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Electronic Waste: A Case Study

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Abstract

WEEE (waste from electrical and electronic equipments) comes under a special category of waste which is the result of industrialization and ever increasing demand of electronic products in daily life. With increasing usage waste production is also increasing. Now, the situation is alarming as a huge quantity of waste is generated by India as well as other countries. The condition in India is much worse because about 80 percent of the e-waste generated in the US is exported to India, China and Pakistan under the name of charity. Only 3% of total WEEE-waste generated is recycled properly in India. The rest of it is handled by workers who work with bare hands, without masks under unhygienic conditions, informally recycling tons of e-waste for about 12-14 hours a day. It causes both environmental as well as health problems. No. of laws are framed but none is able to stop this informal recycling. In this paper, national and international e-waste scenario is discussed along with hazards caused by e-waste and bit about its recycling.

Keywords: WEEE, Informal recycling, hazards

Introduction

According to the OCED (Organization for Economic Co-operation and Development) any appliance using an electronic power supply that has reached its end-of-life would come under WEEE. WEEE (waste from electronic and electrical equipments) is a special category of waste that has received great deal of attention over past 15 years. WEEE is diverse and complex in terms of the material and component make up as well as in terms of original equipment manufacturing process.

The electronic industry is the world's largest and fastest growing manufacturing industry [1, 2]. The Indian information technology (IT) has a prominent global presence today largely due to software sector. More recently, policy changes have led to tremendous influx of leading MNC's into India to set up manufacturing facilities, R&D centers and software development facilities. Starting with 13 IT companies in 1991, about 3000 IT companies as of now in Bangalore are providing world class infrastructure. This phenomenon of Bangalore is getting replicated in several other cities of India viz., Chennai, Mumbai, Hyderabad, Pune, Gurgaon etc. This asymptotic growth in IT industry has brought its share of waste disposal problem.

Three categories of WEEE account for almost 90% of the total waste generation, which includes[3] 42 % large house hold appliances, 34 % ICT equipment and 14 % consumer electronics.

Economic Growth and Digital Revolution: 1980 was the year when the great digital revolution started and has not ceased till date. The digital revolution provided variety of products which were not only economical but also easy to use therefore they invaded our households completely. They are now easier and convenient to replace rather than getting them repair. Figures, as illustrated in table 1, indicate the constant growth in sales volumes of some consumer electronics goods in India.

Table-1
Sales figure for consumer electronics in India

Item	2005-06	2006-07	2007-08
Desktop	4.61472	5.49059	5.0
Notebook	0.43183	0.85086	1.82213
Washing Machine	1.68	1.70	1.95
Mobile	41.9	66.5	93.0
TV	10.3	11.7	14.8
Refrigerator	4.36	4.79	5.27

Source: Toxic Link 3/3/10

Due to their affordable prizes and easy usage these products have a huge market even in smaller towns. In the last five years the sale of desktop PC and laptops has been shown a tremendous growth in smaller cities and towns. India, with around 500 million mobile users, is now the second largest

market in the world after China and in 2008-09 rural India outpaced urban India in mobile growth rate. According to data available with the Telecom Regulatory Authority of India, 48 million rural consumers took a new mobile connection in the first six months of calendar 2009 compared with just 32 million in the cities, thus taking the mobile penetration in rural India to around 17 %[4]. 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]. The 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[6,7].

Table-2
E-Waste generated by different countries

Country	Total e-Waste Waste Generated tonnes/year	Categories of Appliances counted in e-waste	Year	Source
Switzerland	66,042(*)	Office & Telecommunications Equipment, Consumer Entertainment Electronics, Large and Small Domestic Appliances, Refrigerators, Fractions	2003	8
Germany	1,100,000	Office & Telecommunications Equipment, Consumer Entertainment Electronics, Large and Small Domestic Appliances, Refrigerators, Fractions	*Estimated in 2005	9
United Kingdom	915,000	Office & Telecommunications Equipment, Consumer Entertainment Electronics, Large and Small Domestic Appliances, Refrigerators, Fractions	1998	10
USA	2,124,400	Video Products, Audio Products, Computers and Telecommunications Equipment	2000	11
Taiwan	14,036	Computers, Home electrical appliances (TVs, Washing Machines, Air conditioners, Refrigerators)	2003	12
Thailand	60,000	Refrigerator, Air Conditioners, Televisions, Washing Machines, Computers	2003	13
Denmark	118,000	Electronic and Electrical Appliances including Refrigerators	1997	14
Canada	67,000	Computer Equipment (computers, printers etc) & Consumer Electronics (TVs)	*Estimated in 2005	15

Source: E-Waste Management in India- Consumer Voice, April 2009

International E- Waste Scenario: According to studies about 4000 tons per hour of E-waste is generated world-wide[7]. E-Waste generated by different countries is given in table-2.

