

E-waste-Effects and Recycling

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Abstract—The demand of man increases continuously as development takes place in the field of Information and Technology and purchasing of electrical goods increases in the same ratio. The handling of e-waste is therefore, becoming an important issue to restore. It is not possible for an individual to reduce e-waste that he should adopt his own way of disposing it, as the electrical substances release various hazardous materials, if not recycled properly. On the other hand, e-waste proves to be a boon, as it serves great employment opportunities, also different precious metals (PM's) can be recovered from it. Indian Government has issued rules to avoid the illegal handling of e-waste but the awareness among the people is not yet developed to satisfactory level. As the issue of e-waste is globally increased therefore all over the world steps are taken to put control on it and extract the best out of e-waste.



FIG. 2. discarded mobile phones

1. INTRODUCTION

E- WASTE OR ELECTRONIC WASTE is the un-repairable electronic or electrical devices which cannot be used further either in work with any device or as working machine and is considered as waste product. With megatons of e-waste in obsolete personal computers, old cell phone(in fig. 2) and waste electrical equipments piling up every year, scientists report fast development of much needed new recycling and recovery technology.

E-waste describes old, end-of-life or discarded appliances run by electricity [1]. It includes consumer electronics, refrigerators, computers etc which has been disposed off by their original users. E-waste contains both valuable materials as well as hazardous materials which require special handling and recycling methods and thus, it is used as a generic term including all types of waste containing electrically powered components.



Fig. 1: Discarded PCB's

2. E-WASTE

E- waste or the generation of waste from electrical and electronic equipment(WEEE) has a broad and growing range of electronic devices ranging from small equipments used in laboratories such as capacitors, integrated circuitry's(IC's), soldered copper boards, chips etc. to large equipments ranging from our household devices such as refrigerators, television sets, computers and all the consumer electronics which have been discarded by their users.

2.1 Recycling of E-waste

As e-waste can be a source of wealth and employment thus, e-waste recycling(in fig. 4) is rapidly thriving business nowadays in the developing world. Recycling of e-waste is done in both formal and informal ways. The difference between them is-



FIG. 4. Recycling of e- waste

Table 1: Difference between informal and formal recycling

Informal recycling	Formal recycling
Done mostly in developing countries Requires intensive labour, large workforce and manual operation It is profitable e-waste management method It lacks skills and technologies to manage e-waste in environment friendly manner	Formal recyclers have capacity to manage e-waste in environmentally friendly way and enhanced resource recovery

Talking globally, Australia is a significant producer of e-waste in the world, currently recycling of e-waste at Australia is limited. The Australian Government has taken an initiative to encourage the recycling of e-waste. Collection of e-waste is a critical step for the recycling of e-waste and the efficient management of resources.

According to one of the largest selling newspaper, India ranks second largest in the world for mobile market and also fifth largest producer of e-waste.[9]

In India, the rough analysis of top metro cities (in fig. 3) such as Delhi that ranks second producer of e-waste in India produces 98, 000 million tonne and Mumbai the biggest producer of e-waste produces 1. 2 lakh million tonnes of e waste per year. India generates 18.5 metric tonnes of electronic waste each year.[10] There are in total 149 units in India for recycling the E-waste which recycle approximately 461059 MTA of e-waste.

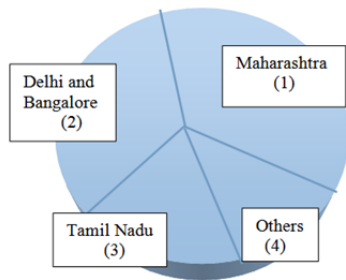


Fig. 3: Pie chart of production of e- waste from different states of India

2.2 Valuable materials from E-waste

Being a waste, e-waste also serves as secondary raw material source or wealth when properly treated. The e-waste contains several precious metals that can be extracted through recycling. One of the barriers in extracting precious metals from e-waste is liberation/separation during mechanical processing. Precious metal is challenging because of the inter linkage with other metals on electronic boards. Australia is a leading country in mineral and mining industries of the world. A ton of used mobile phones contains following valuable materials.[6]

Table 2: General view of precious metals(PMs) from e-waste

Gold	340 gm
Silver	3.5kg
Copper	130kg
Palladium	140gm

Most of the electrical equipments have gold electroplating on their electronic boards. It is a process of coating gold by the electrochemical process of electroplating. By gold electroplating conductivity and protection of wires are done. There are various methods for extracting gold from these circuit boards and it proves to be a profitable deal.

Burning - It is a simple extraction process but proves to be very harmful and cannot be done professionally. As because the circuit boards and other electronic equipments do not only contain precious metals but do contain other chemically baked materials which on burning gets reacted and release harmful gases.

Cyanide Process- It is a general process of extracting gold from electronic devices by using cyanide solution. The cyanide with gold forms gold ions, which can be distilled and gold can be obtained. As cyanide is highly toxic material therefore the extractors have to follow strict rules for using this method.

