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RESEARCH ARTICLE

E-WASTE MANAGEMENT IN INDIA: FORMAL VS INFORMAL SECTORS

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ABSTRACT

This paper is a result of an innovation project completed by us under Delhi University, Cluster Innovation Centre. In this study, we tried to understand the mechanism of formal and informal sector managing E- waste. The informal sector manages more than 90 percent of India's E-waste. Low infrastructure set-up and operational costs enable them to make the profit and dominate the market. They are not liable to many expenses like rents and legitimate wages, do not invest in modern technology, follow unscientific processes for recycling and extraction, and are not bound by any laws and regulations. Considering the future scenario, it is imperative that the safe management of waste is done in an organised manner with sufficient resources and sustainable recycling technologies on the one hand and effective legislations and monitoring mechanisms on the other. It also calls for the regulatory infrastructure to allow for the protection of workers and community rights. This lack of organisation, which leads to the adoption of inefficient techniques, calls for the development of certain structure in this sector. A need is there to channelize and bring these informal players in the mainstream in order to manage e-waste in a sustainable manner. This study suggests one such process innovation to channelize the electronic waste being produced in different regions of the country. The future scope of this report lies in the regularisation of this sector, to turn it into a lucrative entry point for more organised private players.

INTRODUCTION

In 2016, India was ranked as the fifth largest generator of electronic waste in the world. A study conducted The Associated Chambers of Commerce and Industry of India (ASSOCHAM) and KPMG in 2016 ranked India among one of the top five countries in e-waste generation, with an estimated 1.85 million tonnes generated annually. Globally, the number is an astounding 40 to 50 million tonnes annually. India accounts for roughly 4 per cent of e-waste generated annually. The United States ranked first in e-waste generation, generating 11.7 million tonnes of e-waste annually. China ranked second with 6.1 million tonnes of e-waste every year. The ASSOCHAM-KPMG study, titled "Electronic Waste Management in India'' identified computer equipment and mobile telephones as the principal e-waste generators in India. According to this study, computers contributed towards 70 per cent of the total e-waste generated in India, while telecommunication equipment accounted for 12 per cent. Among cities, Mumbai topped the list as it generated an estimated 1,20,000 tonnes of e-waste annually. Delhi and Bengaluru ranked second and third, with 98,000 and 92,000 tonnes of e-waste generation respectively. Approximately 70 per cent of heavy metals found in landfills are accounted for by E-waste. As per the estimation by United Nation University, e-waste will rise from the 41 million tonnes currently produced each year to 47 million tonnes in 2017. A whopping 2.7 million tonnes of E-waste is generated annually in India. More than 95% of this waste is handled through the informal sector, leading to irreversible damages to the people engaged in dismantling electronic devices by getting exposed to lead, mercury, cadmium, flame retardants and other dangerous toxins. Although e-waste is a serious environmental problem, it is also a source of livelihood for many in the informal sector in India. Most e-waste is collected, stored, dismantled and even reclaimed for metals and plastics by the informal sector. In Delhi alone, there are over 25,000 persons earning their living from e-waste handling, collection, dismantling and metal extraction. (ASSOCHAM-KPMG joint study-cKinetics study 2016)

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E-waste generation in informal sector

India has the label of being the second largest e-waste generator in Asia. More than 90 percent of the e-waste generated in the country ends up in the unorganised market for recycling and disposal. The unorganised sector consists of an assortment of small and informal businesses not governed by any stringent health and environmental regulations. Workers face dangerous working conditions as they may be without protection like gloves or masks. Released gases, acid solutions, toxic smoke and contaminated ashes are some of the most dangerous threats for the workers and for the local environment. Many workers function from homes to reprocess waste, further exposing themselves, their families and the environment to dangerous toxins. For instance, to extract metals from circuit boards, gas torches are used to heat a board just enough to melt the solder, which separates the metal parts from the boards. In this sector, the dismantlers extract metals on their own or work with a big trader, earning about Rs. 100 /- per day. The circuit board recycling process involves either open burning of the circuit boards or using acid stripping. Both processes first involve removal of the chips, condensers and capacitors from the board. Open burning and acid baths are fraught with occupational health risks as well as risks to the people living in the surrounding community.

