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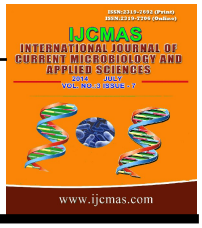

Review Article

Environmental Impacts and Assessment of Electronic Waste Management

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A B S T R A C T

E-waste has been escalating rapidly with the rise of the information society. It is the fastest growing sector of the municipal solid waste stream. Every year, according to the United Nations Environment Program (UNEP, 2005), 20 to 50 million tons of electrical and electronic equipment wastes are generated worldwide. 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 The existing management practices related to E-waste in India are reasonably poor and have the potential to risk both human health and the environment. The paper gives an insight into various sources of E-waste generation, it's composition along with health and environmental hazards caused by E-waste. The paper also discusses the national and international scenario of E-waste.

Introduction

According to the OCED (Organization for Economic Cooperation 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 (Reena, G and Sangita, V. K., 2011).

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 (Davis, G and Heart, S. 2008). In India alone, 330 thousand tones of e-waste generated in 2007, which has rise to about 470 thousand tons by 2011 (Raghupathy, L et al 2010). The information communication technology (ICT) revolution, global economic progress, coupled with urbanization and insidious appetite for consumer electronics such as personal computers (PC), cell phones and home electronics has increased both the

consumption of EEE and the production e-waste. The main problem with e-waste generated from PCs is the fact that computers are manufactured from over 1,000 different materials. Some of these materials are toxic and not only cause environmental pollution but have been linked to human health problems. (Raghupathy, L et al 2010).

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. (Cui, J and Zhang. L. 2008). 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.

Manufacturer

Around 1,050 tonnes of electronic scrap is being produced by manufacturers and assemblers in a single calendar year. 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%) (Annual report, MAIT 2003). 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 (Reena, G and Sangita, V. K., 2011).

Consumer

About 22% of junk computers are generated from Indian household. 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 www.toxicslink.org 2004. The junk computers from business sector are often sold during auction or sometimes donated to educational institutes or charitable institutions for reuse. Due to innovative products and offers, the life cycles of products are shrinking. Attractive market offers push customer to buy new product rather than upgrading new one.

Import of E-waste

Import of e-waste is legally prohibited but it is still continued. reports prove that lots of e-waste is imported from abroad. Of the e-waste imported into India, it is estimated that approximately 80% is imported from the US, while the remaining 20% is predominantly imported from the EU (Pratap, A. 2009).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 (www.toxicslink.org 2004) 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.

Global scenario

Escalating rapidly with the rise of the information society. It is the fastest

growing sector of the municipal solid waste stream. E-waste equals 1% of solid waste on average in developed countries. In developing countries, E-waste range from 0.01% to 1% (Quarterly News 2006). Every year, according to the United Nations Environment Program (UNEP, 2005), 20 to 50 million tons of electrical and electronic equipment wastes are generated worldwide. In 1994, approximately 20 million Personal Computers (PCs) become obsolete worldwide and in 2004 it had increased to 100 million PCs (Quarterly News 2006). The EPA (Environmental Protection Act) estimates that 29.9 million desktops and 12 million laptops were discarded in 2007. According to the EPA, in 2008, 3.16 million tons of E-waste in the U.S. was generated and only 430,000 tons or 13.6 % of this amount was recycled. The rest was trashed in landfills or incinerators. The total E-waste increased from 3.01 million tons of e-waste generated in 2007, but the recovery rate stayed at 13.6%. Some 20 to 50 million metric tonnes of E-waste are generated worldwide every year, comprising more than 5% of all municipal solid waste. (EPA 2008).

Indian scenario

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. The preferred practice to get rid of obsolete electronic items in India is to get them in exchange from retailers when purchasing a new item. The business sector is estimated to account for 78% of all installed computers in India (www.toxicslink.org 2004). It is estimated that the total number of obsolete personal computers emanating each year from business and individual households in India will be around 1.38 million. 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 (CII 2006). 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 Jha, M. K et al., (2011). These figures have been shown through the table 3.