The use of electronic devices, such as PC's has proliferated in recent decades and the quantity of electronics disposed off is growing rapidly throughout the world**[16].**

Note: The table gives only an overview of the quantities of e-waste generated in different countries. It is difficult to make direct country-to-country comparisons regarding e-waste quantities, because each country has as different categories of appliances counted in e-waste and different methodologies of estimation.

(*) This is the quantity of e-waste generated in Switzerland that is physically weighed and accounted for. It is a much more accurate measure of e-waste quantities than for other countries for which only estimates exist.

E- Waste Scenario in India: In present times if we study closely e-waste is one of the fastest growing pollution problems which is increasing almost three times than that of municipal waste globally. With the increase in consumption of electronic goods and also with their usage pattern the generation of e-waste also increases. As there is no separate collection of e-waste in India, no reliable figures are available as yet to quantify the e-waste generation. The current data shows that by 2012 global e-waste will reach 53 million tons from 42 million tons in 2008 thus growing at a CAGR(*Compound Annual Growth Rate)* of 6 percent**[4]**. E-Waste is continuously growing in developed countries by 2010 it has grown to 2% in comparison to previous 1%. While in developing countries e-plastic waste contribute 0.01% -1% of total solid waste generation**.**

India with population of over 1 billion[17], is one of the fastest growing economies of the world[18]. The growing economy and increasing consumption is estimated to be generating approximately 4, 00,000 tons of waste annually (computers, mobile phone and television only) and is expected to grow at a much higher rate of 10-15%.

The situation is alarming as India generates about 1.5 lakh tones of e-waste annually and almost all of it finds its way into the informal sector as there is no organized alternative available at present **[19]**. E-waste generated in few cities across the nation show an alarming picture. Mumbai generates 11,000 tons of E-waste, Delhi 9000 tons, Bangalore 8000 tons and Chennai 5000-6000 tons each year. Maharashtra State (including Mumbai city) alone produces 20270 tons of E-waste annually[20]. These figures have been shown through the table 3 and table 4.

Toxics link, a Delhi-based non-government organization (NGO), says that India annually generates 1.5 billion worth of e-waste. As per a study done by Bangalore-based NGO, Saahas, the city generates around 8,000 tons of e-waste every year. It is true that the e-waste spectrum is broad, but IT companies are the single largest contributors to the growing mountains of it. This is because 30% of their equipments are rendered obsolete every year. Reason being is that the life cycle of some electronic goods as short as about 15-20 months. This average age of computer is only 3 years and is progressively decreased because of the demand for ever-accelerating speeds in the processing capability of the tele-communication infrastructure.

According to Manufacturer's Association for Information Technology (MAIT) report India in 2007 generated 3, 80,000 tones of e-waste from discarded Computers, Televisions and Mobile Phones. This is projected to grow to more than 8, 00,000 tones by 2012 with a growth rate of 15 %. According to this estimate about 50, 000 tones of such e-waste which is imported from developed countries as a gesture of charity for reuse is basically recycled informally either immediately or after discarding the reused product. It has become difficult for custom department to put a stop to illegal inflow of e-waste because of no availability of specific measures and policies**[21].** 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 tones of WEEE comprising of PC, television, washing machine and refrigerators are expected to generate during the period of 2007-11**[22].**

Take back policy in India: Some of the well renowned companies like Apple, Sony, PCS, Philips, Microsoft, Panasonic, Sony Ericsson and Toshiba, HCL have adopted take back policy option at their production plant. HCL and WIPRO have the best take back policy in India. Even Nokia, Acer, Motorola are follow the policy at a good pace. But with such large population only one collection centre is not sufficient. Even a big company like Samsung claim to have a take back service but only one collection centre in India**[23]**.

