Electronic Waste and India

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Abstract

Electronic waste (e-waste) is one of the fastest growing waste streams in the country. Growth of Information and Communication Technology sector has enhanced the usage of the electronic equipment exponentially. Faster obsolescence and subsequent up-gradation of electronics product, are forcing consumers to discard old products, which in turn accumulate huge e-waste to the solid waste stream. E-waste is growing in India at the rate of 10%. Major recycling of e-waste is carried out in the non-formal sector using primitive and hazardous methods. Adequate legislative measures and cost-effective, environmental friendly, technological solution would be needed to address the issue. This article provides the basic information on electronic waste management in India.

1. Introduction

The discarded and end-of-life electronics products ranging from computers, equipment used in Information and Communication Technology (ICT), home appliances, audio and video products and all of their peripherals are popularly known as Electronic waste (E-waste). There is, however, no standard or generally accepted definition of e-waste in the world. In most cases, e-waste comprises of the relatively expensive and essentially durable products used for data processing, telecommunications or entertainment in private households and businesses.

E-waste is not hazardous if it is stocked in safe storage or recycled by scientific methods or transported from one place to the other in parts or in totality in the formal sector. The e-waste can, however, be considered hazardous if recycled by primitive methods. E-waste contains several substances such as heavy metals, plastics, glass etc., which can be potentially toxic and hazardous to the environment and human health, if not handled in an environmentally sound manner. E-waste recycling in the non-formal sector by primitive methods can damage the environment.

The ill effects of e-waste could be on soil through leaching of hazardous contents from landfills; in water due to contamination of rivers, wells and other water sources; in air due to emission of gases and burning of e-waste. The

recycling process, if not carried out properly, can cause damage to human being through inhalation of gases during recycling, contact of the skin of the workers with hazardous substances and contact during acid treatment used in recovery process.

The hazardous and toxic substances found in e-waste include lead (Pb) and cadmium (Cd) in printed circuit boards (PCBs). Lead is primarily found in all electronic products/ assembly, cathode ray tubes (CRT) etc. Cadmium is found in monitor/ CRTs while there may be mercury in switches and flat screen monitors. Mercury is also found in CFL, relays and some other specific products. Besides the cadmium in computer batteries, cadmium is also used for plating metal enclosures/ metal parts in sub assemblies. Polychlorinated biphenyls are found in capacitors and transformers and as brominated flame retardant on printed circuit boards, plastic casings, cable and polyvinyl chloride (PVC) cable sheathing for insulation and PBD/PBDE in plastic parts of electronics.

No exclusive study has so far been made to know the effect of the e-waste in the environment. Few NGOs have, however, found that the recycling of e-waste in non-formal sector is hazardous. These units use primitive, non-scientific, and non-environment-friendly methods. As these units are working in unorganized sector, no data is available to substantiate the fact that they are violating the prevailing laws for labour, environmental protection and industry.

Greenpeace had undertaken a survey of the environmental pollution during manufacturing of electronic products in China, Thailand, Philippines and Mexico (*source: www.greenpeace.org*). The study is an assessment on pollution due to the use of some of the hazardous chemicals in the manufacture of electronic products in these countries. The industries included the printed circuit board and semiconductor chip manufacturing units and various assembly units of television, computers, monitors etc. No such study has been carried out in India.

2. Inventory of Electronics Waste

Actual data on generation or import of e-waste is not currently available in India. Several studies have been conducted by various agencies to find out the inventory of e-waste in the country. Most of these studies are based on the model of obsolescence of electronic products, which needs to be validated with the field data. A survey was carried out by the Central Pollution Control Board (CPCB) during 2005. It was estimated that 1.347 lakh MT of e-waste was generated in the country in the year 2005, which is expected to increase to about 8.0 lakh MT by 2012. During 2007, Manufacturers' association for Information Technology (MAIT), India and GTZ, India had, however, carried out an inventory on e-waste, arising out of three products: computers, mobile phones, and televisions. The total quantities of generated e-waste in India, during 2007, were 3, 32, 979 Metric Tonnes (MT) (Computer: 56324MT, Mobile Phones: 1655MT, and Televisions: 275000MT) (*Sources: Report on "E-waste Inventorisation in India", MAIT-GTZ Study, 2007*). The finding of the study is given as under:

Sr. No.	**Items**	**Weight (MT)**
1	Domestic Generation	332979
2	Imports	50000
3	**Total**	**382979**
4	WEEE available for recycling	144143
5	WEEE actual recycled	19000
6	Projected quantity of WEEE by 2011 (without including the imports)	467098

Source: MAIT,GTZ, 2007

Considering the growth rate, the volume of e-waste will reach nearly 0.7 million MT by 2015 and 2 million MT by 2025 (**Fig.1**).