Aqua- Regia- It is a mixture of hydrochloric acid and nitric acid, which is used in large scale to dissolve gold. It does not have any ill effect to environment. As a mixture is completely acidic therefore, it is toxic. So, proper ventilation is mandatory.

Reverse Electroplating- It is a method of Ionization by which gold can be fixed to the devices.

Bio-leaching- It involves the use of micro-organism called *Chromobacterium violaceum*. As this process is harmless to environment so considered to be the best way of extracting gold.



Fig. 5: Extracting of PM's from e- waste

2.3. Hazardous materials from E-waste

The electrical devices undoubtedly provides lot of comfort when utilized in a proper way but on disposing carelessly this

e-waste harms a lot to the environment and the human health as well. While some naturally occurring substances are harmless in nature, their use in electronic equipment often results in compounds which are hazardous (for example-chromium becomes chromium VI). Some of which are discussed as follows.

One of a most troublesome component of e-waste is PCB's i.e. Printed Circuit Boards.

(a) PRINTED CIRCUIT BOARDS (PCB's)

In a scheduled China report on Feb 15 points out that PCB's are an ideal target for recycling and reuse. PCB's are self-contained modulus of inter connected electronic components formed by a thin layer of conducting material deposited in the form of "printed", on the surface of the insulating board. Materials used in making of PCB's are heavily toxic when released in environment.

The technology used in reuse of the materials from PCB's proves to be profitable by researchers. As PCB's on proper recycling technique are rich potential source of valuable metals and non- metals (other materials). The researchers describe a test which showed that almost half- ton of scrap PCB's is efficient and environmental friendly. The technique involves special crushing of scrap PCB's, followed by separation of metallic and non- metallic materials with an electric field.

(b) Brominated Flame Retardants (BFR's)

By-product from E-waste	Occurrence
TBBA (tetra bromo biphenyl-A)	It is most widely used flame retardant in printing wiring boards and casings
PBB(poly brominated biphenyls) PBDE (poly brominated biphenyl ethers)	Fire retardants for plastics (thermoplastics and cable insulation)

The three major products used in electrical appliances are TBBA, PBB and PBDE (as mentioned above). They are nothing but the flame retardants. Flame Retardants are the products which make materials especially plastics more resistance to heat, i.e. while manufacturing of thermoplastic BFR's are used that is why those plastic on keeping in instantaneous flame do not get easily molded. Combustion of these halogenated raw materials at lower temperature releases a toxic emission which includes dioxins and continuous confrontation of it may lead to severe hormonal disorders. They have been found in air and dust-particles through migration and evaporation of plastics.

Table 3: The other substances which are harmful for the lives on this planet Earth are aforementioned.

Substance	Disease Caused	Explanation
Arsenic	It can cause various skin diseases. Chronic exposures may lead to lung cancer	It is poisonous metal present in dust or soluble metals(ex. light emitting diodes)
Barium	Short- term exposures results in brain swelling, muscle weakness and damage to heart, liver and spleen	In pure form, it is highly unstable and form poisonous oxides when contact in air
Beryllium	Berylliosis (Chronic Beryllium Disease, which primarily affect lungs), lung cancer, skin diseases	Found in power supply boxes which contain silicon rectifiers and x-ray lenses
Cadmium	Acute exposures causes flu like symptoms, Long exposures can cause lung cancer and believed to cause pulmonary emphysema and bone disease (osteomalacia and osteoporosis).	Found in re-chargeable Ni-Cd batteries, printer inks and toners
Chloro Fluoro Carbons (CFC's)	Skin cancer in humans and genetic disorder in many organisms	Used in refrigerators and air- conditioners, when released out in the atmosphere they accumulate in stratosphere and destroys the ozone layer
Chromium	Chromium (VI) compounds causes irritation in eyes, skin and mucous membrane. Continuous exposure can lead to permanent eye injury and may cause DNA damage	Chromium (VI) is easily absorbed by human body and produces toxic effects within the cells
Dioxins	Malformations in foetus, decreased reproduction and growth rate both in animals and human	Formed as unwanted by- product during the manufacture of pesticides as well as during combustion
Lead	Short- term exposures can cause vomiting, diarrhea etc. Long term exposures i.e., for industrial workers can affect kidneys kidney damage, it is also	
Mercury	If ingested or inhaled causes liver and brain damage	It is a toxic heavy metal that Bio- accumulates. It is largely found in batteries, fluorescent bulbs etc.
Poly Vinyl Chloride (PVC)	When inhaled on burning causes respiratory problems	It contains 56% of chlorine, on burning produces hydrogen chloride gas which combines with water and give hydrochloric acid

Selenium	Selenosis	The major sign of this disease is hair loss, nail brittleness, neurological disorders.
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3. REMEDIED SUGGESTED/ REFORMS

