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Present E-waste Handling and Disposal Scenario in India: Planning for Future Management

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Abstract
In developing country like India E-waste management is being reckoned as a challenging task due to unplanned discarding of E-waste along with municipal solid waste. A "systematic & scientific" trade chain of E-waste is essential to manage the present scenario both in terms of environmental protection and health perspective. The prevalence of informal E-waste handling in India has put forward several issues of concern (metals, plastic, informal recycling) that need to be addressed to protect environment and human health. One of the important aspects of current informal handling of E-waste is its recycling to minimize exposure level. However, it needs skillful protocol (formal handling) to ensure the implementation of policy. Legal frame work is another essential part that will also help in E-waste management even in grass root level. A comprehensive E-waste management plan is also needed to improve disposal practice (recycling, landfill, and reuse) to reduce the magnitude of exposure notably toxic metals and flame retardants. A multistage approach has been recommended as per policy guideline for the trade chain practionners which will provide benefits to control exposure as well as environmental risk.

Key words: E-waste management, trade chain, recycling, legal frame work, management plan

I. Introduction

In an era of technological advancement the problem of electronics waste (E-waste) management is gradually becoming a global issue [Dasgupta et. al., 2014]. The production rate of Electrical and Electronics Equipment (EEE) is enhancing the business opportunity and also economic growth. Another important issue is EEE manufacturing progress, (i.e. annual generation and growth rate) that can be connected with E- waste generation [Jain, 2008 and Bandyopadhyay, 2010]. Globally, the high obsolesce rate of EEE has always been a serious concern [Kohler, et al, 2004]. The replacement market in developed countries is often contributing towards E-waste generation. The scenario is quite different in developing countries where increasing market penetration is the basic rule [Jain, 2008]. Over the years EEE production and waste generation are accelerating because the global and local markets are far from saturation whereas the lifespan of EEE is visibly decreasing e.g. Personal Computer (1997 – CPU lifespan 4-6 yrs; 2005-CPU life span 2 yrs.) [Babu et al, 2007].

Global E-waste generation was nearly 20-50 MT/yr in 2006 and noticeably increasing (~ upto 1.0MT/yr) of the generated solid waste [UNEP 2006, OECD 2008]. Organization for Economic Cooperation and Development (OECD) study predicts that E-waste generation will be as high as 9.8 MT/yr (2015) and growth rate is 0.86 % (base year 2010) [Cobbing , 2008].

In India, E-waste is being generated rapidly due to increased consumption behavior [Sinha, 2008]. However, both the consumption and waste generation pattern are different as they primarily depend on life style and economic strength. The collection, recycling and disposal of E-waste are governed by the traders where Local Small E-waste Dealers (LSEWD) play a vital role in handling of E-waste. The Large E-Waste Dealers (LEWD) are dependent on these LSEWD. The auctions for non-household generated E-waste are arranged for sale in both private and government sectors. The chain is complex and it normally operates on the basis of economics of the E-waste. Finally the collected E-wastes are dismantled, segregated and market demand portions are recycled. The utilization of the

recycled E-waste is solely dependent on the nature and the type of the materials and their market values [Toxic Link, 2003, Betts, 2008]. The principal characteristics of E-waste are different from other forms of waste (both municipal and industrial) and have distinctly different physical and chemical properties**.**

E-wastes mainly have both precious and hazardous metals and materials as constituents that should be dealt carefully during handling. This regulated practice (collection, dismantling, recycling and disposal) will help minimizing and may even avoid environmental contamination, caused by different hazardous substances. The most important and serious concern is the exposure of toxic materials to humans particularly to the waste handlers.

The useful component of the E-waste management is the recycling of the secondary raw materials, provided the toxic components have to be taken care of [Bandyopadhyay, 2010]. The major lacuna in the current Indian E-waste management practice is the "Systematic and scientific" handling of E-waste. The complexity in nature and type of EE appliances and rapid variability in composition including addition of new items makes it difficult to handle E-waste efficiently for recycling and reuse purpose by the Indian E-waste managers (LSEWD and LEWD) [Widmer,2005 and Wath et al.,2011]. Nevertheless, a legal mandate is often helpful to encourage recycling and reuse of E-waste that have been practiced by the developed countries in several ways (Basal Convention, NEAP, EPR, ARF) [Kumar et al., 2007].

