Occupational health hazards related to informal recycling of E-waste in India: An overview

Abstract

The innovation in science and technology coupled with the change in lifestyle of an individual has made an incredible change in the electronic industry, showcasing an assorted range of new products every day to the world. India too has been impacted by this digital revolution where consumption of electronics goods grows at a rapid rate producing a large amount of waste electrical and electronic equipment. This substantial generation of electronic waste referred to as e-waste accompanied with the lack of stringent environmental laws and regulations for handling the hazardous e-waste has resulted in the cropping of number of informal sectors. Over 95% of the e-waste is treated and processed in the majority of urban slums of the country, where untrained workers carry out the dangerous procedures without personal protective equipment, which are detrimental not only to their health but also to the environment. This paper focuses on the occupational health hazards due to the informal recycling of e-waste and then proceeds to show the safe disposal methods for handling the large quantities of e-waste generated in this electronic era and thus finds a sustainable solution for the formal processing of e-waste.

Key words: E-waste, informal sectors, occupational health hazards, recycling, waste electrical and electronic equipment

INTRODUCTION

E-waste comprises of waste electrical and electronic products, which cannot continue for their original intended use and are directed for reuse, recycle and recovery or disposal. It is one of the fastest growing waste streams in the world. The waste electrical and electronic equipment’s (WEEE) constitute 8% of the municipal waste stream. It includes a wide range of consumer electronics such as refrigerators, air conditioners, washing machines, microwave ovens, televisions, VCRs, stereos, electric lamps, audio equipment and batteries besides IT and telecommunications equipment which includes discarded computers, cell phones, copiers, fax machines, etc. The industrial revolution, followed by urbanization has resulted in massive generation of electronic waste. The electronic goods are discarded generally due to the following:

- Innovation in science and technology
- Changes in lifestyle of an individual
- Nearing the end phase of their intended usage.

The various reasons for which the electrical and electronic equipment discarded are given as a graphical representation in Figure 1.

The e-waste has been identified as hazardous waste by the Basel Convention and developed a framework for control on transboundary movement of such waste. The massive generation of e-waste on one side accompanied with the lack of stringent legal policies and environmental regulations for managing the hazardous e-waste has resulted in the formation of number of informal sectors. These unorganized sectors continue to use rudimentary processes and practices such as open burning, acid baths and heating of circuit boards, resulting in emissions and release of toxic elements into the environment. These clusters have been operational for many years and have been handling extensively large volumes of e-waste without any personal protective equipment’s and not using proper pollution-control devices or measures to capture the pollutants being released into land and water sources in and around the area. The spent acid with residual metals is discharged into open land and finally absorbed by soil and surface water. Even though the damage caused by informal e-waste recycling activities in India is immense, there is no specific law in places that regulates the e-waste and thus poses a serious...
occupational health risk. This study attempts to reveal the various occupational health hazards related to the informal recycling of e-waste and takes a special interest in creating the public awareness especially for children who are actively involved in e-waste processing.

COMPOSITION OF E-WASTE

The composition of e-waste differs from product to product. Broadly it consist of diverse of materials which includes ferrous and nonferrous, metals, plastics, glass, wood and plywood, printed circuit board, rubber, ceramics and other items. Iron and steel constitutes 50% of the e-waste, plastics 21%, nonferrous metals 13%, and the rest other constituents. Nonferrous metals consist of metals such as copper, aluminum and precious metals such as gold, silver, platinum, palladium, etc. The presence of elements such as lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants beyond the threshold limit in e-waste classifies them as hazardous waste.

INDIA SCENARIO OF E-WASTE

It is reported that in India about 800,000 MT of e-waste is generated annually. It has been estimated that e-waste generation in India is expected to exceed 1,200,000 tons by 2015. The Exponential growth of e-waste in India is shown in Figure 2.

There are only two sectors which carry out e-waste recycling process formally in India. These facilities are M/s. Trishiraya recycling facility, Chennai and M/s. E-Parisara, Bengaluru. There is no large-scale organized e-waste recycling facility in India, and thus the recycling exists in un-organized sector. The maximum e-waste treatment is being carried out in an unregulated environment, where there is no control on emission of toxic material. Over 95% of the e-waste is treated and processed in the majority of urban slums of the country, where untrained workers carry out the dangerous procedures without personal protective equipment, which are detrimental not only to their health but also to the environment. Illegal imports of used EE products or WEEE from overseas has been added to the volume of e-waste being treated in India.

In the growing economics, e-waste which is flowing from the wastes imports not only offers a business opportunity, but also satisfies the demand for cheap second-hand electrical and electronic equipment. An entire new economic sector is evolving around trading, repairing and recovering materials from redundant electronic devices. Though it is a source of livelihood for the urban and rural poor, it often causes severe risks to humans and the local environment.

It is imperative that developing countries and India in particular wake up to the monopoly of the developed countries and set up appropriate management measures to prevent the occupational health hazards and mishaps due to mismanagement of e-wastes.

