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E-Waste management for sustainable development of environment

Gurcharan Dass

A Bharat Group of Colleges, Sardulgarh, Mansa, Punjab, India

Abstract
E-Waste is a collective name for discarded electronics devices that enter the waste stream from various sources. While E-Waste contains both valuable materials such as gold, palladium, silver and copper, it also contains materials such as lead, cadmium and mercury etc. that are hazardous depending on their density and condition. In the absence of suitable techniques and protective measures, recycling E-waste can result in toxic emission to air, water and soil and pose serious health and environmental hazards. Many of the E-waste can be re-used, refurnished or recycled in environment friendly manner so that they are less harmful to the eco-system. This paper brings out the hazards of E-waste, the need for its appropriate management and options that can be implemented for sustainable development of environment.

Keywords: recycling, ecosystem

1. Introduction
The electronics industry is the world's largest and fastest growing manufacturing industry. Recent policy changes in India have led to an additional tremendous influx of leading multinational companies to set up electronic manufacturing facilities and research & development centers for hardware and software in the sector. Due to strong economic growth there has been increase in consumption rates of electrical and electronic products, and higher obsolescence rates are leading to growing generation of E-waste. Of all the electronic wastes, computer-wastes are most significant due to their fast generation r ate coupled with difficult recycling process. Computer waste contains certain component which is highly toxic such as chlorinated and brominated substances, toxic gases, toxic metals, acids, plastics etc. The hazardous content of the materials pose an environment and health threat. Therefore, proper management is necessary while disposing or recycling E-waste.

1.1 Hazardous nature of E-waste
Electrical and Electronic equipment are made up of a multitude of components that contains toxic substances (over 1000). Often risk from these hazardous waste arises due to improper recycling and unsafe disposal processes used. Due to the hazards involved disposing and recycling E-waste has serious legal and environmental implication. When E-waste is land filled or incinerated, it poses serious contamination problems. Landfills leach toxins into ground water and incinerators emit toxic air pollutants including dioxins. The various hazardous constituents present in the E-waste are shown in Table 1.

1.2 Sources of E-Waste
E-waste is generated by three major sectors:
- Individuals and small businesses
- Large businesses, institutions and governments
- Original equipment manufacturers (OEMs)

Table 1: E-waste Constituents and health effects**.**

Constituents	Source of E-waste	Health effects
Lead (Pb)	Solder in printed circuit boards, Blass panels and gaskets in computer monitors	Damage to central and peripheral nervous systems and kidney damage; affects brain development of children
Cadmium (Cd)	Chip resistors and semiconductors	Toxic irreversible effects on human health; accumulates in kidney and liver; Causes neural damage, teratogenic.
Mercury (Hg)	Relay and switches, printed circuit boards	Chronic damage to the brain, respiratory and skin disorders due to bioaccumulation in fishes
Hexavalent chromium (Cr)VI	Corrosion protection of untreated and galvanized steel plates, decorator, or hardener for steel housing	Asthmatic bronchitis; DNA damage
Plastic including PVC	cabling and computer housing	Burning produces dioxin. It causes reproductive and development problems; Immune system damage; Inter face with regulatory hormones
Brominated Flame Retardants (BFR)	Plastic Housing of electronic equipment and circuit boards	Disrupts endocrine system functions
Barium (Ba)	Front panel of CRTs	Short term exposure causes:
		· Muscle weakness
		· Damage to heart, liver and spleen
Beryllium (Be)	Motherboards	Carcinogenic (Lung cancer); inhalation of fumes ad dust causes chronic beryllium disease or beryllicosis
		· Skin diseases such as warts

Individuals and Small Businesses

Electronic equipments and computers in particular, are often discarded by households and small businesses, not because they are broken but simply because new technology has rendered them obsolete or undesirable. With today's computer industry delivering new technologies and 'upgrades' to the market about every 18 months, the useful life-span of a personal computer has shrunk from for or five years down to two years. Often new software is incompatible or insufficient with older hardware so that customers are forced to buy new ones

computers via landfill and thus, this E-waste goes to the re-use/ recycling/ export market.

Original Equipment Manufacturers- OEMs generate E-waste when units coming off the production line don't meet quality standards, and must be disposed off. Some of the computer manufacturers contract with recycling companies to handle their electronic waste, which often is exported.