Of late, India has implemented a comprehensive rule in the form of "E-wastes Management and Handling Rules, 2011" which has been effective from 1st May 2012. Existing informal E-waste management practice is the pressing issue and concern for both human and environment. The time scale demands a switching over from informal to formal sector of E-waste management and the mechanism of the governance is the key factor for implementing a sustainable E-waste management scheme though it requires few decades with several modifications in the legal frame work.

The present paper focuses on a roadmap for the E-waste management system after reviewing the current situation of E-waste generation, operation and recycling practice. A bridge has been put forward to make systematic and scientific plan to reduce the impact of major issues and concern of trade chain of E-waste. A summary of legal framework has also been outlined to highlight its importance for E-waste recycling.

II. Composition

Critical analysis of E-waste management indicates that the major issues are EEE production, end of their useful life (loss of utility) and means of ways of disposal. These three major issues are changing from country to country, within country (state to state) and consumable practice where E-waste composition plays an important role. The practice becomes more complicated due to E-waste constitution (Fig. 1)

The percentage of Iron and Steel is more than other materials (Fig.1) where plastics occupy a major percentage in the house hold items [Widmer, 2005]

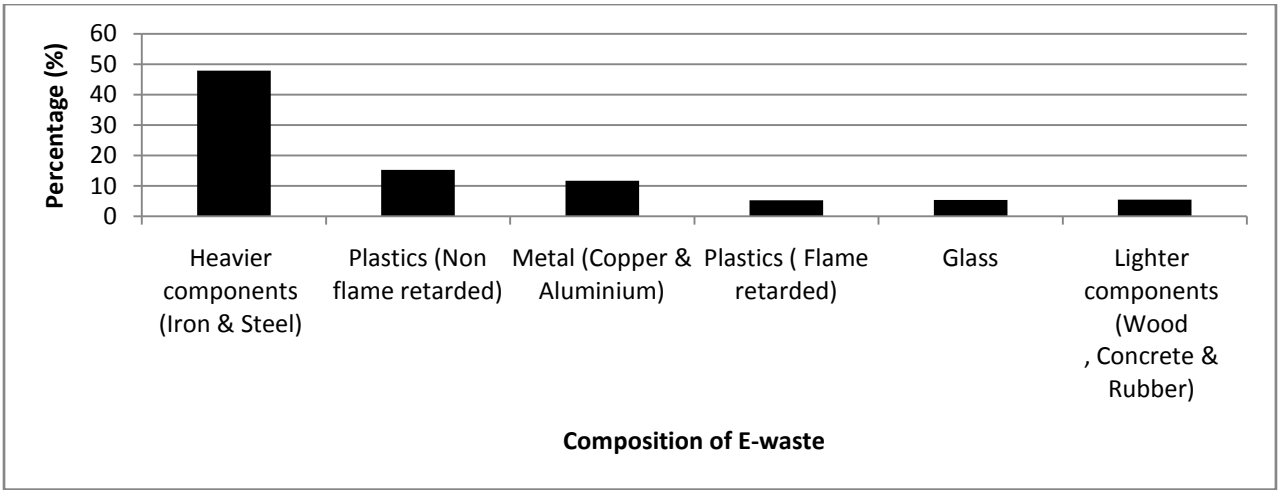

Fig.1: Composition of E waste

III. Trade chain and Indian scenario

In India, uncoordinated collection, segregation, dismantling, recycling and disposal are the principal steps for E-waste management. The entire process, by and large, is governed by manual even physical means. There are several key players in the trade

chain such as vendor lobby, scrap dealers and dismantlers. The vendors often collect E-scrap from various sectors like domestic, commercial sectors and waste dumping sites. They can also procure E- wastes by auctions and through import. The collected E-waste is now transported to scrap dealer for dismantling purposes. Dismantling is the major step before final disposal where several operations (crushing, extraction, processing etc.) are available for the collection of valuable substances. The flow diagram of E-waste trade chain in India is given in Fig. 2.