E-waste generation in formal sector

A problem facing the formal sector is the lack of proper collection and disposal mechanisms and appropriate technologies in the face of a large informal sector. Due to lack of proper collection systems, households and institutions at times end up storing obsolete products in their warehouses or storerooms. Even when these are sold or exchanged, they are refurbished and then resold. Only a small proportion of obsolete electronics products actually find its way into the e-waste processing stream. The formal sector also lacks refineries for precious metals recovery. Opinions, however, differ on the issue of the license to import as the only way to sustain formal business in the current scenario. The toxics link holds that the aim of e-waste management should be safeguarding environment rather than sustaining businesses. Allowing imports would mean many non-recyclable hazardous materials dumped in our landfills, which should not be allowed. The country generates very large quantities of waste and the critical need was to establish a sound collection mechanism and not permit waste import to sustain capacity utilisation of plants. Unlike the informal recyclers, the formal recyclers do not use any chemicals or incinerations and use environmentally sound processes. (collegebuddi.com/.../ Ewaste_generation_in_organised_sector_and_unorganised_sector)

Research objective

To Study the current scenario of formal and informal sector handling e waste in India.

1 To understand the e-waste managementmechanisms and processes both formal and informal.
2 To understand and analyse conventional disposal system and different risks associated with it.

Research methodology

In order to fulfil research objectives of the research project, the primary and secondary data has been used for empirical analysis.

Data Collection and Sampling: The primary data is collected through structured questionnaire containing the close ended as well as open ended questions. To understand current practices of E-Waste disposal and to explore the possibility of their applicability on a micro level, surveys and interactions were conducted with companies, E-waste collectors, Aggregators, dismantlers, Extractors and Recyclers. The sample had 100 of these located in various parts of Delhi NCR, primarily in Mayapuri,Seelampur, Shastri Park, Bawana, Nangloi and Noida. To understand and compare the mechanisms or practises adopted by formal and informal sector visited Attero's Recycling plant at Roorkee.

Secondary data: A review of secondary sources through the university library and a wide range of information sources such as academic and commercial abstracts, Delhi Government guidelines on E-Waste disposal, and Internet search engines were conducted.

E-Waste Disposal Methods Adopted in India

Electronic scrap in India is handled through various approaches in management alternatives such as product reuse, conventional disposal in landfills, incineration, and recycling. The recycling of electronic waste requires efficient and advanced processing technology, which apart from being capital intensive, entails high-end operational skills and training of the processing personnel. However, the disposal and recycling of EOL devices in the country has become a menacing problem compounded on account of rudimentary methodology for disposal and recycling by entrepreneurs in the unorganised sector which are drawn more with profiteering motive, despite not having adequate access to sustainable technology. Thus posing grave environmental and health hazards. Apart from having to handle its own burden arising from the accelerated accumulation of EOL-EEEs, India also faces the herculean task of managing the waste being especially dumped by developed countries, leading to the rapid escalation of the risk phenomena associated with solid waste management. Taking advantage of the relative slackness on environmental standards and working conditions in developing countries, vis-à-vis stringent environmental norms followed in the developed countries, e-waste is being sent or dumped for processing in India and China—in most cases, illegally. The random open-air disposal of e-waste, including incineration, is actually contributing to the rapid escalation in pollution menace, affecting both life and environment. Currently, the likely modes of disposing E-waste are:

Modes of Disposing E-Waste

Product Reuse

This is the easiest way to again utilise an item. This is a trend generally followed by retailers to exchange their old items against new gadgets, in the form of additional discounts, are actually marketing gimmicks for accelerating sales volume. Refurbishing used electronic goods for reuse after minor modifications, apart from the prevalent trend of passing on the same to relatives and friends, is a common societal practice.

