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E-WASTE MANAGEMENT IN INDIA: OPPORTUNITIES AND PREDICAMENTS UNDER SWACHH BHARAT ABHIYAN

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ABSTRACT

Electronic waste or E-waste is relatively a narrative addition to the ever budding perilous waste stream. It includes superfluous electronic and electrical equipment. Developing countries are facing mammoth challenges related to the generation and management of E-waste which are either internally generated or imported illegitimately; India is no exception to it. The accessible management practices related to E-waste in India are reasonably meager and have the aptitude to risk both human health and the environment. Moreover, the policy level initiatives are not being employed in an appropriate way. The ascetic problem of E-waste along with its policy echelon implications is looked upon in the paper. During the course of the study it has been created that there is an urgent need to take up the issues related to E-waste in India in order to evade its unfavorable future consequences. This paper is anticipated to offer a practical, scientific, safe and environmentally apposite model system for implementation of E-waste Regulations in the Sub-Continent especially in the wake of recently launched Swachh Bharat Abhiyan in India. Common but differential roles have been recommended at all ranks of e-waste management. E-waste inhibitsa superior amount of valuable eco-friendly materials also and has the prospective to become a worth while business in the country.

Keywords-E-Waste, Environmentally Sound Management, Human Health Risk, Recycling, Swachh Bharat Abhiyan

I. INTRODUCTION

E-waste or electronic waste is labeled as Computers, Televisions, VCRs, Stereos, Copiers, Fax Machines, Mobiles and other Electronic Paraphernalia, which have been discarded, have become archaic, have ceased to function or are no longer wanted. Regrettably, electronic discards is one of the fastest growing wedges of our nation's waste stream. Certain components of some electronic products contain materials that leave the mperilous, depending on their condition and density. For instance, CRTs (cathode ray tubes) from televisions and monitor are exceptionally hazardous, especially since most of them are smeared with a radioactive substance Zirconium (Zr).However, the accessible management practices related to E-waste in India are reasonably meager and have the aptitude to risk both human health and the environment [1].

CED's are common Consumer Electronic Devices that are employed in the domicile or office, such as telephones, cellular phones, answering machines, tape players/recorders, phonographs, video cassette players/recorders, compact disc players/recorders, calculators, copiers and fax machines. The DTSC has concluded that CED's enclose noxious substances and should not be disposed of in landfills. Electronic waste is growing at three times the rate of other wastes [2]. Industrial revolution followed by the progress in information technology during the last century has fundamentally changed people's way of life. E-toxic components in computers could be recapitulated as circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; brominates flame retardants applied on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) painted copper cables and plastic computer sleeves that liberate highly toxic dioxins & furans when burnt to recuperate valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc. Basel Action Network (BAN) reckons that the 550 million computers in the humankindenclose2.78 billion kg of plastics, 700.7 million kg of lead and 286,600 kg of mercury [3]. The average 14-inch monitor uses a hose that contains an estimated 2.6 to 5 kg of lead. The lead can leach into the ground water from landfills thus polluting it. If the tube is mashed and burned, it emanates toxic smoke into the air. The technical dexterity acquired during the last century has shamed a new confront in the management of wastes. Consequently proper management is obligatory while disposing or recycling e-wastes[3].

II. ENVIRONMENTAL AND OCCUPATIONAL HAZARDS OF E-WASTE

Electronic appliances such as computers and television sets are a complicated assembly of more than 1000 materials, many of which are highly toxic such as chlorinated and brominated substances, toxic gases, toxic metals, photo-active and biologically active materials, acid and plastic additives, etc. Each computer color monitor contains an average of 1.8 to 3.6 kg of lead, which can enter the environment, when a monitor is disposed of in unsecured landfills [4]. One of the main dangers comes from cathode ray tubes and the glowing screens used in computer monitor and television circuit boards containing toxic PCBs. Other toxic materials including cadmium, lead oxide, barium, and mercury, causes hazards such as pollution in drinking water, harms fish and wildlife, high rates of miscarriages, birth defects and cancer clusters among workers [3, 4].E-waste poses direct health risks when it degrades and internal chemicals are released to the environment. Lead and mercury are highly potent neurotoxins, particularly among children, who can suffer IQ deficiency and developmental abnormalities even at very low levels of exposure. Cadmium, a toxic metal found in circuit board, is listed by EPA as a “probable human carcinogen”, and also produces pulmonary damage when burned and inhaled [4]. Hexavalent chromium, also used in circuit boards, has been found to produce sinus and tumors in lungs when inhaled at high doses. In addition to metals in electronics, many environmentalists worry that the brominated flame retardants (BFR) in plastic pose a health risk [5].It is found that all the imported e-waste from countries like the US is dismantled and processed in some areas of Delhi like Mandoli, Sadar Bazar, Kanti Nagar Extension, Old Seeampur and Turkman Gate, by burning, smashing and tearing apart electronic wastes to scavenge for precious metal [5]. In the process, laborers are unwittingly exposed the mselvesand their surroundings to toxic hazards including lead poisoning, chemical blindness etc. The Environmental and occupational Impacts due to computer/ e-waste processing are presented in Table 2**.** Hazards Associated in E-

