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Status of E-Waste in India - A Review

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ABSTRACT: The mammoth generation of e-waste has created a new e-waste stream in the country containing obsolete, End of life Electrical and Electronics Equipments discarded after their intended use. The innovation, dynamism in product design and globalization replacing these equipments in very duration and made it fast growing waste in the world. E-waste is being generated by both indigenous and outsourced electrical and electronics equipments besides Basel Convention. The knowhow and compatible infrastructure for e-waste treatment is limited in India and informal recycling survived under the ambit of flexible legislative framework. The presence of toxic and hazardous substances in e-wasted equipments attracted the attention of the waste managing agencies in the country because these substances endanger the human health, environment, wherever present in uncontrolled conditions. The existence and implementation of Environmentally Sound Management is partial and progressing very slowly due to obvious reasons. The formal recyclers have commissioned comprehensive e-waste treatment facilities; but inadequate in proportion to the e-waste generation in the country since the informal recyclers are treating 95% of the e-waste generated with hazardous practices. The formal e-waste collection from all sources is ambiguous. E-waste contains a good amount of valuable recyclable materials also and has potential to become lucrative business in the country.

KEYWORDS: E-waste, Globalization, Basel Convention, Recycling, Toxic and Hazardous, Environmentally Sound Management.

I. INTRODUCTION

The waste generated due to the discarded, obsolete, end of life electrical and electronics equipments is known as E-waste world over. It is well known by acronym WEEE (Waste from Electrical and Electronics Equipments). However, various definitions have been presented by different agencies.

India is generating e-waste more than 8,00,000 tonnes annually**[MoEF, Guidelines, 2008]**.The 70% e-waste is being generated by ten states in the country **Rajya Sabha Report].**The obsolete, short lived, damaged, End of life EEEs (Electrical and Electronic Equipments) all together made e-waste a fast growing waste in the country. In India, IT industry has promoted both software and hardware segment and become leader in the world. The growth rate of IT[**Information Technology]** industry was 42.4% between 1995 to 2000**[EMPA, 2006].** The use and dynamism of EEEs for information and telecommunication technology have been enhanced by manufactures and marketing agencies manifolds, resulted a huge infrastructure expansion in the country. The new technology needs new compatible infrastructure replacing the old one in a very short duration of time. In view of that EEEs in installations have increased manifolds in the country and a huge quantity of e-waste has been generated due to obsolescence. The computers, televisions, servers, music systems, mobile phones, refrigerators, air-conditioners, medical equipments and their respective assemblies and illegal outsourcing are the major contributors of e-waste in the country. There may be more obvious reasons behind their generation in huge quantity. The flow of e-waste is very rapid causing threats to the human health, environment due to its toxic and hazardous attributes. It is all due to presence of toxic and hazardous substances like mercury, lead, cadmium, chromium (VI)**[MoEF, Guidelines, 2008]** etc. in the components of these e-wasted EEEs when not handled in controlled conditions while storage,

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transportation, recycling, recovery processes. Maharashtra among the states and Mumbai among the metropolitan cities are leading in the e-waste generation in the country.

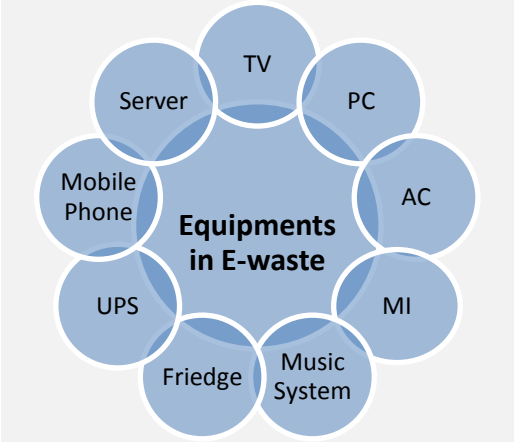

Figure 1 E-waste Equipments

In these states the various sectors like manufacturing, industrial, commercial, institutional, household, research and development are the major contributors for e-waste generation. No doubt, the e-waste collectors from all sources are the secondary source of e-waste and act as major stake holder and contribute in a big way as the e-waste collection is made from door to door by the stakeholder in the society. The recycling and recovery of components and materials out of e-waste is a pressing need of today as it provides a good support for the components refurbishment and ample quantity of secondary recyclable metals and other materials for the manufacturing of new equipments. Both informal and formal stakeholders are participating in e-waste treatment in the country. Presently the informal recyclers are dominating over formal and treating 90 to 95% of the total e-waste generated by environment unfriendly manner in the country **[Khattar, 2007].**The EEEs are being manufactured with the composition of more than one thousand substances [**MoEF, Guidelines, 2008].**The presence heavy metals like Hg, Pb, Cd, Cr (vi) etc. in the e-wasted components made them hazardous and toxic and attracted the attention of e-waste stakeholders to arrange a separate treatment place for them. Apart from hazardous contents, it has valuable and precious recoverable and recyclable metals in it. The share of metals in composition varies as steel, aluminium, copper, tin, nickel are present in bulk quantity; cadmium and mercury in small quantity and barium, nickel, gold, titanium, cobalt, palladium, manganese, silver and platinum in traces in the equipments Rajya Sabha Report**].**

Figure 2 E-waste Hazardous Material

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The informal recyclers are not serious about the guidelines issued by CPCB (Central Pollution Control Board) and using hazardous methods of e-waste disposal like open burning for the recovery of targeted metals like copper, aluminium, iron and steel from equipment peripherals and acid leaching for the recovery of copper and precious metals from PCB (Printed Circuit Boards), mother boards and leave all hazardous metals like Pb, Hg, Cd etc at the treating sites in open causing an explosion of pollutants in the environment. Apart from these materials, 36 chemicals are also being used in the manufacturing of these e-wasted equipment [**Amitava Bandyopadhyay, 2010]**.

