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E- Waste Problem and its biological solution

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ABSTRACT: In the modern world , pollution has dominated each facet of life. With advancement and use of modern electronic gadgets e waste is accumulating with alarming rate. Nature finds solution to the problem of pollution through recycling. Reduce, reuse, recycle are the three main solutions to the problem of e- waste.

E-waste comprises discarded electronic appliances, of which computers and mobile telephones are more abundant due to their short lifespan. The current global production of E-waste is estimated to be 20–25 million tones per year, with most E-waste being produced in Europe, the United States and Australasia. China, Eastern Europe and Latin America will become major E-waste producers in the next ten years. E-waste contains valuable metals (Cu, platinum group) as well as potential environmental contaminants, especially lead (Pb), Antimony(Sb), Mercury (Hg) ,Cadmium (Cd),Nickel(Ni), polybrominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs).

Burning E-waste generates toxic gases such as dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polyhalogenated aromatic hydrocarbons (PHAHs), and hydrogen chloride. The chemical composition of E-waste changes with the development of new technologies and pressure from environmental organizations on electronics companies to find alternatives to environmentally damaging materials. Most E-waste is disposed in landfills. Effective reprocessing technology, which recovers the valuable materials with minimal environmental impact, is expensive. Rich countries export an major quantity of E-waste to poor countries, where recycling techniques include burning and dissolution in strong acids with very few measures to protect human health and environment.

KEYWORDS: e waste, heavy metals, landfill , bioleaching, incineration

I. INTRODUCTION

E-waste include discarded appliances that use electricity. E-waste describes waste electronic goods, such as computers, televisions and cell phones. It also includes traditionally non-electronic goods such as refrigerators and ovens. Programmable microprocessors are now incorporated into electrical equipment, such as refrigerators. Therefore refrigerators are also e waste. However, it is the rapid growth of computing that is driving E-waste production. In the next five years, one billion computers will be retired [1]

E-Waste is chemically and physically very distinct from other forms of municipal or industrial waste which includes more biological component. It contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and hazardous effects on human health. Recycling can recover reusable components and base materials, especially Cu and precious metals. However, due to lack of facilities, high labour costs, and tough environmental regulations, rich countries tend not to recycle E-waste. Instead, it is either landfilled, or exported from rich countries to poor countries, where it is recycled using primitive techniques and little regard for worker safety and of environmental protection [2]

The environmental effects of E-waste disposal are drawing increasing attention of non Governmental Organisations (NGOs) as well as the scientific community. This review aims to assess the global production of E-waste, the contaminants associated with E-waste, and the likely environmental impact of E-waste associated contaminants. This paper focuses on the physical, chemical and environmental effects of E-waste.

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Related work on the global production of E-waste

In 2006, the world's production of E-waste was estimated at 20–50 million tonnes per year [3] representing 1–3% of the global municipal waste production of 1636 million tonnes per year [4] Cobbing (2008) calculated that computers, mobile telephones and television sets would contribute 5.5 million tonnes to the E-waste stream in 2010, rising to 9.8 million tonnes in 2015. In rich countries, E-waste may constitute some 8% by volume of municipal waste (Widmer et al., 2005). The contribution of an item to the annual E-waste production, E (kg/year) depends on the mass of the item, M (kg), the number of units in service, N, and its average lifespan, L (years)

E = MN /L

Computers, which have an average lifespan of three years [5], comprise a greater proportion of e waste than refrigerators and ovens, which have life spans of 10–12 years.

II. AN ESTIMATION OF GLOBAL E-WASTE PRODUCTION

Calculating global E-waste production requires information on the number of items presently in use.. These data are generally available in rich countries so E-waste production can be calculated using Eq. (1). Switzerland country produces 9 kg per person per year [6] European countries produce E-waste at a rate of 14 kg per person per year [7] The United States produced some 2.63 million tonnes in 2005 [2] while China produced 2.5 million tonnes [8]

E-waste production data for poorer countries are less readily available. India and Thailand are for example estimated to have, respectively, produced just 0.33 and 0.1 million tonnes of E-waste in 2007 [2] Available data indicates that the global production of E-waste was at least 13.9 million tonnes per year in the middle of this decade. The total E-waste production, 11.7 million tonnes as per the estimate. It includes E-waste of Computera, Facsimile machine, Mobile telephones , Televisionc , Video recorder and DVD players, Air conditioning unit , Dish washerb Electric cookers, Electric heaters, Food mixers, Freezers , Hair dryers, Irons, Microwaves, Refrigerators, Telephones, Toasters, Tumble dryers, Vacuum cleaners, Washing machines, Again, the total global E-waste production will be considerably higher because some of the data are six years old. Similarly, the mass of e waste produced will be higher because it includes heavy electrical items, such as refrigerators and air conditioning units. Adjusting the calculated figure of 13.9 million tones per year for the 20% growth in the World's Gross Domestic Product (GDP) over the last five years, gives 16.8 million tones. Given that computers form the bulk of E-waste and that most E-waste is produced in rich countries [2] it is probable that the actual global E-waste production is 20–25 million tones per year, at the lower end of estimation of 20– 50 million tones per year [3].

Potential hazards associated with E-waste

The chemical composition of E-waste varies depending on the age and type of the discarded item. However, most E-waste is composed of a mixture of metals, particularly Cu, Al, and Fe, attached to, covered with, or mixed with various types of plastics and ceramics . A discarded personal computer with a CRT monitor typically weighs 25 kg and consists of metal (43.7%), plastics (23.3%), electronic components (17.3%) and glass (15%) [9]. Heavy items, such as washing machines and refrigerators, which are mostly composed of steel, may contain fewer potential environmental contaminants than lighter E-waste items, such as laptop computers, which may contain high concentrations of flame retardants and heavy metals.

