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E- Waste Status and Management in India

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Abstract
Due to improvement in our standard of life and technology advancement more e- waste is generated now. Quantity of e- waste is continuously increasing not in the developing countries but also in the poorer countries. The disposal of E–waste is a matter of concerns, as it contains hazardous materials. E- waste also contains high purity precious metals. In this review article we review the definition of e-waste, composition , and current situation of the e waste in the world. Status of E-waste in India and effects of E-waste constituents on environment and human health is described. In all Indian states Maharashtra is the highest producer of WEEE Andhra Pardesh and Tamilnadu are at second and third number. Because of the many fold increase in hazards due to increase in E-waste and recycling by untrained technicians using old methods there is a regulatory responses to the E- waste phenomenon. The aim of The Basel Convention and the Bamako Convention to prevent and minimize the trans boundary passage of hazardous waste is described. Methodologies used to minimize the E-waste in India are described. Management of E-Waste in India is highlighted. At Last list of organization processing e-waste in India along with their URL is provided.
Keywords: E-Waste, WEEE, Reduction, Recycling, Environment, Human Health, Basel Convention, The Bamako Convention, Extended Producer Responsibility.

Introduction

In the past our lifestyle has affected the environment. A More sustainable consumption habits is to be adopted. In the industrial sectors fast consumption and short life cycles due to rapidly developing technology generated huge amount of e-waste . These days the e-waste is land filled. Because of material composition and unavoidable restrictions in landfills recyclability, is becoming unavoidable. This has compel the researchers to develop new techniques for the recycling and re-use of e -waste. The recycling of e-waste is required for proper waste management and also to recover valuable materials'. The E-waste is basically "Waste of Electrical and Electronic Equipment (WEEE)" including old computers and IT equipments. Several e-waste definitions are :-

European Directive 2002/96/EC : "Waste electrical and electronic equipment, including all components, subassemblies and consumables which are part of the product at the time of discarding". The Directive 75/442/EEC, Article I (a), defines as "waste" "any substance or object which the holder discards or is required to discard in compliance with the national legislative provisions". Basel Action Network (www.ban.org) : "E-waste includes a wide and developing range of electronic appliances ranging from large household appliances, such as refrigerators, air-conditioners, cell phones, stereo systems and consumable electronic items to computers discarded by their users". OECD (www.oecd.org) : "Any household appliance consuming electricity and reaching its life cycle end"..In this article, "e-waste" and WEEE are considered synonymous. According to the Directive 2002/96/EC the e-waste is of following ten types :.

- Large appliances for household
- Small appliances for household
- Telecommunications and information technology equipment
- Consumer durable
- Equipment required for Lighting
- Electrical and Electronic and Electrical tools (E&E tools)
- Sports equipment and Electronic Toys
- Devices required for Medical purpose
- Monitoring & control instruments (M&C)
- Automatic dispensers

E-waste contains both valuable and hazard materials[1] . It is chemically and physically different from solid waste. E- waste need to be specially treated and recycled to prevent environment and human health. It is possible to recover the valuable base metals recovery by recycling of e-waste. The recovery of valuable materials involvesthe high labor cost and the environmental legislation in Western countries are strict .There fore recycling is carried out in poorer Asian countries such as China and India[2]. Asian countries uses obsolete methods with not much emphasis on the employees' protection[3]. Because of this , the e-waste disposal has become concern of politicians and several non-governmental organizations, such as Greenpeace

(www.greenpeace.org), Basel Action Network (www.ban.org), Silicon Valley Toxics Coalition (www.svtc.org).

WEEE composition varies from equipment to equipment. Interestingly WEEE composition also depends on the age of the equipment. High amount of precious metals are available in IT and telecommunication system WEEE. Scrap is present in household appliances. Average composition of WEEE is metal (40%), plastic(30%) and refractory oxides (30%) [4]. Out of 40% metal about 20% is copper . Rest of the 20% of metal contains ,8% iron 4% tin, 2% nickel , 2%lead, 1%, zinc, 0.02% silver, 0.01%, gold and 0.0055 palladium [5,6]. The plastic components are Polyethylene, polypropylene, polyesters and polycarbonates [4]. The treatment of WEEE troublesome because of the presence of substances like heavy metals and organic compounds. The volatile metal halides formed by the combination of plastic fraction and halogens show a catalytic effect on the formation of dioxins and furans [5].