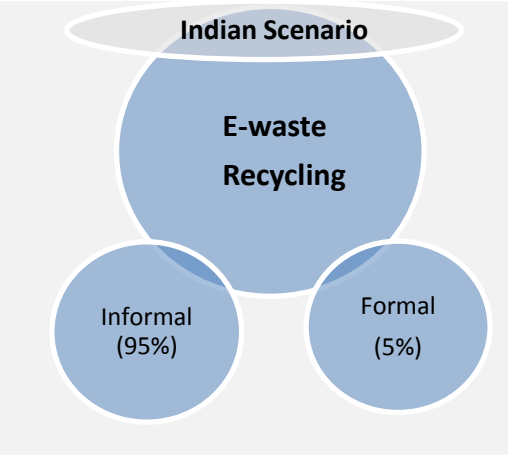

Figure 3 E-waste Recycling Status

However, CPCB has registered 23 recyclers for treating e-waste by environmentally sound methods **[Agarwal R.(1998)].** Also, the CPCB has encouraged informal recyclers to be part of formal recycling which can be carried out with compliance under single umbrella of guidelines issued in 2008**[MoEF, Guidelines, 2008].** Presently, there is no separate law for e-waste (Management and Handling) for restricting the informal recycling in the country. However a rule for e-waste management and handling is in force since 1st May 2012 to restrict the environment unfriendly methods but it is based on voluntarily clause **[E-waste (M&H) rule 2011].** In subsequent paragraphs, E-waste Inventory, E-waste sources, E-waste Treatment Scenario, Legal Support to E-waste E-waste Disposal Strategy, Challenges for ESM, and E-waste hazards in India will be discussed.

II. E-WASTE INVENTORY

The use of EEEs is increasing every day in public services, household logistics, manufacturing sectors etc to support the infrastructural requirement in the country. The e-waste generation has affinity to population and GDP **(Gross Domestic Product)** of the country. Both are increasing at varied rate. The consumption of new electronic goods is an index of societal progress and further decides the country technological rank in the world. The waste generated depends upon the demographic, geographical, socio-economic perimeters etc. [**Beigl *et al.*, 2008**]. The e-waste is being generated more in urban area than rural as 31% of people are living urban areas in the country [**Population, 2014**]. The use of these equipments like computers and its peripherals, servers, mobile phones, televisions, stereos is maximum in the society. However, other equipments are also being used for general and specific requirement. After EOL (End of Life), all equipments are supposed to be disposed of as per rule 2011. The infrastructure and inventory detail is the basic need for its disposal. A tentative estimate is available based on study conducted for e-waste generation. Presently, India is generating more than 8,00,000 tonnes annually comprising all kinds of EEEs discarded from intended use**[MoEF, Guidelines, 2008]**. Globally, 20 to 50 million tonnes per annum are being generated, which is 5% of the municipal waste at global scale [**UNEP Press Release, 2006**]. However, it will go up to 40 to 70 million tonnes by 2014/15[**IAER, 2009**]. The per capita e-

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waste generation in India is about 1 Kg per annum. The present population of the country is 1250 billion. With this figure total e-waste accounts to 12,50000 tonnes per annum, which is merely 2.5% of the global production taking base of 40 million tonnes e-waste generated per annum. However, the per capita e-waste generation in EU is 14 to 15 times to India [**Rajya Sabha, 2010**.]. In India e-waste is increasing at the rate of 10% per annum [**Ravi Agarwal, 2010**].

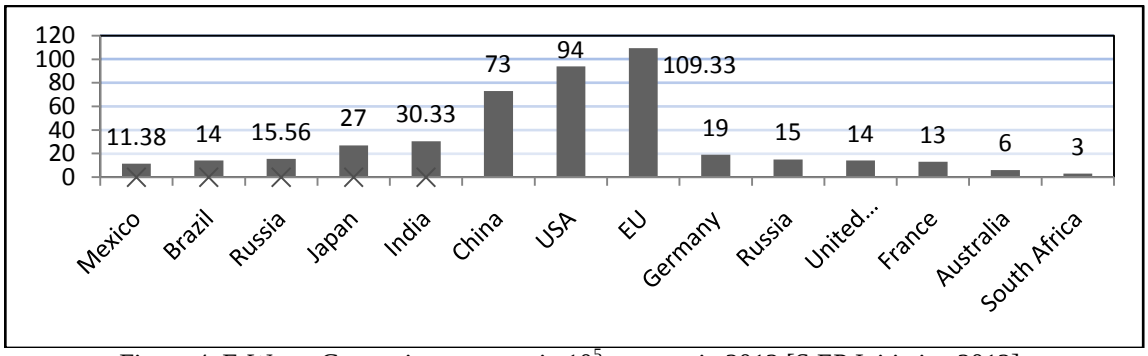

Figure 4 E-Waste Generation per year in 10^5x tonnes in 2012 [StEP Initiative 2012]

However, in EU it is estimated that 3 to 5% per year. In e-waste generation, USA is leading followed by China by 30,00,000 tonnes and 23,00,000 tonnes respectively[**Rajya Sabha ,2010**]. It has become fastest growing waste in the municipal waste stream [**Rajya Sabha ,2010**]. However, in the past 1990s, the use of EEEs was limited and life span was also more. After, globalization and invent of new EEEs products enhanced the production of these equipments manifolds. The life span of the equipments has also reduced appreciably. Based on the study made, 4,00,000 tonnes of e-waste was being produced initially in 2010[**Ravi Agarwal,2010**] and further CPCB had also reported the e-waste production in the country as 1,47,000 tonnes annually or 0.573 metric tonnes per day in 2010[**Lok Sabha,2010**]. Also, a figure of 4,34,000 tonnes annual e-waste generation was estimated for 2009[**Poonam J.Prasad,2012**] and further estimated by CPCB that it will above 8,00,000 tonnes in 2013[**Moushumi Basu,2010**]. As such, the approach for e-waste production estimation and calculation is ambiguous. E-waste quantity is being anticipated but not authenticated formally as receipt as formal collection is yet to be devised by the CPCB.

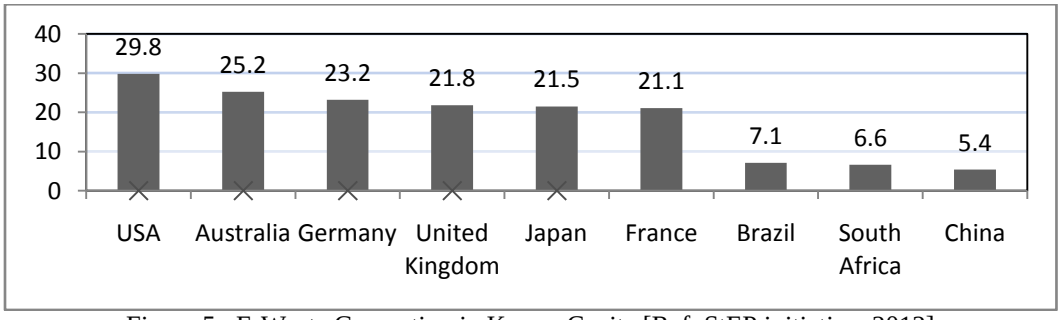

Figure 5 E-Waste Generation in Kg per Capita [Ref: StEP initiative, 2012]

Further predictions show an alarming e-waste generation at a faster rate in the country. By 2020, computer based e-waste will increase 500% and mobile phone 18 times with respect to the 2007[**Tom Young, 2010**]. A glimpse of e-waste generation in 2009 by top ten states and metropolitan cities is presented in table 1.

