Review Article

Managing E-Waste: An Ocean of Opportunities or a Threat to Survival

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Abstract

E-waste is used to describe old, end-of-life or discarded appliances using electricity which include old and dilapidated desktop and laptop, computers, mobile phones, printers, pagers, digital cameras, music devices, refrigerators, toys, televisions etc. According to UNEP's (United Nations Environmental Programme) recent report "Recycling from E-Waste to Resources"**,** sales of electronic products in countries like China, India and also in Africa and Latin America are set to increase sharply in the next 10 years. Unless drastic action is taken for proper collection and recycling of materials, many developing countries face the specter of hazardous e-waste mountains resulting in serious issues for public health and the environment.

Modern electronics contain up to 60 different elements-many valuable, some hazardous. Manufacturing mobile phones and personal computers only consume 3 per cent of the gold and silver mined worldwide each year; 13 per cent of the palladium and 15 per cent of cobalt. The electronics manufacturing leads to global e-waste generation by about 40 million tons a year.

The e-waste generation is a necessary evil of societal progress which cannot be stopped. It creates depletion of natural resources, health hazards, environmental pollution and threat to sustainability. However, it has all the possibilities of creation of wealth from these sources of e-waste. An efficient recovery and retrieval system can make e-waste an ocean of opportunities rather than a threat to survival. E-waste recycling in developing countries can have the potential to generate decent employment, reduce greenhouse gas emissions, improve sustainability and recover a wide range of precious metals. By planning now and acting forward, many countries can turn an e-challenge into an e-opportunity.

Keywords: E-waste, Reuse, Recycle, Retrieval, Threat, Opportunity.

Introduction

"E-waste" or Waste Electrical and Electronics Equipments (WEEE) is used as a generic term embracing all types of waste containing electrically powered components. E-waste contains both valuable materials as well as hazardous materials which require special handling and recycling methods.

'Electrical and electronic equipment' or 'EEE' means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex IA and designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current.[1]

The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their disposal was brought into force in 1992 and put strict rules and regulations on the import and export of toxic waste-including E-waste. The Basel Convention aims to minimize the transportation

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of hazardous waste around the world by making it illegal to export goods without a special agreement.

The e-waste has diverse compositions that are classified as "hazardous and non-hazardous categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminum and precious metals like silver, gold, platinum, palladium and so on**.** [2]

According to a report by the United Nations University, US and China together produce 32% of the world's e-waste, followed by Japan, Germany and India. However, the per capita leaders are mainly wealthy European nations, the top countries being Norway (28.4 kg), Switzerland (26.3 kg), Iceland (26.1 kg), Denmark (24.0 kg), United Kingdom (23.5 kg), Netherland (23.4 kg), Sweden (22.3 kg), France (22.2 kg), USA and Austria (22.1 kg).[3]

Why is E-waste Management important?

E-waste is classified as hazardous material; therefore it should be managed properly. Further, the presence of precious metals (PMs) in e-waste such as gold (Au), silver (Ag), platinum (Pt), gallium (Ga), palladium (Pd), tantalum (Ta), tellurium (Te), germanium (Ge) and selenium (Se) makes it attractive for recycling.[4]

E-waste management is mandatory for product manufacturers, suppliers, users as well as for traders and recyclers. Failure to comply with the WEEE Directive places these manufacturers at risk for prosecution and inability to place their products in the EU market.

Being a social and global concern, it cannot be taken in lighter vein. It is a social, global economic, legal, health, environmental, sustainability and attitudinal issue. Hence it needs to be addressed at highest level.

The challenge of dealing with e-waste represents an important step in the transition to a green economy. New technologies, combined with national and international policies, can transform waste into assets, creating new businesses with decent green jobs.

E-waste Management Status around the Globe

According to a report from Markets and markets, the global volume of e-waste generated is expected to reach 93.5 million tons in 2016 from 41.5 million tons in 2011 at a compound annual growth rate of 17.6 percent from 2011 to 2016. According to a market research report, Global E-Waste Management Market (2011-2016), the revenue generated from the e-waste management market is expected to grow from $9.15 billion in 2011 to $20.25 billion in 2016 at a rate of 17.22 percent.[5]

The UNU report shows global e-waste levels are increasing by 2 million tons a year, with only 16% recycled or reused. There are metals in that e-waste that are toxic, but are also valuable. The report also revealed that among the 48.1 million tons of electronic waste thrown away during 2014, there is an estimated US$10.5 billion worth of gold. The total value of recyclable e-waste produced in 2014 stands at around US$52 billion.[6].

Some of the organizations working on the issues of e waste management are Basel Action Network (BAN), Bureau of International Recycling (BIR), Global e-Sustainability Initiative (GeSI), Partnership for Action on Computing Equipment (PACE), StEP Initiative (Solving the E-waste Problem), Silicon Valley Toxics Coalition (SVTC), Strategic Approach to International Chemicals Management (SAICM), Toxic Link, UNEP Global Partnership on Waste Management (GPWM), WEEE Forum etc.