1. Re-evaluate i.e. to check the specifications of gadgets with complete requirements before buying so that there will be no need of buying various gadgets with only use.
2. Proper Maintenance of Electronic Device so that it has long life. By keep the external hardware parts dust free and covering the device with cloth or especially designed covers.
3. Buy environment friendly electronics of government licensed company, labelled with Energy Star or certified by Electronic Product Environmental Assessment Tool (EPEAT).
4. Before discarding any expensive large electronic machine check once around your locality if any economically weak person can make any use of it.
5. Reuse large and expensively purchased electronics by just few repairings and replacing of small electrically equipments used within it.
6. Do not discard any electrical or electronic equipment anywhere in the nature as aforementioned that they even release toxic substances. Therefore, always dump them in e-waste recycling bins located around your campus.[11]

3.1. Government Rules for E-waste Management

The Government of India has issued rules from producer to collector of the E-waste for its proper management. It is aforementioned that e-waste serves as great employment opportunities but it has now become necessary to take permission from Government to give all records as on recycling valuable as well as toxic materials are expelled. Therefore, list of authorities and corresponding duties are assigned, application procedure for obtaining for authorization for generation, collection, storage, dismantling, recycling of e-waste is assigned.

The collection, storage, transportation, segregation, refurbishment, dismantling, recycles and disposal of e-waste shall be in accordance with the procedures prescribed by the Central Pollution Control Board (CPCB).

Our household electronics generates 75% of e-waste, which is discarded by people. It has been found that most people are

unaware that whom they should they should approach for proper dispose of their discarded e-waste like mobile phones, laptops etc. So, a few companies like Pom Pom Recycling Ltd. has taken an initiative and released an app to take orders and help people to get rid of their unwanted e-waste, while also

paying them for providing recyclable materials.[12] There are some illegal dealers who definitely recycle the e-waste and extract PM's as much as they can but they harm the environment in other way like releasing toxic exhaust gases, toxic materials which includes carcinogens, lead, heavy metals etc. without filtering them i.e. Again an improper disposal of e-waste. To overcome with illegal dealers of e-waste the Delhi Pollution Control Board had started issuing the license to those collectors who have the filtering method and machinery which can retrieve PM's but also releases the residues in safe manner.

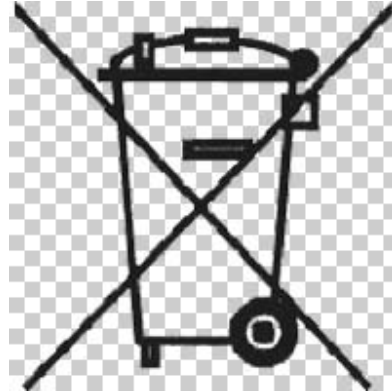


Fig. 6: E-waste disposing logo found on electronic equipments

The Extended Producer Responsibility (EPR) regulation is the most defining provision in India. According to this regulation, the manufacturers are responsible for their post-consumer waste of their electronics products. As per the E-waste Rule 4(6), 2011 the producer of any electronic equipment is responsible for creating awareness for the consumer about the product that has been placed on the market. The following logo is usually printed. Symbol may be placed either on the product or printed on the accompanying documentation product.[8] The e-waste rules which were notified in the year 2011 were came into effect in the year 2012.

3.2. Future Progressive plans which could be adopted by Government and Private Companies for making full use of e-waste

In a general survey of year, 2007 India produces about 1.5 million tons of e-waste per year and as per UN predictions by the year 2020 it would increase by 500 per cent and would be 18 times higher than 2007. Indian Government has already recognized the e-waste problems and the Supreme Court have issued the legislative rules for its management. But, due to lack of proper awareness among the people it is ignored.

WHO, National Green Tribunal (NGT), Child Health Initiative Act has warned about consequences of e-waste. [5] Swachh Bharat Abhiyan initiated by honorable Prime Minister of India, Narendra Modi focuses on the awareness among people for cleanliness for proper sanitary dispose and near roads or surroundings of locality should be clean to avoid

health issues and to clean the environment. Similarly, to reduce the harmful effects of e-waste government has launched a plan called "e- Swachh Bharat Programme" which could go a long way in making reuse of WEEE. [10]

The Central Zone bench of NGT in Bhopal had ordered all the manufacturers and producers of electrical and electronic equipment to set up collection centres and take back the discarded electronic waste in Madhya Pradesh, Chattisgarh and Rajasthan.

4. CONCLUSION

As per the teaching of **Mahatma Gandhi**-"**Be the change you wish to see in the world**" which is very much true for today's scenario. The abruptly increasing e-waste needs to be controlled somewhere, either reuse the electronic equipments by improving general mechanism or be sure that it must be recycled so as to obtain valuable and precious metals and to decrease the outlet of hazardous unwanted phase out substances. Be the part of this change by yourself alone once and then let the people be aware of this. Because by doing this we won't only save our loving ones but saves the whole planet. As e-waste also serves as an opportunity of employment therefore it must be promoted by all.

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