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Table 1 E-waste Generation [Consumer Voice,2009].

Sr. No.	States	E-waste Generated in MTA	Metropolitan Cities and others	E-waste Generated in MTA
1.	Maharashtra	20270.59	Mumbai	11017.1
2.	Tamil Nadu	13486.24	Delhi	9729.15
3.	Andhra Pradesh	12780.33	Bangaluru	4648.4
4.	Uttar Pradesh	10381.11	Chennai	4132.2
5.	West Bengal	10059.36	Kolkata	4025.3
6.	Delhi	9729.15	Ahmadabad	3287.5
7.	Karnataka	9118.74	Hyderabad	2833.5
8.	Gujarat	8994.33	Pune	2584.2
9.	Madhya Pradesh	7800.62	Surat	1836.5
10.	Punjab	6958.46	Nagpur	1768.9

The growth rate of the mobile phones (80%) is very high compared to that of PC (20%) and TV (18%)[**CII (2006)].** However, the e-waste generation quantity given in the table is the data provided to CPCB by obvious sources, since there is no mechanism of collection of data from ratified sources. The issued instruction by CPCB to promote handing over e-waste to the registered recyclers is yet to be implemented uniformly throughout the country on every e-waste stake holders. People are yet to be ready to accept it concensously.

The e-waste is being imported from developed countries in the name of 2nd hand use of the EEEs for charity, recycling and refurbishment of these equipments. The data are not available for its quantification as it is a hidden kind of e-waste. The e-waste quantification had been made based on computers, mobile phones and television in 2007 and found that 3,82,979 tonnes e-waste generated in India and 50,000 tonnes was imported illegally**[Khattar, 2007]** from USA and EU countries in the ratio of 80 to 20 to the total quantity imported respectively**[Pratap, A, 2009]**. Out of total e-waste quantity of 3,82,979 tonnes, only 1,44,143 tonnes of e-waste has been reported back and remaining 238836 tonnes e-waste(more than 62%), either people have handed over to the informal recyclers/local collectors or kept in the house **[Khattar,2007].** However, only 19000 tonnes(13%) of e-waste has been recycled out of 1,44,143 tonnes **[Khattar,2007].**

The 70% e-waste produced in the country is being produced by ten states only and 60% by 65 cities **[**Rajya Sabha Report**].**The viable e-waste treatment facilities have been commissioned by registered recyclers as per CPCB norms in nine states of the country, other states are supposed to divert their e-waste towards the nearest installed facility easily.

III. E-WASTE SOURCES

E-waste is being produced by various sources in the country like Govt. sectors, commercial establishments, institutional sectors, research and developments, household and manufacturing sectors of the country. The above mentioned sectors are free to handover the waste who is going to bid more for it, that may be formal recyclers or informal recyclers or any local e-waste collectors or a Kabadees. The quantity may vary depending upon the demography and types of EEEs installations of the establishment. However, main stakeholder is local collectors supposed to do door to door collection of e-waste. The Government along with industrial sectors of the public and private partners contributes 70%, individual households 15% approximately **[Satish Sinha,2007].** The e-waste received from different sources predominantly comprising of the following EEEs as televisions and desktops 68%, servers 27%, mobile phone 1% and import from developed countries 2% respectively **[IMRB, 2009].** However the other equipments like refrigerator, air conditioner, music system, recorder, monitoring and control, Medical equipments, ovens etc are also contribute in the e-waste generation marginally as their life is more and their use is limited in the society.

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Figure 6 E-Waste Sources

IV. E-WASTE TREATMENT SCENARIO

Presently, the e-waste is treated by both informal and formal recyclers sharing total e-waste quantity in 95 to 5 ratios in the country **[Khattar, 2007; Raghupathy, L, 2009].** From the total e-waste generated in the country 60% e-waste remains in warehouses/storages and only 40% is made available for recycling process. In recycling process 95% E-waste is being used for the refurbishment and only 5% need process of disposal [**MAIT**]. The enormous energy may be saved by adapting recycling of e-waste.

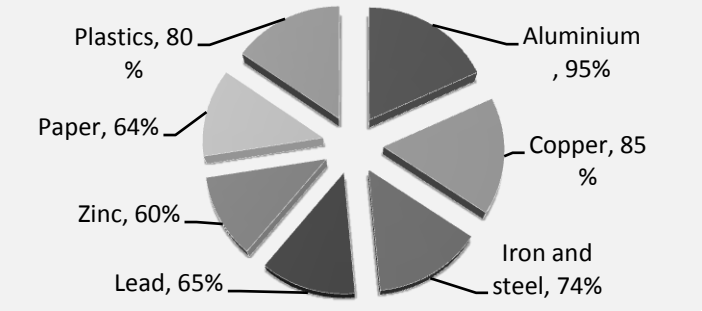

Figure 7 Energy saving %age by recycled material **[Cui, 2003]**

It is presented in fig 7 as in recycling of aluminium 95%, copper 85%, iron and steel 74%, lead 65%, Zinc 60%, plastics 80% energy can be saved and for extraction of virgin material CO^2 emission takes place for each tone of metal. It is presented in figure 8. So, this environmental loading also can be avoided if recovery of metals is done from e-waste and put in the recycling of the metals for further use. The informal recyclers get the e-waste from local waste collectors at very cheap price and recover the targeted metals like copper, aluminium, iron and steel with rudimentary and primitive methods and put a heavy environmental loading of pollutants on atmosphere. They are using open burning, acid leaching for the recovery of metals, which are non-environment friendly methods. The informal recyclers treat 95% of the e-waste generated by all sources **[Khattar, 2007].**These activities of e-waste treatment are cause of concern of the ambience and society as these are detrimental to the air quality, human health as the pollutants persist in the environment years together and harm it