E-Waste Current Situation : At present E-waste produced [7]is about 2% of global urban waste production (1636 Mt/year)[8,3]. In 2010 the WEEE was 5.5 Mt due to PCs, cell phones and TVs , by 2015 this may increase to 9.8 Mt. In future the contribution of WEEE will increase to 8% of the urban waste volume[9]. Actually each electronic item's contribution, E, in the annual WEEE production depends upon its mass, M (kg), its numbers , N, and its average life cycle, L (year). Then E = MN/L .Hence contribution of computers (average 3-year life cycle)[10] is more than refrigerators and electrical cook-stoves, having an average life cycle of 10-12 years. Table -1 summarize e-waste types , their mass and estimated life cycle . There is 3-5% per year [11]increase in quantities . During the 1990-1999 period approximately 3.3-3.6 kg/resident, of the e-waste was produced in EU-15. Swiss produces about 9 kg/person/year[9]. the European population produces about 14 kg/person/ year[12]. The total EU-15 produces 5.5 Mt/ year and, of EU-27 produces 8.3-9.1 Mt/year[13]. USA and China produced approximately about 2.6 Mt/year[3, 14]. No data is available for poorer countries.. In in 2007 , it was assessed that India and Thailand produced 0.3 and 0.1 Mt of e-waste [3]. According to another data 0.78 billion units PCs, 3.4 billion units cell phones, 1.2 billion stationary phones

Table-1 : E-waste type and their estimated life cycle

Item	Mass of Item in Kg	Estimated life
Personal Computer (PC)	25	3
Fax Machine	3	5
High Fidelity System	10	10
Cell Phone	0.1	2
Electronic games	3	5
Photocopiers	60	8
Radio	2	10
Television (TV)	30	5
Video Recorder DVD Players	5	5
Air Conditioner	55	12
Dish Washer	50	10
Electric Cooker	60	10
Food mixer	1	5
Freezer	35	10
Hair dryer	1	10
Iron	1	10
Kettle	1	3
Microwave	15	7
Refrigerator	35	10
Telephone	1	5
Toaster	1	5
Tumble Dryer	1	5
Vacuum Cleaner	10	10
Washing Machine	65	8

1.4 billion TVs 1.4 billion and 2.5 billion units radios, produce total 11.7 Mt/year [15]of WEEE, excluding relatively large-mass electrical appliances such as refrigerators, air-conditioners etc. in the calculations. Global WEEE production , disposal , recycling and import /export estimate is given in Table-2

Table-2: Global WEEE production , disposal , recycling and import /export estimate(2005)

Country / Region	Annual house hold production in million Tons	Land filling storage and incineration in million Tons	Domestic recycling million Tons	Amount exported in million Tons	Annual import in million Tons
U.S.A	6.6	5.2	0.13	1.3	-
EU-25	7.0	1.6	3.53	1.9	-
Japan	3.1	0.6	1.94	0.62	-
China	3.1	3.6	1.5	-	2.0
India	0.36	0.85	0.36	-	0.85
West Africa	0.05	0.45	0.17	-	0.57
Total	20.21	12.3	7.56	3.85	3.42

Source: Zoeteman.2009 , http://ewasteguide.info/system/files/Zoesteman2009TilburgUniversity.pdf

E-waste Status in India

In India E-waste collection, transportation, segregation, dismantling, recycling and disposal is done manually by unorganized sectors, manually by untrained labors. Because of less awareness , E-waste is thrown along with garbage. Rag pickers collect and segregate the E-waste. E-waste contains reusable and precious material. Rag pickers sell this E-waste to scrap dealers and run their livelihood. The scrap dealers supply the E-waste to recycling industries. The recyclers use old and hazardous technologies and equipment, to recycle/treat the E-waste. There is a continuously rising trend in E-waste growth in India. The E- waste generation was 332979MT in 2005. It increased to 589893 MT in 2013. The expected E- waste is 1851330MT by the year 2025. There is alarming signal for Indian environmentalist and policy makers.

