(General article)

Management of Electronic Waste: An Integrated Approach

Sandeep Singla[a] & Manjeet Bansal[b*]

[a]*Department of Civil Engineering, RIMT Institute of Engineering and Technology, Mandi Gobindgarh, Punjab, India*
[b]*Department of Civil Engineering, Giani Zail Singh College of Engineering and Technology, Bathinda, Punjab, India*

Abstract

In this paper the authors will present options for e-waste management in India. These options are being developed, implemented and evaluated in the framework of different Indian bilaterally financed studies focusing on Delhi, Bangalore, Pune and Kolkata. Electrical and electronic waste (e-waste) is one of the fastest growing waste streams in the world. According to a recent study about 380,000 tons of e-waste are generated annually in India and the generation of e-waste has touched 470,000 tons in 2011. The study also reveals that only about 6 percent of the e-waste is recycled, of which 95 percent is recycled through the informal sector. E-waste recycling in the informal sector provides jobs to thousands of people and supports the formal waste management agencies like municipalities. Investigations showed that the existence of an informal but entrepreneurial SME based infrastructure permits a profitable e-waste management business. At the same time, the informal sector is lacking skills and technologies, and manages hazardous material without any regard to occupational health and safety requirements and in an environmental harmful manner. It is observed that with rising e-waste quantities the recycling scenario is changing, with the formal recyclers increasingly entering the e-waste recycling sector. There is a widespread expectation that these formal sector recyclers would be able to manage e-waste in an environmentally sound manner by using Best Available Technologies (BAT) leading to better environment management and enhanced resource recovery. However, it is not clear whether the advent of formal recycling would come at the expense of informal sector recyclers or would complement their activities. In this paper, we present the integration of the informal and the formal sectors in India. We show that there are mutual gains to be obtained from an increased cooperation between the formal and informal sector because of their competitive advantages. Social welfare is enhanced through this interaction. It furthermore leads to reduced pollution, better resource management and creation of green jobs in the recycling sector. The outcomes of the investigation suggest that the collection, segregation and primary dismantling of non-hazardous fractions of e-waste should be focused in the informal sector while the other higher order recycling processes may be concentrated in the formal sector.

Keywords: E-Waste, recycling

1. Introduction

The electrical and electronics industry is one of the world's largest and fastest growing manufacturing industries. Rapid growth, combined with rapid product obsolescence through short innovation cycles turns e-waste into the fastest growing waste stream worldwide. E-waste is characterized by two main attributes: It is hazardous, due to its content of toxic substances such as lead, cadmium, mercury, PCBs (polychlorinated biphenyls) etc., but at the same time it is valuable, due to the content of precious and strategic metals such as gold silver, platinum and copper. The extraction of these valuable items is especially critical in terms of environmental and health hazards during dismantling and wet processing. E-waste recycling by the informal sector with little or no control, using highly hazardous and polluting techniques is a reality in some of the densely populated cities of India like Delhi, Bangalore, Chennai, Kolkata, Mumbai etc. India is one of the pioneers among developing countries in exploring the avenues for the management of electronic waste.

As early as 15th March 2004, the "Way Forward" was discussed at a national workshop organized by the Ministry of Environment and Forests (MoEF), Central Pollution Control Board (CPCB) and supported by Gesellschaft für Technische Zusammenarbeit (GTZ). The workshop discussed the need for proper management of

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[*]Corresponding author's email: push_kar5@yahoo.com

e-waste in the country. One of the first steps identified was to conduct an assessment at the national level, covering important e-waste processing centres. This study, accomplished in December 2007, showed that the potential annual e-waste generated on account of three components – Televisions, Computers and Mobile Phones – is approximately 380,000 Metric Tons generated in India in the year 2007 (GTZ-MAIT Assessment Study 2007). Out of this potential waste, only 144143 Metric Tons was available to be recycled because of the presence of considerable refurbishment and re-use market. Moreover, of this 144143 Metric Tons, only 19000 Metric Tons of e-waste was recycled in 2007. The rest lay stored in the warehouses of institutions or in the cupboards and drawers of households. The e-waste generated was projected to increase to 410,000 tonnes in 2008 and reached 4700,000 tonnes by 2011. The other major finding of the study was that 95% of the actual recycling is done in the informal sector using primitive and highly polluting backyard operations with low or non-existent risk awareness polluting ambient air, water and soil and affecting the health of workers. In 2007, formal recyclers handled a minor proportion, approximately 5% of the overall e-waste being recycled in India.

