AN OVERVIEW OF ELECTRONIC WASTE MANAGEMENT

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Abstract: Electronic waste is increasing all around the world across all countries with rapid urbanization and increasing use of modern technology as well as telecommunication systems. Average lifecycle of electronic gadgets has decreased and in case of mobiles this lifespan is less than two years. On an average mobile phones are replaced in eighteen months. Different strategies are being adopted by different groups to tackle this menace of electronic waste. Generally, precious metals and other reusable components are segregated from these wastes. The remaining materials are mostly plastics and its different forms like in printed circuit boards, cabinets etc. Disposal of these materials is crucial as they are not bio degradable. Using these materials in different types of products may help in effectively managing electronic waste. Non fibrous non metallic materials from these electronic waste leftovers may be moulded into small chips and may be used as filler for different products. An overview of different procedures to tackle electronic waste is discussed in the paper.

Index Terms: E-waste, recycle, PCB, CRT

I. INTRODUCTION

Electronic waste (ewaste) is mainly the discarded electronic and electrical devices that may or may not be reusable in one or the other way. Processing of ewaste is crucial and if not done under professional supervision may lead to hazardous effects on human health as well. Developing countries are more prone to harmful effects as most of the informal processing is undergoing in these countries and moreover the ewaste of developed countries is also being exported to these developing countries [1-3]. Hazardous effects of few of the components of ewaste may be long term because of the presence of toxic elements in these wastes. Governments all around the world including India are taking measures for safe disposal of ewaste and working for informative as well as legal formulation for safe disposal of ewaste [4-5].

Initially the countries overlooked this problem of ewaste because of lack of processing facilities and the price involved in the processing but with time its harmful effects were becoming evident and need to be addressed and eventually all countries started working to minimize the harmful impact of this ewaste. Companies and entrepreneurs are using this opportunity to turn it into lucrative business [6]. Government of India is very seriously working to minimize the harmful impact of ewaste disposal and have fixed responsibilities of manufacturer and producer for proper and effective recycling [5].

Researchers and institutions are working world over to find better solutions to tackle this problem and in the process developed many techniques to recycle or reuse the ewaste effectively. Printed circuited boards are the major component in the electronic gadgets that has metallic contents in it. All non metallic materials are directly sent to appropriate recycling units for their reuse but printed circuit boards require additional processing to separate its metal content. Various techniques are commercially used for this purpose like pyrolysis, hydrometallurgical methods, air separation, using organic solvents, magnetic separation, biometallurgical methods etc.

Developing countries are to tackle this problem with manifold facets. At one side they have to develop proper laws and enforce them and at the same time educate the people so that ewaste does not simply dumped into landfills. The toxic materials of the ewaste may leach into the soil and may degrade the soil or even make it barren in the long run. If these toxic materials are leached into the underground water then the water may contaminate and may be hazardous for people and environment in the vicinity. Therefore ewaste has become a matter of concern for developing and developed countries alike.

The growth of electronic gadgets is increasing alarmingly with globalization and estimates put around 4% increase in production of these gadgets per year while the growth rate of electronics industry in India is projected to be much higher. Most of the recent growth is happening in mobile phones and telecommunication equipments [7-8]. Mobiles generally have a short life span and on an average people change or upgrade it in two years. With advancing technologies and cheaper productions of these smartphones as well as planned introduction of new versions of operating software, like android, from time to time is also motivating the young tech savvy generation to upgrade or switch the smartphone earlier then its life span. Before learning more about the recycling technologies for electronic wastes it would be appropriate to discuss the environment and health hazards briefly.

II. THREAT TO ENVIRONMENT AND HEALTH

Ewaste includes unusable or discarded electronic gadgets, appliances, batteries, electronic components like resistances, capacitors, parts of printed circuit boards, television, cathode ray tubes and electrical appliances. Some time the appliances or gadgets may be working but because of the change in technology or planned upgradation they are rendered useless. Most of the times they are abandoned or thrown away and ultimately find its place in landfills.