Table 3 describes the E-waste generation in India, here 332979 metric tones waste is generated from imports of WEEE. The domestic generation is 50000 metric tones. 144143 metric tones waste is available for recycling but only 19000 metric tone waste is recycled. During 2007, Manufacturers' association for Information Technology (MAIT), India and GTZ, India has estimated, was 3, 32, 979 Metric Tones , e-waste, arising out of three products : Computer: 56324MT, Mobile Phones: 1655MT, and Televisions: 275000MT. (*Sources: Report on "E-waste Inventorisation in India", MAIT-GTZ Study, 2007.*

Table-3 E- Waste Generation in India

Item	Weight(MT)
Import	332979
Domestic Generation	500000
Total	382979
WEEE available for recycling	144143
WEEE actual recycled	19000

Source : MAIT-GTZ (2007). E-waste Inventorisation in India, MAIT-GTZ study.

The wastes generated by each state in India is listed in Table-4. Maharashtra is the number one producer of WEEE Andhra Pardesh and Tamilnadu are at second and third number. In total about 1.5 lakh tones of e-waste per year is generated in India. Almost all of the E-waste is processed informal sector. Some of cities across the nation show an alarming picture. In India Mumbai produces 24.02 percent of E-waste followed by Delhi with 9730.5 metric tones e-waste (21.21%). Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur takes 3rd, 4th, 5th, 6th 7th, 8th, 9th and 10th place respectively. The generation of large quantity of e-waste is due to high growth of the IT industry during and early product obsolescence due to continuous innovation and consumerism . Out of 144,143 MT e-waste available in 2007 only 19,000 MT of e-waste was processed.

Table-4 WEEE Generating States of India

S.No	State	WEEE(Tonnes)	S.No	State	WEEE(Tonnes)
1.	Andaman and Nicobar Island	92.2	19.	Lakshadweep	7.4
2.	Andhra Pradesh	12780.33	20.	Maharashtra	20270.59
3.	Arunachala Pradesh	131.7	21.	Madhya Pradesh	7800,627
4.	Assam	2,176.7	22.	Manipur	231.7
5.	Bihar	3,055.6	23.	Meghalaya	211.6
6	Chandigarh	359.7	24.	Mizoram	79.6
7.	Chattisgarh	2,149.9	25.	Nagaland	145.1
8.	Dadra and Nagar Haveli	29.4	26.	Orissa	2937.8
9.	Daman and Diu	40.8	27.	Puduchery	284.2
10.	Delhi	9729.15	28.	Punjab	6,958.5
11	Gao	427.4	29.	Rajasthan	6,326.9
12.	Gujarat	8,994.3	30	Sikkim	78.1
13.	Haryana	.4,506.9	31	Tamilnadu	13486.24
14.	Himachal Pradesh	1,521.5	32.	Tripura	378.3
15.	Jammu and Kashmir	1521.5	33.	Uttar Pradesh	10381.11
16.	Jharkhand	2,021.6	34.	Uttarkhand	1,641.2
17	Karnataka	9118.74	35	West Bengal	10059.36
18	Kerla	6,171.8	Total		146,180.7

Source: (International Resource Group) systems South Asia Pvt. Ltd, India Country Level Study (2005)

In India, Due to modernization and consumerism the growth rate of E-waste is high , for last 60 years. But so far, no scientific system is available in our country to dispose of the E-waste. Even now E-waste is not collected separately. Therefore reliable figures are yet not available to quantify the E-waste generation**.** In India open burning of plastic waste, exposure to toxic solders, dumping of acids etc is common. Because of unscientific disposal, pollutants are spread into the land, air, and water, and causing serious environmental problems. The untrained labor having no basic knowledge about the serious occupational and health hazardous are employed at low wages in the dismantling and recycling units . Due to poor awareness of safe disposal of E-waste, important e-waste components are not recycled by environmentally friend methods. The disposal usually enter landfills causing severe ecological and health hazards.