Conventional Disposal in Landfills

The product is dumped in landfill sites, where it may remain indefinitely. According to the Environmental Protection

Agency (EPA), more than 3.2 million tonnes of e-waste ended up in US landfills in 2007 (Smith T. Silicon Valley Toxics Coalition Report, 2007). The extremely low biodegradable characteristics of plastic components get further compounded in dry conditions, which complements landfills and in strictly regulated landfill sites, degradation is even slower. The highly toxic constituents found in the different components of the devices contribute to metal leaching, leading to large-scale soil and groundwater pollution, and the situation worsens with a passage of time for sites subjected to dumping for prolonged periods of time. When disposed-off in landfills, the multi-layered configuration of computer waste becomes a conglomeration of plastic and steel casings, circuit boards, glass tubes, wires, and other assorted parts and materials. About 70% of heavy metals (including mercury and cadmium) found in landfills come from electronic discards (Global Futures Foundation, 2001).

Incineration or Open-Air Burning

In today's digital Chip based scenario large composition of E-waste generated constitutes IT devices such as computers, mobile phones, CRTs etc. In a case of PCs after manual separation of components, motherboards are burnt in open pit for extracting the thin layer of copper foils laminated on the circuit board, which after charring, is distilled through a simple froth floating process. The ash is washed out and the copper, with some carbon impurity, goes to the next recycling stage. The defective IC chips and condensers, which do not have a resale value, are burned in small enclosures with chimneys for extracting the embedded metallic parts. (Agarwal et al., 2007)

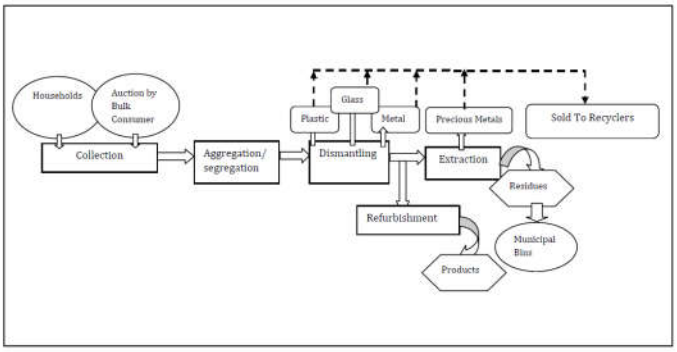
Recycling

Recycling is another very important method to lessen disposal waste. When discarded, electronic items are recycled, the metal recovered from waste is reused in producing different new items and thus decreases consequent financial costs. Though a good fraction of E-waste is recycled in the process, the unscientific methodology adopted for material salvaging has an extremely high environment and health hazard impact attached to it. Such method of recycling has its inherent limitations with respect to recovery of both metals and non-metals e.g., copper, gold, silver, aluminium, iron, tin, lead, and plastics are recovered to some extent while such processing technique does not aid value addition in a true sense, keeping in mind the fact that many vital metallic components, such as germanium, barium, platinum, antimony, cobalt, nickel, etc. remain unrecovered.

Informal Sector and E waste management

E-waste recycling in India is mostly confined to the informal sector because of less usage of scientifically focused and sustainable mechanisms. Also, there are constraints of limitation in processing capacity which contributes significantly to pollution and environmental degradation. This trade has mostly grown on the fringes of metropolitan and larger cities surrounding the industry hub, however, with incremental growth in the processing of e-waste, a shift to the periphery of smaller towns has also been observed of late. The phenomena of e-waste processing comprising dismantling and recycling for extracting valuable metals from PCBs, including CRT re-gunning, etc., adopting crude process methodology such as open-air burning or incineration, use of the acid bath, etc., is primarily focused upon profiteering motive with minimal capital investment. This leads to escalating the grave damage implications for both life and environment, apart from endangering both the lives of workers engaged in the processing activities and the residents of the surrounding localities.