However, with rising quantities, awareness and interest from policy makers in the issue, the recycling scenario is changing with formal sector players entering the e-waste recycling sector. There is widespread expectation that these formal sector recyclers would be able to manage e-waste in an environmentally sound way using Best Available Technologies (BAT) leading to better environment and enhanced resource recovery. However, it is still not clear whether the advent of formal recycling would come at the expense of informal sector recycler. Experiences worldwide, however, show that there are mutual gains to be obtained through the trade of material between the informal and formal sector because of their comparative advantages. It is also clear that the social welfare is enhance by this interaction between the formal and informal sector by reduced pollution, better resource management and creation of green jobs in the recycling sector. The Government of India has emphasized the role of the informal sector in its policy statements. The National Environment Policy (NEP, 2006) mentions that there should be efforts to, "Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various materials. In particular enhance their access to institutional finance and relevant technologies." In March 2008, in a major step forward the Government of India notified Guidelines for the Environmentally Sound Management of Electronic Waste. The guidelines emphasized two salient points: Extended Producer Responsibility and Reduction of Hazardous Substances. The guidelines also mentioned the need for a dedicated legislative framework for Electronic Waste Management.

Subsequent to the release of the guidelines, various stakeholders including the industry have expressed the need for a dedicated legislation for Electronic Waste.

In this paper, we present the integration of the informal and the formal sectors in India. The expected mutual gains from an increased cooperation between the formal and informal sector is brought out. The other benefits highlighted include social welfare, reduced pollution, better resource management and creation of green jobs in the recycling sector.

2. E-Waste scenario in India

The electronics industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. The share of software services in the electronics and IT sector has gone up from 38.7 percent in 1998-99 to 61.8 percent in 2003-04. The liberalization, and the opening up of Indian markets together with the change in India's import policies vis-à-vis hardware leading to substitution of domestically produced hardware by imports has facilitated an IT penetration in the Indian market at an accelerated pace. The IT industry is the prime mover with an annual growth rate of 42.4 percent between 1995 and 2000. By the end of financial year 2005-06, India had an installed base of 4,640,000 desktops, about 431,000 notebooks and 89,000 servers. According to the estimates made by MAIT the Indian PC industry is growing at 25 percent annually. During 2007-08 ICT PC sales grew at 16 percent annually and consumer electronics sales grew at 13-15 percent annually while the cellular phone subscribers reached a growth rate of 96.8 percent in 2008. With the increased use of electrical and electronic equipments the e-waste generation also increased but the assessment shows that only about 5.7 percent of this e-waste is being recycled. The fate of the rest of the waste is still unknown.

According to the assessments made, 60-70 percent of the total e-waste generated is from ten states and sixty-five cities in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of e-waste generating states in India. Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. There are a number of e-waste dismantling facilities that are operating in almost all of these cities. At these facilities the e-waste is usually dismantled and exported, and sometimes even processed locally to extract precious metals. Some large scale organized e-waste recycling facilities are being set up in India of which one is currently ready for full operation.

3. Understanding the existing system

The informal sector has a historic role in waste management and recycling in India and it is well known that e-waste recycling is no exception to this with an estimated 95 percent of e-waste being recycled through the informal sector (GTZ-MAIT study, 2007). The informal e-waste recycling sector provides jobs to thousands of people in urban and peri-urban areas, and supports the formal waste management agencies like municipalities.

It is a well known fact that most recycling activities in India are carried out in the informal or the unorganized sector and e-waste recycling is no exception. The informal sector has a historic role in waste management and recycling, partly because of the notion of waste being a fringe commodity, rather than being a waste. As a result, historically the fringe commodity was left to be handled by the fringes of society – the informal sector. With the widespread development of governments over the last few decades, waste management has fallen into the hands of local governments which have been overwhelmed by the quantities of waste generated in large cities. The existing informal sector has been contributing to reduce the burden of formal waste management agencies. Their widespread and active network and manual skills make recycling of e-waste a profitable business venture. The MAIT-GTZ e-waste assessment study mentioned above also revealed that 94% of the manufacturers included in the study did not have an IT disposal policy and were not aware of the current waste handling practices. Therefore, most of the e-waste was being disposed off to the scrap dealers who in turn sold the waste to the recyclers in the informal sector. The recycling in the informal sectors essentially involves dismantling and sometimes includes the extraction of precious metals.

