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Electronic waste: Its Hazardous Impact on Environment

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ABSTRACT: *Electronic waste and electronic apparatuses generated in huge amount surround the earth today, and has become a global environmental issue. Electronic industry is the world's largest and fastest growing manufacturing industry.The harmful content of these materials pose a threat to human health and environment. Its toxic emissions mixed with soil and air and causing harmful effects to the entire biota either directly or indirectly. E-wastes are considered dangerous, as certain components of some electronic products contain materials that are harmful, depending on their condition and density. Direct impacts include release of acids, toxic compounds including heavy metals, carcinogenic chemicals and indirect effects such as bio magnification of heavy metals. This paper focuses on the current and the future production of e- waste, the forthcoming environmental problems associated with their disposal and management practices are also given consideration. New electronic gadgets and appliances have infiltrated every aspect of our daily lives, providing our society with more comfort and security and with easy information acquisition and exchange. The knowledge society with educatedpeople however, is creating its own toxic footprints. 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 a good opportunity to show the world that India is ready to deal with future problems andset a standards concerning environmental and occupational health.*

KEYWORDS: *Electronic waste, Environmental problems, Hazardous chemicals and Environmental pollution*

I. INTRODUCTION

E-waste is defined as a "waste of electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded" whereas electrical and electronic equipment has been defined as 'equipment which is dependenton electrical currents or electro-magnetic fields to be fully functional'. There is a need for e-waste management as e-waste components may cause severe health risks and environmental damage, when crude, unscientific methods are applied for recovery of useful components. There is a need to encourage recycling of all useful and valuable material from e-wastes to preserve the natural resources.[1] Electronic waste has raised concerns because many components in these products are toxic and are not biodegradable. Based on these concerns, many European countries banned E-waste from landfills long before in the 1990s. Alarming levels of dioxin compounds, linked to cancer, developmental defects, and other health problems in the samples of breast milk, placenta, and hair, these compounds are linked to improper disposal of electronic products. Many studies indicated that, E- waste is disposed unsafely in developing countries, leaving an environmental and health problem in these regions. Impacts from those countries, especially Asia, have already been reported. Meanwhile, recycling and disposal of E-waste are also grown in the regions beyond Asia, particularly in certain African countries. Today's paradigm is one of disposable electronics, and as a result we now stand at the forefront of a growing environmental catastrophe.[2]

These days computer has become most common and widely used gadget in all kinds of activities ranging from schools, residences, offices to manufacturing industries. E-toxic components in computers could be summarized as circuit boards containing heavy metals like lead& cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; brominated flame retardants used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVe) coated copper cables and plastic computer; casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc. Basel, Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286,700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead can seep into the ground water from landfills thereby contaminating it. If the tube is crushed and burned, it emits toxic fumes into the air.[3] E-waste is a global, interregional, and domestic problem. Of the 20 million to 50 million tons generated yearly, it is estimated that 75% to 80% is shipped to countries in

Asia and Africa for "recycling" and disposal.[4]

E-Waste is generated when Manufactures need to use certain chemicals, elements, and compounds to synthesize a final consumer product. Items that contain numerous electrical components, generate the largest amount of e-waste. (i.e. Computers) Toxins in E-waste include polyvinyl chloride (PVC plastics), copper, lead, mercury, arsenic (in older models), cadmium, manganese, cobalt, gold, and iron. Between 1994 and 2003, disposal of PCs resulted in 718,000 tons of lead, 287 tons of mercury, and 1,363 tons of cadmium being placed in landfills. Mercury, chromium, lead, and brominated flame retardants are likely to cause the most adverse health effects in humans. The issue at large is that because of the toxic nature of electronic components, our landfills are becoming polluted and these toxins are seeping into underwater reservoirs. This presents an environmental danger for our habitat and ecosystem. In the United States and Europe, E-waste, at large, is regulated, however many other countries have less stringent regulations. Economically speaking, a lot of countries, instead of investing money to develop a process to recycle this waste, ship it out to third world countries. Initially this seemed like the logical move, until public awareness increased in regards tothe situation.