This tendency may create lot of problem in future. In a recent study around Delhi it has been found that heavy metal has contaminated the soil and groundwater in and around an unauthorized e-waste recycling site [9]. The study revealed that informal sector of e-waste recycling is still operating despite it is legally banned in Delhi. It is observed that the heavy and toxic metal content of e-waste leach into the soil and groundwater in the vicinity of the improper e-waste processing or landfills. They

observed that copper, lead, cadmium and other pollutant materials were much higher than the prescribed level by Central Pollution Control Board. Long term exposure to such water may cause severe problems related with liver, kidneys and other organs in people living in nearby areas.
According to Basel convention countries have started working for efficient e-waste recycling technologies [10] but that are costly and therefore informal processing is also undergoing to some extent in developing countries like China, India, Thailand, Ghana, Vietnam, Philippines etc [11,12]. Various researchers have also observed such contamination in soil and water bodies in the vicinity of the informal e-waste processing sites [11-14].
Well established and formal electronic waste techniques are now available and required technologies with machineries are also available but they are expensive and hence it is not always followed by informal sectors. Hopefully with stringent rules the processing units in the future will be more environment-friendly.
By means of contact, ingestion or through contaminated water, soil or air the humans can come into contact with these pollutants and get affected. Different researchers observed and found that lack of awareness as well as improper management of electronic waste is a great concern for society [15-16]. It has been observed by many researchers that the awareness level is low and requires proper campaign to create awareness about the harmful effects of electronic waste [17-21]. India is proactive in managing the electronic waste and has enacted Extended Producers Responsibility 2016 in which producer will be liable for reuse or proper recycle the electronic waste. Recently the Centre Pollution Control Board has been given the Extended Producer Responsibility (EPR) authorisation under the new e-waste rules by the Environment Ministry of Government of India [22].

III. RECYCLING OF ELECTRONIC WASTE

Electronic waste contains many material including plastics and heavy metals that are dangerous and require proper recycling or reusing them. Generally the electronic waste recycling procedure involve following procedures:

1. Collection of Electronic Waste.
2. Sorting of Electronic Waste (Mostly Manual).
3. Manual disassembly of parts.
4. Recycling of PCBs.
5. Magnetic separation.
6. Separation of Metallic materials.
7. Recovery of other materials.
8. Reusing non-metallic part of PCBs.

3.1 Collection of Electronic Waste: Electronic waste is collected through different means and in India mostly it is done manually by waste pickers in the first place where they purchase from different households or pick it up from the garbage wherever it is dumped. The electronic waste is then sent to formal or informal ewaste processing units by middle man, scrap dealers or by waste pickers directly.

3.2 Sorting of Electronic Waste: The electronic waste thus collected is then sorted and parts that are purely plastic or metal like gadget's covering are separated as they may be directly recycled or reused as per the requirement. Batteries are also removed for further processing. Printed Circuit boards are separated and other parts are also separated like Cathode Ray Tubes or Liquid Crystal Display Units etc. CRTs are separately processed because they are mostly glass and heavy metals like lead etc that require special attention [23].

3.3 Manual Disassembly of parts: The printed circuit boards and other components are manually dismantled after sorting. Generally using vacuum guns and other equipments the components are dismantled from the assemblies and then these components and parts are further sorted for their further processing [23]. In 2013 Chen et al proposed that if electronic components of the printed circuit boards are removed using hot air by melting the soldering then it may be more efficient and less hazardous. They designed automated dismantling equipment that use the industrial heat reuse [24].

3.4 Recycling of Printed Circuit Boards: After separation of electronic components the Printed Circuit Boards (PCBs) are processed in different steps. Invariably the process starts with cutting the PCBs into small pieces. Shredders and granulators are used to cut the PCBs into small pieces of around one square centimetre. Size is further reduced by cutting mills and centrifugal mills. Most of the time the recycling industry use shape separation by tilted plate and sieve [25]. Inclined Conveyor and inclined vibrating plates are generally used to separate particles by shape and mostly copper is recovered from printed circuit board scrap electric cable waste by this method [26].

