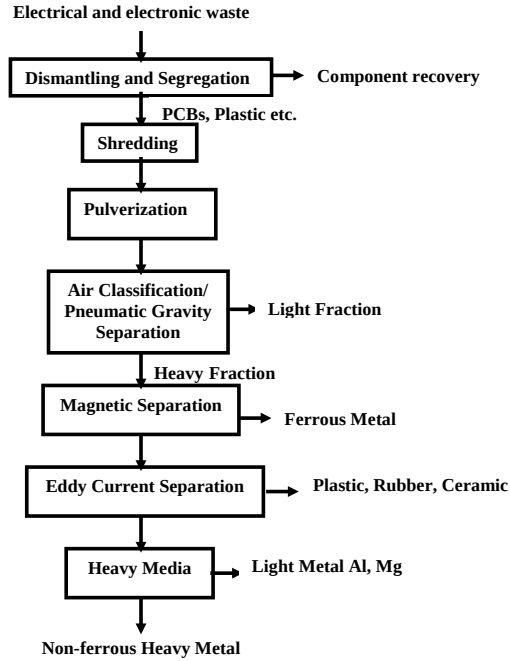

Figure 6. Schematic flow diagram of physical processing of e-wastes

Pulverized material undergoes for other physical separation techniques based on the physical properties of the material such as density, magnetic susceptibility, electrical conductivity, surface property etc. The pulverized materials are then processed following air classification, magnetic separation of heavy fraction, eddy current separation and heavy media [9]. The product obtained in the process is light fraction (rubber plastics), ferrous metals, ceramics, light metals (Al, Mg) and non-ferrous metals. These separated materials could be further processed to produce valuable products depending on their constituents for certain applications.

Hydrometallurgical Treatment: The metallic fractions obtained after physical processing are further processed for the recovery of valuables following pyro/ hydro-metallurgical routes. Several authors studied leaching, solvent extraction and electro-winning processes for the recovery of valuables in form of metals [11, 12, 13, 14, 15]. The e-scraps are leached for the dissolution of metals present using basic or acidic reagents like sulfuric acid, ammonia, nitric acid etc. Obtained leached solution containing metals undergoes liquid-liquid extraction by the use of organic extractants viz. dialkyl monothiophosphinic acid (Cyanex), di-(2-ethylhexyl) phosphoric acid (D2EPHA), 2-hydroxy-5-nonylacetophenoneoxime (LIX84) etc. for the extraction and separation of metals. Fig. 7 shows the schematic diagram for the extraction and separation of metal mixtures for example A, B and C present in the leach liquor of electronic waste using different organics. Organic enriched in metallic values are stripped by using suitable reagents and lastly the purified solution is crystallized/electro-won for recovery of salt/metal.

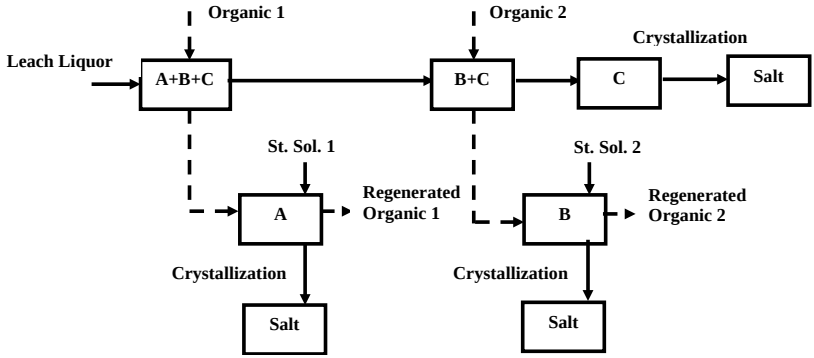

Figure 7. Schematic flow diagram for the extraction and separation of metals from the leach solution

At NML Jamshedpur work has been done for the recovery of metals like Cu, Zn, Cd and Ni from the sulfate leach solution of e-waste. Copper was selectively recovered by using LIX84 at aqueous feed pH ~2, and then Cyanex and D2EHPA were used at different feed pH for the selective extraction and separation of Zn, Cd and Ni from the Cu free leach solution. Another approach for process development to recycle metals from waste PCBs is going on under joint collaboration between NML, India and KIGAM, South Korea. Metals encapsulated between plastic layers are found poor in its effective leaching, therefore a novel pre-treatment technique i.e. organic swelling of e-waste is employed for the separation of metallic layers from the plastic layer [16] followed by selective dissolution of lead and tin in suitable reagents. The selective

dissolution of lead in nitric acid followed by tin dissolution in hydrochloric acid for the recovery of metals from the organic swelled materials of printed circuit boards is carried out. Various other hydrometallurgical processes have been proposed for the recovery of precious metals like gold. Leaching of gold in cyanide medium is most beneficial route but due to hazardous effect of cyanide, thiourea might be the substitute for leaching of gold [17]. For the recovery of gold from the leached solution, cementation process may be applied using zinc and sodium borohydride from cyanide and thiourea leached solutions, respectively.

Although attempts are being made in India and abroad for the recovery and recycling of large quantity of e-wastes, there is need to develop feasible and eco-friendly technology and their enforcement for the effective recycling and management to conserve the resources. Considering the depth of problem, government is serious to implement adequate system of law, control and administrative procedure, ban on imports and export of hazardous materials, identification of components containing toxic materials collection of e-wastes from manufacturers/ consumers, incentives for their collection, awareness programs, etc.

Conclusion

E-waste is one of the fastest growing solid municipal wastes in India. Out of 20-50 million tones of e-waste being generated in the world, it is estimated that India will alone generate 4.7 hundred thousand tones by the end of 2011. E-waste collection, trading and recycling are mostly carried out by unorganized sectors. Only 5% of the total e-waste being generated is recycled by the formal sectors, while large involvement of non-formal sector may cause threat to the environment. E-wastes contain hazardous, valuable and precious metals. In general, the e-waste comprises of 30% plastics, 30% refractory, and 40% metals. Most of the Indian recycling companies are treating e-waste up-to pretreatment stages only. Considering the depth of this problem, government is serious to implement law, administrative procedure, ban on imports and export of hazardous materials, identification of components containing toxic materials collection of e-wastes from manufacturers/ consumers, incentives for their collection, awareness programs, etc. The Indian R&D work related to e-waste recycling is directed towards the development of feasible process consists of mechanical pre-treatment and pyro/ hydro-metallurgical techniques. Several researchers reported bench and pilot scale studies for recycling of e-waste using mechanical/ organic pre-treatment processes followed by leaching, solvent extraction and electro-winning. Eco- friendly and energy-saving processes are necessary to comply with stringent environmental regulations.

Acknowledgement

This paper is based on the sponsored work supported by Resources Recycling R&D Centre, South Korea under collaboration between National metallurgical Laboratory (CSIR), Jamshedpur, India and Korea Institute of Geosciences & Mineral Resources (KIGAM), South Korea

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