GLOBAL SCENARIO OF E-WASTE

A UN report estimates that the worldwide generation of e-waste is around 30–50 million ton/annum. Nearly 50–80% of e-wastes collected are exported for recycling by us. Since the export is legal in us, the export is due to cheaper labor and laxed standards in developing countries. E-waste recycling and disposal in China, India and Pakistan are highly polluting due to the release of toxic chemicals. The lack of responsibility on the part of federal government and electronics industry, consumers, recyclers and local governments toward viable and sustainable options for disposal of e-wastes. This has paved the way for the emergence of unorganized sectors for the informal recycling of e-waste.

HEALTH HAZARDS DUE TO INFORMAL RECYCLING OF E-WASTE

Since the e-waste is blend of plastics and chemicals, improper handling of e-waste is harmful to the environment as well as mankind. For the recycling of e-waste, India heavily depends on the unorganized sector as only a handful of an organized e-waste recycling facilities are available. Over 95% of the...
e-waste is treated and processed in the majority of urban slums of the country, where untrained workers carry out the dangerous procedures without personal protective equipment, which are detrimental not only to their health but also to the environment.

In developing countries, the e-waste is dismantled manually and releasing the nondegradable plastics and persistent chemical to the environment thereby contaminating the quality of air, water and soil.

Examples of such crude techniques worth mentioning are:
1. Physical dismantling using tools such as hammers, chisels, screw drivers and bare hands to separate different materials
2. Removing components from printed circuit boards by heating over coal-fired grills
3. Stripping of metals in open-pit acid baths to recover gold and other metals
4. Chipping and melting plastics without proper ventilation
5. Burning cables to recover copper, and burning unwanted materials in the open air
6. Disposing unsalvageable materials in fields and riverbanks.

These illegal methods to recover the precious metals expose the workers to harmful chemicals such as heavy metals, inorganic acid, polycyclic aromatic hydrocarbons, etc., which are potential pollutants and cause serious occupational health hazards that are listed in Table 1. Figure 3 represents informal processing of e-waste.

**Health risks of dioxins and furans exposure**
Plastics made from polyvinyl chloride (26% of the plastic found in e-waste by volume), once processed through uncontrolled open burning, can generate polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) which are persistent organic pollutants. This dioxins and furans can enter the body via inhalation, ingestion and skin absorption. Exposure to PCDD/PCDFs at high levels can lead to chloracne (severe skin disease), darkening of the skin, and altered liver function. Long-term exposure can lead to damage of the immune, nervous and endocrine systems and impaired reproductive function.

**Health risks of lead exposure**
Lead is one of the most commonly used heavy metals - it is used in both computer and television screens, and in the solder used to anchor various circuit board components. Short-term exposure to high levels of lead can cause vomiting, diarrhea, convulsions, coma or even death. The main areas of the body affected by lead are the brain, kidney, and nervous system. Once exposed to lead, it can remain in your body for years in bone or circulating through the bloodstream. Children are particularly susceptible to lead at even lower levels of exposure, due to increased absorption. The harms noted in children include impacts on intellectual development, behavior, size, and hearing. During pregnancy, lead can also cross the placenta and affect the unborn child. Studies have shown that the female worker in informal sectors, who are exposed to high levels of lead have more miscarriages and stillbirths.

**Health risks of beryllium exposure**
Beryllium is sometimes used in circuit boards as an electrical connector and/or to insulate microprocessors. When

| Potential pollutants | Occupational health hazards |
|----------------------|-----------------------------|
| Dioxins and furans from poly vinyl chloride | Open burning of plastics produces dioxin and furans. It causes reproductive and developmental problems; immune system damage; interfere with regulatory hormones |
| Lead (PB) | Damage to central and peripheral nervous systems, blood systems and kidney damage |
| Beryllium (Be) | Affects brain development of children |
| Cadmium (CD) | Toxic irreversible effects on human health; causes neural damage |
| Mercury (Hg) | Teratogenic; inhalation of fumes and dust. Causes chronic beryllium disease or berylliosis; skin diseases such as warts |
| Hexavalent chromium (Cr) VI | Chronic damage to the brain; respiratory and skin disorders due to bioaccumulation in fish |
| Barium (Ba) | Asthmatic bronchitis; DNA damage |
| Brominated flame retardants (BFR) | Short term exposure causes: muscle weakness; damage to heart, liver and spleen; disrupts endocrine system functions |

Figure 3: Schematic diagram of informal processing of e-waste
improperly handled during disposal or recycling, beryllium dust can be released, which is known to cause severe lung disease and lung cancer.[6,7]

**Health risks of cadmium exposure**
Cadmium can be found in plastics, cadmium plated steel, solders, and TV picture tubes.[8-10] Cadmium toxicity can lead to kidney, bone, and pulmonary damage. There are three modes of exposure: Dermal, pulmonary (lungs), and gastrointestinal (mouth).

**Health risks of mercury exposure**
An estimated 22% of the mercury used worldwide each year goes into electrical and electronic equipment including batteries, flat-panel display screens, and switches.[11] Even very small levels of mercury exposure are known to cause damage to the brain, spinal cord, kidneys, liver and even for a developing fetus.

