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Scenario of E-waste in India and application of new recycling approaches for E-waste management

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ABSTRACT

Increasing trends of e-waste implication and hazard of indecorous handling is a global menace. Both the developed and developing countries like India are going through the problem of e-waste management. The rapid growth of technology accompanied with up gradation in technical innovation and high rate of obsolescence in electronic industry has made e-waste as one of the fastest growing waste streams in the world. E-waste includes diverse range of electronic and electrical equipment's many of which contain toxic materials which can create an irreversible impact to human health and environment if improperly disposed. In this paper an attempt is made to discuss the scenario of e-waste in India and some new recycling approaches and technology for the proper management of e-waste, thereby discarding into environment is either nil or minimal. The Paper also focusses on the health hazards of e-waste and various management methods for handling this hazardous waste. Thus finding a sustainable solution for handling the mass volume of e-waste generated without creating an impact to the environment and public health is the need of the hour.

Key words: E-waste, health hazards, environmental impact, recycling approaches.

INTRODUCTION

Electronic waste or e-waste describes discarded electrical or electronic devices. Although e-waste is a general term, it covers a wide range of equipment's such as mobile phones, computers, laptops, printers, white goods like refrigerator, washing machines, dryers, home entertainment, stereo systems, toys, toasters, kettles and etc., – almost any household or business item with circuitry or electrical components with power or battery supply that have been disposed of by their original intended users forms a category of e-waste.

The Categories of E-Waste as per European Council are[1]:

- ➢ Large household appliances
- ➢ Small house hold appliances
- ➢ IT and telecommunications equipment
- ➢ Consumer equipment
- ➢ Industrial tools
- ➢ Lighting equipment
- ➢ Toys, leisure and sports equipment
- ➢ Medical devices (with the exception of all implanted radiotherapy equipment)
- ➢ Monitoring and control instruments
- ➢ Automatic dispensers

Used electronics which are destined for reuse, resale, salvage, recycling or disposal are considered as e-waste. Electronic scrap components, such as CRTs, may contain contaminants such as lead, cadmium, & beryllium, brominated flame retardant and other heavy metals makes e-waste more hazardous and toxic. Since E-Waste contains both valuable as well as hazardous materials it requires special handling and proper recycling methods.

This paper showcases the various challenges faced by the Indian nation in the handling of e-waste and some innovative recycling approaches and technology for the recovery of valuable metals, thereby toxic components getting discarded into environment is either nil or minimal. The Paper also emphasis on the health hazards due to the improper disposal of e-waste and various management methods for handling this hazardous waste. Thus finding a justifiable solution for handling the bulk volume of e-waste generated without leaving an impact to the environment and public health is the need of the hour.

Figure: 1 represents the scenario of e-waste in India

COMPOSITION OF E-WASTE

Electronic appliances are composed of hundreds of different materials that can be both toxic and equally of high value. While majority materials such as iron, aluminum, plastics and glass account for over 80 weight % of e-waste, whereas valuable and toxic materials are found in smaller quantities but are still of high importance[1-2]. The material composition of different appliances is often similar, but the percentage of different components can vary a lot.

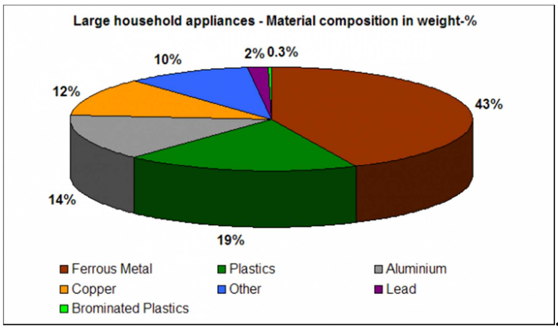

Figure: 2 represents the composition of e-waste

The precious metals such as Gold, silver, copper, platinum etc., turns recycling of e-waste into a lucrative business opportunity. On the other hand, the recycling of hazardous e-waste which possesses carcinogens such as lead and arsenic is critical and cause serious health risks and environment dangers if not properly handled.

