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Environmental Problems of E-Waste and its Management

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***Abstract*- E-waste is growing at a very fast rate globally as well as in India. The waste generated from e-waste contains variety of toxic substances which are responsible for degradation of environment and pose problems to human health. This paper shows an overview of different toxic and hazardous substances present in e-waste and their ill effects on environment and human being. The various measures such as Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Multi Criteria Analysis (MCA) and Extended Producer Responsibility (EPR) to control the e-waste has been discussed. It was concluded that proper collection of e-waste, recycling of electronic equipments by safe methods, disposal using proper techniques and make people aware of the impact of e-waste on environment, can be helpful in managing the e-waste.**

Keywords- E-waste, Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Multi Criteria Analysis (MCA) and Extended Producer Responsibility (EPR)

I. INTRODUCTION

The world's largest and fastest growing manufacturing industry is electronics industry. The Indian government changes the policy results in increase of the leading multinational companies to set up electronics manufacturing facilities and R&D centres for hardware and software. Indian economy has grow rapidly due to increase in utilization of electronics products. The emergence of new smart designs in the last 20 years creates the rapid discard of electronic items. The latest design and advancement of electronic goods has attracted the consumer to change these items in a very short interval, yield in increase of e-waste. Electronic waste (e-waste) include electronics/electrical equipments/items such as computers, servers, mainframes, monitors, CDs, printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, medical apparatus, refrigerators and air-conditioners. E-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery. One research paper revealed that the average lifespan of a new computer has decreased from 4.5 years to 2 years and is further decreasing [1] results in a huge amount of computers for either disposal or export to developing countries. Table 1 shows the discard rate of electronics items.

Table I**:** Discard Rate of Electronics Items

Items	Discard Rate (Years)
Mobile telephone	1 -3
PC	2
Camera	3 -5
Television , Refrigerator, Washing Machine	10-15
IT accessories	At a fast rate

The developing countries like India, China etc. has imported e-waste and electronic goods (about 80 %) from developed countries [2]. In India, it is estimated that approximately 1.42 million PCs are getting obsolete every year. It is estimated that e-waste would increase by 500% in India while in China it is between 200 to 400 % by 2020. One of the findings reported that mobile phone e-waste increased to 18 times higher by 2020. Report from CAG state that 7.2 MT hazardous waste from industries, 4 lakh tonnes electronic waste, 1.5 MT of plastic waste, 1.7 MT of medical waste, 48 MT of municipal waste are produced annually in India. Around 30,000 people are involved in the informal e-waste recycling in India. Lack of legislation, policies and enforcement of the safe disposal of e-waste and electronic goods create serious human and environmental problems in developing countries. Various researchers have published about the harmful chemicals and metals present in e-waste such as toxic metals, polyhalogenated organics include polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) posing great threat to human life and the environment [3,4]. India, China and other Asian countries have amended their regulations for the safe disposal and management of e-waste[1]. Different methods such as Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Multi Criteria Analysis (MCA) and Extended Producer Responsibility (EPR) are being used for managing e-waste management at the national scale. The aim of this article is to create spread awareness among masses about the different issues involved in generation and management of e-waste with respect to Indian perspective.

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II. E-WASTE AND ITS IMPACT ON HUMAN

According to Manufacturers Association of Information Technology (MAIT), the Indian PC industry is growing by 25% compound annual growth rate. Study reports that in 2007, 2.2 million computers were made obsolete and 14 million mobile handsets replaced. The e-waste generated was estimated to be 3,32,979, tons out of which 144,000 tons was recyclable and actually e-waste recycled was 19,000, tons. The e-waste processed contained 12000 tons of computers and 7000 tons of TV. It was also estimated that around 50,000 tons of e-waste was generated through import besides 3,32,000 tons generated domestically. Developed countries find it profitable to send e-waste for reuse/ recycling to developing nations because of economic disparities e.g. cost of recycling of a computer in US is $ 20 whereas in India it is $2. So the import of e-waste to India has got enough chance to jump high. There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India. E-waste contains various materials which are toxic in nature and can pollute the environment and human as well as aquatic life. E-waste consists of more than 1000 toxic substances [5] such as barium, beryllium, cadmium, cobalt, chromium, copper, iron, lead, lithium, lanthanum, mercury, manganese, molybdenum, nickel, silver, hexavalent chromium and persistent organic pollutants such as dioxin, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and polyvinyl chloride. These waste when released into the environment cause health hazards to human life. The effect of e-waste disposals on human health is through food chain and direct exposure to toxic elements released from e-waste. The table II shows the effect of e-waste on human health (in terms of chronic and acute conditions) [6,7]. Concentrations of different heavy metals such as Cu, Sb, Bi, etc. was more in the workers involved in recycling of e-waste in India [6,7]. This study confirmed that exposure to these toxic metals pose serious health hazards to the workers and especially women and children.