Typically all E-waste contains some valuable components such as Cu. These are environmentally important, because they provide an incentive for recycling, which occurs predominantly in poor countries, and may result in a human health risk and environmental pollution. Platinum group metals are included in electrical contact materials due to their high chemical stability and conductance of electricity. Contaminants, such as heavy metals, are used in the manufacture of electronic goods, while others, such as polycyclic aromatic hydrocarbons (PAHs) are generated by the low-temperature combustion of E-waste. The burning of insulated wire, which typically occurs in open iron barrels, generates 100 times more dioxins than burning domestic waste[10]. The concentrations of environmental contaminants found in E-waste depend on the type of item that is discarded and the time when that item was produced. E-waste composition is spatially and temporally heterogeneous. Concentrations of Cd, Cu, Ni, Pb and Zn are such that were

these elements released into the environment they would pose a risk to ecosystems and human health [11]. Using the estimation that 20 million tonnes of E-waste are produced annually, the amounts of some potential contaminants that are contained in the annual E-waste stream have been calculated .Although recycling may remove some contaminants, large amounts may still end up concentrated in landfills or E-waste recycling centres, where they may adversely affect human health or the environment. Some 820,000 t of Cu are included in the annual flow of E-waste. Despite recycling, it would seem E-waste is a major contributor to the some 5000 t of Cu emitted into the environment annually [12] Polybrominated diphenyl ethers (PBDEs) are flame retardants that are mixed into plastics and components. There are no chemical bonds between the PBDEs and the plastics and therefore they may leach from the surface of E-waste components into the environment . PBDEs are lipophilic, resulting in their bioaccumulation in organisms and biomagnification in food chains (Deng et al., 2007). PBDEs have endocrine disrupting properties [13].
Old refrigerators, freezers and air conditioning units contain ozone-depleting Chlorofluorocarbons (CFCs). These gases may escape from items disposed in landfills .

Uncommon contaminants present in E-waste

E-waste may contain complex mixtures of potential environmental contaminants that are quite unique from other forms of waste. Some potential contaminants in E-waste are uncommon. There has been little work on their environmental effects. Examples include Lithium in lithium batteries, Berelium as contact material, Antimony flame retardant, Galium used in silicon chips [14].

Disposal and recycling of E-waste

Most E-waste is currently landfilled [15] However, the chemical cocktail that leached from a variety of consumer electronics was found to be toxic to aquatic organisms. Incineration prior to landfilling may increase the mobility of heavy metals, particularly Pb [10] On an average the plastic fraction of E-waste has Sn, Pb, Ni, Zn and Sb concentrations >1000 mg/kg. It also has more than 100 mg/kg of Cd [16] While contained in a plastic matrix, these elements do not leach and are not available for degradation. . However, burning in open air liberate these elements. As with other materials, leaching of many heavy metals such as Pb from E-waste is increased at low pH and in the presence of organic ligands . Antimonate has been shown to be more mobile and more toxic in soil than Pb, and is more soluble at higher pH values and readily taken up by plants. Niu and Li in 2007 showed that compaction of E-waste, prior or during landfilling, can increase leaching through the disruption of circuit board components. The same authors showed that cement solidification, which imparts impact resistance, raises pH and reduces water flux through the waste, reduced Pb leaching from E-waste to below regulatory levels. Recycling E-waste recycling involves the disassembly and destruction of the equipment to recover new materials . Recycling can recover 95% of the useful materials from a computer and 45% of materials from cathode ray tube monitors [14] In rich countries, such as Japan, high tech recycling operations function well with little environmental impact . Modern techniques can recover high-Pb glass from discarded CRT with minimal environmental impact.

Any ecological benefits of recycling are more than offset if the waste has to be transported long distances due to the negative environmental effects of fossil fuel combustion [15] However, recycling always has a lower ecological impact than landfilling of incinerated E-waste. Mechanical separation of components is the first step in E-waste recycling. Components may be separated for reuse or metallurgical processing .This process can be automated or carried out by hand. In poor countries, there is a risk that children may be employed to separate E-waste components [1] An open flame is often used to free components which may result in exposure to volatilised contaminants. Valuable metals may be recovered from E-waste by pyro- hydro- and bio-metallurgical processes .Pyrometallurgical processing includes incineration of the matrix and smelting of the target metals. Such operations have the potential to emit dangerous compounds into the environment. Hydrometallurgical processes involve the dissolution and recovery of the target metals with acids, cyanide, halides, thiourea or thiosulphate. Presently limited to rich countries, bio-metallurgical processing is attractive due to its low-cost and high specificity for the target elements . Brandl et al. in 2001[16] showed how Thiobacilus bacteria and fungi (*Aspergillus niger*, *Penicillium simplicissimum*) could facilitate metal leaching from electronic scrap. Creamer et al. in 2006 [17] employed *Desulfovibrio desulfuricans* to recover Au, Pt and Cu from E-waste.

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III. CONCLUSION AND FUTURE WORK

E-waste is omnipresent. It is characterized by its unusual chemical composition and the difficulties associated with its disposal at local and global level. Contamination associated with E-waste has already caused tremendous environmental degradation in poor countries and negatively affected the health of the people who live there. Cleansing of such large contaminated sites is probably not possible, since they have been heavily contaminated with numerous contaminants, many of which are not studied in detail. However, the negative effects of the contaminants at these sites may be reduced using standard remediation technologies. There is very limited knowledge on the ecological effects, human health risks involved and remediation options available for some E-waste contaminants, such as Lithium and Antimony. In future more research is required in this topic.

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