The voluminous EE items collected from domestic, private and institutional sectors are treated only for use of certain component having economical value and the rest of the material is simply discarded as a solid waste.

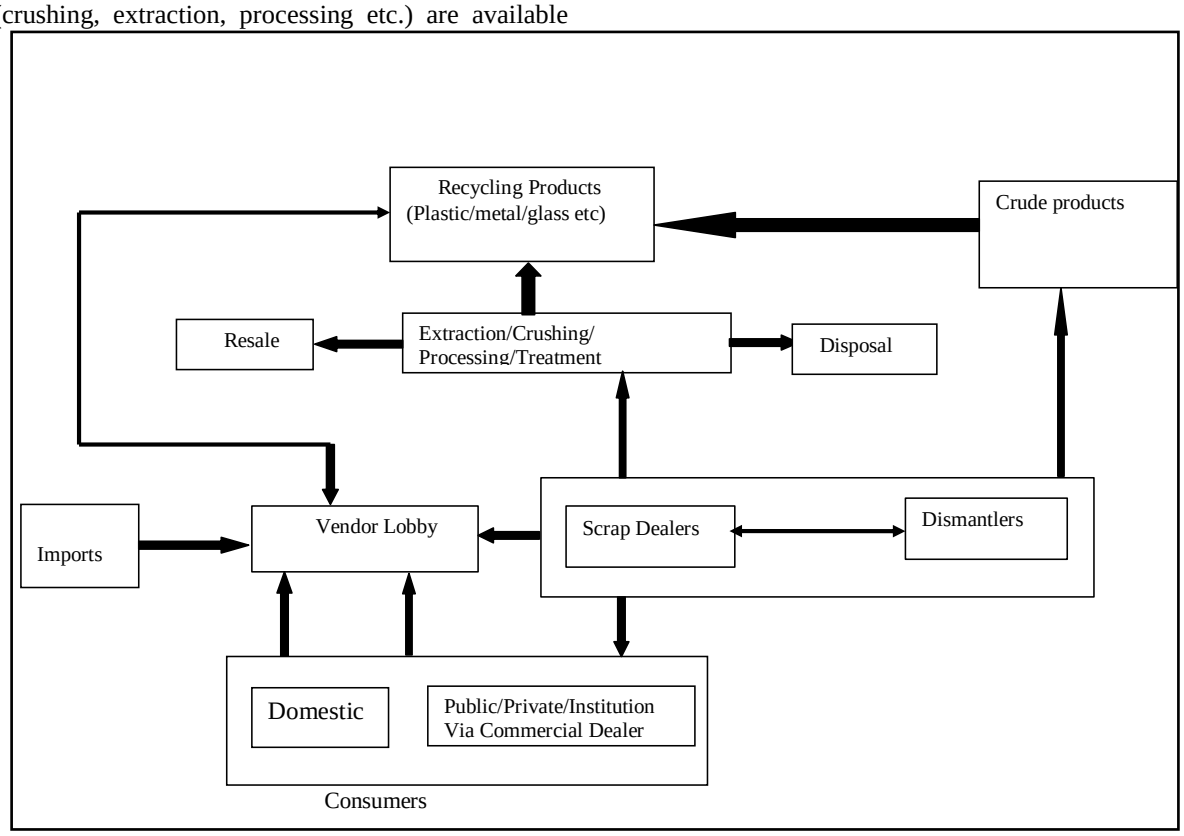

Fig. 2: The flow diagram of E-waste trade chain in India

IV. Issues and Concern

4.1Metals

In E-waste, metals are found in various forms viz. hazardous, nonhazardous and precious [Wath et al, 2010]. Metals are mainly added to the plastic polymers which fail to form strong chemical bonds with plastic. These metals remain in suspension over the plastic polymers and consequently cause serious environmental pollution due to leaching [Dasgupta, et al., 2014].

A metal flow diagram (Fig.3) is depicted to denote the pathway of environmental pollution due to metal contamination.