Sources of e-waste

Manufacturer: According to surveys conducted about 50% of PC's which are sold all over the country are basically from the secondary market and are reassembled on the old components. The rest of market share cover by MNC's (30%) and Indian brands (20%)**[24]**. Besides manufacturers are major contributors of e-waste. The waste consists of defective IC chips, motherboards, CRTs and other peripheral items produced during the production process. It also includes defective PCs under guarantee procured from consumers as replacement items.

Consumer: About 22% of junk computers are generated from Indian household[25]. The routine process of getting rid of obsolete computers include exchanging from retailers or pass on the same to friends or relatives. The business sector accounts for 78% of all installed PC's in India[25]. The junk computers from business sector are often sold during auction or sometimes donated to educational institutes or charitable institutions for reuse.

Import of e-waste: Import of e-waste is legally prohibited no doubt the reports prove that lots of e-waste is imported from abroad. The ministry of environment has no data related to import of e-waste but above says that 100% control of the borders is not possible.

Table-3
E- Waste / WEEE Generation in Top Ten Cities

S. No.	States	WEEE (Tones)	S. No.	States	WEEE (Tones)
1.	Maharashtra	20270.59	6.	Delhi	9729.15
2.	Tamil Nadu	13486.24	7.	Karnataka	9118.74
3.	Andhra Pradesh	12780.33	8.	Gujarat	8994.33
4.	Uttar Pradesh	10381.11	9.	Madhya Pradesh	7800.62
5.	West Bengal	10059.36	10.	Punjab	6958.46

Table-4
E- Waste / WEEE Generation in Top Ten States

S. No.	City	WEEE (Tones)	S.No.	City	WEEE (Tones)
1.	Mumbai	11017.1	6.	Ahmadabad	3287.5
2.	Delhi	9730.3	7.	Hyderabad	2833.5
3.	Bangalore	4648.4	8.	Pune	2584.2
4.	Chennai	4132.2	9.	Surat	1836.5
5.	Kolkata	4025.3	10.	Nagpur	1768.9

Source: E-Waste Management in India- Consumer Voice, April 2009

India a dumping ground: A large producer of e-waste is U.S. About 315 million obsolete computers were dumped by US in between 1997 – 2004. A smaller amount of e-waste comes from Japan, Republic of Korea, and Europe. Additionally considerable quantities of e-waste are reported to be imported[26]. But exact figures on the amount of e-waste and their sources has not been confirmed as most of it imported on the pretext that it is reusable or it is being donated to developing countries.

End-of-life products find their way to recycling yards in countries such as India and China, where poorly-protected workers dismantle them, often by hand, in appalling conditions. About 25,000 workers are employed at scrap-yards in Delhi alone, where 10,000 to 20,000 tons of e-waste is handled every year, with computers accounting for 25 percent of it[27]. Other e-waste scrap-yards exist in Meerut, Firozabad, Chennai, Bangalore and Mumbai.

"Trade in e-waste, like that in other scrap, is dominated by the 'informal' sector. Although the waste trade sector in India is known as part of the 'informal' sector, it has a system that is highly organized with extensive co-ordination in an established network," says K.K. Shajahan, principal consultant for Bangalore's Indian Institute of Material Management.

Only 3% of total WEEE-waste generated is recycled properly in India. The rest of it is handled by workers who work with bare hands, without masks under unhygienic conditions, informally recycling tons of e-waste for about 12-14 hours a day. The workers which are involved in collection and recycling come from socially and economically poor families. Most of them are landless or small farmers. None of the labour laws or environmental laws is implemented while using this rudimentary tech. As a result it causes health hazards to the workers and pollutes the environment.

About 80 percent of the e-waste generated in the US is exported to India, China and Pakistan, and unorganized recycling and backyard scrap-trading forms close to 100 percent of total e-waste processing activity.

Many of India's corporations burn e-waste such as PC monitors, PCBs, CDs, motherboards, cables, toner cartridges, light bulbs and tube-lights in the open along with garbage, releasing large amounts of mercury and lead into the atmosphere

There is an urgent need for improvement in e-waste management covering technological improvement, institutional arrangement, operational plan, protective protocol for workers working in e-waste disposal and last but not the least education of general population about this emerging issue posing a threat to the environment as well as public health[28]. Developed countries like USA, Europe and Japan have adopted fully automated, high cost technology for E-waste recycling[29]. E-waste is crushed, shredded in total, followed by separation of metals and non-metals by adopting unit operations/metallurgical principles[30].

