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E-Waste Management – Current Scenario

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Abstract

Fast development of technology and venturing of new products in the market has increased the production of electrical and electronic devices in turn increased the E-waste generations. The E-waste contains harmful contaminants such as polychlorinated, polybrominated, heavy metals, toxic gases etc. and therefore they are classified as hazardous waste. The global issue about E-waste is now a known factor due to environmental implications and therefore the developing countries framed laws and acts and indicated that the producers are sole responsible for all the damages. E-waste management involves complex and employability of new technologies and equipment and it should ensure proper handling and disposal under Government Act. E-waste management is considered as secondary resource since the recovery of elements varies from noble metals to trace metals which can be recycled and reused.

Keywords: *Technology, environment, eco-friendly, toxic, recovery, noble metal, nonmetal, sustainable.*

1. Introduction

The term WEEE refers to the E-waste Electrical Electronics Equipment generated and declared as wastes1. Rajya Sabha Secretariat, India recorded that about 70% of total waste generated in India is from various sectors like Government, Public and Private and the contribution from individual households is 15% and rest from manufacturing sectors (As per MAIT in 2007 was 3,80,000 tons of E-waste generation)2. The E-wastes are considered to be an important secondary precious resources for its elements but at the same time it may become a serious threat to the environment [3] [4]. The major alarming increase of E-waste is the lack of awareness and appropriate skill to handle the problems [5] [6]. The management process involves huge initial investments for advanced equipment, treatment process and provide personal health proyection equipment etc. [7] [8]. Under 1986, Environment (Protection) Act by Central and State Government, India laws are amended to safeguard the people from exposure to toxic or hazardous materials [9]. The electronic equipment uncompressed of heavy metals like beryllium, lead, cadmium, copper, aluminum etc. (60%), plastics (30%) and other pollutants (10%) [10] and these materials create environmental contaminations and results in health problems [11]. Evidences prove that around 29-59 million tons of e-waste worldwide and an increase of 10% every year [12] [13]. The percentage of E-waste produced is tabulated in Table 1.

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Table 1: Percentage of e-waste generation from electronic goods [12] [14]

Electronic goods	Percentage of e-waste (%)
Washing machine, vacuum cleaner, ovens, air conditioner, coffee / tea machines	30
Refrigerators	20
DVD / VCR, CD, radio, Hi Fi devices	15
Computers, phones, fax machines, printers	15
Television	10
Monitors	10

According to World Economic Forum report about 48.5 million tons of E-waste has been generated and Spain registered 113.131 tons of E-waste15. In US alone around 100 million computers E-waste are thrown as waste in which only 20% has been recycled. China with 160 million electronic devices / year and Indian waste was around 146,000 / year (ranking fifth in the world) [16] [17].

2. E-Waste Management in India

Environmental epidemiological studies are required in terms of E-waste generation, their impact amplitude and recycling process. Many countries have developed legal laws to restrict the inflow of hazardous materials in the environment by Restriction of Hazardous Substance (RoHS) Regulations which includes electronic equipment [18]. Environmental (Protection) Act 1986 indicates “Pollution Pays Principle” where the party will be responsible paying for the damage in the environment [19] and any violation will be liable for punishment [20]. Due to urbanization and advancement in technology demand for electronic newer goods are increasing day by day and this in turn increased the generation of E-waste significantly[21] and it is estimated that E-waste generated three times faster than the municipal solid waste[22] (20-50 million tons) in the developing countries[23]. The developing countries are exporting the E-waste to Ghana, Indonesia, Thailand, Malaysia, Nigeria etc. [24]. It has been estimated about 3,00,000 tons of E-waste generated in India and only 3% is recycled by authorized recyclers[25].Report evidence revealed that there was 53.1% increase of domestic household sales from 1998 to 2002[26] and this will accelerate 10% of E-waste generation annually[27] and affect environment drastically[28]. According to Central Pollution Control Board (CPCB), the companies are responsible for collection and disposal of E-waste according to EPR authorization plan in India [26] [27].