E-Waste Management

The best option for dealing with E wastes is to reduce the volume. Recycling and reuse of material are the next level of potential options to reduce e-waste (Ramachandra, T.V and Saira, V. K. 2004).Recovery of metals, plastic, glass and other materials reduces the magnitude of e-waste. These options have a potential to conserve the energy and keep the environment free of toxic material that would otherwise have been released. Extended Producer Responsibility (EPR) and Advance Recycling Fee (ARF) are the backbone of e-waste management system in Switzerland and other developed countries (Wath, S.B, et al 2010). According to EU directives (2003), it is mandatory for all 27 countries of European Union to recycle their e-waste. Basel Convention is also nice step taken by UNEP to control the international trading of hazardous waste and India is also signatory to this (Williams, E et al., 2008), (Pinto, V, N. 2008).

i. Extended producer responsibility

Extended Producer Responsibility (EPR) is being propagated as a new paradigm in waste management. The OECD defines EPR as an environmental policy approach in which a producer's responsibility for a product is extended to the post consumer stage of the product's life cycle, including its final disposal (OECD. Extended producer responsibility 2001). Keeping in line with the Polluter-pays Principle, an EPR policy is characterised by the shifting of responsibility away from the municipalities to include the costs of treatment and disposal into the price of the product, reflecting the environmental impacts of the product. Legislators are increasingly adopting EPR policies to manage various kinds of wastes, such as discarded cars, electrical and electronic appliances and batteries, which require special handling and treatment (OECD. Extended producer responsibility 2001)

ii. E-waste recycling

Many discarded machines contain usable parts which could be salvaged and combined with other used equipment to create a working unit. It is labor intensive to remove, inspect and test components and then reassemble them into complete working machines. 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. These facilities should be approved by the regulatory authorities and if required provided with appropriate incentives. Establishment of e-waste collection, exchange and recycling centers should be encouraged in partnership with governments, NGOs and manufacturers (OECD. Extended producer responsibility 2001).

iii. Capacity building, training and awareness programmes

The future of e-waste management depends not only on the effectiveness of local government, the operator of recycling services, but also on the attitude of citizens. Collaborative campaigns are required to sensitise the users and consumers should pay for recycling of electronic goods. Consumers are to be informed of their role in the system through a labelling requirement for items. Consumers should be educated to buy only necessary products that utilize some of the emerging technologies such as lead-free, halogen-free, recycled plastics product. Awareness raising programmes and activities on issues related to the environmentally sound management (ESM), health and safety aspects of e-wastes in order to encourage better management practices should be implemented for different target groups (OECD. Extended producer responsibility 2001)

Health Impacts of E-Wastes

E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidney and bones, and the reproductive and endocrine systems, and some of them are carcinogenic and neurotoxic.

Table.1 Composition of metals for different e-scrap samples (Jha, M. K et al 2011)

S.No	Electronic waste	Weight (%)					Weight (ppm)		
		Fe	**Cu**	**Al**	**Pb**	**Ni**	**Ag**	**Au**	**Pd**
1.	TV board scrap	28	10	10	1	0.3	280	20	10
2.	PC board scrap	7	20	5	1.5	1	1000	250	110
3.	Mobil phone scrap	5	13	1	0.3	0.1	1380	350	210
4.	Portable audio scrap	23	21	1	0.14	0.03	150	10	44
5.	DVD player scrap	62	5	2	0.1	0.05	115	15	4
6.	Calculator scrap	4	3	5	0.1	0.5	260	50	5
7.	PC main boar scrap	4.5	14.3	2.8	2.2	1.1	639	566	124
8.	Printed circuit board scrap	12	10	7	1.2	0.85	280	110	NR
9.	TV scrap (CRTs removed)	NR	3.4	1.2	0.2	0.038	20	<10	<10
10.	Electronic scrap	8.3	8.5	0.71	3.15	2.0	29	12	NR
11.	PC scrap	20	7	14	6	0.85	189	16	3
12.	Typical electronic scrap	8	20	2	2	2	2000	1000	50
13	E- scrap sample 1	37.4	18.2	19	1.6	NR	6	12	NR
14.	E- scrap sample 2	27.3	16.4	11.0	1.4	NR	210	150	20
15.	Printed circuit board	5.3	26.8	1.9	NR	0.14	3300	80	NR
16.	e-scrap (1972 sample)	26.2	18.6	NR	NR	NR	1800	220	30
17.	E-waste mixture	36	4.1	4.9	0.29	1.0	NR	NR	NR

