E-Waste Management: A Case Study of Bangalore, India

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Abstract: The management and recycling of E-waste was assessed in the city of Bangalore (India) based on rapid growing waste stream, waste valuable resources, hazardous substances and low recycling rate. For this purpose, the personal computer was defined as the tracer and accordingly a model was designed. The model depicts the life cycle of tracer, from production to consumption-including reuse and refurbishment-to material recovery in the formal recycling industry. The process of data collection for the study involved field survey and analysis of the available data. The analysis of data could highlight the strategy for the management of E-waste in the city. In this context, the study intends to reduce the environmental and health impacts from unscientific E-waste management and for understanding of E-waste collection, flow, recycling. All in all E-waste management in Bangalore has moved forward in many ways and can now serve as a model for other cities and state in the country.

Key words: Upgrading and refurbishing, personal computer (PC), Hazardous substances, Precious metals and E-waste recycling.

INTRODUCTION

Consumer oriented growth combined with rapid product obsolescence and technological advances are new environmental challenge - the growing threat of "Electronics Waste" or "E-waste" that consists of obsolete electronic devices. E-waste is a complex mixture of Ag, AU, Pb and Pt as precious metals; Cu, Al, Ni, Si, Zn and Fe as base metals; Hg, Be, Cd, Cr (VI), As, Sb and Bi as metals of concern due to their toxicity along with halogens and combustible (plastics, flame retardants) many of which are toxic (Hagelüken and Art, 2006). E-waste has been a problem of great concern not only for the government but also for the public due to their hazardous material contents (Cui and Forssberg, 2003; Niu and Li, 2007). Currently, the main options for the treatment of electronic waste are involved in reuse, remanufacturing and recycling, as well as incineration and land filling.

The hierarchy of treatment of E-waste encourages reuse of whole equipment first, remanufacturing and upgradation, then recovery of materials by recycling techniques, and as a last resort, disposal by incineration and land filling. However land filling of E-wastes can lead to the leaching of lead into the ground water. If the CRT is crushed and burned, it emits toxic fumes into the air (Ramachandra and Saira, 2004). All electronic equipments contain printed circuit boards which are hazardous because of their content of lead (in solder), brominated flame retardants (typically 5-10% by weight) and antimony oxide, which is also present as a flame retardant (typically 1-2% by weight) (Devi et al., 2004). Recycling of electronic waste takes care of both waste treatment and valuable material recovery and hence has both ecological and economic relevance. Precious metals recovered from E-waste have a wide application in the manufacture of electronic appliances, serving as contact materials due to their chemical stability and their good conduction properties. On a broader scale, analyzing the environmental and societal impacts of E-waste reveals a mixture of benefits and costs (Alastair, 2004). Proponents of E-waste recycling claim that greater employment, new access to raw materials and electronics, and improved infrastructure will result due to E-waste recycling activity. This will further improve the region's progress towards prosperity.

This study focuses to document existing sources of E-waste streams along the life cycle including product assembly, pre and post usage, management and disposal and identify to improved practices based on E-waste collection, flow and recycling system in Bangalore city of India.

METHODS

This study was conducted in the month of March, 2009 in the Banglore city of India. Apart from survey and data collection in the city, outer reaches of it like Banglore Rural District and Dobaspet Industrial area were also chosen for assessment of current practices followed in the E-waste management. Bangalore is the information technology hub of India having more than 1700 IT

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companies generating 8,000 tonnes of E-waste annually. For this study the tracer item chosen was the personal computer (PC). A tracer item in this context stands for an electrical or electronic item which is surveyed along its whole life span, from the cradle to the grave. The definition of one tracer item PC represents all sorts of PCs. Reliable statistics of measurable recycling practices and the high dynamics in the information technology sector were reasons for the decision to use the PC as a tracer.

The assessment strategy followed a certain order: Players and stakeholders of the E-waste recycling stream were identified including consumers, traders, repair shops, dissemblers, scrap dealers and dismantlers. Qualitative research involved semi-structured in-depth interviews with the formal E-waste recyclers present in Bangalore: (a) Ash recyclers (b) E-Parisaraa. One-to-one interviews were conducted to gather information with respect to following areas:

- Detailed understanding of each stage: Sourcing, Logistics, Processing of E-waste
- Current handling capacities
- Status of technology being used currently and challenges faced

RESULTS

A field study and personal interaction with members from formal recyclers produced a model. The survey results are presented first, followed by the model calculations and material flow analysis.