E-waste Management Status in India

Although the per-capita waste production in India is still relatively small, the total absolute volume of wastes generated will be huge. Further, it is growing at a faster rate. The growth rate of mobile phones (80%), PCs (20%) and TVs (18%)-all lead to more e-waste generation.

Seventy per cent of the total e-wastes generated in the country are from ten states, and in fact, more than 60% of the total e-waste in India is from 65 cities. Among the e-waste generating states, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, lhi, Gujarat, Karnataka and West Bengal. Of the total e-waste generated in India, approximately 1.5% is recycled by formal recyclers or institutional processing and recycling, and another 8% of the e-waste generated is rendered useless and goes to landfills. The remaining 90.5% of the e-waste is being handled by the informal sector.[7]

Out of the 138 Central Pollution Control Board certified recyclers/ dismantlers in the country, 22 are in Maharashtra, 13 in Haryana, 11 in Uttar Pradesh, 52 in Karnataka, 2 in West Bengal, 14 in Tamil Nadu, 7 in Gujarat, and 2 in Andhra Pradesh. The total capacity of these plants is 3,45,154 metric tons per annum (MTA). There are 21 recycling facilities in Delhi which have been issued licenses by the Delhi Pollution Control Committee for collection, segregation and storage of e-waste without dismantling and recycling.[7]

India mostly depends on the unorganized sector for the recycling of e-waste as only a few organized e-waste recycling facilities are available. Over 95% of the e-waste is treated and processed in the majority of urban slums of the country, where untrained woman and child workers carry out the dangerous procedures without proper personal protective equipments.

A recent study by ASSOCHAM estimates that India produces 13 lakhs MT of e waste per annum with a CAGR of 25 percent. Hyderabad is the sixth largest generator of E-Waste amounting to 25000 MT of e-waste annually.[8]

Ministry of Environment and Forest, on 12 May 2011, through a notification, invited objections and suggestions from all persons likely to be affected on e-waste (Management and Handling) Rules 2010. As per this, the rule has come to effect with effect from 1st May 2012.

Managing E-waste-3Rs

Solid waste management, which itself is a mammoth task in India is becoming more complicated by the invasion of e-waste. To manage e-waste effectively requires a holistic integrated approach with 3Rs of reduce, reuse and recycle concept. The best e-management approach is to prevent the happening of e waste, and if not practicable minimize the generation of it. Next best practices are reuse, recycle and ultimate disposal to proper landfill. The state of the art recoveries of precious metals from electronic wastes are by pyro-metallurgical processing, hydrometallurgical processing, and bio-metallurgical processing.

Pyro-metallurgical processing has been a traditional technology for recovery of precious metals from waste electronic equipment. However, state-of-the-art smelters are highly depended on investments. Recent research on recovery of energy from PC waste gives an example for using plastics in this waste stream. It indicates that thermal processing provides a feasible approach for recovery of energy from electronic waste if a comprehensive emission control system is installed. In the last decade, attentions have been removed from pyro-metallurgical process to hydrometallurgical process for recovery of metals from electronic waste.[9] Hydrometallurgical processing techniques include cyanide leaching, halide leaching, thiourea leaching, and thiosulfate leaching of precious metals. However, new solutions for more economical and ecologically efficient recovery of metals are constantly being searched for. Bio-metallurgy can become a promising technology of recovering metals from industrial waste. Bioleaching-- one of the methods applied in that technology-is the subject of particular interest of many scientific centers.

E-waste-A Threat to Survival

Due to the presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants beyond threshold quantities in one form or the other in Cathode ray tubes (CRTs), Printed board assemblies, Capacitors, Mercury switches and relays, Batteries, Liquid crystal displays (LCDs), Cartridges from photocopying machines, Selenium drums (photocopier) and Electrolytes, e-waste becomes hazardous in nature. It contains different substances, many of which are toxic, and creates serious pollution upon disposal. Obsolete computers pose the most significant environmental danger and threat to human health among the e-wastes.[10]

Electronic waste management is fast becoming a health concern for the informal sector that recycles e-waste in India. About 76% of e-waste workers in India suffer respiratory ailments like breathing difficulties, irritation, coughing and choking due to improper safeguards, according to a study entitled Electronic Waste Management in India by industry lobby group -Assocham.[7]

Agbogbloshie in Accra, Ghana is one such slum where e-waste has been dumped for over a decade. There, migrants from the north of Ghana who escaped food insecurity and civil unrest live in temporary dwellings and survive on the e-waste. They dismantle the dumped e-waste in primitive manners, breaking apart the electronics by hand and burning unwanted materials to harvest precious metals such as gold and copper to be resold for petty cash.

This process is destroying the environment and health of the Agbogbloshie community. As e-waste is taken apart, people are directly exposed to noxious substances such as lead, mercury, and cadmium that enter the body and cause debilitating chronic diseases. In addition, chemicals and smoke from the burning enter the local water supply and food chain in the nearby market, leaving even those not involved in the industry vulnerable.[11]

Land filling of e wastes can lead to the leaching of lead into the ground water. If the CRT is crushed and burned, it emits toxic fumes into the air. These products contain several rechargeable battery types, all of which contain toxic substances that can contaminate the environment when burned in incinerators or disposed off in landfills. The cadmium from one mobile phone battery is enough to pollute 600 m^3 of water.