waste Processing In addition to the recent evidence of worker exposure to flame retardants, the environmental risks posed by land filling and burning are also significant. When computer, television wasteis land filled or incinerated, it poses a contamination problem, in the form of leachate and toxic air emission**.** Hazards due to Incineration. The incineration of brominates flame-retardants at a low temperature of 600–800 °C maylead to the generation of extremely toxic poly brominated dioxins (PBDDs) and poly brominated furans (PBDfs) [6]. Significant quantity of PVC is contained in e-waste, which makes the flue gas residues and air emissions particularly dangerous. The introduction ofe-waste into incinerators results in high concentration of metals, including heavy metals in the slag and fly ash [5, 6].

Table 1 Health Hazards of Constituents in E-Waste

Constituents	Health Effects	Source of Constituents
Lead	• Cause to damage the central and peripheral neural system, blood systems and kidney • It effects badly on child brain development, damage to the circulatory system and kidney.	Available in solder in printed circuit boards, glass panels, and gaskets in computer monitors.
Cadmium	• Irreversible toxic effects on human health. • It accumulates in kidney and liver. • Damage neural	Available in chip resistors and semiconductors.
Mercury	• Cause chronic damage to the brain. • Cause respiratory and skin disorders due to • Bioaccumulation in fishes.	Available in relays and switches, and printedcircuit boards.
Chromium	• It causes bronchitis.	Available in galvanized steel plates and decorator or hardener for steel housing.
Plastic and PVC	• While burning produces dioxin that causes reproductive and developmental problems.	Available in Cabling and computer body.
Brominated flame retardants	• It disrupts endocrine system functions	Available in electronic equipment and circuit Boards.
Barium phosphorus and heavy metals.	• It cause muscle weakness and damage to heart, liver, and spleen.	Present in front panel of CRTs.
copper	• It causes stomach cramps, nausea, liver damage, or Wilson‘s disease.	Present in copper wires, printed Circuit boardTracks.
Nickel	• Causes allergy to the skin results dermatitis while allergy to the lung results in asthma.	Present in nickel-cadmium rechargeable batteries.
Lithium	• It can pass into breast milk and may harm a nursing baby.	Present in Lithium-ion battery

Beryllium	• It is Carcinogenic (lung cancer). • The inhalation of fumes and dust causes chronic beryllium disease.	Present in Motherboards.

2.1 Challenges for Esm

The unceremonious recyclers with primordial and environment aloof e-waste disposal schemes lead to pollutants outburst in the atmosphere. After recovery of objective material, it is being left either in open or put in the municipal waste resulting contamination of air, water and soil. The heavy metals trickle out from the components if not handled properly and mischief our natural resources through leach ate. The ESM is not in practice fully in India as on ground only registered recyclers are complying ESM. However, more recyclers have uttered their curiosity in ESM but their numbers are not increasing in the proportion to the e-waste generation. As more than 92% e-waste generated hit upon their way to utmost to Local collectors (Kabadees) and rest to land filling [7]. It is very factual that e-waste handling is a business driven line of work and even under the realm of ESM, the observance from e-waste stakeholders is lacking since they are not working consistently. The ESM execution is a big contest in the country to heal e-waste. These are the stumbling blocks hindering implementation of ESM. Gargantuan e-waste generation in the country. Lack of concern towards e-waste compilation from sources. Unanimity for common e-waste dumping point/Centre in towns, metros. Persistent e-waste Sources are not classified. Heedlessness in EEEs disposal. Sloppy E-waste Collection and Restoration System. Gaucheness in Recycling and Recovery of materials. Incompetence of proficient Incinerating Facility. Dearth secured Land Fills. Tentativeness of recyclers towards allotted quantum of e-waste. Uselessness appealing approach to fascinate people to come forward for e-waste resolution. Ineptness of acquaintance with e-waste treatment expertise. Formal e-waste compilation and storage system is not in place. No formal reporting of e-waste generated by foremost e-waste generators to CPCB on yearly basis. A formal e-waste handling and disposal structure has been defined by CPCB. For e-waste treatment, awareness about their ailing effects helps to pact with it[8]. The above mentioned gaps need to be filled for execution of ESM uniformly in the country.