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continuously. The dispersion of pollutants due to treatment in uncontrolled conditions and further transportation ahead, resulting various kinds of diseases to the human beings effecting kilometers distant human being and environment.
The recovery of materials: metals etc. are a lucrative business and acts as feedstock for the manufacturing of the new equipment, which is going to meet the user equipment demand at very cheap rate [**Rajya Sabha, 2010].** The state of the art is available to recover metals to the maximum from the e-wasted equipment easily. Umicore in Belgium and Attero in India are the appropriate examples recovering gold up to 99% efficiently **[Gupta, R,2009].**

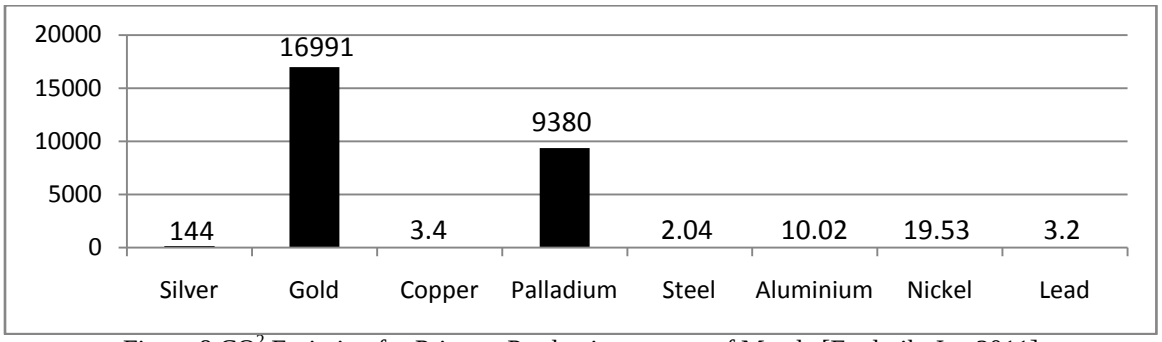

Figure 8 CO^2 Emission for Primary Production per ton of Metals [Frederik, Jan 2011]

The formal recycling in the country is in the transition and CPCB is registering recyclers every year and presently registered 23 recyclers have been registered for the treatment of e-waste produced in the country [**MoEF Registered Recyclers**]. The registered recyclers have to comply the e-waste management guidelines and adhere to rule 2012**[E-waste (M&H) rule 2011].** A fixed quantity of e-waste is being allotted to them; however they are not getting it easily and always strive to get it from import channels so that the state of the art facility may be run at full load.
The informal recovery system is less environ efficient comparably to the formal in terms of the state of the art technology. For example: for the recovery of 1 g gold and 6 g of silver, the informal recyclers are using more than 50 litres water, 3 and 21 Kg Chemicals and explode 1.3 g and 3 g of mercury in the environment due to uncontrolled treatment[**Keller, M. (2006**)]. However, the metal yield by using chemical processes 10 to 20% more if it is carried out by informal recyclers**[Keller, M. (2006)]** but they are not carrying out it in the ambit of ESM. The e-waste generated reporting process is not in place. The inadequate record keeping by all e-waste stakeholders made the e-waste treatment very tedious task. The infrastructure cannot be created based on estimated quantity of e-waste.

Table 2 Registered Recyclers and E-waste Allotments [MoEF Recyclers].

Sr. No.	States	No. of Registered Recyclers	Total Quantity of E-waste Allotted for recycling by CPCB
1.	Andhra Pradesh	02	11800 MTA
2.	Karnataka	07	3140.6 MTA and 120000 nos. cartridges
3.	Gujarat	01	12000 MTA (Shredded PCBs and mother boards.
4.	Maharashtra	03	8060 MTA
5.	Haryana	01	1200 MTA
6.	Rajasthan	01	450 MTA
7.	Tamil Nadu	06	38927 MTA
8.	Uttar Pradesh	01	1000 MTA
9.	Uttarakhand	01	12000 MTA

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People should look forward to hand over the e-waste to the registered recyclers rather than treat it themselves otherwise they would be victimized by the toxic and hazardous substances in the e-waste. However, for the informal recycler's research scholar are striving to get environment friendly, low cost, effective, handy e-waste processing and treating techniques [**Sepúlveda et al., 2010**]. New techniques may bridge the informal and formal processing methods and environmentally sound e-waste management may be established easily.

V. 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. 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 manpower if e-waste profession is organized professionally in the country. The glimpse of employment flow for the e-waste processing has been presented in the table 3.

Table 3 Manpower Detail for e-waste processing on Annual Basis [Amitava, 2010]

E-waste processed in one year	**Manpower employed in Numbers**	**Working Hours per day**	**Daily Wages Rate**	**Per Annum Employment Business**	**Working Place**	**Safety Measures**
10,000 tonne to 20,000.	25000	8 to 10	Rs 350/-	3193750000 or Rs.319 crore	Basements/close units	Minimum

The table shows for the 10,000 MT to 20,000 MT e-waste processing 319 core has been spent which arrives as Rs. 160 per Kg maximum as processing charges.

There is lot of possibilities of multi-crore business of e-waste treatment and concurrently e-waste recycled material market like other types of materials can be created very easily. There is a wide scope of this type of market as e-waste is growing at a 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 organized properly then low cost EEEs can be made available to the second hand use easily. The installation of these equipments comes under non-sophisticated equipments as these reassembled kind of equipments but a separate kind of market can be established like Nehru Place in India where both assembled and branded equipments 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.

VI. LEGAL SUPPORT TO E-WASTE

Before 1989, e-waste was not in inception so far; afterwards, it covers under Hazardous Waste Management (HWM) rules (1989,2000, 2003) indirectly since electronics equipment mentioned in schedule-1, contain hazardous material in their composition. A ray of hope came in 2008 when it is addressed separately. CPCB has issued guidelines to manage e-waste by environmentally sound manner to all state pollution control Boards in April 2008. These are applicable to all e-waste

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stake-holders viz. generators, collectors, transporters, dismantlers, recyclers etc. In 2011, under Environmental Protection Act 1986, E-waste (Management and Handling) rule was introduced and enforce from 1st may 2012. It confirms the environment friendly handling, transportation, storing and recycling of e-waste, obviating any kind of implications occurrence with the existence of hazardous substances **[E-waste (M&H) rule 2011]**. It is applicable on producers, marketing agencies, refurbishing centres, collection centers, dismantler and recyclers of EEEs and its components mentioned in schedule1. The responsibilities of each stakeholder i.e. Producer, Collection centre, Consumer or bulk consumer, dismantler, other stakeholders have been explained accordingly so that it can be strengthened further. The SPCBs (State Pollution Control Boards) compliance report regarding implementation of these rules need to be furnished to CPCB latest by 30th September every year. The e-waste storage duration is permitted for 180 days, the further storage of it would be offensive until unless it is permitted by SPCB concerned in unavoidable circumstances.