Figure 1 shows the end to end recycling process by the informal sector



Source: Learning to Recycle, Chintan Environmental Research and Action Group

Recycling of EOL EEEs is a very complex process because its multi-layered configuration comprising numerous materials and components aimed at recovering the valuable metals and other ingredients factually entails the deployment of advanced processing technology and skilled technical personnel. The first level involves a collection of E-waste by the scrap collectors. Small scale collectors/Door to door scrap collectors' pick up waste from the households. Large Scale/ professional scrap collectors usually collect from offices through auctions or from repair shops or from small scrap collectors. Their function involves aggregation and segregation of E-wastes for Specialised stakeholders i.e. Dismantlers. Sometimes, large scale collectors forward integrate and get involved in second level handling/dismantling / repair, depending upon factors like quantum of waste, a number of helping hands, a location of operation etc. At the second level come the dismantlers. These categories of stakeholders are exclusive in nature. They collect their material from Scrap collectors, E-waste generators – directly from institutions/offices (not from households), E-waste manufacturers – old products of exchange schemes from dealers, the defective lot of manufacturing. Scrap collected from the sources is checked for reselling/reuse/repair. Scrap which can be directly sold for reuse is sold to second-hand market. Scrap which has some defective parts is repaired and then sold in second-hand market. Scrap which cannot be repaired is further disassembled/dismantled. At the third and final level come to the Recyclers/Processors. The non-repairable components of e-waste extracted by dismantlers are processed/recyclers at this level. Their role involves Extraction of sub-components from components; Shredding – reduction of the size of metals like copper, aluminium and other material like plastic cabinets –to make it suitable for recycling/smelting; Smelting–recycling various materials for making new products. Key activities which take place at this level of e-waste trade are stripping wires for copper, IC‟s extraction from PWB, surface heating of PWB, Gold extraction from pins and comb, the acid bath of PWB, Plastic Shredding, and Smelting of metals like copper, aluminium. The recovery of the components from e-waste depends on their market value, while the residue and leftover such as ashes and plastic residues from charred IC chips, condensers, etc., are disposed of -off in landfills.

Table 2 show Various components of PC, their recovered Modules and Methods employed to recycle

batteries going to the battery recycling section, the display going to the LCD recycling section, the printed circuit boards going to the PCB recycling section and the plastic going to the plastic recycling operation. After processing the recovered materials can be used again in a number of different industries, such as electronics, plating, jewellery, automotive and art foundries.

Table 2. Techniques and tools used for e-waste recovery

Items	toxins Module/Component/Materials	Methods Employed
Computer Monitor, TV	•Cathode ray tube •Circuit Board •Copper, Steel •Glass, Plastic Casting	•Dismantling using screw drivers and pliers •Non-Working CRT broken with hammer
CPU/Hard Disk of Computer	•Aluminium and Steel •Non-Metal Parts •Actuator •Platter •Circuit Board •SNPS	•Manual with the help of screw driver, hammer and pliers
Populated PCB	•Capacitor and Condensor •Gold •Copper •Lead •IC AND Chipped Board	•After preheating the plate, removed with the help of Pliers •Acid treatment/Bath •Heating/Incineration •Crushing of Boards with custom made crushers
Computer Printer	•Motor •Plastics •Cartridge	•Dismantling using screwdrivers
Cables and Wire	•Copper •Aluminium	•Incineration or Stripping
SNPS	•Copper and Brass Alloys •Aluminium •Iron •Magnet	•Melted after manual separation of each part
Capacitors and Condensers	•Aluminium	•Incineration to extract metallic part

Source: Vidyadhar Ari, A Review of Technology of Metal Recovery from Electronic Waste

E waste management by organised sector: a case of Attero

Recycling at Attero

In order to understand the effectiveness of the Formal Sector Recyclers vis a vis Informal Players, we collaborated with **Attreo** which is India's Largest Asset Management Company and is the Only E-waste Recycler and metal Extraction company currently in the country. The company uses NASA recognised fully automated patented technology to process E-waste and extract precious metals.