Table 1 shows the composition of e-waste for different kind of electronic appliances

Materials	Large household appliances	Small household appliances	ICT and consumer electronics	Lamps
Ferrous metal	43	29	36	-
Aluminum	14	9.3	5	14
Copper	12	17	4	0.22
Lead	1.6	0.57	0.29	-
Cadmium	0.0014	0.0068	0.018	-
Mercury	0.000038	0.000018	0.00007	0.02
Gold	0.00000067	0.00000061	0.00024	-
Silver	0.0000077	0.000007	0.0012	-
Palladium	0.0000003	0.00000024	0.00006	-
Indium	0	0	0.0005	0.0005
Brominated plastics	0.29	0.75	18	3.7
Plastics	19	37	12	0
Lead glass	0	0	19	0
Glass	0.017	0.16	0.3	77
Other	10	6.9	*5.7*	5
Total	100	100	100	100

INDIAN SCENARIO OF E-WASTE

India generates about 4.1 million tonnes of e-waste currently and it is expected to reach8 million tonnes by 2025. In India e-waste is growing at the rate of 10% per annum and it constitutes 3- 8% of municipal solid waste[3]. At present recovery is restricted to only useful components and for precious metals such as gold, silver, copper and other metals but the rest is discarded in to environment. There are about47 recycling companies accounting for only 27% recycling of E-waste leaving 83% just into the environment.

Table 2shows the amount of e-waste generated in top ten states

S.NO	STATE	WEEE (Tonnes)
1	Maharashtra	20270.59
2	Tamil Nadu	13486.24
3	Andhra Pradesh	12780.33
4	Uttar 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

E-WASTE PROJECTION AND SCENARIO IN FOUR MAJOR CITIES

The Four main hubs where e-waste is re-cycled in the country are Delhi, Mumbai, Hyderabad and Bangalore which have been the centers of the electronics and information technology industry and they are among the top ten cities, where projection & recycling of e-waste in these four major cities are discussed below.

❖Status of e-waste in Delhi

The main factors that contribute to the thriving e-waste recycling business in Delhi - its status as the capital and hence its connectivity to all parts of the country; the many satellite towns around it, where several hundreds of small units treat e-waste; and the availability of cheap migrant labor. Nearly 70 % of electronic waste collected at recycling units in New Delhi was actually exported or dumped by the developed nations. The amount of e-waste generated is about 12,000 tonnes per annum. Though not the leading generator, Delhi is the leading e-waste processor in the country. According to the study conducted by the GTZ in 2007, there were about 25,000workers refurbishing 10,000-20,000 tonnes of e-waste annually. The work takes place in small illegal units where neither regulations nor environment or health safeguards are in place. Due to lack of facility for proper storage and disposal of such waste, it frequently results in mishaps. [4-5].

❖Status of e-waste in Mumbai

Mumbai, the financial nerve center of India and which is India's largest port city where the Information Technology industry has originated contributes20270.59tonnes of e-waste per annum. In India, Mumbai ranks first among top ten cities generating waste electrical and electronic equipment's (WEEE).The Mumbai-Pune industrial belt is one of the electronic items manufacturing hubs of the country. As a result, Mumbai is not only the port of import for new and used electronics; it is also home to a large user and manufacturer base, both generating large volumes of e-waste[6].

❖Status of e-waste in Bangalore

Bangalore, the Silicon capital of India, e-waste recycling is a multi-crore market where e-waste is received in Goripalyam and Nayandahalli. The e-waste scrap dealers send the segregated and dismantled e-waste parts to Delhi and Mumbai every alternative day. The e-waste recyclers earn around 2-3 lakhs a month from selling the dismantled e-waste to Delhi. There are nearly 50 registered recycling centers in Karnataka like M/s. E-Wardd & Co., M/s. E-Prarisaraa Pvt. Ltd., M/s. K. G. Nandini Recyclers, M/s.Ash Recyclers, and M/s. New Port Computer Services India Pvt. Ltd., E-R3 Solutions Pvt. Ltd., etc. In the formal sector, E-Prarisaraa has been encouraged by the Central and State Pollution Control Board to get replicated in all major cities in the country.

❖Status of e-waste in Hyderabad

For some time, Hyderabad has been known as the emerging Silicon capital of India. The annual e-waste generation has been estimated to be 3,263,994 MT from various kind of equipment's such as computers, printers, television and mobile phones. The breakup is as follows: 3111.25 MT from computers, 86.46 MT from printers, 61.0 MT from televisions and 5.284 MT from mobile phones. In 2010, the total e-waste projection for Hyderabad with a population of z74.42 lakh was 98,163 kg. Including 42,869 computers, 53,581 televisions and 1,713mobile phones. In 2013, with a projected population of 81.8lakh, the total e-waste volume is expected to reach 1, 07,886 kg. Including 47,117 computers, 58,890 televisions and 1,881mobile phones. Most of the e-waste collectors and recyclers only do size reduction (shredding) and segregation [7]. M/s. Earth Sense Recycle Pvt. Ltd. and M/s. Ramky E-waste Recycling Facility are two formal recycling units in Andhra Pradesh, where most of the e-waste generated ends up in informal recycling centers.

