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A Review Paper on E-Waste Management

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***Abstract**: Electronic waste or e-waste is one of the rapidly growing Problems of the world. E-waste comprises of a multitude of components, some containing toxic substances that can have an adverse impact on human health and the environment if not handled properly. In India, e-waste management assumes greater significance not only due to the generation of its own e-waste but also because of the dumping of e-waste from developed countries. This is coupled with India's lack of appropriate infrastructure and procedures for its disposal and recycling. This review article provides a concise overview of India's current e-waste scenario, namely magnitude of the problem environmental and health hazards, current disposal and recycling operations, existing legal framework organizations working on this issue and recommendations for action.*

***Keywords:** E-waste, disposal and recycling, legal frame work*

I. Introduction

E-waste refers to discarded electrical and electronic equipment (EEE). "E-waste is electronic waste. It includes a broad and growing range of electronic devices from large household appliances such as refrigerators, air conditioners, hand-held cellular phones, personal stereos, consumer electronics and computers. E-waste is hazardous, and it is generated rapidly due to the extreme rate of obsolescence. E-waste contains over 1,000 different substances, many of which are toxic, and creates serious pollution upon disposal. These toxic substances include lead, cadmium, mercury, plastics, etc."

In terms of production, internal consumption and electronics export industries have emerged as the fastest growing segment of Indian industry. In the last five years (1995-2000), the Indian IT industry has recorded a CAGR (Compounded Annual Growth Rate) of more than 42.4 per cent, which is almost double the growth rate of IT industries in many of the developed countries. In the IT action plan, the government has targeted to increase the present level of penetration, from 5 per 500 people to 1 for 50 people, by 2008. This envisages applying IT in every walk of the economic and social life of the country.

When compared to the USA, the Indian configuration of 5 PCs per 500 people does not represent any sign of massive rise in PCs' obsolescence rate. But of the nearly 5 million PCs in India, 1.38 million are either 486s or below. This figure represents a vast amount of equipment soon to be added to the waste stream as up gradation beyond a point becomes uneconomical and incompatible with software in demand. In any case, this invisibility has started blurring with the huge import of junk computers that, in turn, create ugly situations for solid waste management in India. The biggest source of PC scrap are foreign countries that export huge quantities of computer waste in the form of monitors, printers, keyboards, CPUs, typewriters, PVC wires, etc.

After separating all remaining components, motherboards are put for open pit burning to extract the thin layer of copper foils laminated in the circuit board.

Although it is hardly well known, E-waste contains a witches' brew of 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 release highly toxic dioxins and furans when burned to retrieve copper from the wires. Due to the hazards involved, disposing and recycling E-waste has serious legal and environmental implications. These materials are complex and difficult to recycle in an environmentally sound manner even in well-developed countries. The recycling of computer waste requires sophisticated technology and processes, which are not only very expensive, but also need specific skills and training for the operation.

In India, most of the recyclers currently engaged in recycling activities do not have this expensive technology to handle the waste. Computer scrap is managed through various management alternatives such as product reuse, conventional disposal in landfills, incineration and recycling. However, the disposal and

recycling of computer waste in the country has become a serious problem since the methods of disposal are very rudimentary and pose grave environmental and health hazards. In addition, besides handling its own computer waste, India now also has to manage the waste being dumped by other countries. Solid waste management, which is already a mammoth task in India, has become more complicated by the invasion of e-waste, particularly computer waste.

The problems associated with e-waste in India started surfacing after the first phase of economic liberalization, after 1990. That year witnessed a shift from in economic policy in turn triggering off an increase in the consumption pattern. This period also witnessed a shift in the pattern of governance. It ushered in an era of infrastructure reform and e-governance. This shift is marked by the application of information technology in a big way in all areas. These developments, along with indigenous technological advancement, have lead to an addition of wide gamut of e-waste churned out from Indian households, commercial establishments, industries and public sectors, into the waste stream. Solid waste management, which is already a mammoth task in India, has become more complicated by the invasion of e-waste, particularly computer waste to India, from different parts of the world.

The import of hazardous waste into India is actually prohibited by a 1997 Supreme Court directive, which reflects the Basel Ban. The developed world, however, finds it more convenient and also economical to export e-waste to the third world countries like India, rather than managing and incurring high environmental and economic cost. Primary investigations carried out for Basel Action Network revealed that indigenous as well as imported computer waste has lead to the emergence of a thriving market of computer waste products and processing units for material recovery in different parts of India. So trade in e-waste is camouflaged and is a thriving business in India, conducted under the pretext of obtaining 'reusable' equipment or 'donations' from developed nations.