One man's trash is another man's treasure. The fact of the matter is that, E-waste contains numerous metals and materialsthat can be processed into raw reusable resources. Lead, tin, copper, silver, gold are few of the metals that can be recovered from E-waste. The Environmental Concern European and American companies since the 1980's have been disposing their electronic waste by shipping them to other countries such as China and India. Initially this seemed like an easy solution to the growing "waste"problem in our own domestic landfills. However, this was not the case. Environmentalists, upon further investigation, learned that these countries were improperly handling e- waste. They were processing components in very crude, inhumane, and destructive ways.[5]

CHALLENGES AND NAGETIVE IMPACT OF E-WASTE

Disposal and recycling of this new kind of waste is posing a serious challenge to both developed and developing countries. While having some of the worlds most advanced high-tech software and hardware developing facilities, but India's recycling sector can be considered as medieval. The dumping of e-waste, particularly computer waste, into India from developed countries and all this has made e-waste management an issue of environment and health concern. Compared to conventional municipal wastes, certain components of electronic products contain toxic substances, which can generate a threat to the environment as well as to human health. For instance, television and computer monitors normally contain hazardous materials such as lead, mercury, and cadmium,while nickel, beryllium, and zinc can often be found in circuit boards. Due to the presence of these substances, recycling and disposal of e-waste becomes an important issue. Most people are unaware of the potential negative impact of the rapidly increasing use of computers, monitors, and televisions. When these products are placed in landfills or incinerated, they pose health risks due to the hazardous materials they contain. The improper disposal of electronic products leads to the possibility of damaging the environment. As more e-waste is placed in landfills, exposure to environmental toxins is likely to increase, resulting in elevated risks of cancer and developmental and neurological disorders. A major driver of the growing e-waste problem is the short life span of most electronic products less than two years for computers and cell phones. In a 2006 report, the International Association of ElectronicsRecyclers projected that, with the current growth and obsolescence rates of the various categories of consumer electronics, somewhere in the neighborhood of 3 billion units would be scrapped by 2010 or an average of about 400 million units a year.[6]

Electronic products are a complex mixture of several hundred tiny components, many of which contain deadly chemicals.These chemicals are a strain on human health and the environment. Most of the components in electronic devices contain lead, cadmium, mercury, polyvinyl chloride (PVC), brominated flame retardants (BFRs), chromium, beryllium etc., TVs, video and computer monitors use CRTs, which have significant amounts of lead and the long term exposure to these substances can damage the nervous system, kidney and bones and the reproductive and endocrine systems and some of them are carcinogenic. These e- wastes will have long lasting effects on the environment, when improperly disposed (incinerated/land filled instead of recycling) with domestic waste, without any controls, can contaminate the soil, water and air. 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. In general the electronic goods/gadgets are classified under three major heads:

- White goods: Household appliances
- Brown goods: TVs, camcorders, cameras

- Grey goods: Computers, printers, fax machines, scanners etc.

Waste from the white and brown goods is less toxic when compared to grey goods. Even a personal computer contains highly toxicchemicals like lead, mercury, cadmium, etc.[7]

The composition of e-waste is very diverse and differs in products across different categories. It contains more than a 1000 different substances, which fall under "hazardous" and "non-hazardous" categories. Broadly, it consists of ferrous and non- ferrous metals, plastics, glass, wood and plywood, circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the e-waste followed by plastics (21%), non ferrous metals (13%) and other constituents 16%. Non-ferrous metals consist of metals like copper, aluminium and precious metals like silver, gold, platinum, palladium etc.[8]

The waste thus produced goes into the hands of informal sector. 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.[9]

All electronic equipments contain printed circuit boards which are hazardous because of their content of lead (in solder), brominated flame retardants (typically5-10 % by weight) and antimony oxide, which is also present as a flame retardant (typically1- 2% by weight). 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. These products contain several rechargeable battery types, all of which contain toxic substances that can contaminate the environment when burned in incinerators or disposed of in landfills. The cadmium from one mobile phonebattery is enough to pollute 600 m3 of water. The quantity of cadmium in landfill sites is significant, and considerable toxic contamination is caused by the inevitable medium and long-term effects of cadmium leaking into the surrounding soil. Because plastics are highly flammable, the printed wiring board and housings of electronic products contain brominated flame retardants, anumber of which are clearly damaging to human health and the environment.[10]

II. OBJECTIVES

- The study highlights the health and environmental impact of e-waste.
- The study highlights the current recycling techniques in India.
- The study further highlights various problems associated with the inappropriate e-waste recycling practices.

III. METHODOLOGY

A study fully depends on secondary data. The secondary data are based on publications like books, journals, magazines, and websites and so on. This study reviews health issues related to e-waste and a concise overview of India's current e-waste scenario,namely extent of the problem, environmental and health hazards, current disposal and recycling processes.