The Company specialises in Various Product Recycling Namely:

Mobile Phone Recycling

Mobile phone recycling at Attero begins with the unloading of the units at Attero's recycling facility, where they are scanned and updated in the system. Once the units have been unloaded, they are separated for recycling and refurbishing. Units destined for refurbishing are sent to Attero's refurbishing operations section, while the others are sent to the recycling section. Devices sent for refurbishing are further tested, and the ones with heavy wear and tear are sent back to the recycling section. Mobiles destined for recycling are first manually dismantled, where the lithium ion battery, the flat panel/LCD, PCBs and plastic are separated. All these separated components are then recycled in different sections, with the

Display Unit Recycling

CRT Recycling: Cathode Ray Tubes (CRT) contain significant amounts of lead and glass which can be recovered and reused. As a first step, CRT display units are unloaded at Attero's recycling facility and scanned by the barcode reader. The scan details are then uploaded to the system. Next, the CRT cutter system separates the glass panel and glass and fluorescent powder (lead & phosphor) are collected. The process involves glass cutting, heating through metal band & air blow. Next, they are sent to the vacuum chamber, following which the lead and phosphor are collected in bags, while the glass is collected in folders. For processing one CRT unit the machine takes roughly 90 seconds. Circuit boards, chips and other parts are recycled separately. Flat Panel Display Unit Recycling: Recycling of TFT and flat panel display units begins with the segregation of the device, following which the unit is dismantled. During dismantling components like wires, cables and PCBs are segregated and sent for recycling separately. The display unit then goes through the mechanical shredder, where it is processed. Next, the unit is passed through the Magnetic Separator, where ferrous metals are automatically removed. The next stage involves the separation and collection of non-ferrous metals like aluminium, copper etc. in the Eddy Current Separator. The separated components are then processed individually. The plastic components left behind after the eddy current separator stage is segregated and recycled. The ferrous components collected from the magnetic separator are processed to iron, while the copper and aluminium collected from the eddy current separator are smelted and go through electro-refining, where metals are refined to 99.9% purity.

Battery Recycling

Recycling of lead acid batteries at Attero's facility begins with battery breaking. The lead acid batteries are broken down to recover the lead. The top portion of the battery is removed and the acid is drained out for neutralisation. The top portion is transported to a hammer mill, where the plastic is shredded and the lead posts that are fixed on the top are released. The remaining portion of the case along with its contents and the battery plates are passed through a trammel, which extracts the plates. The plastic is then separated by passing through a mill, and extracted via clarifies and stockpiled for furnace feed. The next step involves furnace smelting. There are three main constituents that make up the charge for lead smelting - lead bearing materials, reducing agents and oxygen. The reducing agents used include coke and iron, along with sodium carbonate for facilitating slag formation. All these materials are charged into the furnace during one operation. The rotary action of the furnace facilitates mixing. The slag is then tapped, cooled, broken, disposed and the recovered lead along with its impurities is sent to the refinery for specification. When the bullion lead reaches the refinery, it is first cleaned of molten oxides and sulphides by lowering the temperature of the lead, which decreases the solubility of the impurities. Once the oxides and sulphides have been removed, the metal is treated for alloy specification to remove metals like copper, tin, antimony etc. After the metal has been purified, it is cast into lead ingots and can be reused. Apart from lead-acid batteries, Attero recycles all other types of batteries classified as e-waste by the EPA.

PCB Recycling

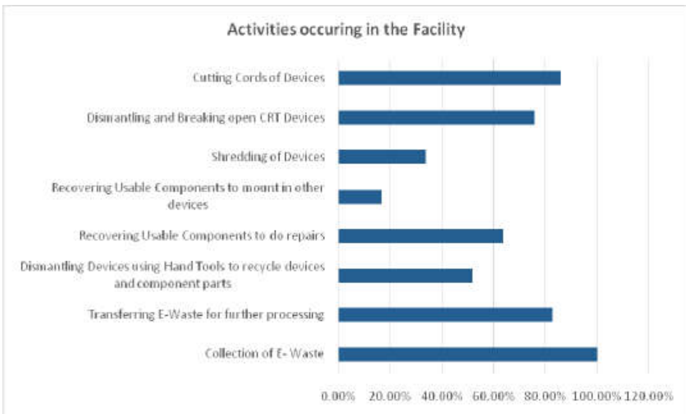
Electronic printed circuit boards are complex assemblies that include numerous materials, and these materials require large quantities of energy and other materials to manufacture. They also include significant quantities of metals such as lead, copper and nickel. While some of these are toxic in nature, all of them are valuable resources. The recycling of electronic printed circuit boards begins with the circuit boards being passed through the Component Removal Machine. This machine automatically separates all the assembled components on the circuit board. It is then pulverised and shredded. The output from these processing stages is the blank board and its components. The blank board primarily contains copper, which is smelted and electro-refined to obtain 99.9% pure copper bars. The separated components are classified as heavy and light chips and include transistors, diodes, connectors and miscellaneous parts such as capacitors and heat sinks among others. Magnetic separation is carried out to separate ferrous metals as well as some of the copper alloys. This is followed by eddy current separation to separate non-ferrous metals. All of these components are smelted to obtain pure metals. Plastic components are separated through density based separation.