The lack of infrastructure facility to handle large volume of e-waste paves way for the evolving of informal sectors. Formal recycling is yet to take up in a big way, as business is more profitable in the unorganized sector. The unorganized sector has to be given little incentive to manage the e-waste in formal recycling units which involves the responsibility of the government [8-11].

HAZARDOUS DISPOSAL METHODS:

The traditional method used for the disposal of e-waste is land filling and incineration, where the disadvantages of the prevailing methods are discussed below.

Landfilling: This is the most common method used for the e-waste disposal. Soil is excavated and trenches are made for burying the e-waste in it. An impervious liner is made of clay or plastic with a leachate basin for collection and transferring of the leachate from the e-waste to the treatment plant. However, landfill is not an environmentally sound process for disposing off the e-waste toxic substances like cadmium; lead and mercury which are capable of contaminating the ground water and also degrades the quality of soil. [12-13].

Incineration: This is a controlled way for disposing the e-waste and it involves combustion of electronic waste at high temperature in specially designed incinerators. This e-waste disposal method is quite advantageous as the waste volume is reduced extremely much and the energy obtained is also utilized separately. However, it is not free from disadvantages like emission of the harmful gases such as dioxins and furans which are highly carcinogenic [14-15].

NEWRECYCLING METHODS: Since e-waste contains valuable metals it can rightly be called as a hazardous resource which can be recovered by using various innovative recycling technologies [16-19]. Some of the recycling methods used are

1. Hydrometallurgy
2. Pyro- metallurgy
3. Bio-metallurgy or bio-leaching
4. Electrometallurgy

Hydrometallurgy: It is also called as chemical leaching method. The method involves using a suitable chemical reagent for the dissolution of metals from e-waste. The various chemical reagents used are aqueous organic solvents, mixed acids, aqua-regia and sodium chloride. The different types of solvent used are halides, cyanides, thiourea & thiosulfate for the recovery of precious metals from e-waste. [20-22].

Pyro metallurgy: The process involves heating the electronic waste in the absence of oxygen in a specially designed reactor, resulting in zero emission and produces an energy rich liquid of good calorific value. The liquid properties can be upgraded and the final product can be used as a fuel in internal combustion engines or for running turbo engines.

- Bio-metallurgy: The method uses preparing a bio-adsorbent like activated carbon from biological organic matter and using it for adsorbing the valuable metals present in e-waste. The metals can be recovered by either decreasing the pressure or by increasing the temperature of the system. The other method involves preparing a biological solvent which can recover the valuable metals present in the e-waste. The solvent is generally prepared by using various biological matters and its properties are chemically modified such that dissolution of metals takes place when bio solvent comes in contact with e-waste.

- Electro metallurgy: It uses electro refining method. The method involves preparing an electrolyte and using suitable electrodes for the deposition of valuable metals on the surface of the electrode from e-waste.

HEALTH HAZARDS OF E-WASTE

Since e-waste is a diverse combination of various type of toxic elements, which are capable of creating an irreversible impact to the environment and human health if not handled properly. The health hazards of few toxic elements are given below [16-18].

Americium: The radioactive source in smoke alarms. It is known to be carcinogenic.

Mercury: Found in fluorescent tubes, tilt switches (mechanical doorbells, thermostats), and flat screen monitors. Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Exposure in-utero causes fetal deficits in motor function, attention and verbal domains. Health effects in animals include death, reduced fertility, and slower growth and development.

Sulphur: Found in lead-acid batteries. Health effects include damages to vital organs such as liver, kidney and heart and also causes eye and throat irritation. When released into the environment, it increases the problem of acid rain.
BFRs: Used as flame retardants in plastics in most of the electronic devices. Health effects include impaired development of the nervous system, thyroid &liver problems. PBBs were banned from 1973 to 1977. PCBs were banned during the 1980s.

Cadmium: Found in light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries. The most common form of cadmium is found in Nickel-cadmium rechargeable batteries. These batteries tend to contain between 6 and 18% cadmium. The sale of Nickel-Cadmium batteries has been banned in the European Union except for medical use. When not properly recycled, it can leach into the soil, harming microorganisms and disrupting the soil ecosystem. The inhalation of cadmium can cause severe damage to the lungs and is also known to cause kidney damage. Cadmium is also associated with deficits in cognition, learning behavior and neuromotor skills in children.