Effects on Environment and Human Health

The e-wastes disposal is a big problem in most of the regions across the world[16-17,1]. For example, leachates produce due to improperly monitored land filling of computer waste, polluted, the ground water and has caused environmental hazards. Throwing of acids and sludge obtained from melting computer chips, is causing acidification of soil . Illegal disposal of E-wastes such as acids, sledges etc. in rivers is causing acute water shortages in Guiyu, Hong Kong. In these cities now water is now being obtained from other places to cater to the needs of the people. Incineration of e-wastes is also not safe. Toxic fumes and gases emitted pollute the surrounding air. Mercury may leach out from electronic devices, when circuit breakers are destroyed. Cadmium may leach into the soilwhen cadmium containing plastics are land filled. The polychlorinated biphenyls (PCBs)may leach out from condensers. Polybrominated dlphenyl ethers (PBDE) also leached out into groundwater .Common occurrence in landfills are lead ions dissolved from broken lead containing glass, such as the cone glass and lead batteries.

The uncontrolled fires at landfills is common in many countries. When e- waste catches fire, metals and other chemical substances, such as: extremely toxic dioxins, tetrachlorodibenzo-dioxin(TCDD),polychlorinateddibenzodioxins(PCDDs), polybrominated dibenzo-dioxin (PBDDs) andfurans such as poly chlorinated dibenzo furans (PCDF) from halogenated flame retardant may be emitted. The open-air burning of plastics to recover copper and other metals is the most dangerous form of processing of e-waste. Both the local environment and broader global air currents are affected by the toxic fall-out from open air burning. The various pollutants related to e-waste and their health effects are listed in Table-5. The electronic items discarded along with household garbage, causes a threat to both health and vital components of the ecosystem by emitting toxic chemicals.

The E-wastes chemical composition varies with age of the electronic item and also on the type of item. Most of E- wastes contains several metal alloys, heavy metals, metals such as: Cu, Al and Fe fixed to plastics or ceramics. Polycyclic Aromatic Hydrocarbons (PAHs) are produced by e-waste burning at low temperature. Burning of plastic cover of cables to isolate copper in open produces more dioxins than domestic waste burning [18].

Table 5: Effects of E-Waste constituent on health

Source of e-wastes	Constituent	Health effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (Pb)	Damage to central and peripheral nervous systems, blood systems and kidney damage. Affects brain development of children.
Chip resistors and semiconductors	Cadmium (Cd)	Toxic irreversible effects on human health. Accumulates in kidney and liver. Causes neural damage. Teratogenic.
Relays and switches, printed circuit boards	Mercury (Hg)	Chronic damage to the brain. Respiratory and skin disorders due tobioaccumulation in fishes.
Corrosion protection of untreated and galvanized steel plates, decorator or hardner for steel housings	Hexavalent chromium (Cr) VI	Asthmatic bronchitis. DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes Reproductive and developmental problems; Immune system damage; Interfere with regulatory hormones
Plastic housing of electronic equipments and circuit boards.	Brominated flame retardants (BFR)	Disrupts endocrine system functions
Front panel of CRTs	Barium (Ba)	Short term exposure causes: Muscle weakness; Damage to heart, liver and spleen.
Motherboard	Beryllium (Be)	Carcinogenic (lung cancer) Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. Skin diseases such as warts.

Reduction of E- Waste

E- waste can be reduced by buying greener electronic products, reuse and recycling [19]. Donation of used electronics items for use is usually preferable to any waste management option including recycling as this increases the lives of valuable products. This keeps the electronic items out of the waste management system for a longer time. Reuse, benefits society as well as ecosystems. The donating of used electronic items, helps lower-income families to use equipment that they otherwise could not afford. Only reusable electronics may be donated to needy. Donation organizations may notaccept so old, less useful equipments. The most viable donation organization are charity and local schools.

a. **Recycling Electronics :** If donation is not a viable option, electronic items may be send for recycling[19]. Many municipalities, public and private organization are collecting E-waste for recycling.Some recycling drop-off center, charitable organization, and some electronics recycling companies are also offering their services. Many local electronics retailers are also collecting used products and sending them to a recycler. Recycling electronics prevent pollution. Recycling also reduces the energy in extracting the valuable resources
b. **Buying Green :** Buy environmentally friendly electronic items, ask the supplier about end of life disposition. Governmental organizations can encourage electronics manufacturers to design greener electronics. Prefer to buy electronics items that:

- Are made with lesser toxic constituents
- Contains recycled material
- Are energy efficient (e.g., showing the “Energy Star” label)
- Can beeasily upgrading or disassembly
- Utilize environmental friendly and lesser packaging
- have take back options or replacement to new model
- Have independent certification

Regulatory Responses to the Electronic Waste Phenomenon

Due to environmental degradation with increase in E- waste many initiatives are being undertaken all over the World. Many are hazardous substances are now been substituted by less toxic substances by the manufactures. Legislative and policy regulations are now imposed with the European Union (EU) with other countries that banned the use of hazardous substances in eight categories of electrical equipment. Now within the EU, restricted substances include lead ,cadmium, mercury and their compounds. The hexavalent chromium (but not chromium metal or chromium in other oxidation states); polybrominated biphenyls (flame retardants); and polybrominated diphenyl ether (a family of flame retardants), are also not allowed [20]. Understanding the seriousness of E- waste two conventions have been organized. Interestingly US is not signatory to either of the convention [21].

a. The Basel Convention : The main objectives of the Basel Convention (1989) are:

(i) reduction and control of trans boundary movements of hazardous and other wastes.
(ii) the prevention and minimization of waste generate on,
(iii) the environmentally sound management of such wastes and
(iv) the active promotion of the transfer and use of technologies.

For the implementation of the Basel convention, the Draft Strategic Plan consider , programs , existing regional plans, , the conference decisions of the Parties and its subsidiary bodies, activities of ongoing project , international environmental governance process, and sustainable development ,at all levels of society. The action on , capacity building with financial support, transfer of know-how, knowledge and sound, proven cleaner technologies is also part of Draft To meet the aims of Basal Convention the following activities are carried out [22].

- To prepare awareness material of high standard by experts.
- To encourage interested parties in fund raising strategies and involve non-governmental organizations and other institutions in joint project.
- To motivate selective partners to bring added value to making progress in the short-term.
- To disseminate the information through Basel Convention Regional Centers (BCRCs) using internet and other electronic and printed media.
- To undertake periodic review of activities in relation to the agreed indicators.
- To promote better use of cleaner technology and its transfer

The Basel Convention has ,paused , the trans boundary movement of hazardous waste but United States (US) is still disposing hazardous E-waste to Asian countries even today. However, according to recent European Parliament legislation, the manufacturers will have to take back their electronic products when consumers discard them. This is called ***Extended Producer Responsibility***. India and other countries are signatory to the convention.

b. The Bamako Convention : The dumping of the hazardous waste in the African countries was not addressed in Basel Convention[23].Organization of Africa Unity (OAU), now African Union (AU) has adopted *The Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa* ('the Bamako Convention'),1991. Bamako Convention imposed more stringent restrictions on transboundary movement of wastes[24] and banned all waste importation into African territories.[25] but in Bamako Convention no *enforcement and monitoring mechanisms was prescribed.* Bamako Convention *suggested states to adopt domestic legislation on generators of waste*[26].The Bamako Convention was restricted to Basel Convention[27]. The Bamako Convention was to manage the trans boundary movement of the hazardous waste in Africa[28]. The Bamako Convention was adopted in Bamako, Mali, on 30 January 1991, but came into force on 22 April 1998. It was signed by ten countries. After Twenty years of adoption, 30 countries are signatories.

Management of E-Waste in India: In India e-waste is not collected separately. The correct data on the quantity of e – waste generated and disposed of each year is not available. Most of the time obsolete electronic items are exchanged from retailers when purchasing a new item. The 78% of all installed computers in India is in business sector. Obsolete computers from the business sector are sold by auctions. According to Confederation of Indian Industries, estimated E- waste is about 1,46,000 tons per yearThe upper income class uses the PC for 3.21 years, TV for 13- years and cellular phones for 1.63 years while the low income household uses the PC for 5.94 years, TV for 8.16 years and the mobile phones for 2,34 years. Although the per capita waste production in India is still relatively small, at present but growing at a faster rate. The total absolute volume of wastes generated will be huge. At present the growth rate of the cellular phones is (80%) , PC is 20% and TV is 18%.