III. RECOMMENDATIONS FORMANAGEMENT OF E-WASTES

3.1Inventory Management

Appropriate control over the materials used in the manufacturing process is an imperative way to trim down waste generation. By reducing both the extent of hazardous materials used in the progression and the amount of surplus raw materials in stock, the magnitude of waste generated can be reduced. This can be done in two behaviors i.e. establishing material-procure review and organize procedures and inventory tracking system. Another inventory management procedure for waste diminutionis to make sure that only the needed quantity of a material is arrayed.

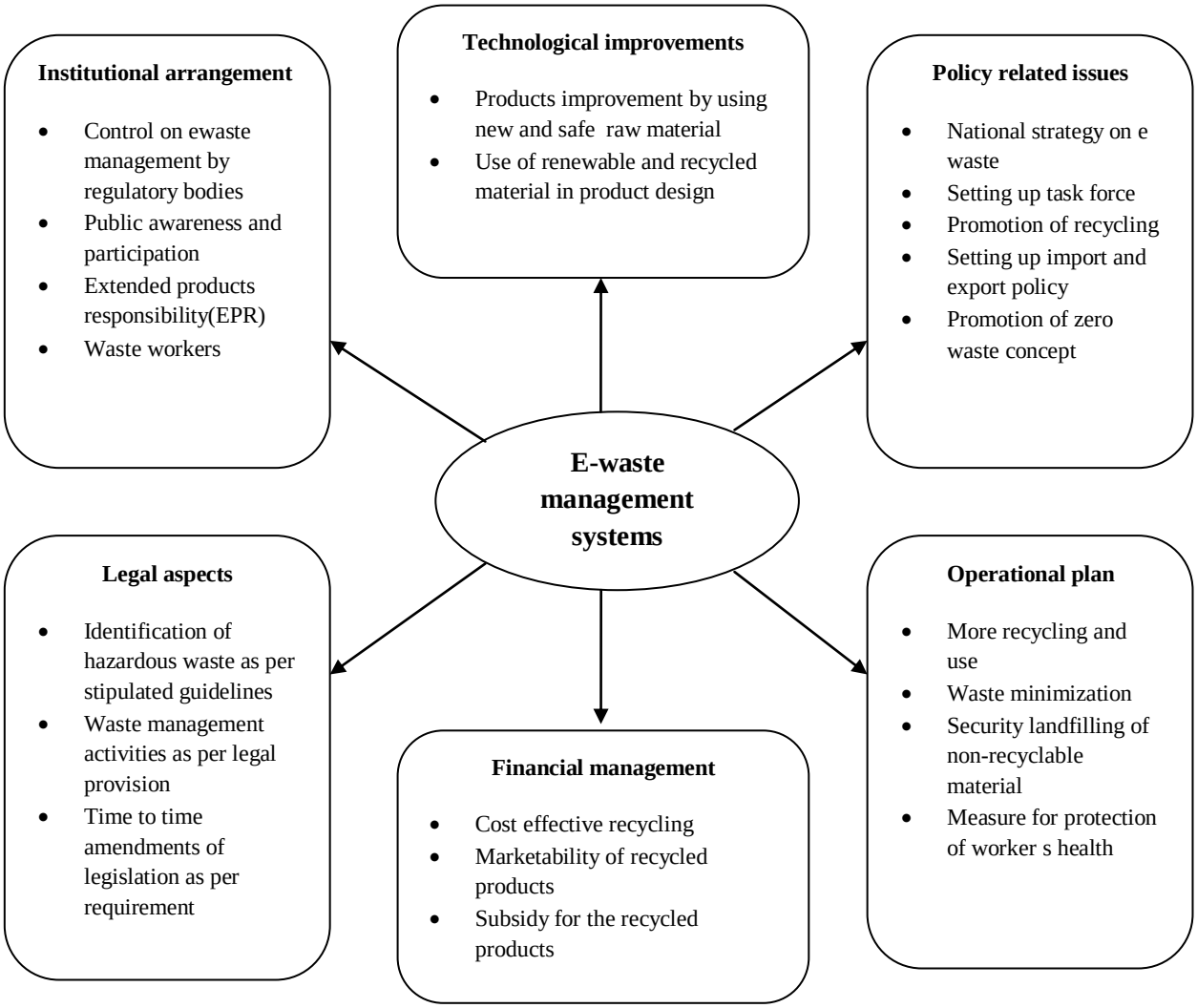

Fig 1 Integrated Approach for Improvement in E-Waste Management Systems

3.3 Volume Reduction

Volume reduction comprises those techniques that confiscate the hazardous fraction of a waste from a non-hazardous portion. These techniques are usually to lessen the volume, and thus the cost of disposing of a waste material. Methods comprise gravity and vacuum filtration, ultra filtration, reverse osmosis, freeze vaporization etc. For example, an electronic module manufacturer can use compaction equipment to diminish volume of waste cathode ray-tube.

3.4 Recovery and Reuse

Waste can be recovered on-site, or at an off-site recuperation facility, or through inter industrys wap over. A number of physical and chemical techniques are accessible to repossessa waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc [8].Sustainable Product Design: Attempts should be made to devise a product with smaller amount of hazardous materials. Renewable materials and energy: Bio-plastics, Bio-based toners, glues and inks etc., should be promoted.