The Huge Amount of E-Waste Not Recycled Can Be Accounted For By: Storage: As a common practice most of the old electronic goods are stored by people in the houses due to this the chances of being effectively used are reduced to a greater extent.

Landfill/Incineration: Most the people in the Indian house hold mix domestic and electronic waste together, which ends up in a landfill or is being incinerated. Hence lot of toxic chemicals are produced which pollute the environment.

Reuse and Export: The developed nations export old computers and phones to the developing countries for reuse and recycling. This is recycled using informal recycling and is a major cause of spreading pollution.

Existing Legislation[31]

Factories Act 1948: There are several contaminants arising out from manufacturing or recycling of electronic components and are listed in this Act.

Environmental Protection Rules 1986 (amended till 2004): There is no direct standard, which can address pollutants from an electronics manufacturing or recycling industries. However certain PCB units fall in electroplating category and are therefore required to be abide by the effluent disposal norms as given in schedule 1 of this rules

Table-5
Hazards of E-Waste

e-waste Components	Process	Potential Occupational Hazard	Potential Environmental Hazard
Cathode ray tubes (CRTs)	Breaking and removal of copper yoke and dumping.	• Silicosis. Inhalation or contact with phosphor containing cadmium or other metals.	Lead, Barium and other heavy metals leaching into groundwater, release of toxic phosphor.
Printed circuit boards	Disordering and removing computer chips.	• Tin and lead Inhalation. Possible brominated dioxin, beryllium, cadmium, mercury Inhalation.	Air emission of Same substances.
Dismantled printed circuit board processing.	Open burning of waste boards to remove inside metals.	• Toxicity to workers and nearby residents from tin, lead, brominated dioxin, beryllium, cadmium and mercury inhalation. • Respiratory irritation.	Tin and lead Contamination of immediate Environment including surface and ground waters. Brominated Dioxins, beryllium, cadmium and Mercury emissions.
Chips and other gold plated Components.	Chemical stripping using nitric and hydrochloric acid along river banks	Acid contact with eyes, skin may result in permanent injury. • Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases can cause respiratory irritation to severe effects including pulmonary edema, circulatory failure and death.	Hydrocarbons, heavy metals, brominated substances, etc., discharged directly into river and banks. Acidifies the river destroying fish and flora.
Plastics from Computer and peripherals e.g. printers keyboards, etc.	-	-	Emissions of Brominated dioxins and heavy metals and hydrocarbons.
Shredding and low temperature melting to be reutilized in poor grade plastics.	Probable hydrocarbon, Brominated dioxin and heavy metal exposure.	Brominated and chlorinated dioxin, polycyclic aromatic Hydrocarbons (PAH) are carcinogenic to workers living in the burning works area.	Hydrocarbon ashes including PAHs discharged to air, water and soil.
Miscellaneous computer parts encased in rubber or plastic e.g. steel rollers	Open burning to recover steel and other metals.	Hydrocarbon including PAHs and potential dioxin exposure.	Hydrocarbon ashes including PAHs discharged to air, water and soil.
Secondary steel or copper and precious metal smelting	Furnace recovers steel or copper from waste including organics	Exposure to dioxins and heavy metals.	Emission of dioxins and heavy metals.

Hazardous waste (management and Handling) rules 1989, amended in 2003: Schedule 2 of this act can be applied for the disposal of e-waste. Schedule 3 entry at SI. No. A1180: Waste electrical and electronic assemblies (For EXIM i. e. Export Import) Schedule 3 entry at SI. No. B1110: Electrical and electronic assemblies not valid for direct reuse but for recycling (For EXIM)

Hazardous Waste (management, Handling and Transboundary movement) rules 08: Part A of Schedule III (Basal No. 1180) consists of list of e-waste applicable for import with prior informed consent. Part B of schedule III (Basal No. 1110) deals with list of e-waste applicable for import and export not requiring prior informed consent**.**

Basal Convention: The Basal convention on the control of transboundary movements of hazardous wastes and their disposal, adopted by a conference in Basal (Switzerland) in 1989, was developed under UNEP**.**

The Basel Convention [32]: Regulating the E-Waste Trade: The 1992 Basel Convention is an international treaty signed by 169 countries to regulate the international trade of hazardous waste. The Convention's central goal is "environmentally sound management" (ESM), which involves controlling hazardous waste from its production to its storage, transport, reuse, recycling, and final disposal. In addition, the Basel Ban Amendment was adopted in 1995 to outlaw the transfer of hazardous waste from developed to developing countries. The Amendment has not yet entered into force, but several countries have already implemented the ban, including the European Union and China. However, illegal trading is pervasive and those who benefit from the waste trade continue to strongly oppose a global ban with European Union`s (EU) directives such as WEEE and restriction of Hazardous substances (ROHS) coming into effect from 2006 in Europe. E-waste recycling is increasingly receiving a major trust.