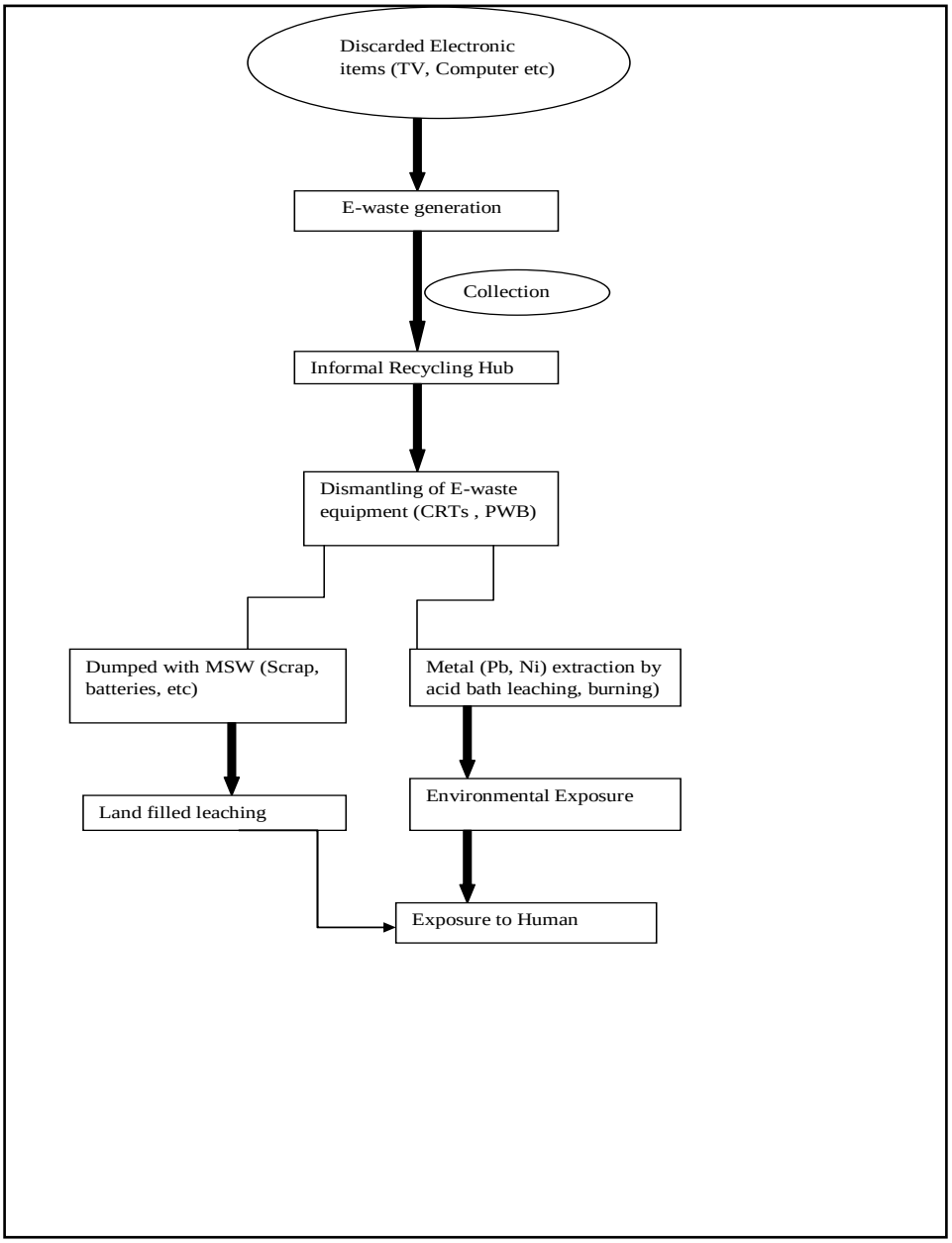

Fig.3: A metal flow diagram for Electronic waste

4.2 Plastics

Plastics are now used in Electrical and Electronics Equipment (EEE) for various purposes like housing, structural and functional parts, insulation, sealing, noise reduction and their connectivity [Yang et al., 2013]. The average growth of plastic in EEE waste is three times the average plastic growth in municipal waste [Molto, et al., 2009]. EEE plastics are a complex mixture of materials severally composed of various type of quality and often incompatible nature of polymers [Schlummer et al., 2007]. In EEE, thermoplastics occupy a major share whereas thermosets have relatively smaller share [Freegard, 2005]. Thermosets in EEE plastic contain Polybrominated diphenyl ethers (PBDEs) that cause leaching to the environment as they are not strongly bound with plastics [Dasgupta, et al., 2014]. The major types of flame retardants and their health effect are given in Table1