3.4.1 An Ideal Model Recycling Procedure

Recycling activities should inaugurate with the acceptance of e-waste material from diverse locations. The material must be primarily weighed, and separated product-wise (monitors, CPUs, printers, keyboards, etc.) for effortless recovery. The material should be then checked by certified technicians to make certain whether the equipment are working or non-working. If the equipment is in working/ near-working state, then the technicians should try to revamp/ upgrade the equipment to make sure that they become re-saleable. If the equipment are not in a working condition, attempts should be made to retrieve components. Accordingly, the technicians must take apart the equipment into components and aim to retrieve whichever working parts thereof. The lasting components should then exceed for shredding into the twin-shaft shredder which aidto "open up" sealed components, unraveling metals from plastic. The shredder allow physically dismantled components through a hopper at one end, passes the feed through the shredding chamber where two counter rotating hexagonal shafts en suited with circular blades mince the components, and the shredded items are slumped on to a moving conveyor belt. Certain components of the computer such as printed circuit boards (PCBs) include expensive metals such as gold, silver, etc. These PCBs should not be sent for shredding, instead be amassed and used for precious metal extraction. That segment of e-waste which enclose hazardous elements and cannot be recycled must be sent to authorize hazardous waste treatment and dumping facilities for ultimate disposal as per the norms of the Pollution Board [8].