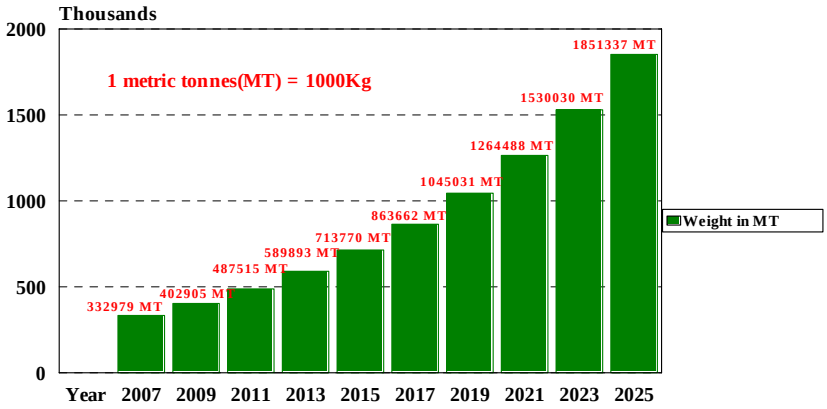

Fig.1: Growth of Ewaste in India

2.1 State and City wise Electronics Waste generation in India

In India, among top ten cities, Mumbai ranks first in generating e-waste followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur. The 65 cities generate more than 60% of the total generated e-waste, whereas, 10 states generate 70% of the total e-waste. The pie chart at Fig.2 is indicates the state wise generation of e-waste whereas Fig. 3 shows the city wise generation of e-waste. (*Sources:* http://www.e-wasteproject.org/docs/del_amitjain.pdf and http://www.cpcb.nic.in/docs/E-Waste Guidelines-2007/Front page1.pdf).

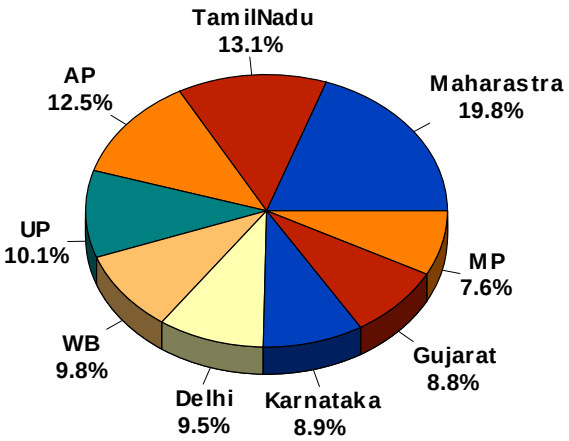

Fig 2 State wise E-waste Generation in India (Tonnes/year)

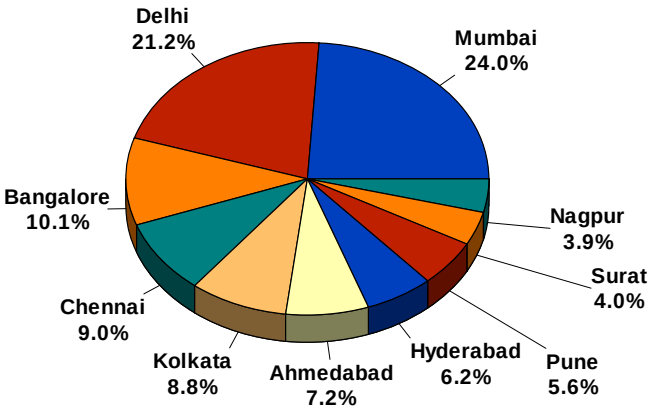

Fig 3 City wise E-waste Generation in India(Tonnes/year)

3. Legislative Measure

Ministry of Environment and Forests (MoEF), Government of India is the nodal agency for policy, planning, promoting and coordinating the environmental programme including electronics waste. The management of e-waste was covered under the Environment and Forests Hazardous Wastes (Management and Handling) Rules 2008. An exclusive notification on E-waste (Management and Handling) Rules, 2010 under the Environment (Protection) Act, 1986 has been notified (S.O. 1035) on 12th May 2011 to address the safe and environment friendly handing, transporting, storing, recycling of e-waste and also to reduce the use of hazardous substances during manufacturing of electrical and electronic equipments. These rules will come into effect on 1st May 2012. The **Table 1** provides the salient features of the Rules. The Central Pollution Control Board (CPCB) India had released guidelines during 2008 for environmentally sound management of e-waste, which should apply to all those who handle the e-waste.