Highly toxic chemicals found in the different components of computer parts can contaminate soil, groundwater and air, as well as affect the workers of the unit and the community living around it. Moreover, the workers in computer waste recycling operations may face dangerous working conditions where health and environmental conditions are compromised. Hence there is a clear reason to be concerned about the trade, the technology in practice and the existing poor disposal practices of computer waste in India.

The management of electronic waste has to be assessed in the broad framework of Extended Producer Responsibility and the Precautionary Principle, so that future policies can be made more responsive in addressing this issue. At present, management options for e-waste are extremely polluting and hence are of grave concern. This problem has assumed a global dimension, of which India is an integral and affected part. Interventions to check the polluting systems of recycling and give viable options for better management of computer waste can best be suggested only after as assessment is done.

Against this backdrop, New Delhi based Toxics Link (an environmental non-government organization and the author's of this article) conducted a study to bridge the gap in understanding and knowledge of the computer scraps' trade and its reprocessing technology. The study looked at the market, the nature and present practice of reprocessing of computer waste components and government policies for e-waste management. Due to the growing computer waste, the use of hazardous chemicals in the production process, the intricacies involved in the recycling process, and illegal dumping in India, the report focused on computer waste. It further gives recommendations in the broad framework of Extended Producer Responsibility and the Precautionary Principle so that future policies can be made more responsive in addressing this issue.

II. Magnitude Of The Problem

Studies so far reveal that the total e-waste generation in India is approximately 1,46,000 tonnes 3.3 lakh tonnes a year and is expected to touch 4.7 lakh tonnes by 2011. Of the total e-waste generated in the country, western India accounts for the largest population at 35%, while the southern, northern and eastern regions account for 30, 21 and 14% respectively. The top states in order of highest contribution to waste electrical and electronic

equipment (WEEE) include Maharashtra, Andhra Pradesh, Tamil- Nadu, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat Madhya Pradesh and Punjab. The city-wise ranking of the largest WEEE generators is Mumbai, Delhi, Bangalore, Chennai, Kolkatta, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. Total WEEE generation in Maharashtra is 20,270.6 tonnes, of which Navi Mumbai contributes 646.48 tonnes, Greater Mumbai 11,017.06 tonnes, Pune 2584.21 tonnes and Pimpri- Chinchwad 1032.37 tonnes. An estimated 30,000 computers become obsolete every year from the IT industry in Bangalore alone.

Home to more than 1200 foreign and domestic technology firms, Bangalore figures prominently in the danger list of cities faced with e-waste hazard. Over 1 million poor people in India are involved in the manual recycling operations. Most of the people working in this recycling sector are the urban poor with very low literacy levels and hence very little awareness regarding the hazards of e-waste toxins. There are a sizeable number of women and children who are engaged in these activities and they are more vulnerable to the hazards of this waste. The following three categories of WEEE account for almost 90% of the generation:

1. Large household appliances: 42%,
2. Information and communications technology equipment: 33.9% and
3. Consumer electronics: 13.7%

III. Health And Environmental Impact Of E-Waste

EEEs are made of a multitude of components, some containing toxic substances that have an adverse impact on human health and the environment if not handled properly. Often, these hazards arise due to the improper recycling and disposal processes used.

It can have serious repercussions for those in proximity to places where e-waste is recycled or burnt. Waste from the white and brown goods is less toxic as compared with grey goods. A computer contains highly toxic chemicals like lead, cadmium, mercury, beryllium, BFR, polyvinyl chloride and phosphor compounds.

Lead:-

Exerts toxic effects on various systems in the body such as the central (organic affective syndrome) and peripheral nervous systems (motor neuropathy), the hemopoietic system (anemia), the genitourinary system (capable of causing damage to all parts of nephron) and the reproductive systems male and female).

Mercury:-

It Causes damage to the genitourinary system (tubular dysfunction), the central and peripheral nervous systems as well as the fetus. When inorganic mercury spreads out in the water, it is transformed into methylated mercury, which bio- accumulates in living organisms and concentrates through the food chain, particularly by fish.

Cadmium:-

It is a potentially long-term cumulative poison. Toxic cadmium compounds accumulate in the human body, especially in the kidneys. There is evidence of the role of cadmium and beryllium in carcinogenicity.

Polycyclic aromatic hydrocarbons (PAH):-

Affects lung, skin and bladder. Epidemiological studies in the past on occupational exposure to PAH provide sufficient evidence of the role of PAH in the induction of skin and lung cancers.