The motive of defining such guidelines is efficient recovery of useful components but also to safeguard the environment from harmful toxic substances such as lead, cadmium, mercury, asrsenic hexavalent chromium and other brominated flame retardants (BFRs)[33] that are present in WEEE. These poisonous substances not only have harmful effect on the people recycling them but they also are the main source of environmental and ecological degradation.

E-waste Hazards

Lots of toxic metals and chemicals can be found in e-waste. If they are not treated properly or not recycled in a proper way even disposed off in landfills they can cause adverse effects on human health and environment as they can leach into the surrounding soil, water and the atmosphere. Waste contains poisonous substances like Pb, Sn, and Hg etc. which give rise to sever diseases like cancer, birth defects, neurological and respiratory disorders. The ill effects of certain poisonous substances are represented here in table 5.

In view of the environmental problems involved in the management of WEEE, many countries and organizations have drafted national legislation to improve the reuse, recycling and other forms of recovery of such waste to reduce the amt. of requiring disposal required. However, the recycling of WEEE is still in its infancy.

Conclusion

The challenges of managing E-waste in India are very different from those in other countries, both the developed and developing. No doubt, there can be several shared lessons; the complexity of the E-waste issue in India, given its vast geographical and cultural diversity and economic disparities, makes WEEE management challenges quite unique. A few of these are:

Rapidly increasing E-waste volumes, both domestically generated as well as through imports. Imports are often disguised as second-hand computer donations towards bridging the digital divide or simply as metal scrap.

No accurate estimates of the quantity of E-waste generated and recycled. Low level of awareness amongst manufacturers and consumers of the hazards of incorrect E-waste disposal. Widespread E-waste recycling in the informal sector using rudimentary techniques such as acid. E-waste workers have little or no knowledge of toxins in E-waste, and are exposed to serious health hazards. Inefficient recycling processes result in substantial losses of material value. The major problem we face in India there is no such technology or clear policy/guidelines to check the disposal of e-waste. E-waste is mostly recycled by backyard practioners.

Recycling of e-waste: Recycling WEEE is an important subject not only from the view point of waste treatment but also in terms of recovery of valuable waste materials. Mechanical/physical processing provides an alternative means of recovering valuable materials but several difficulties exist. The main difficulty, industries have to afford is the separation of the different material in WEEE. This problem leads to several approaches to optimize the process.

One of the most successful is the definition of separation systems based on the physical – chemical properties of materials to make recycling of material constituting WEEE economically profitable[34,35]

Amount of plastics in e-waste obtained from computer: The data available shows that the major portion of WEEE comes from computer bodies and computer monitors.

Five hundred million PCs contain approximately 2,872,000 t of plastics, 718,000 t of lead, 1363 t of cadmium and 287 t of mercury[36]. This may also contain 861 t of hexavalent chromium[37.] E-plastics account for about 15-22% of the weight of WEEE out of which one third is suitable for mechanical recycling and 2/3rd needs to dispose by other means[38].

The recycling of this plastic waste generally involves low level processing such as granulation or pelletization followed by melt or partial melt and extrusion to form the end product. E-plastic waste rather difficult to recycle: Because of diversity of polymeric materials used. E. g thermoplastics as well as thermosets and relatively high levels of flame retardants (halogen containing compounds) added during production. When we try to recover the plastic material from discarded electronic devices, we have to take into account the usual high halogen contents resulting from the addition of flame retardants. Thermoset polymer cannot be remolded or reprocessed by remelting. Thermoset composite contain high amount of inorganic glass reinforcement or mineral filler. Fire retardants are used with-plastic material in order to increase fire safety when generates toxic substance during combustion. The miniaturization of electronic equipment reduces the volume of waste make collection, repair and recycling more difficult.

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