Field Survey and Material Flow Analysis: Bangalore is generating around 12,000 tons of E-waste (from computers and peripherals) per year. This estimate is based on information received from recyclers in Bangalore and from the fact that 30% of all equipment in IT industry became obsolete every year and end up as E-waste. Representatives from two governments authorized recyclers Ash recyclers and E-Parisaraa have conducted surveys in the field of WEEE recycling, and the authors participated in this discourse. The resulting model (Fig. 1, 2) shows a chain of process through which the tracer item PC was followed. The system is divided into two sections: pre- and post-recycling processes. Five percent of the items produced are rejected and go directly into the "Recycling" process. The field assessment of this study revealed the existence of a vital refurbishing and upgrading industry, dealing exclusively with used personal computers. The numbers of flow from the "Repair" to "Traders" processes include the upgrading of PCs with faster processors, increase in hard disc memory or other replacement of whole components. The reuse of components (flow from "Reuse" to "Traders") depicts the recycling of components- such as IC processing chips, memory cards, capacitors or other individual components-
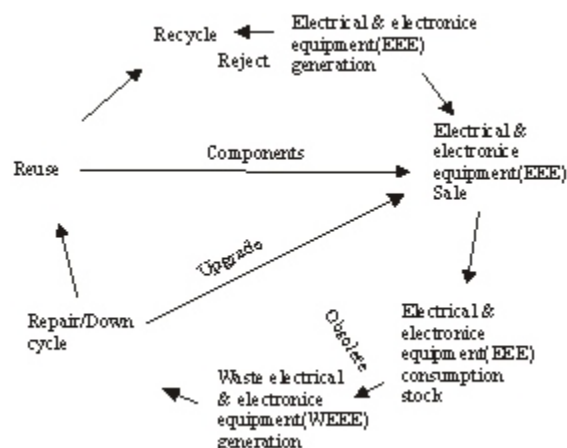

Fig 1: Material flow of the pre-recycling processes of the tracer item personal computer within the system border Bangalore.

which enter the market by being sold after having their functionality checked. Fig. 1 shows the material flow of the pre-recycling processes whereas Fig. 2 shows the post-recycling processes. The process "Recycling" links the two sections of the system and at the same time symbolizes a "point of no return". After entering the "Recycling" process, no items, components or materials even return directly to the pre-recycling processes.

The post recycling process adopted is simple and having minimum landfill options without incineration. In general, mechanical and recovery operations are being carried out. Mechanical operations include: manual dismantling, segregation, pulverizing and density separation in an ecofriendly manner, while recovery operations are carried out separately for metals, glass, and plastics.

E-waste Management at Organizational Level: Bharat Electronics Ltd., (BEL) set-up to meet the specialized electronic needs of the Indian defense services, has been the first public sector company to initiate E-waste management. The public sector companies have recently initiated a programme to manage E-waste. E-waste is segregated into four categories namely-

- Computer and Computer peripherals
- PCBs (printed circuit boards) and electronic components
- Electrical wires/cables, cut wires
- All other electronic equipments