Table 1: Salient features in E-waste Rule (S.O. 1035)

Chapters, schedules and forms	Titles	Issues Addressed
CHAPTER I Preliminary	1. Short title and commencement 2. Application 3. Definitions	Chapter discusses the title and commencement of the laws, applicable stakeholders and related definitions of the terminology
CHAPTER II Responsibilities	4. Responsibilities of the producer 5. Responsibilities of collection centers 6. Responsibilities of consumer or bulk consumer 7. Responsibilities of dismantler 8. Responsibilities of recycler	Responsibilities and the dos and don'ts of the stakeholders are discussed in this chapter
CHAPTER III Procedure for seeking authorization for handling e-wastes	9. Procedure for grant of authorization 10.Power to suspend or cancel an authorization 11. Procedure for grant of registration	Chapter discusses the procedure and formalities for potential e-wastes handlers to obtain authorization. Procedure for grant of registration at State Pollution Control Board (SPCB) is also discussed.
CHAPTER IV Procedure for storage of e-waste	12.Procedure for storage of e-waste	Maximum permissible storage period of e-waste with any consumer is 180 days. SPCB may extend the period, if no authorised recyclers are found in that state.

Table 1: Salient features in E-waste Rule (S.O. 1035) (cont.)

Chapters, schedules and forms	Titles	Issues Addressed
CHAPTER V Reduction in the use of hazardous substances in the manufacture of electrical and electronic equipment	13. Reduction in the use of hazardous materials (HS) in the manufacture of electrical and electronic equipment	Chapter advises the manufactures to reduce the HS in the electrical & electronic products. Maximum permissible limit of lead, mercury, cadmium, and hexavalent chromium and polybrominated biphenyls and polybrominated diphenyl ethers is discussed.
CHAPTER VI Miscellaneous	14.Duties of Authorities 15.Annual Report 16.Transportation of e-waste 17.Accident reporting and follow-up 18. Collection, storage, transportation, segregation, refurbishment, dismantling recycling and disposal of e-waste shall be in accordance with the	Miscellaneous chapter discusses the duties of the authority, & norms of collection, storage, transportation, refurbishment, dismantling recycling and disposal of e-waste, duties of the authorities, etc. and reporting of e-waste

	procedures	
SCHEDULE-I Categories of e-waste covered under the rules	Electrical and electronic equipment is categorised as:	Centralized Data Processing, Mainframes, Minicomputers, Personal Computers, Laptop, Notebook, Notepad, Printers Including Cartridges, Copying Equipment, Electrical And Electronic Typewriters, User Terminals And Systems, Facsimile, Telex, Telephones, Pay Telephones, Cordless-Phones, Cellphones, & Answering Systems.
	Consumer electrical and electronics products are categorised as:	Television sets, Liquid crystal display, Light emitting diode display, Refrigerator, Washing machine, and Air-conditioners.
SCHEDULE-II Application which are excepted from the requirement of Sub-rule(1) of Rule 13	Applicable to categories of electrical and electronic equipment as listed at Schedule-I	List of exempted applications of lead, mercury, cadmium in various processes with their admissible limit

Table 1: Salient features in E-waste Rule (S.O. 1035) (cont.)

Chapters, schedules and forms	Titles	Issues Addressed
SCHEDULE III List authorities and corresponding duties	Central Pollution Control Board (CPCB), Delhi	Duties and authorities include preparation of guidelines of environmental sound e-waste management, set target for RoHS compliance, enforcement of non-compliant etc.
	State Pollution Control Board (SPCB)/ Committee of Union Territories	Duties and authorities include Inventorisation of e-waste, registration, grant and authorisation of recyclers, channelization e-waste to authorised recyclers etc.
FORM - 1	Application for obtaining authorization for generation/ collection/storage/dismantling/recycling e-waste	
FORM - 1(a)	Form for granting authorization for generation/collection/ storage/ dismantling/ recycling of e-waste	
FORM - 2	Form for maintaining records of e-waste handled/ Generated	
FORM - 3	Form for filing Annual Returns	
FORM - 4	Application form for registration of facilities possessing environmentally sound management practice for recycling e-waste	
FORM - 5	Form for annual report to be submitted by the State pollution control board/committees to the Central Pollution Control Board	

3.1 Global Scenario

The EU legislations restricting the use of hazardous substances in electrical and electronic equipment (Directive 2002/95/EC) and promoting the collection and recycling of such equipment (Directive 2002/96/EC) were enforced in February 2003. The legislation provide for the creation of collection schemes where consumers return their used e-waste free of charge. The objective of these schemes is to increase the recycling and/or re-use of such products. They also requires heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives.