**Health risks of flame retardants exposure**
Polybrominated diphenyl ethers (PBDEs) are synthetic chemical compounds that are used as flame retardants (chemicals that are added to polymers to prevent fires) in electrical and electronic equipment which are present in high-tech electronics such as TVs, computers or cell phones. Exposure to PBDEs has proven increased cancer incidence and altered thyroid function.

The above occupational health hazards related to informal recycling of e-waste is just a mockup. The actual impacts are just beyond the mind’s eye. Thus, improper handling of e-waste may pose a serious hazard either by accidental release or spillage of toxic chemicals and release of obnoxious gases. Problem of increasing proportions are faced especially when crude methods are adopted for recovery of useful components from e-waste. In spite of continuous insist on the various health hazards related to informal recycling the manual disassembly and illegal burning of e-waste continues to occur. These primitive practices not only create an enormous amount of health threats and environmental degradation, but also disseminate genotoxic agents that threaten the health of current and future generations living in the local environment. Thus, there is a need to reassure safe disposal methods.[12,13]

**SAFE DISPOSAL METHODS**

The various disposal methods available to manage the e-waste heaps are:
- Landfilling
- Incineration
- Recycling and reuse.

**Landfilling**
It is one of the most widely used methods for disposal of e-waste. In landfilling, trenches are made on the flat surfaces. Soil is excavated from the trenches and waste material is buried in it, which is covered by a thick layer of soil. Modern techniques like secure landfill are provided with some facilities such as impervious liner made up of plastic or clay, leachate collection basin that collects and transfer the leachate to wastewater treatment plant. The degradation processes in landfills are very complicated and run over a wide time span.[14]

**Hazard of landfilling**
- Leaking landfills
- Leachate contaminating soil and groundwater
- Chemical reactions
- Vaporization
- Uncontrolled fires.

Thus landfilling does not appear to be an environmentally sound treatment method for substances, which are volatile and not biologically degradable (Cd, Hg, CFC), persistent (polychlorinated biphenyls [PCB]) with unknown behavior in a landfill site (brominated flame retardants). As a consequence of the complex material mixture in e-waste, it is not possible to exclude environmental (long-term) risks even in secured landfilling.

**Incineration**
It is a controlled and complete combustion process, in which the waste material is burned in specially designed incinerators at a high temperature (900–1000°C). Advantage of incineration of e-waste is the reduction of waste volume and the utilization of the energy content of combustible materials. Disadvantage of incineration is the emission to air from substances escaping flue gas and the large amount of residues from gas cleaning and combustion process. E-waste incineration plants contribute significantly to the annual emissions of cadmium and mercury. In addition, heavy metals are not emitted into the atmosphere and are transferred into slag and exhaust gas residues which can reenter the environment on disposal. Therefore, e-waste incineration will increase these emissions if no reduction measures like removal of heavy metals are taken.

**Incineration hazards**
- Dioxin formation
- Heavy metal contamination
- Contaminated slag, fly ash and flue gases
- Health and safety hazards.

**Recycling of e-waste**
Recycling options for managing plastics from end-of-life electronics are of three types.
- Chemical recycling
- Mechanical recycling
- Thermal recycling.
Any recycling process involves dismantling, that is, removal of different parts of e-waste containing dangerous substances such as PCB, Hg, separation of plastic, removal of cathode ray tube (CRT), segregation of ferrous and nonferrous metals and printed circuit boards. Recyclers use strong acids to remove precious metals such as copper, lead, gold. The value of recycling from the element could be much higher if appropriate technologies are used. The recyclers are working in poorly-ventilated enclosed areas without mask and technical expertise results in exposure to dangerous and slow poisoning chemicals.

Monitors and CRT, keyboards, laptops, modems, telephone boards, hard drives, floppy drives, Compact disks, and mobiles, fax machines, printers, CPUs, memory chips, connecting wires and cables can be recycled.\[^{[3]}\]

**Hazardous effects due to recycling**

- Potential threat to human health and the environment
- Lead causes damage to the central and peripheral nerve system, blood system and kidneys in humans
- Mercury impacts brain functioning and development.

Therefore, recycling is the best possible option for the management of e-waste.

**Reuse**

It constitutes direct second-hand use or use after slight modifications to the original functioning equipment. It is commonly used for electronic equipment such as computers, cell phones, etc. Inkjet cartridge is also used after refilling. This method also reduces the volume of e-waste generation.

**CONCLUSION**

It is the responsibility of the government to turn away more e-waste flowing from informal to formal sectors and to achieve positive utilization of informal collection networks for collecting e-waste from households thereby developing efficient incentive system for poor collectors and recyclers. Technical improvements of informal recycling processes coupled with proper training in handling WEEE has to be offered to the local industry and community so to obtain better environmental performance without sacrificing the economic and social benefits. This will provide a remedy for the occupational health hazards related to the informal recycling of e-waste.

Developing a better understanding of informal recycling and implementing more supportive policies for the informal sector that could result in hundreds of job opportunities for low-skilled workers in a complete safe environment is a sustainable solution for the current issue. Educating the children who are actively involved in e-waste processing in their own line creates e-experts for future generation and can handle this hazardous waste and turn in to the valuable resource.

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