The segregated waste is recycled at authorized E-waste recycling facilities in Bangalore. As per government regulations, tenders are called for the sale of this E-waste. Earlier all authorized scrap dealers were invited to take part in the tender. In the present situation the tender is restricted to only authorized E-waste
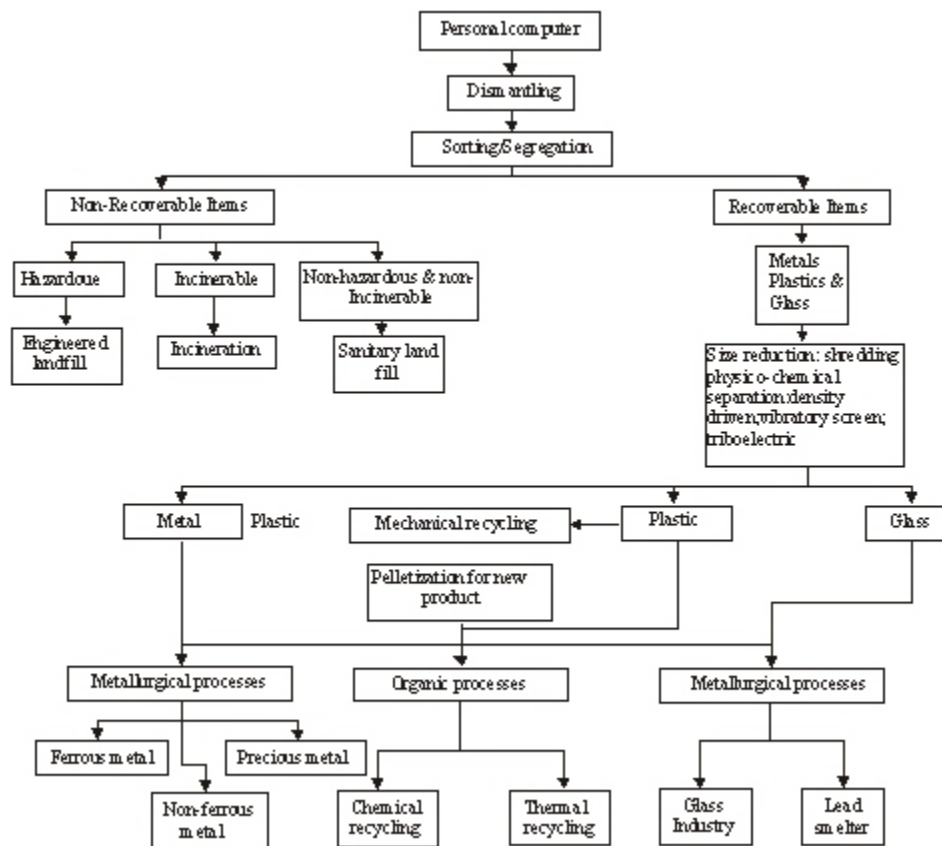
Fig 2: Post recycling processes for the tracer item personal computer

recyclers. In addition to the public sector, large private companies including the multinationals used the auctions to dispose their E-waste. At the same time, there are large public sector organizations that are engaged in the manufacture of various electronic components and telecommunication equipment.

Role and status of stakeholders' involvement: Bangalore has emerged as a key city, which has identified the different stakeholders and is making demands to ensure that attention is given to E-waste and its proper management and disposal. Currently three main stakeholders have been identified. Namely

- The Government- agencies associated with E-waste that include Karnataka State Pollution Control Board (KSPCB), Bruhat Bengaluru Mahanagar Pallike (BBMP), Department of Information Technology, Government of Karnataka
- The Generators (mainly producers and consumers)
- The Recyclers (Both formal and informal recyclers)

Government agencies: The Karnataka State pollution Control Board (KSPCB) has the responsibility for enforcement of the rules and legislation. Discussions with the department made it clear that the hazardous waste rules are currently sufficient to address the safe disposal and recycling of E-waste. The industries are bound to dispose of the E-waste to a proper recycler who is authorized by the KSPCB or to find a proper land fill. None of the legislations objects to sale of E-waste to authorized bodies but selling to scrap dealers that do not have an authorization from the KSPCB is against the law. Bangalore has three authorized E-waste recycling units. A tracking system is also on place whereby waste disposed through the authorized vendors is documented under the hazardous waste rules. KSPCB has also made it mandatory for all new establishments seeking Consent for Establishment (CFE) to comply with E-waste regulations. All large companies in Bangalore are now well aware about the regulations regarding safe disposal of E-waste. Similar initiatives are required promptly from other pollution control board agencies of different states.

Generators: The corporate sector and government institutions contribute largely to E-waste in the form of IT equipment. In addition educational institutions and households are also significant contributors. Within the corporate sector the hardware companies been looked at with special interest since they are required to take responsibility for the generation of E-waste.

E-waste is also generated from the small and medium scale enterprises (SMEs) that manufacture components. These SMEs also act as suppliers to the large multinationals. In Karnataka there are 2,000 SMEs engaged in various different manufacturing activities including manufacture of components for the electrical and electronics industry. It is also noted that SMEs generate E-waste not just from manufacturing but also contribute through extensive use of electronic equipment. If the service sector is included then the potential for generation of E-waste is huge. Most large IT companies in Bangalore have introduced well-defined E-waste management systems including identification, segregation and safe disposal of E-waste.

Recyclers: There are two types of recyclers in Bangalore that play important role for managing the E-waste; (a) formal recyclers, (b) informal recyclers. Out of the two, the formal recyclers handle maximum E-waste recycling. E-Parisaraa, Ash recyclers are the two major formal recyclers and many big names as their customers. This included HP, IBM, GE, Intel, Motorola, ABB, Philips, Sony etc.