Note: NR: not reported

Table.2 E-Waste Generation in India

S.No.	**Components**	**Generated**	**Avail. for Recycling**	**Processed**
1.	Computers	56,324	24,000	12,000
2.	Cellular Phones	1,655	143	7,000
3.	Televisions	2,75,000	70,000	–
4.	Imports	–	50,000	–
	Total	**3,32,979**	**1,44,143**	**19,000**
Note : All data in MT;				

Source : MAIT

Table.3 WEE Generating Top Ten State (Reena, G and Sangita, V. K., 2011)

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

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

Table.4 Effects of E-waste constituent on health (Sastry, Murthy V.R., 2012)

S.No	Source of e-wastes	Constituent	Health effects
1.	Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (PB)	➢ Damage to central and peripheral nervous systems blood systems and kidney damage. ➢ Affects brain development of children.
2.	Chip resistors and semiconductors	Candmium (CD)	➢ Toxic irreversible effects on human health. ➢ Accumulated in kindly and liver. ➢ Causes neural damage. ➢ Teratogenic
3.	Relays and switches, printed circuit boards	Mercury (Hg)	➢ Chronic damage to the brain. ➢ Respiratory and skin disorders due to bioaccumulation in fishes.
4.	Corrosion protection of untreated and galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr) VI	➢ Asthmatic bronchitis. ➢ DNA damage.`
5.	Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes ➢ Reproductive and developmental problems; ➢ Immune systems damage; ➢ Interfere with regulatory hormones
6.	Plastic housing of electronic equipments and circuit boards.	Brominated flame retardants (BFR)	➢ Disrupts endocrine system function
7.	Front panel of CRTs	Barium (Ba)	Short term exposure causes: ➢ Muscle weakness; ➢ Damage to heart, liver and spleen.
8.	Motherboard	Beryllium (Be)	➢ Carcinogenic (lung cancer) ➢ Inhalation fumes and dust. Causes chronic beryllium disease of beryllicosis. ➢ Skin diseases such as warts.

A study conducted by Greenpeace in 2005 in electronic recycling yards in Delhi clearly indicates the presence of high levels of hazardous chemicals including deadly dioxins and furans in the areas where this primitive recycling takes place. Workers in e-waste disposal sector are poorly protected against the risk of it Saoji, A. (2012).

Environmental Impacts of E-Wastes

Electronic wastes can cause widespread environmental damage due to the use of toxic materials in the manufacture of electronic goods Mehra, H, C. (2004)e-waste contains toxic substances such as Lead and Cadmium in circuit boards; lead oxide and Cadmium in monitor Cathode Ray Tubes (CRTs); Mercury in switches and flat screen monitors; Cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and polyvinyl chloride (PVC) cable insulation that releases highly toxic dioxins and furans when burned to retrieve Copper from the wires (Devi, et al., 2004).

Landfilling 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 (Ramachandra, T.V and Saira, V. K. 2004). The cadmium from one mobile phone battery is enough to pollute 600 m3 of water Trick, J. (2002). In addition, uncontrolled fires may arise at landfills and this could be a frequent occurrence in many countries.

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