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Effective Management of e-waste and Sustainable Development

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ABSTRACT

It is unavoidable to deny that we are currently living in a world where technology plays a important role of our lives, and that this technology is very quickly transforming with the rapid development of new electronic products with generation of non-eco-friendly e- waste. The influence of electronic-waste materials, over public health and the environment by entering in the form of toxicants and exposing the population to harmful chemicals, in the form of polycyclic aromatic hydrocarbons and persistent organic pollutants are focused in this study. The complexity of electronic wastes, which frequent requires special approach in disposal and developed techniques in recycling for sustainable development. The key component to the ecological cycle is sustainable development that keeps our earth undamaged. Chemical toxicants, like As, Ba, Co, Cu, Lithium, Mercury, from e-waste can easily record into the ecosystem through multiple routes, where they can get pass to the food chain leading to indirect exposure. The extent to which these contaminations contribute to unfavourable health effects is difficult to resolve. However, the harmful effects on health of communities living in areas where casual recycling takes place are noted to be more considerable. Now the new approaches have been developed for sustainable development of environmental issues with the support of green chemistry, in which society, environment and economy are balanced in scientific way. The systematic approach for effective disposal, recycle of e- waste and eco-friendly production of electronic items are discussed and reviewed.

Keywords: e-waste, Health effect, Toxicants, Sustainable Approach, Recycle Techniques.

INTRODUCTION

In modern era technology is changing at an exponential rate; new electronic devices are more convenient to use by means of speed and size. What about the old devices like phone, computer, or camera that is dismissed because of new alternatives? The consumer driven society and it's marketing, is based on replacing the newly launched technology. This trend leads to dumping of electronic waste. Electronic waste known as E-waste is one of the rising and budding problem in this world. The improper and unskilled handling of these waste have adverse effect on human health and surrounding environments as they consist of many toxic substances. Electronic Waste or E-waste is the term used for old, end-of-life electronic appliances such as computers, laptops, TVs, DVD players, refrigerators and freezers, mobile phones, MP3 players, etc. which have been disposed of by their original users. Thus, the growing quantity of E-waste from many advanced industry, private households and from many advanced industry, private households and businesses are reach in

complicated condition to treat. The adverse consequences for health and the ecology of exposure to waste products from human consumption have long been recognized. The toxic or hazardous substances present in discarded electrical and electronic equipment (EEE), also consist of some costly components that have many economic values, if recycled [**1-4**].

As per the described in ANNEX IA the Categories of electrical and electronic equipment are as follows:

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

In India, Schedule 3 of "The Hazardous Wastes (Management and Handling) Rules, 2003" covered E-waste. Schedule 3, defined E-waste as "Waste Electrical and Electronic Equipment including all components, sub-assemblies and their fractions except batteries, falling under these rules". "Guidelines for Environmentally Sound Management of E-waste" formulated by the Ministry of Environment and Forest, Government of India, in the year 2008 followed the same definition [**5**].

Composition of e- waste: On the basis of different analysis of e-waste, it consists of mainly ferrous and non-ferrous metals, many forms of plastics, specially designed glass, wood and plywood, printed circuit boards for categorized equipment, concrete, ceramics, rubber and other items. The composition of e-waste is diverse and falls under 'hazardous' and 'non-hazardous' categories. Many homogenous solid components like heavy metals, different polymers, flame retardants, polychlorinated biphenyls, are some of E&E products [**6-10**]. Some examples are given below:

Table 1. Average weight and composition of Waste Electrical and Electronic Equipment (WEEE). commonly used

Devices/ Machines	Av. Wt. in kg	Ferrous metal % wt	Non-Ferrous Metal % wt	Glass % wt	Polymers % wt	Electronic Component% wt	Other % wt
Refrigerator and Freezer	48	64.4	6	1-3	10-14	1-3	15.1
Washing Machine	40-45	55-6-	3-5	2-4	1-4	1-3	25-35
PC	28	50-55	5-9	13-18	18-22	15-19	0.5-1.5
TV Set	36-38	5-7	3-8	55-65	18-22	1-3	5-10
Cellular Phone	0.01-0.1	7-8	17-22	8-12	48-60	---	1-3

[UNEP E-waste Assessment Manual Vol I (1) Data compiled from Waste from electrical and electronic equipment (WEEE)—quantities, dangerous substances and treatment methods, EEA Copenhagen (2003)].