I.T. Goods Recycling

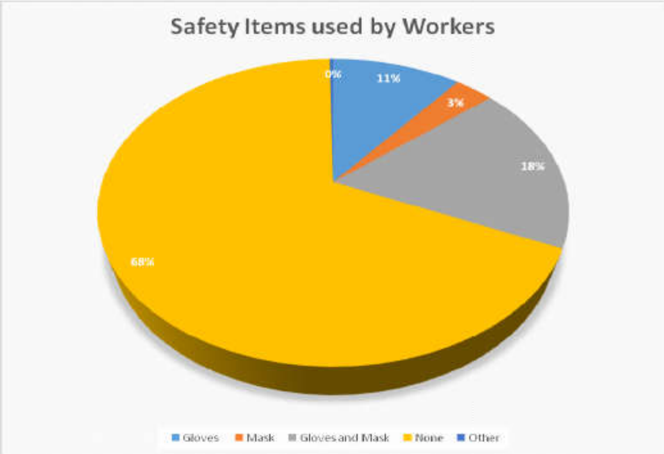
I.T. goods include various electronics ranging from desktops, laptops and servers to printers, scanners and copiers. Once these electronics items are received at Attero's processing plant they are checked to determine whether they should be recycled or refurbished. After segregating the units suitable for refurbishing they are forwarded to Attero's refurbishing section, while the remaining units are sent for recycling. The electronics sent for recycling are first segregated and then dismantled. During dismantling, the wire and cable components in the devices are taken out and sent for recycling. Next, the components like LCD, PCB, RAM, SMPS and plastic parts are segregated and recycled separately. The remaining components are sent for processing to the mechanical shredder, following which they are sent to the magnetic separator. The magnetic separator separates the ferrous components from which iron is extracted. The remainder is then passed through the Eddy Current separator, which separates non-ferrous metals like copper and aluminium. These metals are then smelted and purified. The plastic components are forwarded for plastic recycling at Attero's plant.

Filed Survey

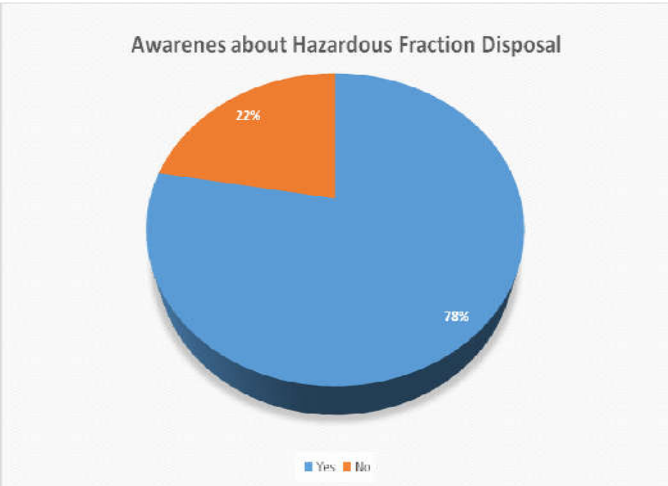
After understanding the E-waste Recycling mechanism and practises in through literature reviews, we shifted our focus on understanding the nitty grits of the E-waste in recycling realities. We went to places like Seelampur, Shastri Park and Mayapuri which are WEEE recycling Hub of Delhi. A large portion of E-waste generated goes to these places from Delhi and Neighbouring states before landing in Landfills. We found out that a large proportion of so called E-waste Recyclers were either E-waste Aggregators or Dismantlers who would do the first stage dismantling and then send the extracts to Biggers E-waste Recyclers. Which on further exploration seemed to use primitive techniques for extracting precious metals using acids, "crude tandoors" and bare hands. Copper and Gold were the most common metals extracted. Copper was extracted using sulphuric acid and gold using cyanide. Most of the Recyclers, since informal players reported no knowledge about the latest provisions in E-Waste Management and Disposal Rules 2016.
Those, not using safety measures for workers, unaware of the harmful consequences of improper disposal on Human Health and Environment and Legislative provisions were also sensitised as a part of the research.