According to the China Labor Bulletin, e-waste recycling activities have contributed to elevated blood lead levels in children and high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers.

UNU researcher Feng Wang estimates that of the 20 million people (roughly equal to the population of Australia) engaged in China's waste management, 2 million are involved in the informal collection, re-use and recycling of e-waste.

China is not alone in facing a serious challenge. India, Brazil, Mexico and others may also face rising environmental damage and health problems if e-waste recycling is left to the vagaries of the informal sector.[12]

E-waste-An Ocean of Opportunities

"Worldwide, e-waste constitutes a valuable 'urban mine'-a large potential reservoir of recyclable materials," UN under secretary-general David Malone said.

"One metric ton (t) of electronic scrap from personal computers (PC) contains more gold than that recovered from 17 t of gold ore. In 1998, the amount of gold recovered from electronic scrap in the United States was equivalent to that recovered from more than 2 million metric tons (Mt) of gold ore and waste".[13]

"A ton of used mobile phones, for example-or approximately 6,000 handsets (a tiny fraction of today's 1 billion annual production) -contains about 3.5 kilograms of silver, 340 grams of gold, 140 grams of palladium, and 130 kg of copper, according to StEP, an expert consortium Solving the e-Waste Problem... The average mobile phone battery contains another 3.5 grams of copper so that the combined value is over US $15,000 at today's prices."[6]

According to another estimates of EPA (Environmental Protection Agency), USA, "Experts estimate that recycling 1 million cell phones can recover about 24 kg (50 lb) of gold, 250 kg (550 lb) of silver, 9 kg (20 lb) of palladium, and more than 9,000 kg (20,000 lb) of copper."[14]

Recycling of e-waste for metal recovery is also important from the perspective of saving energy. The U.S. Environmental Protection Agency [15] has identified seven main benefits for using recycled iron and steel over their virgin materials. One of the major benefits is significant energy saving using recycled materials compared to virgin materials.

A UN study found that the manufacturing of a computer and its screen takes at least 240 kg (530 pounds) of fossil fuels, 22 kg (48 pounds) of chemicals and 1.5 tons of water-more than the weight of a rhinoceros or a car."[16]

In addition, management of e-waste provides benefits such as job creation, improved technological knowledge, and environmental benefits. In developing countries, job creation also helps in alleviation of poverty and improved health conditions.

This commoditization of e-waste is evident in a certain level of specialization of commercial entities in different parts of the world. The clearest trend however is the emergence of Chinese domestic patent activity overall within the e-waste industry. Patent application rates have increased seven-fold in just 6 years, and are largely driven by academic institutions. A number of Japanese companies like JX Nippon Mining and Metals, Kobe Steel, Mitsui Mining and Smelting and others are not just applying for patents, but in some cases investing heavily in recycling technology.

Conclusion

Product obsolescence coupled with the speed of innovation and the dynamism of product manufacturing and marketing has resulted in a short life span for many electronics products. Further, most electronic products are not designed with the end-of-life stage of the product in mind. Designers focus on the Design for manufacturability, Design for Quality, Design for Testability and even for Design of Maintainability of the product, of course, but they generally ignore the realities of how the product will be handled when it's discarded. The designers are clearly not thinking about how the products could be recycled. The LCD TV is perhaps the "poster child" for how electronics are not designed with recycling in mind, because of both material selection and physical design. Further, many products are not designed to be easily disassembled, glue is used instead of fasteners, a whole range of screw sizes in one product (making the recycler use many different screwdrivers to remove them), making it hard to disassemble and recycle.[17]

Informal collection and manual dismantling activities do not necessarily need to be transformed to formalized processes and often have advantages over the introduction of new technologies from a sustainability point of view. The informal collection system is rather efficient in countries like India and China because the daily informal collectors are penetrating into each community of the city to collect e-waste from house to house. Moreover, deep-level manual dismantling in formal or informal environments is preferred over semi-automatic processes due to the abundant workforce and low labor costs. However, all other informal activities such as pre processing, end processing and land filling have great adverse environmental and social impacts and are also often less attractive from an economical point of view than innovative technologies.

Informal recycling, inadequate legislation, improper implementation, poor awareness and reluctance on part of both government and corporate sectors are the critical issues in e-waste management. The consequences are that on one hand toxic materials are entering into the main stream with no special precautions to avoid the known adverse effects on the environment and human health as well as marine life and on the other hand resources are being wasted and wealth are being overlooked and dumped.[18]

Some developed countries have adopted a method of exporting e-waste to developing countries under the guise of aid, donation, or sale of second hand electronics.

These countries (developing countries) have thus gradually become their e-waste dumping ground. Thus developing countries are shouldering a disproportionate burden of a global problem without having the technology to deal with it.[19]

An integrated e waste management approach and plan are needed with the inclusion of e-waste in curriculum of the universities and in the certification of product and process (OSHAS and environmental certification). In case of corporate, stress for inclusion of Design for Resource (DFR) efficiency concept, an extended producer responsibility and a more cost effective pre-processing and recycling technology can prove e-waste a wealth for the developing countries.

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