The European Commission proposed to revise the directives on electrical and electronic equipment in December 2008 to tackle the increasing volume of waste stream as it was felt that inadequately treated e-waste poses environmental and health risks (source: http://ec.europa.eu/environment/waste/weee/index_en.htm). The EU had triggered several similar initiatives around the world. Major initiatives on RoHS were taken in California, Norway, China, South Korea and Japan. Many countries including Australia, New Zealand, Thailand, Malaysia, Taiwan, Canada and Brazil are also seriously considering the matter.

3.2 Enforcement Agencies in India

Indian Enforcement Agencies involved in E-waste

i. Ministry of Environment and Forests, Government of India is responsible in identification of hazardous wastes and provides permission to exporters and importers under the Environment (protection) Act, 1986.

ii. Central Pollution Control Board (CPCB) was constituted under the Water (Prevention and Control of Pollution) Act, 1974. CPCB coordinates activities with the State Pollution Control Boards and ensures implementations of the conditions of imports. It also monitors the compliance of the conditions of authorization, import and export and conduct training courses for authorities dealing with

management of hazardous wastes and to recommend standards for treatment, disposal of waste, leachate and specifications of materials and recommend procedures for characterization of hazardous wastes.

iii. State Pollution Control Boards (SPCB) constituted under the Water (Prevention and Control of Pollution) Act, 1974 to grant and renew authorization, to monitor the compliance of the various provisions and conditions of authorization, to forward the application for imports by importers and to review matters pertaining to identification and notification of disposal sites.

iv. Directorate General of Foreign Trade constituted under the Foreign Trade (Development & regulation) Act 1992 to grant/ refuse licence for hazardous wastes prohibited for imports under the Environment (protection) Act, 1986.

v. Port Authorities and Customs Authorities under the customs Act, 1962 verify the documents and inform the Ministry of Environment and Forests of any illegal traffic and analyze wastes permitted for imports and exports and also train officials on the provisions of the Hazardous Wastes Rules and in analysis of hazardous wastes.

vi. The Directorate General of Foreign Trade (DGFT) is the certifying authority for permitting imports of second-hand goods.

4. E-waste Recycling Practices in India

4.1 Non-formal Sector

Ninety-five percentage of the e-waste in India is being recycled in non-formal sector and five percentage of the e-waste volume are handled in formal unit. In and around of metropolitan cities in India, there are over 3000 units engaged in non-formal sector for e-waste recycling. Non-formal units of e-waste recyclers are distributed all over India. A large cluster of industries are in Delhi, Tamil Nadu, U.P., Karnataka, Maharashtra, Gujarat,

Kerala, Andhra Pradesh, West Bengal, Rajasthan, etc.

Non-formal units generally follow the steps such as collection of the e-waste from the rag pickers, disassembly of the products for their useable parts, components, modules, which are having resell value. The rest of the material is chemically treated to recover precious metals. Due to inadequate means, it may cause leaching of hazardous substances to the air, soil, and water. This recycling method has low efficiency and recovery is carried out only for valuable metals like gold, silver, aluminum, copper, etc. Other materials such as tantalum, cadmium, zinc, palladium etc. could not be recovered.

4.2 Formal Sector

Few formal recyclers are operating in India. The processes followed in formal sector are mainly limited to the segregation, dismantling of e-waste till the size reduction stage of printed circuit boards (PCBs). A shredder is employed for PCBs size reduction. The pre-processed PCB is exported to smelting refineries in developed countries for further recovery of precious metals like copper, silver, gold, aluminum, palladium, tantalum, ruthenium, platinum etc. and also treating the slag byproduct in an eco-friendly manner. The end-to-end solution of e-waste recycling is still not available in India

The recycling/ recovery of valuables substances by units in formal sector is carried out in protected environment and with due care to minimize any damage to the environment or society. The use of advanced processes and technologies leads to efficient recovery of metals. Recovery technology by units in formal sector will be economically viable as the high cost of capital equipments and needed techniques could be shared by the volume of products. Efficiency of recovery in the formal recycling is high and metals at the trace level can also be recovered. Some technology works with zero-landfill approach.