3.1 Environmental and Health Implications

Environmental concerns due to the operations in the informal sector can be attributed to the emissions of dioxins, heavy metals such as lead, cadmium, mercury etc. Further concerns arise due to the sludge from processing leads to contamination of the water bodies and soil due to brominated flame retardants (BFRs), spent fluids/chemicals, traces of poly chlorinated biphenyls (PCBs) etc.

The other major challenges are the Occupational Health and Safety (OH&S) and Child Labour. The dismantling activities could also lead to the spread of toxic dust while open burning of wires and printed circuit boards result in emissions of dioxins & furans, lead, cadmium and mercury fumes. The contact with the chemicals used during the operations, improper ventilation and non usage of personal protection equipments leads to exposure to hazardous chemicals. Apart from the issues mentioned above, the workers in the informal sector are also exposed to other work place hazards leading to physical injuries, respiratory disorders, asthma, malnutrition, skin diseases, eye irritations etc. and in some cases long term incurable diseases. Most of the adverse effects on health can be attributed to:

- Improper ventilation, no exhaust pipes in the working environment
- No personal protection equipment is used
- Child labour is employed
- The fall out of the toxic materials in the environment also causes contamination of air water and soil leading to health effects

3.2 Socio-Economic Implications

The informal sector focuses on cherry picking of the precious components for metal recovery and the non-recoverable are disposed off in landfills. The study conducted in Bangalore on precious metal recovery by the informal sector states that the efficiency of the processes adopted by the sector is around 28-30% whereas the gold extraction efficiency is around 99.99% by the smelting companies in developed countries. The e-waste trade chain in India comprises of aggregators who purchase scrap from households and businesses, followed by segregators who dismantle the components manually and sell off to recyclers who process the waste further for extraction of precious metals. The waste aggregators and segregators form an intergral and important part of the e-waste trade chain as fas as the channelization and collection of e-waste are concerned. They are highly networked and skilled workers engaged in sale/ purchase and dismantling of e-waste. The aggregators and segregators also have skills to extend the product's life cycle by reusing the components. By extending the life of old electronics, they prevent pollution by saving the amount of energy required to make new products, reduce carbon footprints and enhance the penetration of IT and consumer durables among the economically disadvantaged people. Most of the workers are usually illiterate, and belong to rural immigrant families. Many commence their profession at the young age of five to eight years. Even after migrating to cities with the hope of improving their economic standards, they are still at a disadvantaged position as they are faced with issues such as competition among members, lack of minimum wages, lack of access to credit, lack of recognition by the authorities and lack of access to social protection schemes, that adds to their vulnerability.

3.3 Legal Framework for E-waste recycling in India

The National Environment Policy (NEP) published by the Ministry of Environment and Forests in 2006 mandates encouraging reuse and recycling of waste with the aim to

conserve the natural resources and at the same time reducing the waste destined for disposal, thus encouraging the use of waste as a resource. The provision to establish a system for collection of recyclable materials has also been provided in the NEP. Additionally, the NEP emphasizes strengthening the informal sector and providing them with a legal status so that they can be involved in the mainstream activity of the recycling industry. In view of the inadequacy of some of the legislative and regulatory measures, NEP provides for the formulation of new legislations and regulations to protect and safeguard the environment and human health.

However, in India, up to date, there are no specific environmental laws or regulations for e-waste management. However several provisions under different regulatory regimes may apply to various aspects of e-wastes. Since e-waste or its residues fall under the category of both 'hazardous" and "non-hazardous waste", they shall be covered under the purview of both the hazardous waste regulations as well as the municipal solid waste regulations. The existing policies and regulatory regime do not distinguish between the informal and formal recyclers which may cause certain impediments in the recycling activities in complying with these regulations.