IV. E waste hazards

As shown in Table bellow;

Table No.1

Computer/e waste Component	Process	Potential occupational hazard	Potential environment hazard
Cathode ray tube.	Braking removal for copper yoke.	Silicosis. Cuts from CRT glass. Inhalation or contact with phosphor containing cadmium or other metals.	Lead, barium and other heavy metals leaching into ground water and release of toxic phosphor.
Printer circuit board.	Disordering & removing computer chips.	Tin and lead inhalation. Possible brominates dioxin, beryllium, and cadmium and mercury inhalation.	Air emission of the same substances.
Dismantled printed circuit board processing.	Open burning of waste board.	Toxicity of workers and nearby residents from tin, lead brominates dioxin, beryllium, and cadmium and mercury inhalation.	Tin and lead contamination of immediate environment including surface and ground waters, brominates dioxin, beryllium, and cadmium and mercury inhalation.
Chips and other gold plated compounds.	Chemical stripping using nitric and hydrochloric acid along riverbanks.	Acid contact with eyes, skin may result in permanent injury. Inhalation if mists and fumes of acids chlorine and sulfur dioxide gasses can cause respiratory irritation to sever effects, including pulmonary edema, circulatory failure and death.	Hydrocarbons, heavy metals, brominated substances etc. discharge directly into river and banks. Acidifies the river destroying fish and flora.
Plastics from the computer and peripherals.	Shredding and low temperature melting.	Probable hydrocarbon brominates dioxin and PAH exposure to workers living in the burning works area.	Emission of brominated dioxin and heavy metals and hydrocarbons
Secondary steel or copper and precious metal smelting wires.	Furnace recovers steel or copper from waste Open burning to recover copper.	Exposure to dioxin and heavy metals. Brominated and chlorinated dioxin and PAH exposure to workers living in the burning works area.	Emission of dioxin and heavy metals. Hydrocarbon and ashes, including PAHs discharged into air, water and soil.

V. Organizations/Networks Working On E-Waste Issues Within India

5.1. Knowledge bank for e-waste management in India. The Asia Pro Ecoprogramme supported by the European Commission is dedicated to the environmental performance in Asian Economic sectors through the exchange of environmental policies, technologies and practices and to promote sustainable investment and trade between the European Union Member States and South Asia, South-East
Asia and China.

5.2. The E-waste Guide, India (www.ewaste.in).

An Initiative of the Indo–German–Swiss Partnership [Ministryof Environment and Forests, German Federal Ministry for Economic Cooperation and Development and Swiss State Secretariat for Economic Affairs] It is designed to serve as an information resource on e-waste as well as a common collaborative work platform for stakeholders.

5.3. National Solid Waste Association of India (NSWAI)

A leading professional non-profit organization in the field of solid-waste management, including toxic and hazardous waste and also biomedical waste in India. It was formed
in 1996. Its objectives include development of solid-waste management as a profession, research and development, development of expertise, standards and goods practices with regards to solid-waste management .Some of the others include improvement in legislation and creating awareness and community involvement.

4. Toxics Link: A Delhi-based environment activist group with a mission of working for environmental justice and freedom from toxics. It is also actively involved in creating public awareness on environmental issues through publications, reports, articles and environment news bulletins besides organizing various events.

International networks

1. Silicon Valley Toxics Coalition

Formed in 1982, located in San Jose, California, it is a diverse
grassroots coalition that engages in research and advocacy
and is organized around the environmental and human health problems caused by the rapid growth of the high-tech electronics industry. The Coalition has built a united campaign of allies, including community residents, consumers, electronics and technology workers and government policy makers to raise the environmental consciousness and performance of the high-tech sector.

2. The Basel Action Network (BAN)

A global network of toxics and development activist organizations that share a vision of international environmental justice. The network seeks to prevent all forms of 'toxic trade' – in toxic wastes, toxic products and toxic technologies. It works to prevent the globalization of the toxic chemical crisis. BAN is administered by the Secretariat services of the Asia-Pacific Environmental Exchange (APEX) based in Seattle, Washington, USA. APEX is an activity of the Tides Centre.

VI. Recommendations For Action

6.1. Technical interventions

Product design and engineering interventions The solution for the e-waste crisis lies in 'prevention at the manufacturing source' or the 'precautionary principle.' This can be done by employing waste minimization techniques and by a sustainable product design.

Waste minimization in industries involves adopting:

1. Inventory management
2. Production process modification
3. Volume reduction
4. Recovery and reuse
5. Rethinking on procedures of designing the product (flat computers)
6. Use of renewable material and energy
7. Creating electronic components and peripherals of biodegradable material
8. Looking at a green packaging option
9. Utilizing a minimum packaging material

Extended Producer Responsibility is considered one of the most appropriate frameworks that amalgamate all the enlisted principles on environmental justice. This shifts the responsibility of safe disposal onto the producers. It promotes sound environmental technology and also aims at better raw material, cleaner production technology and designing for longevity.