Most of the e-waste in India is channelized to non-formal sector, whereas, the formal sector is facing problem of not having sufficient input materials. In order to address the issue, MoEF had introduced adequate clauses in the Hazardous Wastes (Management, Handling & Transboundary) Rules, 2008. The MoEF had advised all the Government Departments/ Offices that e-waste generated in various offices is essentially to dispose of in an environmentally sound

manner in accordance with these Rules. The occupier has now responsible for safe and environmentally sound handling of such wastes generated in their establishments. It was further advised that the units handling and engaged in activity like collection, segregation, dismantling and recycling of e-wastes are required to register with Central Pollution Control Board (CPCB). The **Table 2** provides the list of authorized dismantlers/ recyclers, registered with CPCB.

Table 2: Authorized dismantlers/ recyclers, registered with CPCB

Sr. No	**Authorised (Expert areas)**	**Quantity *(Metric Ton per annum)***
1.	Ramky E-waste Recycling Facility, Maheswaram Andhra Pradesh	10000
2.	Earth Sense Recycle Pvt.Ltd., Maheshwaram Mandal, Andhra Pradesh	1800
3.	Ash Recyclers, Hoskote, Banalore	120
4.	New Port Computer Services (India)Private Limited, Bommasandra, Bangalore	500
5.	EWaRDD & Co., Bommanahalli, Bangalore	600
6.	E-R3 Solutions Pvt. Ltd., Peenya, Bangalore (Only Printer Cartridge)	1,20,000 Units
7.	Ash Recyclers, Thimmiah Road, Bangalore	120
8.	E-Parisara Pvt. Ltd., Nelamangala, Bangalore	1800
9.	Surface Chem Finishers, Bangalore	600Kg/Annum

(*source: http://www.cpcb.nic.in/divisionsofheadoffice/hwmd/e-Waste.pdf*).

Table 2: Authorized dismantlers/ recyclers, registered with CPCB- cont.

Sr. No	**Authorised (Expert areas)**	**Quantity *(Metric Ton per annum)***
10.	Jhagadia Copper Ltd., Jhagadia, Gujarat *(Shredded PCBs/Mother Board only)*	12000
11.	ECO Recycling Limited, Thane, Maharashtra	7200
12.	Earth Sense Recycle Pvt. Ltd., Thane, Maharashtra	360
13.	Hi-Tech Recycling India (P)Ltd., Mulshi, Pune, Maharashtra	500
14.	Earth Sense Recycle Pvt. Ltd., Manesar, Gurgaon, Haryana	1200
15.	Greenscape eco management Pvt. Ltd., Alwar, Rahasthan	450
16.	Trishyiraya Recycling India Pvt. Ltd., Tambaram, Chennai	740
17.	TES AMM Private Limited, Sriperumpudur, Tamil Nadu	30000
18.	Global E-waste Management and Services (GEMS), Kancheepuram, Tamil Nadu	387
19.	Victory Recovery & Recycle Technologies India Pvt.Ltd., Thiruvallur, Tamil Nadu (ICs, PCBs, Solder Dross *(Pb bearing*	6000

	Waste) and PCBs assemblies)	
20.	Ultrust Solutions (India)Pvt.Ltd., Thiruvallur, Tamil Nadu	1500
21.	INAA Enterprises, Sriperumpudur, Chennai	300
22.	TIC Group India Pvt. Ltd., Noida U.P.	1000
23.	Attero Recycling Pvt. Ltd., Haridwar, Uttrakhand	12000

(*source: http://www.cpcb.nic.in/divisionsofheadoffice/hwmd/e-Waste.pdf*).

5. Initiatives of Department of Information Technology

Department of Information Technology in the Ministry, of Communication & Information Technology, Government of India, is the nodal Ministry for electronic industry. In order to address the urgent need of the cost-effective environmental-friendly technology, DIT is involved in promoting R&D to develop technological solutions for e-waste management in an environmental friendly manner. The focus is on developing recycling technology for all types of e-waste leading to minimum landfill and zero emission to air, land and water. The recovery of valuable materials and reuse of plastics is aimed at making recycling an economically profitable business. A number of R&D projects have been initiated at national institutions in India. Some such projects are:

a. The project, entitled, "Development of processing technology for recycling and reuse of electronic waste" has successfully been implemented at National Metallurgical Laboratory, Jamshedpur, India - an R&D laboratory under the Council of Scientific and Industrial Research (CSIR) in March, 2011. In this project, indigenous technology has been developed to recover metal contents from e-waste with a recovery rate of 90%. The process is free from the generation of toxic gases and harmful effluents. Thus it would reduce the environmental hazards that are attributed to e-waste recycling units in unorganized sector. The developed process has successfully recycled waste upto a pilot scale of around 1 Metric Tonne of e-waste. This aim is to take it to possible commercial application.