3.5 Magnetic Separation: Magnetic separation is one of the most used techniques to separate the ferromagnetic materials from non magnetic and non metallic materials. Low and high intensity separators are used to separate iron and strong magnetic materials. Magnetic separation is one of the widely used techniques in electronic waste management [27-28].

3.6 Separation of Metallic Materials: Different techniques are used to recover the metallic materials from the electronic waste. Corona electrostatic separators are used to recover copper and aluminium from the waste materials. In this method the rotor has corona charging effect and it separates raw materials into conductive and non conductive fractions. Corona charge and differentiated discharge mechanism leads to different charges and different forces on them and helps in separating them [29].

3.7 Recovery of other materials: Electronic waste contains many materials and different methods are employed to separate them. Density separation technique is used to separate materials based on their densities [30]. In this method material of higher density are separated from materials of lower densities. Generally, materials with different gravity are faced to air or water based system where they are separated as per their densities. To get effective results from this method the materials should be properly sized as movement in liquid is size dependent. To separate plastics the tribo-electric separation technique is used [31].

Once physical separation process is completed then the waste material is treated further to obtain metal and other materials. Chemical recycling process is applied on PCBs to decompose it. Pyrolysis and gasification process are employed in this process. Generally PCB scraps have high metal content and therefore metal is extracted from the PCBs for its reuse or reselling. Pyro-metallurgy is one of the popular methods to recover the metal from the PCBs. Hydrometallurgy and bio-metallurgy is also gaining importance in recovering metal content from PCBs.

3.8 **Reusing non-metallic part of the PCBs:** The non-metallic parts of the PCBs are complex and contain thermosetting resins, plastics, fibreglass, additives and other materials [32]. Reusing this material is important as it is almost seventy percent of the printed circuit board by weight and need to be properly managed. Researchers have different opinion on using this material. Franz advocates that these non-metallic materials of waste PCBs are best suited for thermoplastics. Many other researchers feel that this material can be used as fillers epoxy resin products [33-34]. Researcher Mou et al found another use of it in making of models, composite boards and other products [35].

Researchers are also trying to use this non metallic waste by changing the polymer by chemical methods. At the same time sometimes it used as combusting agent as fuel. In the last it is tried that this waste is converted into non-hazardous form and then it is put in landfills. It was proposed by Li et al and others that the rest of the non metallic materials of the PCBs are made into non metallic plates. These plates can be used in different materials as fillers. In this way different procedures are being worked on to effectively manage the electronic waste [36-39].

IV CONCLUSION

Recycling is important for electronic waste management. Governments of almost all countries are working to minimise the harmful effects of electronic waste by creating awareness on one side and framing rules and fixing the responsibilities of the producers in the long run for better waste management. Different methods have been proposed to recover precious as well as toxic metals and other materials from the electronic waste by various authors but the market requires commercial viability for sustained long run implementations. In the absence of that most of the times the final waste materials are converted into non dangerous form and then put into landfills. Though it always possess the risk of leaching the harmful residual contents into soil and underground water resources but this practice is still continuing as reusing all the material is very difficult and proper technologies may not be available or commercially viable especially in developing countries. The governments are also trying to encourage producers to help in recycling of the products and devising rules that will finally fix their responsibility to recycle or reuse a certain percent of the electronic waste produced by them with time. Awareness is also being created not to discard the gadgets unwarranted.

It is important to note that the purity of the metals present in the printed circuit boards is almost 10 times higher than the available resource of those materials. The most common recycling techniques are chemical and mechanical separation. Methods like size separation, shape separation, electrostatic separation etc is used to mainly separate different materials from the printed circuit boards. The final non metallic waste of the PCBs is the main challenge to use properly. Sometimes it is combusted in pyrolysis to work as fuel but if proper care is not taken then toxic fumes may generates. These non metallic materials are now being used in different products and are also giving better strength in molding, models, as a replacement of wood flour, in bricks, in concrete etc but more widespread efforts are needed to make environment friendly and commercially viable products of these types of wastes.

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