Table-1: Different types of Flame retardants and their health impact

Flame Retardants	Health Effect	Mechanism of Action	References
PBDEs	PBDEs excels endocrine –interfering activity and causes cryptorchidism in new born babies.	It is incorporated with the polymers without chemically bound thereby causes leaching to the environment.	[Main et al., 2007]
TBBPA	Exposure of TBBPA to human population may an issue of concern	Study on Wistar rat shows that it disrupts the circulation of Thyroxine (T_4) hormone.	[Van der Ven, 2008]
HBCD	Causes thyroid gland hypertrophy and HBCD (>5 µ M) exposed to epithelial cervical cancer cell can enhance TR–mediated gene expression in human being at the presence of T_3	Not known	[Palace et al., 2010]
DDE	Children of exposed mother have low birth weight and also have hyperbilirubinemia, and pigmentation of the gingival, nails, nose and axillaries and groin folds.	It is stored in human fat and only excreted via lactation	[Rogan et al., 1986]

4.3 Recycling and Exposure

The market scenario of various Electrical and Electronic (EE) appliances is changing fast and it is more prominent in the cases of home appliances, communicating industry, computer applications and practice. On the other hand, the E-waste trade chain is mainly governed by unorganized sector [Sinha, 2008] E-waste is also a regular source of revenue generation when recycling operation is practiced significantly at the outskirts of any mega city.

Field experience reveals that a large segment of economically weaker section of India, (rag pickers) is depending a lot on this trade for earning their livelihood. The labors generally work without taking any protective gadgets like gloves, goggles etc. They use only hammer, chisels, hand drills, cutters and electric torch/burners for dismantling process [Dasgupta et al., 2014]. The recent studies on Bangalore and Chennai highlight metal exposure including hazardous metal in E-waste recycling site [Ha et al., 2009].

Study focuses that accumulation of metal in hair has been found of those children using mercury (Hg) for extraction of valuable metals in close confined room where direct or indirect exposure is prevailing.

E-waste recycling has become a profitable trade, flourishing as an unorganized sector, mainly as backyard workshops [Sinha,2008].

The informal practice of E-waste handling also involves open burning of plastics, exposure of toxic metals and wide-spread mixing with municipal wastes. This finally results in several environmental consequences where land, air and water may undergo severe degree of contamination. The major environmental impact is associated with human health, particularly for workers engaged in informal dismantling and recycling activities.

V. Legal Frameworks

5.1 International regulation

The Control of Transboundary Movements of Hazardous Waste and its Disposal (Basal Convention) has an effective role to stop the trading of E-waste from developed to developing country. European Union has formulated laws, RoHs (Restriction of Hazardous Substances) and WEEE Directives (2002/96/EC) to provide detailed guidelines and essential duty for the manufacturers, handlers and consumers of electronics goods [Wath et al.,2011].

5.1.1 United Kingdom

In the WEEE legislation the total responsibility regarding reporting, financing and treatment of agreement is given to the operator of producers not the individual one (producer).The producers are needed to be registered by paying fees so that the operational cost can run [Turner et al ,2007].

5.1.2 United States of America

US Environmental Protection Agency commence a green NEAP to manage consumables electronics items. Nevertheless, a collection of ARF has been introduced in the states of California to minimize the E-waste generation [Gregory et al., 2007].