Considering the need for specific e-waste regulation the Government of India, Ministry of Environment and Forests has submitted a draft "E-waste (Management and Handling) Rules, 2010" in mid 2010. This draft legislation is currently being reviewed, and objections and suggestions from the public are being obtained. The Indian Government announced on 4 October 2010 that the new E-waste legislation shall enter into force on 1.1.2012. The proposed draft rules provide for the regulation of e-waste which is a post-consumer waste, generated at the end of life of a product. These rules call for the registration of all of those dealing with e-waste such as collection, dismantling, refurbishing and recycling activities irrespective of being located in the informal or formal sector. These rules also impose the Extended Producer Responsibility (EPR) and the Reduction of Hazardous Substances (based on the EU RoHS Directive) provisions.

These E-waste rules will provide the basis for further legislation and guidelines that are currently being developed to further specify the legal framework. The existence of an adequate legal framework is fundamental precondition to enable the establishment of a sound e-waste management system for India. It particularly requires further elaboration of distribution of responsibilities, definition of means for implementation and institutional set-up and for enforcement measures. Furthermore, specification of an implementation mechanism for producer responsibility either collectively through a Producer Responsible Organization (PRO) or individually is being required. The authors are involved in

supporting the development of some of these guidelines. The Rules also mandates the deposition of the WEEE at the collection centre or with the recycler specifying the collection and channelization of e-waste. Thus the enabling regulatory framework will need effective participation and adequate investments by the responsible actors.

4. Integration of formal and informal sector

The way forward hence, involves formalising the informal sector e-waste recyclers through means of forming associations, register these and professionalise their businesses. It is obvious that the formalisation process, which the informal sector can undergo within the envisaged time horizon is limited. Restricted human as well as particularly financial resources as well as legal obligations will most likely restrict this formalisation process to those e-waste recycling activities that take place at the beginning of the recycling chain e.g. collection, dismantling, dissembling for re-use, preparation for recycling (e.g. shredding). Additionally, the current nature of the informal sector and its predominance use of manual instead of mechanical recycling methods favour the informal sector to keep those manually focused activities. The following two graphics show a simplified architecture of the existing e-waste recycling system and the distribution of activities between the formal and informal sector
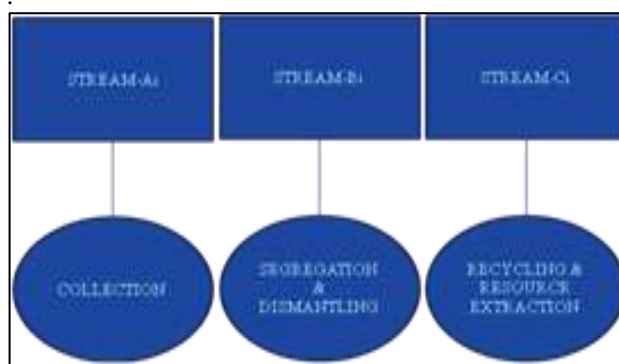
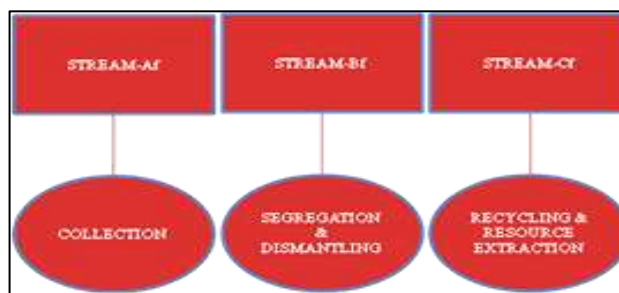.

Fig.1 Current Scenario – Informal Sector

Fig. 2 Current Scenario – Formal Sector

The scenario is changing at a faster pace now with the formal recyclers entering the scene and high-end recycling envisaging complete environmental compliance and efficiency in the processing of waste and the recovery of a high quality product. But such units are unable to access the materials due to the informal collectors, scrap dealers and recyclers in the informal sector who are able to reach for the door-to-door collection and are able to pay a good price for the e-waste in comparison to the formal recyclers. The formal recycling units have high investments and high overheads to meet the environmental compliance requirements. As a result they are not able to meet the price demanded by the vendors or the consumers and are thus unable to access e-waste.