EPR (Extended Producer Responsibility) is in place but its strengthening process is still underway and hope so it will work comprehensively very soon. The applicability option is voluntarily, so there is a laxity for the informal recyclers to opt it. Violation of any kind rule pertaining to e-waste does not penalize the culprit. However, CPCB has made lot of efforts in bridging the informal to formal by inviting all kinds of professionals in the workshops on common platform. But by the introduction of EPR the electronics producer has taken financial responsibility for the disposal of all equipment produced under his control. In fact the responsibility has shifted from municipality to OEM (Original Equipment Manufacturer)[**Yu, Welford & Hills, 2006**]. Take back is inclusive of the EPR and however the producer can apply RoHS (Restriction of Hazardous Substances) concurrently and implemented by incorporating green product design in the forth coming manufacturing.

However, India has ratified the Basel convention, prohibiting trans-boundary movement of e-waste. Despite Basel Convention the developed nations are dispatching e-waste to the developing Nations continuously in the name of recycling, charity, second hand use. The CPCB has strived in organizing various seminars and conferences with the objective to disseminate the information among all stakeholders. The role of non-governmental organizations cannot be ignored as they have conducted various qualitative and quantities studies for quantification of waste. Also, the comprehensive e-waste treatment initiative by Attero in Roorkee is an example to move forward towards the environmental sustainability and overcome e-waste threat to a maximum.

The take back initiatives by the OEMs (Original Equipment Manufacturers) have started by Nokia, Wipro and Dell in the country.

VII. E-WASTE DISPOSAL STRATEGY

In CPCB guidelines issued in 2008, the Environmentally Sound Management (ESM) has been suggested to deal with the e-waste at SPCB (State Pollution Control Board) level in the country. The e-waste is being treated in phase manner and divided in to various activities. For each activity and material the treatment is different. The objective of the strategy is to dispose of the e-waste in sustainable and environmental friendly manner with the help of infrastructure having controlled conditions and adhering to the occupational health norms suggested by OSHA (**Occupational Health Standards in Ambience**). The treatment of e-waste is well monitored by the SPCB time to time and adequacy report of the installed infrastructure is being scrutinized on regular basis by the SPCB confirming viable infrastructure is sound to dispose of e-waste in an effective manner. For comprehensive treatment, the e-waste undergoes various stages of treatments i.e. 1st Level, 2nd Level and 3rd Level treatments are presented below.

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1st Level E-waste Treatment[MoEF, Guidelines, 2008]

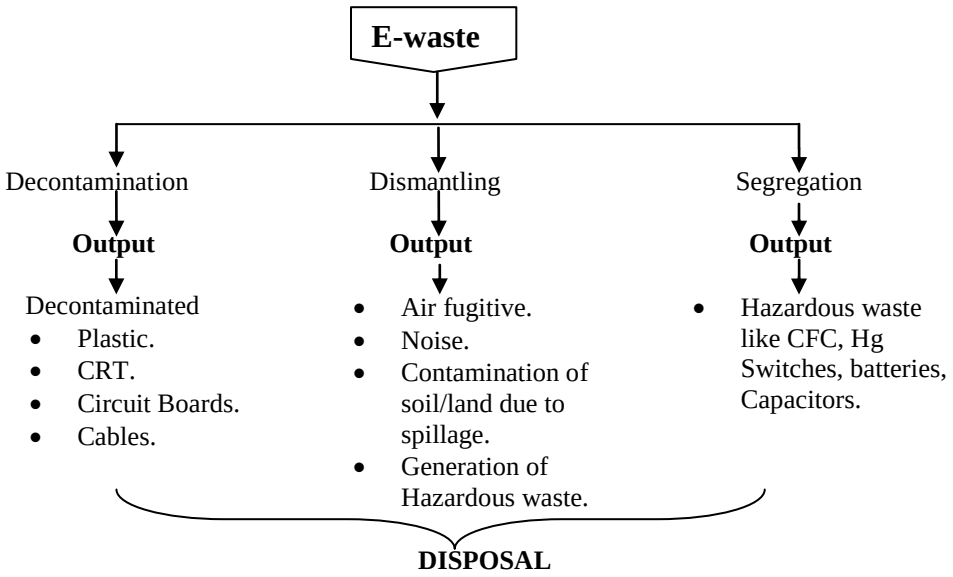

Fig. 9 Flow Chart 1st Level Treatment

In 1st level treatment the e-waste is being decontaminated, dismantled and segregated. The further outputs are represented in fig. 10

After 1st level e-waste treatment, the disposal becomes the input of the 2nd level treatment. In 2nd level treatment e-waste is being hammered, shredded and special Processes like CRT treatment, electromagnetic separation, eddy current separation and density separation are to be carried as per need. The flow chart has been drawn in fig.10.

2nd Level E-waste Treatment[MoEF, Guidelines, 2008]

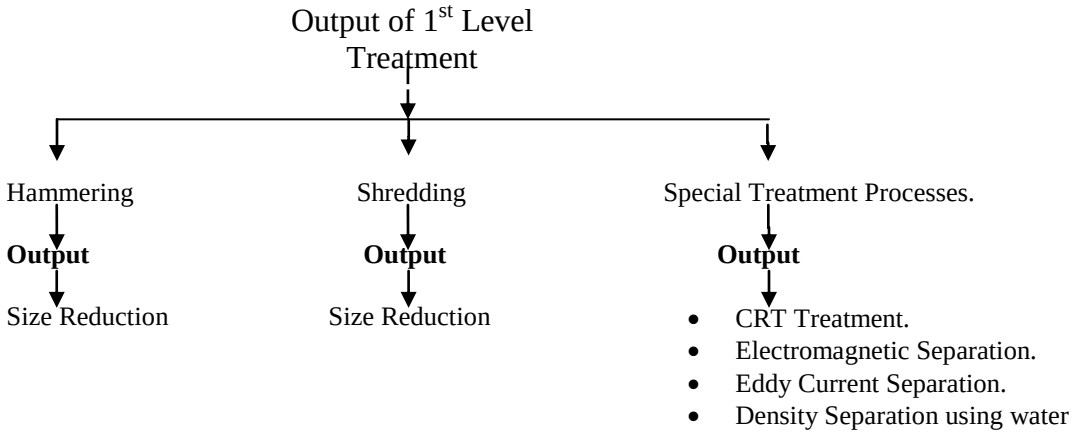

Fig: 10 Flow chart of 2nd level e-waste treatment.