GLOBAL SCENARIO OF E-WASTE

Quantity of E-waste generated and the content of toxic and valuable materials, it has become an emerging problem throughout theworld. In 1994, it was estimated that approximately 20 million that is about 7 million tons of PCs became obsolete. In 2010 this figure has increased to over 150 million PCs. Over the past two decades, the global market of EEE continues to grow exponentially, while the lifespan of those products becomes shorter and shorter. In the United States (US) market, less than 80 million communication devices were sold in 2003, 152 million by 2008, a growth of over 90 percent in 5 years and by 2015 this numbers would be skyrocketing. Meanwhile, in 2006, more than 34 million TVs have been exposed in the market, and roughly 24 million PCs and 139 million portable communication devices have been produced. In the European Union (EU), the total units of electronic devices placed on the market in 2009 were more than 3.8 billion units, including 265 million computers, roughly 245 million in home consumer electronics, and 197 million consumer appliances. In China, approximately 20 million refrigerators and more than48 million TVs were sold in 2001, and nearly 40 million PCs were sold in 2009. The situation is exacerbated by the rapid turnover of electronic devices. Because of the fast pace at which technology is evolving, most electronics have only a 2 to 3 year useful life. Apple sells more than 300,000 new phones every day in the world market and in this same time frame,

more than 150,000 new Blackberries are also sold and 700,000 new Android phones are being activated. Most of the phones that are replaced by these newdevices end up in a draw or in municipal landfills. [11]

BASEL CONVENTION-FRAMING OF THE LAW

The Basel Convention on the control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to a public outcry following the discovery, in the 1980s, in Africa and other parts of the developing world of deposits of toxic wastes imported from abroad. Awakening environmental awareness and corresponding tightening of environmental regulations in the industrialized world in the 1970s and 1980s had led to increasing public resistance to the disposal of hazardous wastes- in accordance with what became known as the NIMBY (Not In Back Yard) syndrome-and to an escalation of disposal costs. This in turn led some operators to seek cheap disposal options for hazardous wastes in Eastern Europe and the developing world, where environmental awareness was much less developed and regulations and enforcement mechanism were lacking. It was against this background that the Basel Convention was negotiated in the late 1980s, and its thrust at the time of its adoption was to combat the "toxic trade", as it was termed. The Convention entered into force in 1992.[12] This law has banned the export of hazardous waste to poorer countries since 1992. The main objectives of the Basel Convention are:

- Minimize the generation of hazardous waste.
- Dispose of hazardous wastes within the country of generation effectively in an environmentally sound manner.
- Establish enhanced controls on exports and imports of hazardous waste.
- Prohibit shipments of hazardous wastes to countries lacking the legal and technical capacity.[13]

RECYCLING PRACTICE

In 2005, more than 2 million tons of E-waste were generated in the US alone, but only 17 to 18 percent of that was collected for recycling, informed by the Environmental Protection Agency(EPA) and the rest, more than 80 percent, was disposed of, largely in local landfills. The hazardous materials in E-waste can leaches out from the landfills into groundwater and streams, and if the plastic components are burned, dioxins are emitted into the air**.** Moreover, it is estimated that 50–80 percent of the E-waste collected for recycling in the US is actually exported to developing countries, even though it is illegal in most of those countries to accept this toxic waste stream. Much of this illegally traded waste is going to the informal recycling sectors in many Asian and West African countries, where it is dismantled or disposed of using very primitive and toxic technologies.

In India, most of the recycling happens in the informal sector where poor people tear apart the different components with their bare hands and without wearing any safety gear. In many such yards people are using cable waste as fuel to cook food. In fact, people are being exposed to toxins 24 hours a day as they live, cook and sleep in the same place where waste being recycled. Though E-waste is being recycled in all metros in India, Delhi is where the illegal and dangerous practices of recycling are adopted. India has become the dumping ground of all kinds of waste from the developed countries. A report from Manufacturers' Association for Information Technology (MAIT) indicates that 50,000 tonnes are being imported every year.[14]

CHEMICAL LEACHING AND BIOLOGICAL LEACHING TECHNIQUES OF E-WASTE

Chemical leaching involves leaching either by using acid or ligand supported complexation. Chemical leaching can also be performed by involving complexometry, where ligands get complexed with metals. Chemical leaching of metals from the E-waste can also be done by utilizing various inorganic-acids like; sulphuric acid (H_2SO_4), hydrochloric acid (HCl), and solution of $H_2SO_4$and HNO_3, Sodium hypochlorite (along with acid or alkali) can also be used for the recovery of precious metals like gold. Lee et al. used organic solvents for the extraction of heavy metals like Fe, Cu, Al, Ni, Au and Ag. Yang et al. (2011) studied chemical leaching of Cu present in waste PCBs with respect to its particle size, by utilizing treated shredded Cu particles of waste PCB with sulfuric acid and hydrogen-peroxide.[15]