The public awareness on e-waste in India is not adequate and the willingness of the public to pay for e-waste management is poor.. The willingness of public to pay for e-waste management ranges from 3% to 6%.

Considerable quantities of e-waste are imported items. But no confirmed figure are available on these trans-boundary e-waste. Most of the e-waste items are obtained as reusable equipment or donations from developed nations. For government it is difficult to distinguish between old and new computers and peripheral parts[29]. The western world is climbing at the technological revolution, but our country is facing an imminent danger. Not only The western world is climbing at the technological revolution but dispose their wastes to India and other Asian countries. Recent it has been found that much of the e- waste turned over for recycling in the United States ends up in Asia. The e –waste in poorer countries are either disposed of or recycled with little or no regard for environment, worker health and safety. Major reasons for exports are low living standards of workers , no proper environmental law and occupational standards in Asia and in this way the toxic effluent as compared to developed nations.. Understanding the magnitude of these problems groups like Toxic Links India has already started working on collating data that could be a step towards controlling this hazardous trade. This is the time for developing countries and India in particular to enact stricter environment control law to prevent the hazards and mishaps due to mismanagement of e-wastes. Considering the severity of the problem, The Draft Rules on E Waste (Management and Handling) 2011 have been enacted and published by Ministry of Environment and are into effect from 1st May 2012[30].

List of Organization Processing e- Waste in India : The following organizations are authorized to process e –waste in India.

1. Trishyiraya Recycling India Private Ltd : Collection and packaging of seggregated waste for global export, Chennai, http://www.ewaste.in/F1290/the_process.html,
2. Global e-Waste Management and Services, Turn key solution for e-waste by door-door collection service, Chennai, http://www.globalewastemanagement.com/technology.html
3. Ultrust Solutions (I) Pvt Ltd, Services for collection, recycling and safe disposal of electrical & electronics scraps,Chennai, http://www.ultrustsolutions.com/e-waste-company.html
4. e-Waste Recyclers India,Data security in computer recycling, New Delhi, http://www.e-waste-recyclers.com/services.php
5. Eco Recycling Ltd, Use of mobile shredding vans to control data leakage and client satisfaction, Mumbai, http://ecoreco.com/abt_profile.html
6. Cerebra Integrated Technologies Ltd, Most technologically advanced E-Waste Shredding System in India, Bangalore, http://www.cerebracomputers.com/e-wasteProducts.htm
7. Attero Recycling, Indigenously developed metallurgical unit for metals and plastic extraction, Noida, http://www.attero.in/
8. E-WaRDD & Co, e-Waste recycling services sending zero waste to the landfill, Bangalore, http://www.ewardd.com/solution.html
9. ReGlobe, e waste project management and waste auditing, Faridabad, http://www.reglobe.in/
10. Earth Sense Recycle Pvt.Ltd., Collection, Transportation, Dismantling, Segregation & Disposal of e-waste, Chennai, http://www.earthsenserecycle.com/index.html
11. Ash Recyclers, e waste processing for material recovery and seggregation of hazardous materials, Bangalore, http://www.ashrecyclers.in/services.html
12. E-R3 Solutions Pvt. Ltd, Eco-friendly products and metals recovery from e wastes Bangalore,http://www.er3solutions.org/s/services/
13. E-Parisara Pvt. Ltd, Recycling technology to treat and separate them to glass, metals and plastics, Bangalore, http://www.ewasteindia.com/services.html
14. Hi-Tech Recycling India Pvt Ltd, e waste recycling, data eraser and logistics services Pune, http://www.hitechrecycling.in/services.php
15. GreenScape Eco, Segregation, collection, storage of materials and recycling of e wastes New Delhi, http://www.greenscape-eco.com/services.htm
16. TES AMM Private Limited, Synchronized electronic waste management solutions with eWTS (Electronic Waste Tracking System), Sreeperumbudur, http://www.tes-amm.com/services.asp?id=3
17. INAA Enterprises, Customized solutions for safe removal of the e-waste, Chennai http://www.inaaenterprises.com/services.html

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