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. **3rd Level Treatment of E-waste[MoEF, Guidelines, 2008].**

Treatment of E-waste **[**Ministry of Environment**]** is based upon the input (residual fractions), technologies used and its final output. Apart from eddy current separation, magnetic separation etc. the e-waste feedstock is treated with incineration; refining, smelting and distillation to get heat energy and concentrated metals.

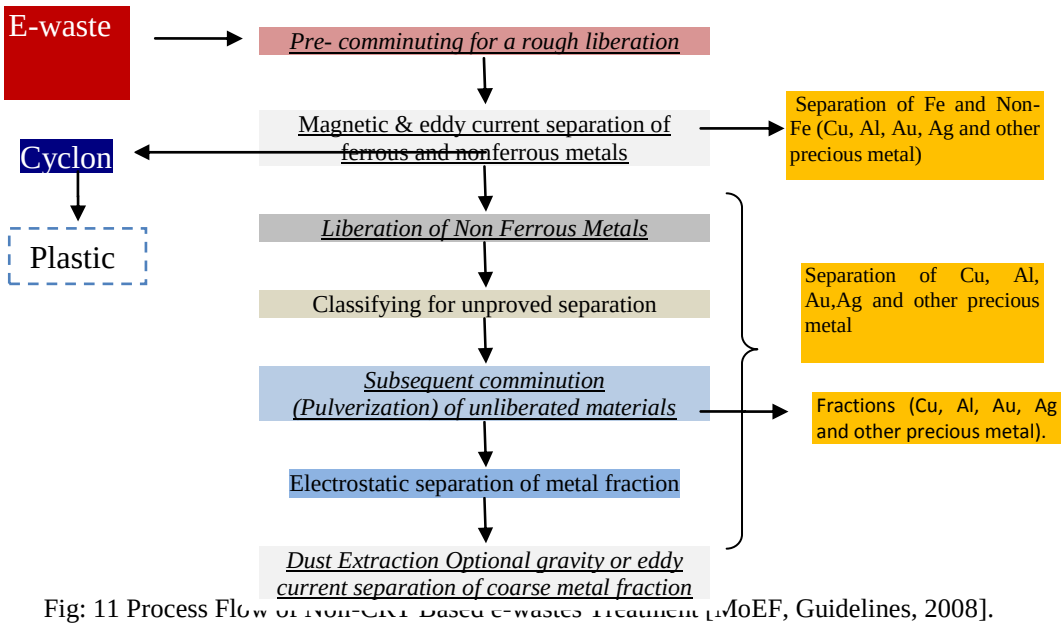

Fig: 11 Process Flow of Non-CRT Based e-wastes Treatment [MoEF, Guidelines, 2008].

The techniques are available with developed Nations to recover recyclable material like plastics, ferrous metals, non-ferrous metals and their efficiencies are high and vary material to material. For example magnetic separation achieves a target of ferrous metal recovery is 90% to 95% from e-waste and eddy current separation of non-ferrous metals is more than 90% **[MoEF, Guidelines, 2008].**

In the recovery of materials from e-waste, an appreciable amount of energy can be saved with respect to the virgin material recovered by exploitation from natural resources. A ready reckoner of few materials is presented in the fig 7. The monetary benefits and fulfilling the demand of these materials.

VIII. CHALLENGES FOR ESM

The informal recyclers with primitive and environment unfriendly e-waste disposal methods lead to pollutants explosion in the atmosphere. After recovery of target material, it is being left either in open or put in the municipal waste resulting contamination of air, water and soil. The heavy metals leak out from the components if not handled properly and harm our natural resources through leachate. The ESM is not in practice fully in India as on ground only registered recyclers are complying ESM. However, more recyclers have expressed their interest in ESM but their numbers are not increasing in the proportion to the e-waste generation. As more than 90% e-waste generated find their way to maximum to Local collectors (Kabadees) and rest to landfilling. It is very true that e-waste treatment is a business driven profession and even under the ambit of ESM, the compliance from e-waste stakeholders is lacking since they are not working cohesively. The ESM implementation is a big challenge in the country to treat e-waste. These are the hurdles hampering implementation of ESM.

- No legislative frame work for EPR (Extended Producer Responsibility), Take back, RoHS as Environmental Protection Strategy is in place in mandatory mode.

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- Mammoth e-waste generation in the country.
- Apathy towards e-waste collection from sources.
- Unanimity for common e-waste disposal point/Centre in towns, metros.
- Perennial e-waste Sources are not classified.
- Carelessness in EEEs disposal.
- Sloppy E-waste Collection and Refurbishment System.
- Clumsiness in Recycling and Recovery of the materials.
- Ineptness of proficient Incinerating Facility.
- Deficit Secured Land Fills.
- Timidity of recyclers towards allotted quantum of e-waste.
- Deprivation of financial and technical assistance for creating infrastructure.
- Ineptness appealing approach to fascinate people to come forward for e-waste solution.
- Ineptness of familiarity with e-waste treatment technology.
- Formal e-waste collection and storage system is not in place.
- No formal reporting of e-waste generated by major e-waste generators to CPCB on annual basis.

A formal e-waste treatment and disposal structure has been defined by CPCB. For e-waste treatment, awareness about their ill effects helps to deal with it. The above mentioned gaps need to be filled for implementation of ESM uniformly in the country.

IX. SUGGESTIONS FOR E-WASTE ESM MODEL

The management of e-waste as per Indian scenario may be divided into three main nodal sections viz: Collection, Recycling and Recovery and Disposal. However, the sections are further divided to the sub sections as per their further activities involved. To optimize the use of available resources and infrastructure of both informal and formal stake holders a few suggestions applicable on Indian scenario are presented so that their potential may be utilized for the Environmentally Sound Management [ESM] of e-waste fully.