6.2. Policy-level interventions

An integrated IT waste management policy Lack of clarity on the issue of e-waste and the inability of current hazardous waste rules to govern and effectively monitor the e-waste recycling are some of the prime reasons for experts and members of civil society demanding a separate set of rules to guide and control these processes.

Take back policies

Producers must be responsible for the entire lifecycle of their products. In developed countries, several efforts have been made on this front. Several dozen cities in the states of California and Massachusetts, including San Francisco, also have passed resolutions supporting 'producer take back' rules. Wipro InfoTech has launched an e-waste disposal service for end customers. Others offering recycling options include Dell
(dell.com), HP (hp.com) and Apple (apple.com).

6.3. Implementation and capacity building:

Legislation for collection, recycling and disposal. Legislation for collection, recycling and disposal.

Bilateral and multilateral cooperation

Formalizing the informal recycling sector.

6.3.1 Technical advantage of processes improvement(restructuring recycling) At Ash Recyclers, one of just two authorized recycling plants in Bangalore, hazardous metals are safely extracted at a special plant and everything else – down to the keys – is recycled.

6.3.2 Protective protocol for workers in e-waste disposal

Workers are given formally recognized jobs where they can use skills and where occupational health safety (information about their occupation-related health hazards involved and self protection, protective gear and equipment and periodic medical checkups) is assured.

VII. Awareness Building

The current awareness regarding the existence and dangers of e-waste are extremely low, partly because the e-waste being generated is not as large as in developed countries. Urgent measures are required to address this issue.

The role of citizens in e-waste management includes:

Donating electronics for reuse, which extends the lives of valuable products and keeps them out of the waste management system for a long time? While buying electronic products, opting for those that are made with fewer toxic constituents, use recycled content, are energy efficient, are designed for easy upgrading or disassembly, use minimal packaging and offer leasing or take back options. Building of consumer awareness through public awareness campaigns is a crucial point that can attribute to a new responsible kind of consumerism.

VIII. Preventive Measures

8.1 **Existing Legislations and Policy Related to E Waste**

Draft Hazardous Materials (Management, Handling and Transboundary movement) Rules, 2007 (dated: September 28, 2007), part of the Environment Protection Act, 1986. India is a signatory to the Basal Convention. (Basel Convention is the United Nations Environment Programme) on the control of Transboundary Movement of Hazardous wastes and their disposal.

8.2 Recycling

Individuals looking for environmentally-friendly ways in which to dispose of electronics can find corporate electronic take back and recycling programs across the country. Consumer recycling options include donating equipment directly to organizations in need, sending devices directly back to their original manufacturers, or getting components to a convenient recycler or refurbished.

In developed countries, electronic waste processing usually first involves dismantling the equipment into various parts (metal frames, power supplies, circuit boards, plastics), often by hand. The advantages of this process are the human's ability to recognize and save working and repairable parts, including chips, transistors, RAM, etc. The disadvantage is that the labor is often cheapest in countries with the lowest health and safety standards.

IX. Conclusion

India is placed in a very interesting position. The need of the hour is an urgent approach to the e-waste hazard by technical and policy-level interventions, implementation and capacity building and increase in public awareness such that it can convert this challenge into an opportunity to show the world that India is ready to deal with future problems and can set global credible standards concerning environmental and occupational health.

Reference

[1] Violet N. Pinto, *Indian Journal of Occupational and Environmental Medicine, August 2008 Volume 12, Issue 2*
[2] E-waste crisis : Around the corner, India Together, Wed 23 Dec 2009
[3] Ramesh Babu B, Parande AK, Ahmed Basha C. *Electrical and electronic waste: A global environmental problem. Waste Management Resources* 2007; 25:307-18.
[4] Sinha S. Downside of the Digital Revolution. Published in Toxics Link, 28/12/2007. Available from: http://www.toxicslink.org/art-view.
[5] Available from: http://www.cpcb.nic.in/Electronic%20Waste/Chapter1 html. Available from: http://www.cpcb.nic.in/Electronic%20Waste/ Chapter2.html.
[6] E-waste posing health hazard. Available from: http://www.hindu.co
[7] E-Waste: The next hazard wave. Consumer Voice 2007;3:6
[8] E-Waste Curriculum Development Project, The Natural Age Projects,2006
[9] Wankhede K.K.. Britain's Environment Agency confi rms huge e-waste Published in Toxics Link, 15/01/2005. Available from http://www.toxicslink.org/art-view.php?id=75.
[10] Harder B. Toxic "E-*waste" gets Cashed in Poor Nations. National Geographic News,* Nov 8, 2005. Available from: http://news.national geographic.com/news/2005/11/1108_051108_electronic_waste.html
[11] Beary H. Bangalore faces e-waste hazards. Available from: http://www. news.bbc.co.uk/1/hi/world/south_asia/4222521.stm.