5.1.3 People's Republic of China

In China, E-waste is regulated (February, 2006) by the Administration of Control of Pollution. Restrictions as well as penalties have been imposed on importers, sellers, manufacturers and designers on the use of hazardous substances and provision of information on the components including hazardous substances [Yu et al., 2010 and Hicks et al., 2005]

VI. Planning & Management

E-waste is now considered as a resource because several valuable and economic materials can be extracted from it and such opportunities will create business options and also contribute to GDP generation. The skilful management of E-waste (recycling and reuse) can also impart environmental protection. A modified and eco-friendly systematic and scientific E-waste management package has been proposed to regulate Indian E-waste management scenario towards informal to formal sectors. The package is classified in different steps "INlTIAL STEP", "MIDDLE STEP" and "FINAL STEP" (Fig.4) where both LSEWD and LEWD will provide entry according to their capability. All the three levels are to be practiced and are emphasizing various goals to create appropriate steps for disposal of waste as per laid down guidelines. The basic design of management plan is the material flow in a sequential pattern during the operation of each step as well as in between the steps (Fig.7) for example INITIAL STEP [Stage I, (Segregation)] is the starting process where E-waste input has been given various unit operation e.g. Dismantling (Manual) followed by disintegration of components (mechanical), later on systematic "Segregation" of the component (Fig.7). During the unit operation a caution will be recommended to care for the hazardous emission in any forms. The offshoot components (DISPOSAL) have to be taken care off.

The MIDDLE STEP is the backbone of proposed management plan. Multistage phenomena are going on in several stages e.g. Stage-II (Operation) and Stage-III (Treatment). Stage II (Operation) consists of several operations such as Hammering and Shredding. The most crucial part is the Stage III (Treatment). In this stage several treatment options are recommended such as CRT Treatment, Electromagnetic Separation, Eddy Current Separation and finally Density Separation. The CRT Treatment can be further classified for treatment such as Funnels and Screen Glass. Finally Disposal option will be taken care off.

The FINAL STEP consists of Stage IV (Recycling) and Stage V (Recovery Process).The Stage IV (Recycling) has several options such as Chemical, Mechanical and Thermal. In Chemical option recycling is opted for plastic and metal whereas Mechanical accommodates shredding and breaking. In the Thermal option E-waste can be used for power generation and cement production.

In Stage V (Recovery Process) several steps are employed to recover metals notably valuable metals.