- The e-waste collection should be emphasized by creating local, urban, District level, and state level collection points so that the maximum amount of e-waste may be collected. Initially, the investment is high and approach is new, but after some time it will be established and well known for e-waste collection point. To attract people for voluntarily disposal, the awareness about the monetary benefits to be given to the people concerned and ill effects to them and their family and ambience should be spell out in terms of type of diseases caused due to e-waste and respective expenditure will be incurred for disease treatment should also be told in their local language by arranging workshops at grass root level. By this way we can motivate people to come forward for e-waste disposal
- The registered recyclers' representative will train the local collectors formal and informal about the e-waste and its detrimental effects on human beings, atmosphere, water, air, soil and ambience in absolute by conducting seminars, workshops with the help of Doctors.
- Set the door to door e-waste collection, its storage and further packaging mechanism in the locality by one to one contact or by phones with the help of formal and informal collectors keeping the incentives to the informal as per minimum monetary expectations.
- The segregation of the various equipment, components and packaging by pasting slip with all details need to be done on local stations and dispatch it to the registered recyclers.
- Transport the e-wasted equipment to the registered recycler's destination.
- After recovery, recycling and refurbishment the remaining material after decontamination disposed of either through incineration or secured landfilling.
- Use the potential of local collectors and fix the rates item-wise which are to be given to the user after receipt of items concerned and its collection charges upto collection point.

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- The informal recyclers are used only up to collection of e-waste and for further treatment the e-waste should be handed over to the formal recyclers only.

The remaining modalities in between sections and sub-sections will work as per existing ESM in India. To make a sound e-waste management, a new working culture with new approaches suit to the locality need to be devised. It is a new field of profession and once people get its exposure then it would be a profit making and environment friendly profession in future.

X. E-WASTE HAZARDS

The handling of e-waste in uncontrolled conditions the hazardous and toxic potency of encapsulated materials in EEEs made it hazards prone. The backyard recycling with minimum safety measures and open burning recovery process made the situation very hazardous in nature. The health condition of the people engaged with bare hands and without masks is very poor and infected with chronic and acute diseases. Professionals in developing countries are employing men, women and children for the sorting and recovery of the materials and keep them in closed backyard. In general, in e-wasted equipment, the metal constitutes more than 60%, plastic 30% and hazardous pollutants 2.7% **[Agarwal R, 2006].** In PCB, BFRs (Brominated Fire Resistants' constitute 5 to 10% and antimony 1 to 2% to the weight of PCB **[Dr. B. J. Mohite, 2013].**
The recycling and reuse of the e-waste equipment and components is 25% all over the world and left 75% is waste **[Widmer R, 2005].** The leftover is being disposed of either in landfills or in municipal dustbins. It has been reported that among total metals, 75% are heavy metals present in landfills where e-waste has been landfilled **[Leke L, 2011].** The landfills are considered a good source of manure and people are taking its use in the vegetation and vegetables thereby the heavy metals get into the human food chain easily and may cause neurological and bone disorders. Even with the ingestion, inhalation and dermal routes, the heavy metals may cause blood and bone disorders, damage to the neurological and kidney, decline mental capacity. The high concentration of heavy metals can be felt in plants, animals, human bodies, water, and air. Due to run off and air transportation the soil concentration changes. **[Yilmax A.B, 2005, Asuqo F.E, 2004, Awokunmi, 2010]** The constituents, health effects and sources of constituents are presented in table. Most of them are carcinogenic.

Table 4. Health Hazards of Constituents in E-Waste [Poonam J.Prasad].

Constituents	Health Effects	Source of Constituents
Lead	• Cause to damage the central and peripheral nervous systems, 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 semi-conductors.
Mercury	• Cause chronic damage to the brain. • Cause respiratory and skin disorders due to bioaccumulation in fishes.	Available in relays and switches, and printed circuit boards.
Chromium	• It causes bronchitis.	Available in galvanized steel plates and decorator or hardener for steel housing.
Plastics 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.

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Copper	• It causes stomach cramps, nausea, liver damage, or Wilson's disease.	Present in copper wires, printed Circuit board tracks.
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 or beryllicosis.	Present in Motherboards.

XI. CONCLUSION

It is fact that e-waste generation is increasing very fast due to obsolescence of the EEEs. People are either store the obsolete equipment in their home or sell it to the local collectors for monetary benefits. Presently there is no legislative binding framework for e-waste management. In view of that there is no e-waste collection mechanism at place. The CPCB has taken lead in declaring e-waste as a new waste stream made new e-waste rules came in force since 1st may 2012 governing all stakeholders of e-waste but it is volunteer kind of law applicable on registered recyclers but encourage informal recyclers to work in ambit of CPCB guidelines issued in 2008, so that ESM may be established effectively. But the informal recycling dominates over formal recycling in the country. The technology is changing every hour of the day due to availability of new technology due to globalization and replacing the old EEEs in large numbers. The infrastructure for e-waste treatment is money intensive but a lucrative business these days as recovery of metals is possible up to 99% from the e-wasted EEEs. Umicore in Belgium and Attero in India are the appropriate examples of metal recovery. People engaged in this profession are not aware about the ill effects of e-waste causing them chronic and acute diseases.

The e–waste management has become a complex and poses hazards to the environment in various ways and patients of chronic and acute diseases are increasing exponentially, however there may be obvious reasons for them. It is evident that air pollution is root cause of these diseases. Recently AIIMS (All India Institute of Medical Sciences) revealed that Arthritis is caused by air pollution. The environment health condition is declining due to the partially managed e-waste in the country. The solution may be sought by splitting it into three parts as user realization, local collectors and controlled treatment may possibly solve e-waste registered recycler's demand of not getting ample quantity of e-waste regularly so that the treating plant may be run at full load.

The ESI(Environmental Sustainable Index) rank was 101in 2005 and 66th in environmental governance, need further improvement by creating e-waste treatment infrastructure by PPPs(People, Private Partnership model in the country via Foreign Direct Investment(FDI) because European countries have technology and India has cheap manpower can collectively make the e-waste treatment viable and economical.