1.3 E-waste Generation in India

India's rate of PC obsolescence is growing dangerously. In India 2 million PCs are either of the generation represented by the chip Inter 486 or lower. As up gradation beyond a point becomes uneconomical and incompatible with new software, a vast amount of hardware will soon be added to the waste stream. Further, as most owners of these technologies are from the government, public or private sectors, they prefer replacing an old computer with a new one, rather than upgrading it. Even in the secondary market the older models have little demand. Owing to the narrowing profit margins between resale and dismantling, the sale of these computers to the scrap market for material recovery is rising.

Large Corporations, Institutions and Government:

Large users upgrade employee computer s regularly. For example, Microsoft, with over 50, 000 employees worldwide (some of whom have more than one computer) replace each computer about every three years. By law it is illegal for these large users to dispose offVarious departments of the governments, public as well as private sectors are feeding old electronic appliances into the waste stream at increasingly fast rate. Other sources of E-waste are retailers, individual households, PC manufacturing units, players of the secondary market, and imported electronic scrap from other countries. Individual households contribute the least to this, being only 20 percent of the overall market. Most it is estimated that total waste generated form Electronic and Electrical equipment (WEEE [waste electrical and electronic equipment) in India is approximately 146 000 tonners per year which is expected to exceed 1.6 million tons by 2012. The Indian states in the order of their contribution to WEEE are as follows:

Maharashtra> Andhra Pradesh> Tamil Nadu> Uttar Pradesh > West Bangal > Delhi > Karnataka> Gurjrat> Madhya Pradesh> Punjab. Cities in the order of the generation of WEEE are as follows: Mumbai> Delhi> Bangore> Chennai > Kolkata> Ahmedabad> Hyderabad> Pune> Surat> Nagpur.

2. Management of E-Waste

It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. These electronic junks lie unattended in houses, offices, warehouses etc, and normally mixed with household wastes, which are finally disposed off at landfills. This necessitates implementable management measures. In industries management of E-waste should begin at the point of generation. This can be done by waste minimization. Waste minimization in industries involves adopting.

- Inventory management
- Production-process modification
- Volume reduction
- Recovery and reuse

2.1 Inventory Management

Proper control over the materials used in the manufacturing process is an important way to reduce waste generation. By reducing both the quantity of hazardous materials used in the process and the amount of excess raw materials in stock, the quantity of waste generated can be reduced. This can be done in two ways i.e. establishing material purchase review and control procedure and inventory tracking system regularly.

2.2 Production Process Modification

Change can be made in the production process, which will reduce E-waste generation. This reduction can be made by changing the material used to make the product or by the more efficient use of input material in the production process or both. Potential waste minimization techniques can be divided into three categories:

Improved operating and maintenance procedures,

Material change and

Process-equipment modification using better production techniques.

2.3 Volume Reduction

Volume reduction includes those techniques that remove the hazardous portion of a waste from a non-hazardous portion. These techniques are usually to reduce the volume, and thus the cost disposing of a waste material.

2.4 Recovery and Reuse

This technique could eliminate waste disposal costs, reduce raw material costs and provide income from a salable waste. Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange. A number of physical and chemical the techniques are available to recover a waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. for example, a printed-circuit board manufacturer can use electrolytic recovery to recover metals from copper and tin-lead plating bath. However recycling of hazardous products has little environmental benefit if it simply moves the hazardous into secondary products that eventually have to be disposed off. Unless the goal is to redesign the product to use non-hazardous materials, such recycling is a false solution.

3. E-Waste Policy and Rules: Indian Scenerio

To counter the ever growing E-waste problem, India needs to have stringent rules and regulations in place. Over the years, the government has instituted a number of regulations for better management of hazardous waste in the country. Some of these are listed below:

- Hazardous Wastes (Management and Handling Rules 1989/2000/2002

- Ministry of Environment and Forests Guidelines for Management and Handling of hazardous wastes, 1991
- Guidelines for Safe Road Transpor of Hazardous Chemicals, 1995
- The public Liability Act, 1991
- Batteries (Management and Handling) Rules, 2001
- The National Environmental Tribunal Act, 1991
- Bio-medical Wastes (Management and Handling) Rules, 1998
- Municipal Solid Wastes (Management and Handling) Rules, 2000 and 2002.

Unfortunately, none of these regulations deal directly and specifically with E-waste. There are no specific laws or guidelines for E-waste or computer waste. Besides, flexible interpretation of the rules framed by the DGFT (Directorate General of Foreign Trade) enables the custom authorities to take on-the-spot decision and provide rule exemption.