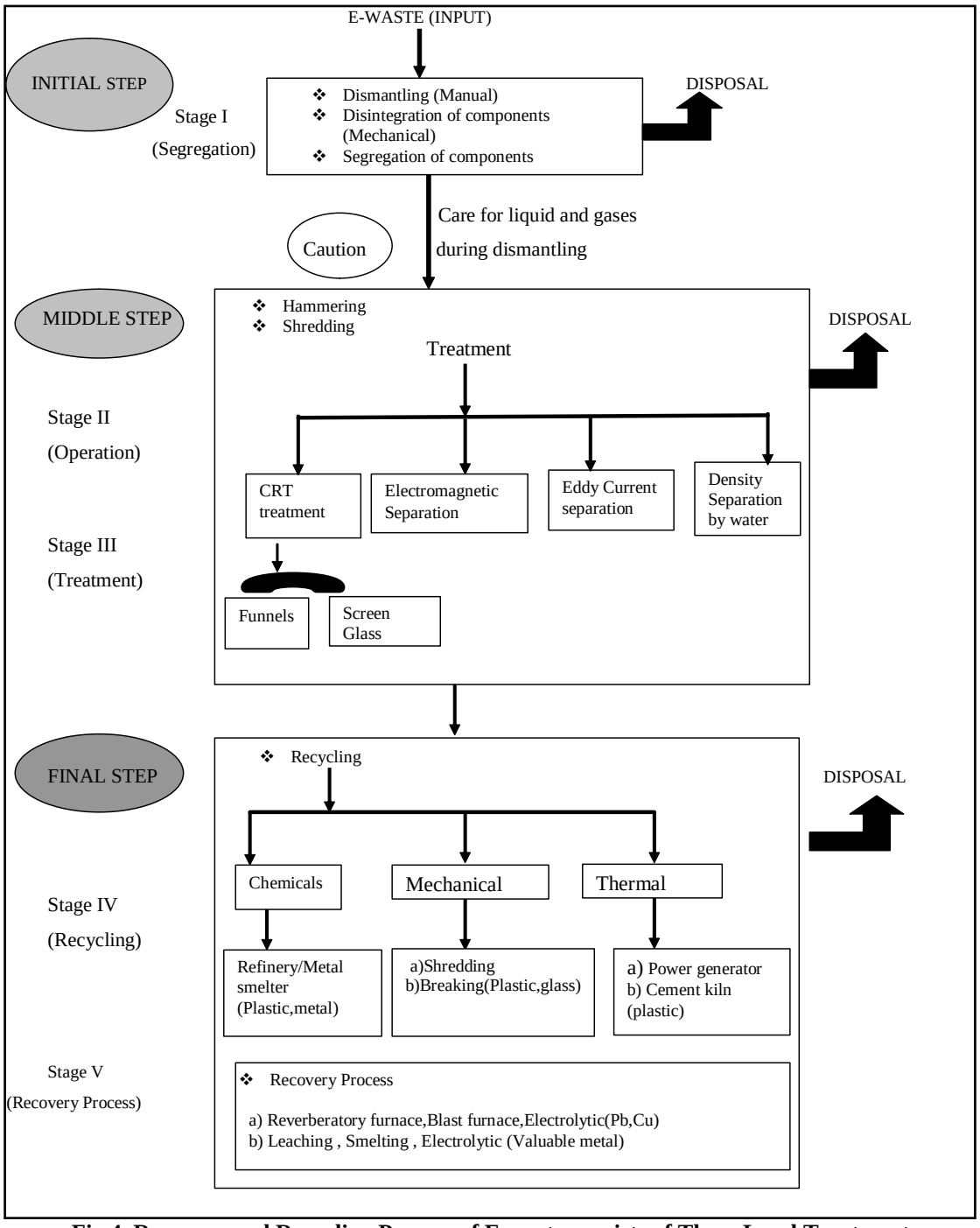

Fig.4. Recovery and Recycling Process of E-waste consists of Three Level Treatment

Several Asian economically developed and developing countries are seriously introducing legislation to manage E-waste. For example, Japan has introduced (The Household Appliance Recycling Law) for the management of WEEE [Bandyopadhyay et. al., 2010].

Japanese covered the E-waste under "used goods", "by products" and "orphan products" to manage the E-waste efficiently from user point of view. This approach definitely help to monitor E-waste generation both quality and quantity.

They have also made law to control manufacturers and importers where Waste electronics has to be taken back by the manufacturers and importers and also provide avenues for separation of E-waste from Municipal solid waste.

In India, E-waste Management and Handling Rules, 2011 are to be upgraded with respect to existing rules and regulations of various Asian countries for effective management of E -waste as well as scope for generation of funds that can be efficiently used to implement modern E-waste

management package and ultimately accelerate the process of transformation in informal sector to formal sector. A special drive is needed to create education and awareness particularly for LSEWD and LEWD for future success of the programme.

A trans-national survey of E-waste per capita generation may be an effective tool to improvise modification in the existing E-waste management and handling rules. The objective and data collection of the survey will be formulized in such a way that NEAP /ARF can be effectively introduced to maintain sustainable E-waste management.

VII. Conclusions

In India, E-waste handling, trade chain and recycling are in primitive stages whereas the E-waste generation rate is increasing in various sectors due to over-usage of both major and minor EEE. The clear understanding of the composition of E-waste is an important prerequisite and effort has to be made to register the growth of individual components (viz. Glass, Plastic, Ferrous, Non-ferrous etc.) so that generation, disposal and recycle can be done in scientific and systematic way. Various issues and concern are now associated with E-waste generation and handling, particularly for metal and plastic components the scenario is reasonably alarming. Several regulations now exist both in national and international arena to control the bulk generation of E-waste. India has already formulated E-waste regulation (E-waste Management and Handling Rules, 2011) to evade uncontrolled E-waste generation. To cope with the situation a management plan is essential and thus has been proposed, where multistep and multistage approaches have been emphasized. Implementation of such E-waste management plans will definitely improve the current uncontrolled situation and also will ensure transformation of informal sectoral practice to its formal counterpart in the domain of E-waste management.

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