HYBRID TECHNIQUE FOR METAL EXTRACTION

Generally biological leaching is a cost effective technique but time consuming, even the complete recovery of metal alone by biological leaching is not possible in most of the cases. Chemical leaching on the other hand is comparatively rapid and efficient but it has its own environmental issues. If a hybrid technique is proposed, involving combination of chemical (safer chemicals) and biological leaching, so that both will complement each other for an effective and improvised method for metal extraction.[16]

E-WASTE RECYCLING PRACTICES IN INDIA

Non-formal Sector

Ninety-five percentage of the e-waste in India is being recycled in non-formal sector and five percentage of the e-waste volume arehandled in formal unit. In and around of metropolitan cities in India, there are over 3000 units engaged in non-formal sector for e- waste recycling. Non-formal units of e-waste recyclers are distributed all over India. A large cluster of industries are in Delhi, Tamil Nadu, U.P., Karnataka, Maharashtra, Gujarat, Kerala, Andhra Pradesh, West Bengal, and Rajasthan. Non-formal units generally follow the steps such as collection of the e-waste from the rag pickers, disassembly of the products for their useable parts, components, modules, which are having resell value. The rest of the material is chemically treated to recover precious metals. Dueto inadequate means, it may cause leaching of hazardous substances to the air, soil, and water. This recycling method has low efficiency and recovery is carried out only for valuable metals like gold, aluminum, copper, etc. Other materials such as tantalum, cadmium, zinc, palladium etc.

Formal Sector

Few formal recyclers are operating in India. The processes followed in formal sector are mainly limited to the segregation, dismantling of e-waste till the size reduction stage of printed circuit boards (PCBs). A shredder is employed for PCBs size reduction. The pre-processed PCB is exported to smelting refineries in developed countries for further recovery of precious metals like copper, silver, gold, aluminum, palladium, tantalum, ruthenium, platinum etc. and also treating the slag byproduct in an eco-friendly manner. The end-to-end solution of e-waste recycling is still not available in India. The recycling/ recovery of valuables substances by unitsin formal sector is carried out in protected environment and with due care to minimize any damage to the environment or society. The use of advanced processes and technologies leads to efficient recovery of metals. Recovery technology by units in formal sectorwill be economically viable as the high cost of capital equipments and needed techniques could be shared by the volume of products.

Efficiency of recovery in the formal recycling is high and metals at the trace level can also be recovered. Some technologyworks with zero-landfill approach. Most of the e-waste in India is channelized to non-formal sector, whereas, the formal sector is facing problem of not having sufficient input materials. In order to address the issue, MoEF had introduced adequate clauses in the Hazardous Wastes (Management, Handling & Transboundary) Rules, 2008. The MoEF had advised all the Government Departments/ Offices that e-waste generated in various offices is essentially to dispose of in an environmentally sound manner in accordance with these Rules. The occupier has now responsible for safe and environmentally sound handling of such wastes generated in their establishments. It was further advised that the units handling and engaged in activity like collection, segregation,dismantling and recycling of e-wastes are required to register with Central Pollution Control Board (CPCB).[17]

IV. CONCLUSION

E-waste is become a global problem, recycling is necessary but it should be conducted in a safe and standardized manner. As little as 25% of e-waste is recycled in formal recycling centers with adequate worker protection. The health consequences of both direct exposures during recycling and indirect exposures through environmental contamination are potentially severe but poorly studied. Policy frameworks aimed at protecting vulnerable populations exist but are not effectively applied. At the same time, tremendous growth in use of ICT devices and services, faster change of technology and frequent innovations in ICT sector, had left the world with a threat of deterioration in environmental conditions and human health. As the E-waste of electronic and electrical equipment, which contains hazardous components, is still handled in an environmentally unfriendly manner mainly in developing nations. It is huge challenge for the nations to handle e-waste in responsible manner and protect the environment. If we are generating these electrical devices in such a large amount at the same time we should also build recycle centers which safely recycle all these products. And government should organize programme which should aware people about the harmful effect of these products towards the

environment as well as for the society. There are challenges ahead in all the aspects of e-waste covered in this paper. This paper highlights the uncoordinated system of governmental agencies, lack of awareness among consumers, a lack of awareness of the potential hazards of e-waste among collectors and recyclers, a lack of funds and investment to finance improvements in e- waste recycling, the absence of recycling infrastructure or appropriate management of e-waste, the absence of implementation of e-waste-specific legislation. Improper handling of E-waste can cause harm to the environment and human health because of its toxic components. 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'shas to be offered to the local industry and community so to obtain better environmental performance without sacrificing the economic and social benefits is the need of the hour.

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