Lead: used as a soldering agent and also used in CRT monitor glass, lead-acid batteries etc., Adverse effects of lead exposure include impaired cognitive function, behavioral disturbances, attention deficits, hyperactivity, conduct problems and lower IQ.

Beryllium oxide: Filler in some thermal interface materials such as thermal grease used on heat sinks for CPUs and power transistors, magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers.

Hexavalent chromium: A known carcinogen after occupational inhalation exposure. The above health effects show that precautions have to be taken in handling the e-waste to overcome the health hazards.

ENVIRONMETAL POLICIES AND LEGISLATION

The menace of E-waste has been increasing has India does not have a dedicated law to take care of this crucial issue through proper guidelines and directions [23]. Some of the existing policies and legislation are

- The Indian E-Waste (Management and Handling) Rules that came into force in May 2012.
- The Hazardous Waste (Management and Handling) (HWM) Rules
- The Batteries (Management and Handling) Rules

The Rules were inadequate to handle the generation, transportation, and disposal of this complex waste, and the regulators were unable to monitor and regulate the informal sector [23]. Therefore, stakeholders, in particular SWITCH-Asia partners GIZ (former GTZ), Toxic Link, and MAIT, pushed for a specific regulation on e-waste as the existence of an adequate legal framework is a fundamental precondition to enable the establishment of a sound e-waste management system for India thereby health hazards related to e-waste can be overcome.

ENVIRONMENTAL MANAGEMENT METHODS

In Industries management of e-waste should begin at the point of generation. This can be done by waste minimization techniques and by sustainable product design. Waste minimization in industries involves adopting:

- Inventory management
- production-process modification
- volume reduction
- recovery and reuse

INVENTORY MANAGEMENT

- By reducing the quantity of hazardous materials and raw materials used in the process the quantity of waste generated can be reduced.
- Production materials are evaluated to examine if they contain hazardous constituents and whether alternative non-hazardous materials are available.

PRODUCTION-PROCESS MODIFICATION

Potential waste minimization techniques can be broken down into three categories:

- Improved operating and maintenance procedures,
- Material change and
- Process-equipment modification

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VOLUME REDUCTION

The techniques that can be used to reduce waste-stream volume can be divided into 2 general categories: source segregation and waste concentration. Segregation of wastes is in many cases a simple and economical technique for waste reduction. Wastes containing different types of metals can be treated separately so that the metal value in the sludge can be recovered.

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. However recycling of hazardous products has little environmental benefit if it simply moves the hazards into secondary products that eventually have to be disposed of. Unless the goal is to redesign the product to use non-hazardous materials, such recycling is a false solution.

RESPONSIBILITIES OF THE GOVERNMENT

Governments should enforce strict regulations and heavy fines levied on industries, which do not practice waste prevention and recovery in the production facilities [23].

- Polluter pays principle and extended producer responsibility should be adopted.
- Governments should encourage and support NGOs and other organizations to involve actively in solving the e-waste problems.
- Uncontrolled dumping is an unsatisfactory method for disposal of hazardous waste and should be phased out.

Governments should explore opportunities to partner with manufacturers and retailers to provide recycling service.

It is the responsibility of the government to turn away more e-waste flowing from informal to formal sectors and to achieve positive utilization of informal collection networks for collecting E-waste from households thereby developing efficient incentive system for poor collectors and recyclers.

CONCLUSION

The e-waste management which is a colossal task in developing countries like India and is more complicated due to the lack of stringent rules and regulation for monitoring the large quantity of e-waste getting generated. Providing proper infra-structure for processing the e-waste and starting an effective training program for innovative recycling & recovery methods and for there use of e-waste will strengthen the future generation technically to solve the burning issue. An effective take-back program providing incentives for producers to design products that uses less toxic materials thereby reducing the resource, and also design products that are easier to disassemble, reuse, and recycle may help in reducing the wastes. Most of the e-waste finds its way to the unorganized sector with profit as the prime motivating factor, hence technical improvements of informal recycling processes coupled with proper training in handling waste electrical and electronic equipment's has to be offered to the local industry and community so to obtain better environmental performance without sacrificing the economic and social benefits. Thus handling of e-waste undeniably requires better management and improved working environment guided by strict regulations.

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