Health Risk from e-waste: As per discussion**,** majority of these components contain toxic substances like metals, non-metals, plastics, and glasses that have adverse impacts on human health and the environment if not handled properly. Some of them substances are fall under the hazardous category. Many countries are now facing an uncluttered problem on disposal of E-wastes. The practice of Land fill disposal of e-waste produces contaminated leachates which ultimately pollute the groundwater and soil. Acids and sludge obtained from melting computer chips, if disposed through land filling, causes acidification of soil.

In India, as per the generation of e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur (Guidelines for Environmentally Sound Management of E-waste, 2008). The list below given, is the pollutants from e-waste, as a source of big challenge for proper disposal. Technically the e-waste is not easily disposed by normal process, so in developing country like India, the disposal and dumping of e- waste are suggested to do by Hazardous waste management [**11-13, 31-33**].

Table 2. Constituent Pollutants from e-Waste and their health effect

Pollutants	Occurrence	Health Effect
Arsenic	Semiconductors, diodes, microwaves, LEDs (Light-emitting diodes), solar cells	Skin Changes, Ling Cancer,
Barium	Electron tubes, filler for plastic and rubber, lubricant additives	Damage to Heart Liver and Kidney
Brominated flame-proofing agent	Casing, circuit boards (plastic), cables and PVC cables	Carcinogenic, genotoxic, endocrine disrupting, metabolic syndromes, low birth weight,
Cadmium	Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes (CRTs)	Affects enzyme activity, kidney injury, decreased bone density, lung damage, carcinogenic, mutagenetic
Chrome	Dyes/pigments, switches, solar	Carcinogenic, genotoxic, mutagenetic, ovotoxic, lung function, allergic reaction
Cobalt	Insulators	asthma-and dyspnea, nodular fibrosis, permanent disability, and death. weight loss, dermatitis
Copper	Conducted in cables, copper ribbons, coils, circuitry, pigments	Headaches, dizziness, nausea, and diarrhea
Liquid crystal	Displays	skin and eye irritation on rabbits, and mutagenic effect on aquatic species
Lithium	Mobile telephones, photographic equipment, video equipment (batteries)	Inhalation, ingestion, and dermal contact
Mercury	Components in copper machines and steam irons; batteries in clocks and pocket calculators, switches, LCDs	nerve cell apoptosis, genetic modification, nephrotoxic, memory loss, immune system toxicity, decrease in IQ, genotoxic, decreased fertility
Nickel	Alloys, batteries, relays, semiconductors, pigments	lung cancer, nose cancer, larynx cancer and prostate cancer
PCBs (polychlorinated biphenyls)	Transformers, capacitors, softening agents for paint, glue, plastic	Probably carcinogenic, thyroid function, cognitive function and development, neuropsychological development
Selenium	Photoelectric cells, pigments, photocopiers, fax machines	Cardiovascular, Cancers Gastrointestinal Hair Loss
Silver	Capacitors, switches (contacts), batteries, resistors	Change in Blood cells, Liver And Kidney Damage

E-waste Sustainable disposal: A country like India, has to develop such a flexible and adaptive system for sustainable management of e-waste, that can handle the variability in quantity and quality of e-waste flow [**14**].

Guiyu and Wenqiao in China, Bangalore, Chennai, Delhi and New Delhi in India, Lagos in Nigeria, and Karachi in Pakistan has developed and suggested some informal electronics recycling process. Some of these processes which may connect the reverse supply chain for computers and sustainability are summarized in table 3 [**15-16**].

Table 3. Sustainability issues and the International reverse supply chain for computers [**14-35**]

Sustainable Area	Issues	International Reverse Chain
Environmental	Emission, Leaching of Toxicants from computers During waste treatment	Recycle in near countries
Social	Health issues near treatment area	Availability of affordable used computers
Economical	Extra loss for treatment	Employment in reuse and recycle industry

Dedicated for the global e-waste management, Switzerland is the first country to develop and implemented the organized e-waste management system. They give the idea of extended Producer Responsibility (EPR) and Advance Recycling Fee (ARF) for other developed countries also [**17**]. Ministry of Environment and Forests (MoEF) Govt of India, took a serious responsible for hazardous waste management. Shedule-3 of "Hazardous Wastes (Management & Handling) Rules, 1989" included the List-A and List-B to summarize the components of e-waste which are to be consider as hazardous waste. With a series of amendment in 2000 and 2003 [8], finally, in 2007 and 2008, e-waste has been included in "The Hazardous Materials (Management, Handling and Tran boundary Movements) Rules, 2008" [**18-19**].