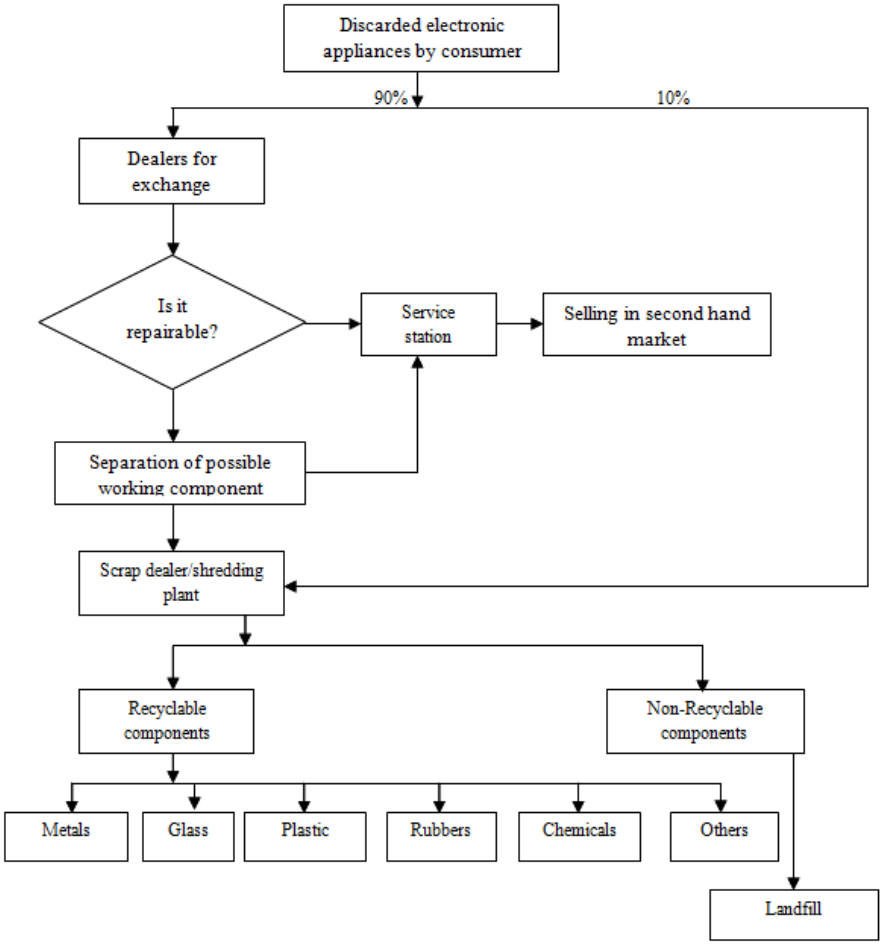

Fig 2Recycling and disposal of electric appliances

Recycling of e-waste is not required simply because it is obligatory or environmental prerequisite, but is also crucial to avoid bad exposure when computers and other office automation systems are found in landfill or third world countries, consequently, the industries should move en route forarche type shift with respect to cost avoidance v/s risk avoidance. Risky substances recovered during the practice of recycling of e-waste are being disposed off through the Common Hazardous Waste Treatment, Storage & Disposal Facility, commonly known as CHWTSDF, sanctioned by the Pollution Control Board in the prearrange dmanner [9]. Withdrawal of precious metals out of e-waste material is an integral and a very imperative part of the complete e-waste recycling chain.

IV. THE INDIAN SCENARIO

Developed countries organize their wastes to India and other developing countries. A recent exploration exposed that much of the electronics crooked over for recycling in the United States ends up in Asia, where they are either disposed of or recycled with diminutive or no watch for environmental or worker's physical condition and safety. Major grounds for exports are cheap labor and lack of environmental and professional standards in Asia and in this way the toxic seepage of the developed nations flood the world's poorest nations. It is crucial that developing countries and India in particular wake up to the domination of the developed countries and set up apposite management measures to thwart the hazards and catastrophe due to mismanagement of e-wastes. In India there is an exceptional technology and machineries for recycling of electrical & electronic waste to suit the environmental intention and best resurgence practices [9]. The process is a combination of physical and mechanical dismantling, size reduction, segregation, dust collection as well as sending unsafe waste for final dumping and precious metal bearing components for refining. Complete system is based on the philosophy of clean environment and zero landfill.

4.1Sources of E-waste

Electronic waste principally computer waste is budding exponentially in volume because of increasing demand of information technology and its relevance in the national development. Various government departments, public as well as private sectors are high-speed feeding old electronic appliances such as computers, telephones, etc, into the squander stream.

In India, two chief sources for e-waste are acknowledged:

- Domestic e-waste.
- Discarding of e-waste from other parts of the world.

Domestic e-waste is engendered from following sectors:

- Individual household and modest business
- Large business, Institutions, government houses and Foreign Embassies
- PC producer and retailers
- Secondary market of old PCs

Out of these sources, individual households have the slightest contribution in the origination of e-product obsolescence. It is the illegitimate dumping of trash computers from other parts of the world that produce the

predicament of managing e-waste. Subordinate processing cost, lower labor cost and lack of environmental decree enforcement are the major reasons for increasing unlawful trading of e-waste[10].

4.2. Quantification and Composition of E-waste

The exact magnitude of the e-waste cannot be determined because there is no reliable parameter to estimate how much of e-waste is generated and how much is imported to India. At the same time, it is still difficult to get the exact statistics regarding where e-waste is getting recycled since most of it is handled by the unrecognized sector. However, during investigation it was observed that e-waste trade is thriving in some areas of Delhi where men,

Women and children break apart and process obsolete computers and other electronic. Products imported from overseas.