Informal recyclers possess remarkable skills, which include the ability to recognize different types of raw materials. They are also meticulous in their recovery of this material from even small components. But the informal units usually operate without a license in residential areas and pose a threat to the surrounding environment and communities. The informal recyclers should have training cum awareness programme on safe E-waste recycling procedures in the existing government recognized E-waste recycling units.

Material Recovery from E-waste: As an example of the case study from our field data, Fig. 3 shows the material recovery from one ton E-waste conducted at E-Parisaraa, Bangalore. Fig. 3 shows the typical computer waste composition per one ton. Glass is 20% by weight; plastics are 23% by weight followed by metals 57%. Metals are recovered from printed circuit boards, cables, non-ferrous metals and ferrous metals. Out of one ton computer waste, 99% is used for recovery of precious metals and another 1% for safe land filling. There is no statistical data for recovery of metals by informal recyclers.

Status of Technology, Challenges and Innovative Options: It was found that current recycling operations of these companies are limited only to pre-processing of E-waste material. The processes used are a combination of manual and mechanical processes, in which manual processes forms a large part. It was also noticed that formal recyclers have a permission to establish a recycling plant and consent to export metals to approved smelters globally.

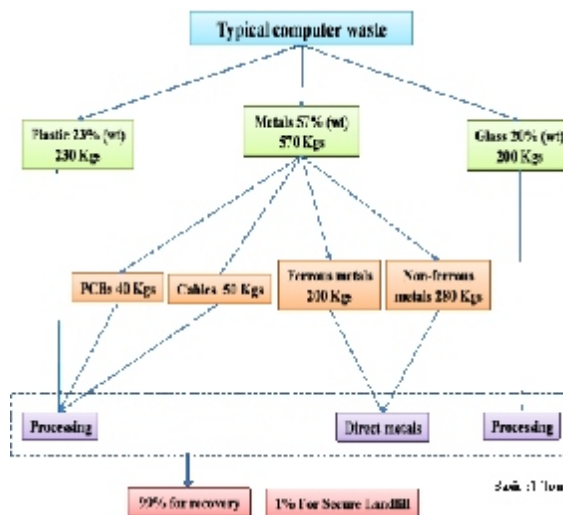The companies use thermal shock techniques for separation process followed by feeding the E-waste into

Fig 3: Computer composition based on the research on material recovery from E-waste conducted at E-Parisaraa company, Banglore

the shredders signaling the start of mechanical stage. The shredder materials, laden with precious metals, are then sent to smelting refineries for extraction of these metals. The only technology being used for E-waste recycling in Bangalore is the shredding/pulverizing technology followed by pyrometallurgical and hydrometallurgical process. There is a need to develop a cost effective technology for extraction of precious metals and for disposal of hazardous metals.

In the last decade, attentions have been removed from pyrometallurgical process to hydrometallurgical process for recovery of metals from electronic waste. Hydrometallurgical processing techniques include cyanide leaching, halide leaching, thiourea leaching, and thiosulfate leaching of precious metals. This process also faces environmental issues and less efficiency in recycling of precious metals.

DISCUSSION

Reuse of end-of-life (EOL) electronic equipment has first priority on the management of electronic waste since the usable lifespan of equipment is extended in a secondary market, resulting in reduction of the volume of treated waste stream. Recycling of electronic waste is another important subject not only from the point of waste treatment but also from the recovery of valuable metals. The value distribution for personal computer shows that, the precious metal make up more than 70% of the value. This indicates that the major economic driver for recycling of electronic waste is from the recovery of precious metals and their industrial application.

CONCLUSION

From the result it was found that, the refurbishing and upgrading of personal computers and monitors constitute

one of the key drivers of the pre-recycling processes. However the material flow is only based on the market values of the upgraded or refurbished items. This scheme comprises one of the most effective mechanisms to: (i) create additional value and (ii) to prevent an accelerated flow rate through the whole system. The incentive is the increasing need for low cost personal computers among the ever-increasing group in the Indian population that uses computers. The market demand creates jobs and business in a second hand industry and at the same time decrease the overwhelming load of E-waste.

Traditional technology, pyrometallurgy has been used for recovery of precious metals from waste electronic equipment. However, it has encountered some challenges from environmental considerations. Consequently, state-of-the-art smelters are highly depended on investments. In the last decade, attentions have been focused to hydrometallurgical process for recovery of metals from E-waste. This process also faces environmental issues and less efficiency in detoxifying effluents. All in all E-waste management in Bangalore has moved forward in many ways and can now serve as a model for other cities and state in the country. However, still there is lacuna in advance technology for recovery of precious metals.

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