E-waste Management: Most of the activities right from the collection, transportation, segregation, dismantling, etc., is done by unorganized sectors manually. Being a rich source of reusable and precious material, E-waste is also a good source of revenue generation for many people in India. The big portion (rag pickers) of the Indian population earned their livelihood by collecting and selling the inorganic waste-like plastics, polythene bags, glass bottles, cardboards, paper, other ferrous metals, etc.

As per recommendations from expertise, "high-tech" methods are required to minimize the e-waste with the recovery of immoderate materials and minimize potential harm to humans or the environment. Unfortunately, because of some ecological and economical parameters the use of these specialized methods is rare and not easy to implement in India. Therefore, extraction of precious materials from e-waste is done through crude techniques, much of the world's e-waste traveling great distances, mostly to developing countries, were crude techniques. This also leads to localized pollution of environment and is health hazards for advanced life forms [**20-22**].

1. Land filling: The most popular and widely used methods for disposal of e-waste. In this method, removal of soil is done for making of specific trenches where the waste material is buried and covered by a thick layer of soil. Now, secure and specially designed landfills are made using modern technique.

2. Incineration: In this method the waste material is burned in specially designed incinerators at a high temperature (900-1000oC) and called controlled and complete combustion process. Reduction of waste volume and the utilization of the energy content of combustible materials are the main advantage of incineration of e-waste.

3. Recycling of e-waste: Many of the e-waste can be recycled, and removal of different parts of e-waste containing dangerous substances like PCB, Hg, plastic, CRT, segregation of ferrous and nonferrous metals and printed circuit boards is done by modern techniques.

Suggested Recycling Process for e-waste:

First Stage (Segregation) - Segregation of components from e-waste done manually, where different parts of e-waste are separated.

Second Stage (Separation) - Through mechanical separation, ferrous, non-ferrous materials, and plastics are initially separated.

Third Stage (First Recycle) – Recycling of separated plastics are done, which further processes the making of other plastic materials.

Fourth Stage (Second Recycle) - Recycling of non-ferrous metals are done by metallurgical treatment and the constituent metals are recovered here [**23-24**].

4**. Re-use:** Reuse is a best recommended method with slight modifications to the original functioning equipment. Reuse of computers, cell phones can be done by donating to primary user like village schools and training institute. Inkjet cartridge is also used after refilling. Computers beyond repairs can be returned back to the manufacturers. This method also reduces the volume of e-waste generation.

5. Biotechnological approaches for e-waste treatment: As to develop environment friendly treatment new technology using with advance biotechnological approach are now appreciated to e-waste treatment**.** E-waste is considered as a secondary source of metals, so ***bioleaching*** is available option to recover and reuse the metals. The Cyanogenic organisms like *Pseudomonas ple-coglossicida*, *Pseudomonas fluorescens* and *Pseudomonas aeruginosa* have profound application for bioleaching of gold from e-waste. *Chro-mobacterium violaceum bacterium* has a significant role in cyanide detoxification [**25-30**]

CONCLUSION

Fast growing e-waste problem is now not focused only by developed countries; it is extended to the developing countries like India. Frequently changing technology as per demand, affect the old electronic equipment unused, which results in massive generation of e-waste. The classification and quantification of valuable and hazardous components from e-waste is a pre-requisite to develop an economical and environmentally friendly recycling system. Several tools including e-waste management and recycling are recommended for Eco-friendly biotechnological approaches.

E-waste problem in developing countries can be resolved up to some extend by the transfer of appropriate technology. But it should keep in mind their social, environmental and economic boundaries. Direct transfer of technology without any consideration given to inter-linked, non-technical aspects has led to failure in a number of cases.

Conflicts of interest: “There are no conflicts to declare”.

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