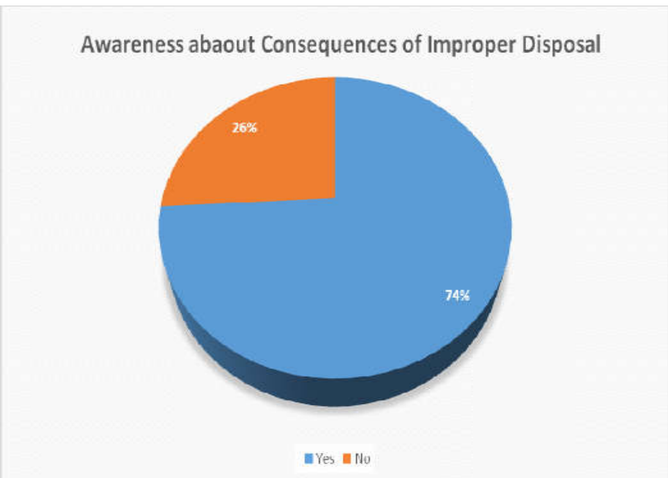


The figure shows the various activities occurring the facility of the respondents. All the respondents favoured on accepting WEEE but only for Bulk Quantity. 83% of the respondents reported the transfer of WEEE for further processing; these were essentially dismantlers and Shredders who draped components for further extraction of Metals. CRT Devices were one of the most common items processed by the respondents. As high as 76% of them reported dealing very closely with dismantling and Breaking CRT Devices. 64% also agreed upon recovering usable components of the devices to do the repairs. And nearly 52% agreed on using bare hands for recovery.



On interacting with some of the labourers working in the facility we realised that most of them (68%) used bare hands for processing. 11% reported only using gloves, 3% reported only using the mask and 18% reported both gloves and mask. Most of them though unconscious of the Health Consequences of improper safety measures reported about suffering from respiratory problems like choking, coughing and irritation.





Almost a quarter of the respondents reported unawareness about proper disposal of Hazardous Fractions of the E-waste and Consequences of Improper Disposal.

Conclusion

During our field visit and earlier reports have also shown that the informal sector of e-waste management is very scattered and unorganised however they are dealing with huge quantity of e-waste coming from various parts of the country and even from other countries. The informal sector has maximum access to the end consumer and the generated E-waste. A need is there to channelize and bring these informal players in the mainstream in order to manage e-waste in a sustainable manner. The informal sector manages more than 90 percent of India's E-waste. Low infrastructure set-up and operational costs enable them to make the profit and dominate the market. They are not liable to many expenses like rents and legitimate wages, do not invest in modern technology, follow unscientific processes for recycling and extraction, and are not bound by any laws and regulations. It is also important to note that E-waste is differently handled at various levels – from collection and segregation to dismantling and recycling. Identify major informal sector clusters and prepare a list of franchisees through recyclers & dealers/retailers.

Suggestions

Define roles and responsibilities of the Informal sector, primarily around collection and segregation.Formal sector, primarily around dismantling and recycling Registering the informal sector with authorities concerned like SPCBs/PCCs, based on their roles. Create awareness and build capacities amongst the informal sector workers on environmentally sound processes, skills up-gradation and process efficiency. As the introduction of certain processes would change the cost structure of the informal sector, this will require government support like providing financial aid, easing access to credit, provision of financial incentives such as subsidies and insurance schemes.

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