Table-II: e-Waste Toxins and Affected Body Parts

Components	Toxic elements	Effect on Body parts
Printed circuit boards	Lead and cadmium	Nervous system, kidney, lever
Motherboards	Berillium	Lungs, skin
Cathode ray tubes (CRTs)	Lead oxide, barium and cadmium	Heart, lever, muscles
Switches and flat-screen monitors	Mercury	Brain, skin
Computer batteries	Cadmium	Kidney, lever
Cable insulation/coating	Polyvinyl chloride (PVC)	Immune system
Plastic housing	Bromine	Endocrine

III. MANAGEMENT OF E-WASTE

Lot of research have been carried out for the management of e-waste both ar national and international level. Different methods and techniques such as Life Cycle Assessment(LCA), Material Flow Analysis(MFA), Multi Criteria Analysis(MCA), Extended Producer Responsibility(EPR), landfill and incineration have been employed to control e-waste. Developing countries due to its social, technological, environmental conditions, economic and cultural conditions, do not have any unique or ideal model for e-waste management. Electrical and electronic equipment waste can be managed using three R's i.e. reduce (reduce the generation of e-waste by maintenance and using smart techniques) , reuse (maximizing the use of such equipments) and recycle (recycle the equipments which cannot be repaired). Ministry of Environment and Forests (MoEF), Government of India through its bodies as CPCB, SPCB, and MAIT is responsible for environmental legislation and its control. Collection of e-waste as individually or jointly organized in a scientific manner is crucial for environment. The environmentally sound recycling of e-waste will start by decontamination/ dismantling of e-waste where the concentration of hazardous material/chemical is reduced, then valued materials are recovered and residual components are disposed in TSDF (Treatment, Storage & Disposal) facility. Recycling and disposal of e-waste to landfill pose a significant hazard to the environment [3,5,8]. E-waste disposal methods include landfill and incineration, both of which pose considerable contamination risks. Landfill leachates transport toxic and hazardous materials into the groundwater and the incinerator process releases polluted gases into atmosphere which can harm the human health.

A. Life Cycle Assessment (LCA)

LCA technique have been used to minimize the e-waste and for eco designing of electronic devices in an environment friendly manner and suited to consumers. LCA is a better option for identification of environmental impacts in eco-design of products such as printers, desktop personal computers, heating and air conditioner devices, washing machines and toys [9,10,11]. This tool is helpful in improvement of performance of products and in determining the environmental impact of toxic substances such as carcinogens, climate change, ozone layer, eco-toxicity, acidification, and land use [12,13,14]. In India, [15] reported about LCA as a useful tool for waste management of computer, its economic aspects and impact on environment. The results predict that life cycle of computer desktop decrease by 25%. LCA suggest that recycling is the best option for management of e-waste in comparison to landfill or incineration in various countries.

B. Material Flow Analysis (MFA)

Study related to e-waste flowing into recycling sites/disposal areas can be performed using MFA tool which discusses about the sources, pathways, the intermediate and final destinations of the material. MFA is a decision support tool for management of environment and waste in terms of economic, social and environmental

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conditions [16]. [17] used MFA and evaluation of economic values as a tool for system analysis of the Au and Cu that flows from personal computer recycling in India. It is apparent from the study conducted by [17] that coupling of MFA and economic evaluation can be a useful tool when limited data is available and for rapid economic growth.

C. Multi Criteria Analysis (MCA)

MCA tool is recommended for e-waste management in combination with other techniques. It is useful in decision making in strategic decisions and for finding out the solution of complex multi-criteria problems which include qualitative/quantitative aspects of the problem [18]. E-waste management can be performed using MCA models by applying to environmental problems. MCA tool is most commonly used for solid waste and management of hazardous waste [19,20].

D. Extended Producer Responsibility (EPR)

EPR is based on principles of return of polluter. It is an approach in which manufacturers is responsible for taking back its products after use [21]. India being a non-OECD country adopted this tool for managing e-waste as it has an enormous ‘‘backyard’’ e-waste recycling sector. CPCB has issued guidelines for Environmentally Sound Management of e-waste in 2007. [22] through his study found that management of e-waste in India using EPR can be possible. Imports of e-waste and huge grey electronic market are the two major obstacles in implementing this tool. Ministry of Environment and Forests (MoEF), Government of India in 2010 proposed regulations for e-waste producer. This regulation clearly prohibited the import of used electronic equipments and measures to control the e-waste in India [23].

IV. CONCLUSION

Both local and global world are facing the ill effects of E-waste which is growing at a very rapid rate due to up-gradation and innovation in technology results in discarded of e-waste. Need for controlling of e-waste at local/national level using in depth assessment of current and future scenario including quantification, characteristics, existing disposal practices, environmental impacts etc. Proper collection of e-waste, its transportation, treatment, storage, and disposal should be established at national/regional levels for the management of e-waste to control the environment. Private entrepreneurs and manufacturers are encouraged to set up collection and recycling centre for e-waste. Any policies and regulation will only be successful when the users are ready to fulfill it and stick to the laws passed by the government. It is the duty of all of us that maximize the use of electronic equipments and less generate e-waste.

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