The Basel Convention on the control of 'Transboundary Movement of Hazardous Waste and Disposal' was signed by India on 15 March 1990, and ratified and acceded to in 1992. A ratification of this convention obliges India to address the problem of transboundary movement and disposal of dangerous hazardous wastes through International cooperation. As per the Basel convention India cannot export hazardous wastes listed in the convention from the countries that have retified the ban agreement. However, the convention agreement does not restrict the import of such waste from countries that have not retified the Basel convention. It is through the orders of the Supreme Court of India that the import of such wastes is now banned in the country. The legal basis, therefore, is regulated in the 'Hazardous waste Management and Handling Rules (1989/2000 amended)'. This document also controls the import of hazardous waste from any part of the world into India. However, import of such waste may be allowed for processing or reusing as raw material. So far there is no specific legislation pertaining to the management of E-waste.

4. Management Options

Considering the severity of the problem, it is imperative that certain management options be adopted to handle the bulk E-waste. Following are some of the management options suggested for the government, industries and the public.

4.1 Responsibilities of the Government

1. Promulgate an all-embracing national E-waste management law, and an all-encompassing policy there under, for substitution the existing Hazardouswaste (Management and Handling) rules 2003.
2. Initiate the process for complete national level assessment: covering all the cities and the entire sector. Such base line study must envelope inventories, existing technical and policy measure required for emergence of national E-waste policy / strategy and action plan for eco-friendly, economic E-waste management.
3. Creation of knowledge data base on end of use full life determination, anticipating the risks, ways of preventing and protecting from likely damage and safe and timely disposal of E-waste.
4. Devise ways and means to encourage beneficial reuse/recycling of E-waste, catalyzing business activities that use E-waste.
5. Formulate and regulate occupational health safety norms for the E-waste recycling.
6. Review the trade policy and exim classification code to plug the loopholes often being misused for cross-border dumping of E-waste into India.
7. Insist on stringent enforcement against wanton infringement of Basel convention and E-waste dumping by preferring incarceration over monetary penalties for demonstrating deterrent impact.
8. Foster partnership with manufacturers and retailers environment so as to dispose E-waste scientifically at economic costs.
9. Enhance consumer awareness regarding the potential threat to public health and environment by electronic product, if not disposed properly.
10. Enforce labeling of tall computer monitors, television sets and other household/industrial electronic devices for declaration of hazardous material contacts with a view to identifying environment hazards and ensuring proper material management and E-waste disposal.
11. Announce incentives for growth of E-waste disposals agencies so that remediation of environmental damage, threats of irreversible loss and lack of scientific knowledge do not anymore pose hazards to human health and environment. Simultaneously, as proactive step, municipal bodies must be involved in the disposal of e-waste lest it becomes too late for their intervention, should large handling volumes necessitate it.
12. Consider gradual introduction of enhance producer responsibility into Indian process, practices and procedures so that preventive accountability gains preponderance over polluter immunity.

4.3 Responsibility and Role of Industries:

1. Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options.
2. All personnel involved in handling E-waste in industries should be properly qualified and trained. Companies can develop their own policies while handling E-wastes. Some are suggested below:

- Use label materials to assist in recycling (particularly plastics).
- Standardize components for easy disassembly.
- Re-evaluate 'cheap products' use, make product cycle cheap and so that it has no inherent value that would encourage a recycling infrastructure.
- Create computer components and peripherals of biodegradable materials.
- Utilize technology sharing particularly for manufacturing and remanufacturing.
- Encourage/promote/require green procurement for corporate buyers.
- Look at green packaging options.

3. Companies can and should adopt waste minimization technique; which will make a significant reduction in the quantity of E-waste generated and thereby lessening the impact on the environment.
4. Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products.

5. Manufacturers of electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products.

4.4 Responsibilities of the Citizen

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time.

But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, nor-profit organization, and lower-income families can afford to use equipment that they otherwise could not afford. E-wastes should never be disposed with garbage and other household wastes. This should be segregated at the site and sold or donated to various organizations. While buying electronics product opt for those that:

- are made with fewer toxic constituents
- use recycled content
- are energy efficient
- are designed for easy upgrading or disassembly
- utilize minimal packaging
- offer leasing or take back option
- Have been certified by regulatory authorities.

5. Conclusion

The disposal and recycling of e-waste, particularly computer and related wastes, in India, has become a serious problem since the methods of disposal are very rudimentary and pose grave environmental and health hazards. The situation is aggravated as current E-waste management and disposal methods. Suffer from a number of drawbacks like inadequate legislations, lack of fund, poor awareness, and reluctance on the part of the governments and the corporate organizations to address the critical issues. I addition, besides handling its own E-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. A plan of action for E-waste management has to address the above mentioned issues in order to come up with a sustainable solution for sustainable development of environment.

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