The technology boom is in 21st century will bring more challenges ahead so our preparedness should be equipped with new infrastructure, awareness and technology for e-waste treatment. For the reduction of environmental loading **5Rs (Report, Reduce, Reuse, Recycle and Recover)** principles should be followed in the country and a multi-crore lucrative business can be explored easily.

REFERENCES

1. Agarwal R.(1998) India: ' *The World's Final Dumpyard!'*, January, Basel Action News, vol. 1 at www.ban.org accessed on 14th September, 2006.
2. Amitava Bandyopadhyay '*Electronics waste management: Indian practices and guidelines'* Vol. No. 1, Issue No. 5, pp.793-804, 2010.
3. Asuqo F.E., EWA- OBOHO I., Asuquo E.F., UDOH P.J. '*Fish species used as biomarkers for heavy metals and hydrocarbon contaminations Cross river Nigeria*'. Environmentalist, Vol. No. 24, Issue No. 29, 2004.
4. Awokunmi E.E., ASAOLU S.S., IPINMORATI K.O. '*Effect of heavy metals concentration of soil in some dumpsites*' Afric. J. Environ. Sci. Tech. Vol. No. 4, Issue No. 8, 495, and 2010.

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5. Beigl, P.G., Wassermann, F., Schneider, and Salhofer, S., Forecasting MSW Generation in Major European Cities, European Commission's Fifth Frame work Programme (EVK4-CT-2002-00087), pp 1-6, 2008.
6. CII (2006), '*E-Waste Management Green Business Opportunities'*, Volume No. 12, Issue No 1, Confederation of Indian Industry, Delhi.
7. Consumer Voice '*E-Waste Management in India*', April 2009.
8. Country level '*WEEE assessment'* study by the International Resource Group Systems South Asia Pvt. Ltd (IRGSSA), (m/s IRG Systems South Asia Pvt. Ltd), 2005.
9. Cui, J.; Forssberg, E. Mechanical recycling of waste electric and electronic equipment: A review. *J. Hazard. Mater*, *99*, 243–263, pp. 16–24, **2003**.
10. Dr. B. J. Mohite 'Issues *and Strategies in Managing E-Waste in India'* IJRMBSS I ISSN No. : 2319-6998 I Vol. 1 I Issue 1 I Mar. 2013.
11. E-waste (*Management and Handling) rule* 2012.
12. EMPA. The e-waste guide; Accessed on Aug 2006: http://www.ewaste.ch/.
13. EU. Directive 2002/96/EC of the European parliament and of the council of 27 January 2003 on waste electrical and electronic equipment (WEEE) — joint declaration of the European parliament, the council and the commission relating to article 9. Official Journal L037:0024-39 [13/02/2003; 2002a http://europa.eu.int/eur-lex/en/].
14. Frederik Eisinger, Ronjon Chakrabarti, Christine Krüger, Johannes Alexeew 'Carbon Footprint of E-waste Recycling Scenarios in India' Berlin, January 2011.
15. Gupta, R.: *Interview on e-waste in India and the Basel Ban.* [Interview] (Personal communication, 11 December 2009).
16. IAER Newsletter '*International News on Electronic Recycling*', January 2009, http://www.isrielectronics.org/communications/NL0109.html].
17. Indian market Research Bureau (IMRB) survey of '*E-waste generation at Source*' in 2009.
18. Keller, M. (2006): *Assessment of Gold Recovery Processes in Bangalore, India, and Evaluation of an Alternative Recycling Path for Printed Wiring Boards*, Diploma Thesis, Zurich: ETH
19. Khattar, V., Kaur, J, Chaturvedi, A. and Arora, R. "*E-Waste Assessment in India: Specific focus"*, 2007.
20. Leke L., Akaahan T., Simon A. '*Heavy metals in soil sand auto mechanic shops and refuse dumpsites in Markurdi, Nigeria'.* J. Appl. Sci. Environ. Manage., 15, (1), 207, 2011
21. Lok Sabha Unstarred Question no.650, dt. 28.07.2010.
22. Ministry of Environment and Forests "*Guidelines for environmentally sound management of e-waste"* March 12, 2008.
23. MoEF "*Implementation of e-waste rules in India*"2011, CPCB Delhi 32.
24. Ministry of Environment and Forests, CPCB Registered Recyclers.
25. Moushumi Basu, *'New e-waste management plan lucrative for states', The Pioneer*, New Delhi, 18 May 2010].
26. Pratap, A.: *Interview on e-waste in India and the Basel Ban.* [Interview] (Personal communication, 14 December 2009).
27. Poonam J. Prasad '*Environmental System Design &Modelling'* 2012 Intl. Journal of Environmental Technology and Management, Vol. 15, pp. 363-376.
28. Raghupathy, L.: *Interview on e-waste in India and the Basel Ban.* [Interview] (personal communication, 9 December 2009).]
29. Rajya Sabha Unstarred Question No. 24, '*Generation of E-waste'* dated 26.07.2010
30. Rajya Sabha Website, http://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf
31. Ravi Agarwal, *'A Policy? Rubbish', The Hindustan Times*, 4 May 2010].
32. Sandeep Joshi, *'Growing e-waste is causing concern', The Hindu*, 28 February 2009.]
33. Satish Sinha, *'Downside of the Digital Revolution', Toxics Link*, 28 December 2007, http://www.toxicslink.org].
34. Sepúlveda, A. et al. 2010. "A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: Examples from China and India", in *Environmental Impact Assessment Review*, Vol. 30, No. 1, pp. 28–41.
35. StEP initiative, 2012].
36. Tom Young, *'E-waste a growing problem for China and India'*, 22 February 2010, http://www.computing.co.uk].
37. UNEP Press Release, *'Basel Conference addresses Electronic Wastes Challenge'*, 27 November 2006 http://www.unep.org/].
38. Widmer R.,Heidi O.K.,Deepali S.M. Heimz B. '*Global perspective on e-waste*'. Environ. Impact Assess. 25, 436, 2005.
39. Yilmax A.B. *'Comparison of heavy metals of Grey mullet'* (M.Cephalus L) and Sea bream (S.Aurata L.) caught in Iskenderun bay (Turkey). Turk. J. Vet. Anim. Sci. 29, 257, 2005.]
40. Yu, J.; Welford, R.; Hills, P. 2006. "Industry responses to EU WEEE and ROHS Directives: Perspectives from China", in *Corporate Social Responsibility and Environmental Management*, Vol. 13, No. 5, pp. 286–299.

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