4.3 E-Waste statistics in India

- India fifth biggest generator of e-waste in 2014 [11]
- 76% of e-waste workers in India suffering from respiratory ailments [11]
- The total e-waste in India has been anticipated to be 1, 46,180 metric tons per year [10,11]
- The e-waste refuse stream is growing at a rate of 5-6 % per year, making it the fastest growing refuse problem in the world.
- The average life expectancy of a new PC is now less than two years [13]
- Delhi tops the list at present with 11,017 tons followed by Mumbai with 9,730 tons and Bangalore with 4,648 tons [13]
- An estimated 30,000 computers become obsolete every year from the IT industry in Bangalore alone. . By 2014 India had about 75 million computers and the base is expected to grow to 140 million computers by 2017 end [14]

V. MANAGEMENT OPTIONS

5.1 Responsibilities of the Government

Governments should set up regulatory agencies in each district, which are vested with the responsibility of coordinating and consolidating the regulatory functionsof the various government authorities regarding hazardous substances with provision of severe punishments. Encouragement of research into the development and standard of hazardous waste management, environmental monitoring and the regulation of hazardous e-waste disposal has to be done. This is more encouraging in India since the launch of Swachh Bharat Abhiyan in October 2014 wherein the revenue generated by recycling e-waste and recovering metals.

5.2 Responsibility and Role of industries

Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options. Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products by educating and rewarding the consumers financially.

5.3 Responsibilities of the Citizen

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford. E-wastes should never be disposed with garbage and other household wastes. This should be segregated at the site and sold or donated to various organizations. NGOs should adopt a participatory approach in management of e-wastes.

VI. EMPLOYMENT PROSPECTIVE OF E-WASTE

The rapidly growing e-waste can be utilized as source of recyclable and recoverable materials and enormous employment opportunities can be explored via this profession. It is evident that the demand of virgin material for the manufacturing of the new EEEs is increasing every day. The use of EEEs have increased manifold in our day to day work. The materials mined from natural resources consume ten times energy with respect to recovery of materials from e-waste. E-waste confirms the availability of these materials but natural resources confirm it partially. In view of that the recovery of recyclable materials from e-waste releases environmental pressure on all natural resources until unless it is carried out by environment friendly techniques and methods. The environment friendly recovery infrastructure adopted by Umicore in Belgium and Attero in India employed specialized, skilled, semiskilled and unskilled manpower in proportion to the e-waste treated [15]. Even before treatment, presently e-waste engages enormous unskilled manpower for the collection, segregation, manual dismantling, packaging, transportation of e-waste. So, there is and would be a huge demand of all kind of man power if e-waste profession is organized professionally in the country.

Table 2 E-waste processing on Annual Basis

Total E-waste produced	E-waste processed in one year	Deficit expected at the end of year	Manpower employed in no's.	Working hours/day	Daily wages	Per annum employment business	Working place	Safety measures
1.7 million tonnes	40000 tonne	1.6 million tones	25000	8 to 10	Rs 400/-	400 crore	Basements/close units	Minimum

Table 2 shows 25,000 MT e-waste processing 400 crore has been spent which arrives as Rs. 160 perKg maximum as processing charges.There is lot of possibilities of multi-crore business of e-waste treatment and concurrently e-waste recycled material marketlike other types of materials can be created very easily. There is a wide scope of this type of market as e-waste is growing ata rapid rate in the country.The refurbishing of EEEs and their components is not established and organized as such in the country, but if it is organizedproperly then

low cost EEEs can be made available to the second hand use easily. The installation of these equipment comes under non-sophisticated equipment as these reassembled kinds of equipment but a separate kind of market can be established like Nehru Place in India where both assembled and branded equipment are being marketed. The e-waste pre-processing is cheap in developing countries due to the availability of human resource at reasonable cost. The availability of update environment friendly recovery technology will strengthen and explores more employment opportunities in the country[16].In India, domestic generation and illegal imports are the two main sources of e-waste [17] and needs to be tackled in elaboration.

VII. CONCLUSION

Electronic equipment is one of the largest known sources of heavy metals and organic pollutants in the waste stream. Without effective collection, reuse, and recycling systems, highly toxic chemicals are found in electronic appliances like, lead, beryllium, mercury, cadmium, chromium, brominated flame retardant, etc will continue to contaminate soil and groundwater as well as pollute the air, posing a threat to wildlife and people. In India, domestic generation and illegal imports are the two main sources of e-waste. It is impossible to determine how much e-waste is generated in India and how much is imported. But the growing quantities at a disastrous proportion and uncontrolled disposal

Practices are alarming the situation from an environmental point of view. Reuse and recycling of electronic equipment is a beneficial alternative than disposal as it reduces the amount of toxic and hazardous substances that may enter the environment through disposal. Thus, it is opined that e-waste management is a new challenge for waste management in India and for its proper management; various measures for improvement in product design by using safe and environmentally friendly raw materials and most emerging technologies have been suggested. Adoption of all those measures will minimize the environmental pollution due to toxic constituents present in electronic products and help in achieving a clean environment.

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