b. European Commission has restricted the import of electronic goods, manufactured using hazardous substances (RoHS) such as lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyles, polybromonated diphenyl ethers exceeding certain level. Indian electronic manufacturers are affected due to this restriction. Department of

Information Technology has, therefore, recently created a testing and certification facility at CMET, Hyderabad, India for the hazardous raw materials used for manufacturing electronic components under the project "Establishment of Testing facilities for the Hazardous Substances as per EU RoHS". This certification would help Indian companies, to export their products to European Union.

c. Another project on "Environmentally sound methods for recovery of metals from PCBs" is being carried at Centre for Materials for Electronics Technology (C-MET), Hyderabad, with active participation of authorized recycler, M/s. E-parisara Pvt. Ltd., Bangalore. The goal of the project is to develop environmentally sound methods for depopulation, segregation and treatment of components and a recovery method for metals from de-populated PCBs.

d. Another project on "Novel recovery and conversion of Plastics from WEEE to value added products" is being carried at Central Institute of Plastics Engineering & Technology (CIPET), Bhubaneswar. E-waste comprises of seven categories of plastics such as ABS, HIPS, PC, PP, PVC, Nylons, Epoxy, Phenolic, Polyesters etc. The project aims to develop value added products from these waste plastics with a goal to minimize the accumulation of plastics waste in the society. An end-user M/s Hairta NTI Chennai is actively participated in the project.

e. DIT had earlier implemented a program on environment management system for Information Technology industry with financial support from UNDP and Ministry of Communications and Information Technology (January, 1999- March, 2003). Under this program a comprehensive document entitled 'Environment Management system for Information Technology industry in India' was prepared and widely circulated among industries in India. It gave details of various technologies to be used for improving the hazardous waste management and reduction in use of hazardous substances in the production of electronic goods. DIT had taken following steps to help regulate pollution in electronic industries. Under this several initiatives to create awareness were taken including:

- The first ever workshop for creating awareness in the field of electronics environment on 'Environmental Management in

Electronics Industry' was conducted by DIT, (then MIT) in collaboration with UNDP and UNIDO on 9-10 February, 2001 at New Delhi.

- A technical seminar on 'Environmental Management in Printed Circuit Board Industry' was organized by DIT, UNDP and UNIDO in association with Indian Printed Circuit Association (IPCA) in Bangalore.
- Several presentations were made at national and international conferences conducted by Electronic Components Industries Association (ELCINA), Electronics Today, IPCA etc.

f. A project on "Development of Lead Free X-ray absorbing coating materials for CRT TV" has been successfully implemented, in March 2011, at Centre for Materials for Electronics Technology (C-MET), Pune, India - an R&D laboratory under the Department of Information Technology, where the hazardous lead contain in CRT glass shell will be replaced with environment friendly phospho-silicate glass composite/ phosphate composite as an X-ray absorbing coating.

DIT had taken step to sensitize the research communities, industry association, recycling industry, NGOs to address the technological solution of the recycling of electronic waste. One such event, "National Seminar on Electronics waste", was jointly organized by National Metallurgical Laboratory, Jamshedpur and Department of Information Technology on 21-22, January 2010 at NML, Jamshedpur to sensitize the stakeholders about the problem and to evolve a strategy of technological solution of the e-waste recycling by means of environmental friendly, cost effective, zero filled approach.

6. Conclusion

Most of the e-waste is recycled in India in unorganized units, which engage significant number of manpower. Recovery of metals from PCBs by primitive means is a most hazardous act. Proper education, awareness and most importantly alternative cost effective technology need to be provided so that better means can be provided to those who earn the livelihood from this. A holistic approach is needed to address the challenges faced by India in e-waste management. A suitable mechanism needs to be evolved to include small units in unorganized sector and large units in

organized sector into a single value chain. One approach could be for units in unorganized sector to concentrate on collection, dismantling, segregation, whereas, the metal extraction, recycling and disposal could be done by the organized sector.