A mutual support system that could be provided by the operations in the informal and formal recycling units as reflected is ideal for developing economies. The system will provide a balance between the cheap labour intensive operations in the informal sector and the sophisticated mechanized operations in the formal recycling units. The following two graphics show first, the intervention scenario and second, the proposed future scenario.
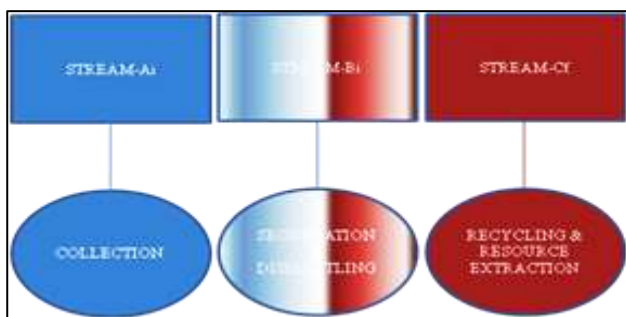

Fig. 3 Integrated future Scenario

The optimization of resource flows is required to obtain quality products and has to be set as a goal while providing the model for integrating informal and formal e-waste recyclers. As a first step in the process all elements of the value chain need to be identified and all stakeholders have to be involved. The mechanism of transfer of e-waste needs to be planned in such a way that the material reaches its destination in the shortest time possible and avoids any pilferage during handling and transit. A system of collection and transportation using third party or involving multi-stakeholder system would be a viable solution. Saving time and energy in the operations should become an integral part of the system.

The model provides the integration of the formal and informal sector taking the interests of both into account in a rational choice framework. The model shows that there are mutual gains to be obtained from the trade of material from the informal and formal sectors because of their comparative advantages. We also show that the social welfare is enhanced by this interaction between the formal and informal sector and results in reduced pollution, better resource management and creation of green jobs in the recycling sector. The model recommends that the collection, segregation and primary dismantling of non-hazardous fractions of e-waste be focused in the informal sector while the other higher order processes can be concentrated in the formal sector.

4. 1 Producer Responsibility

An important role in the process of enhancing the e-waste recycling system in India will play the waste generators and in particular the large branches. The above mentioned MAIT-GTZ e-waste assessment study revealed that 94 percent of large enterprises / organisations included in the study did not have an IT disposal policy for the obsolete and end-of-use IT products or e-waste and were not aware of the required practices. Therefore, most of the e-waste is being disposed off to those that pay the highest price. Environmental and health and safety standards and registration requirements are not considered. It is crucial to motivate the large e-waste generators to apply minimum standards for their e-waste disposal. The new legal framework will help implementing this. Awareness measures need to provide accompanying guidance to enhance enforcement.

Conclusion

Some of the major issues and challenges faced in the implementation process can be attributed to the gaps and overlaps in the system. First and foremost the gaps in the legal framework need to be closed. The current framework does not specify the role of different stakeholders. No mandatory requirements are provided for the specific activities that are likely to cause direct or indirect impact on environment or health. These actions are not justified as there is no difference between those who comply and those who do not comply. In other words there is no reward for compliance and no punitive action against the erring units.

There is a lack of viable working models to suite the Indian conditions. One of the important issues is the conflict arising among the groups which have their origin in the formal business, administrative and financial models. The business ventures have not been made attractive and investments are not sufficient to meet the high level operations. One of the important links in the informal-formal integration is an efficient collection operation, which has not been put in place. In many cases of recycling post-consumer waste, the reason for the failure of formal recycling operations is the lack of a collection and take back system. Though there are millions of scrap or junk dealers collecting all sorts of wastes that have recycling potential, these are not

organized and they operate purely on economic basis. They do not contribute effectively to the system and focus only on the individual survival and sustenance. The most important factor that influences the Indian system is the prevailing political scenario.

The integration of activities in the informal and formal sectors is essential to establish a viable recycling model for e-waste recycling. There is a need to dovetail the activities of the informal sector with those of the formal recycling units in order to achieve optimal solutions for the recycling practices without compromising environment and health. The combined effort would also meet the requirements under the NEP to organize the informal sector and bring them into the mainstream activity and facilitating them to overcome the problems related the pollution and health hazardous. The streamlined system will operate efficiently only if these are supported by cooperation between the various stakeholders in the value chain.

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