3. Novel Approach for E-Waste Management

E-waste contains around 1000 different elements which are considered as the second generation resources [21]. Improper recycling methods in China and India according to report published by Basel Action Network and Silicon Valley Toxin Coalition has caused serious environmental pollution [24][27]. Since the techniques used are primitive and lack technical capabilities [28] and various harmful effects are listed in the Table 2.

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Table 2: Harmful effects of primitive techniques [21] [29-32]

Techniques employed	Harmful effects
Use of concentrated nitric acid and hydrochloric acid	Exposure to volatile compounds of nitrogen and chlorine
Burning of E-waste	Formation of carcinogenic agents / dioxin / furan etc.
Heating of boards	Exposure of metal / hazardous fumes
Landfills	Leaching of residual metals
Incineration (Low temperature)	Release of air pollutants
Mechanical methods	Spillage and wastes generation of toxic dusts / contaminants in the environment

Evidences of key components of Printed Circuit Boards (PCB) are listed in the Table 3 and it is revealed that one ton of PCB contains copper (20% and gold (250g)).

Table 3: Constituents of Printed Circuit Board (PCB) [21]

Constituents	Percentage (%)
Metals	28-30
Nonmetals (plastic, resins, glass)	70
Cadmium	16
Iron	3
Lead	2
Nickel	2
Silver	0.05
Gold	0.03
Palladium	0.01
Antimony	< 0.01
Bismuth	<0.01

A novel approach for recycling of PCB was attempted by two methods namely, Laser induced Inductive Coupled Plasma Mass Spectrometry (ICP-MS) and Pyrolysis method [21] and the results are tabulated in Table 4.

Table 4: List of elements recovered through Laser Induced Inductive Coupled Plasma Mass Spectrometry (ICP-MS) and Pyrolysis from Printed Circuit Board [21]

Elements	ICP-MS(µg/g)	Pyrolysis (µg/g)
Ag	229.05	1.46
Al	2780	692.9
As	27.15	17.77
Au	2.47	0.83
Ba	4089	84.18
Ca	8559	3681
Cd	4.11	0.88
Co	13.1	3.38
Cr	187.1	60.36
Su	30442	645

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Fe	1945	500.7
Mn	38.99	119.0
Ni	76.79	9.5
Pb	29296	72.89
Pd	1.23	0.1
Sb	18623	1522
Si	61114	21928
Sn	62622	185-5
Ti	2550	252.0
Zn	200.2	174.5

Recently, microbial recycling technologies for metal extraction from E-waste has been taken a new dimension[33-35] where, microorganisms are involved in the bioleaching of metals[36,37] and Table 5 represents the microorganisms involved in the bioleaching of E-waste.

Table 5: Efficiency of microorganisms in the recovery of metal elements

Microorganisms	Metal recovery (%)
Aspergillus niger	Li- 100, Cu- 94, Mn-72, Al-62, Ni-45, Co-38 [38]
Chromobacterium violaceum	Cu-13.79, Au-2.55, Ag-0.44 [39]
Kombucha Sp.	Li-100, Sr-10 [40]
Acidithiobacillus thioxidine	Cerium, Curapium, Neodymium->99, Yttrium and Lanthanum – 80 [41]
Psuedomonus putida	Cu- 98, Au – 44 [42]
Sulfobacillus thermosulfidoxidens	Cu – 95, Al= 91, Zn – 96 [43]
Acidophillic consortium	Cu – 77, Al – 88, Zn – 92 [44]
Sulfobacillus thermosulfidoxidans	Cu – 89, Ni – 81, Zn – 83 [45]
Acidothiobacillus ferroxidens	Cu – 96.8, Zn – 83,8, Al – 75.4 [46]
Aspergillus niger	Li- 100, Cu- 94, Mn-72, Al-62, Ni-45, Co-38 [38]
Chromobacterium violaceum	Cu-13.79, Au-2.55, Ag-0.44 [39]
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4. Conclusion

E-waste management if applied systematically and effectively taking into consideration all the issues in the environment it will surely pave a way for additional resource to mankind. Among other recycling technology, microbial application will have high attention by the researcher to venture into it for lesser cost effective and ecofriendly methodology for a sustainable environment.

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