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E-wastes and their impact on environment and public health

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Abstract
Solid waste management, which is already a mammoth task in India, is becoming more complicated by the invasion of e-waste, particularly computer waste. The hazardous content of these e-waste materials pose a threat to human health and environment. This article highlights the hazards of e-wastes, the need for its appropriate management and options that can be implemented. Improper disposal of these e-wastes and other substances reach the soil and groundwater. Most of the e-waste materials can be reused, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem.

Keywords: E- waste, waste management, environment, hazardous Substances

Introduction
E-waste is a popular, informal name for electronic products nearing the end of their useful life. Electronic industry is the world's largest, innovative and fastest growing industry during the last century which radically changed the people's lifestyle. Although this development has helped the human race, mismanagement has led to new problems of contamination and pollution. Almost every used electronic items are considered as e-waste such as discarded cell phones, cameras, CD players, TVs, radios, drillers, fax machines, photocopiers, printers, toners, ink cartridges, batteries, re-chargeable batteries, digital calculators and clocks, CRT monitors, electric solders, computer mother boards, key board, industrial and house hold electronic machinery such as oven, fridge, sewing and washing machines, fan, air-conditioner, grinder, iron, heater, military and laboratory electronic equipments, etc.
Electronic equipments contain many hazardous metals such as lead, cadmium, and beryllium and brominated flame-retardants like tetrabromobisphenol-A (TBBA), polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE). Every year tons of electronic items are shipped over oceans, however, after their usage they become a complex waste matter which consists of iron, copper, aluminium, gold and other heavy metals in e-waste is over 60%, while non degradable plastics accounts for about 30% and the hazardous pollutants comprise only about 2.70% (Widmer *et al*., 2005) [24]. An estimated 50 million tone of e-waste is produced each year in the world.
Mostly e-wastes are dumped, burnt or exported to recyclers. During dismantling process like shredding, tearing and burning, the smoke and dust particles are eliminated. These smoke and dust particle consists of carcinogens and other hazardous chemicals which causes severe inflammations and lesions including many respiratory and skin diseases (Sivakumaran and Sivaramanan, 2013) [15]. Circuits are burnt to hunt the valuable metals such as gold, platinum, cadmium but the wire coat of these consists of PCV and PCB which may produce erotic smoke and carbon particles from the toners are carcinogens, they may lead to lung and skin cancer (Kevin *et al*., 2008) [8].
E-waste from developed countries find an easy way into developing countries in the name of free trade is further complicating the problems associated with waste management (Joseph, 2007) [7]. The Basel Action Network (BAN) stated in a report that 50-80% of e-waste collected by the USA is exported to India, China, Pakistan, Taiwan, and a number of African countries (Monika and Kishore, 2020) [11]. Poverty and availability of cheap labor in these

countries are the main reason to consume e-wastes from Europe and USA (Sivakumaran and Sivaramanan, 2013) [15]. Disposal of e-waste is an emerging global environmental and public health issue, as this waste has become the most rapidly growing segment of the formal municipal waste stream in the world (Dahl, 2002) [3]. The rapid growth and faster change in modules of computers, cell phones and consumer electronics becomes major issue that enhances the amount of e-waste generation.

E-waste Scenario in India

E-waste of developed countries, such as the US, disposes their wastes to India and other Asian countries. A recent investigation revealed that much of the electronics turned over for recycling in the United States ends up in Asia, where they are either disposed of or recycled with worker health and safety. Major reasons for exports are cheap labour and lack of environmental and occupational standards in Asia and in this way the toxic effluent of the developed nations' would flood towards the world's poorest nations. The magnitude of these problems is yet to be documented. However, groups like Toxic Links India are already working on collating data that could be a step towards controlling this hazardous trade. 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 hazards and mishaps due to mismanagement of e-wastes.

In India, solid waste management, with the emergence of e-waste, has become a mammoth task. Due to development in software sector, the Indian information technology industry has a major global presence today. More recently, policy changes have led to a tremendous influx of leading multinational companies into India to set up manufacturing facilities, R & D centers and software development facilities. This growth has significant economic and social impacts.

As there is no separate collection of e-waste in India, there is no clear data on the quantity generated and disposed of each year and the resulting extent of environmental risk. According to a report of Confederation of Indian Industries, the total waste generated by obsolete or broken down electronic and electrical equipment in India has been estimated to be 1,46,000 tons for the year 2005 (CII, 2006) [2]. However, according to the Greenpeace Report, in 2007, India generated 380,000 tones of e-waste. In India, about 1.38 million personal computers obsolete every year, increasing the rate of e-waste generation, which is approximately 10%, annually going to affect environmental health indicators (Monika and Kishore, 2020) [11].

Despite a wide range of environmental legislation in India there are no specific laws or guidelines for electronic waste or computer waste (Devi *et al*., 2004) [4]. As per the Hazardous Waste Rules (1989), e-waste is not treated as hazardous unless proved to have higher concentration of certain substances. Though PCBs and CRTs would always exceed these parameters, there are several grey areas that need to be addressed. As the collection and re-cycling of electronic wastes is being done by the informal sector in the country at present, the Government has taken the following action/steps to enhance awareness about environmentally sound management of electronic waste (CII, 2006) [2].

Hazardous substances in E-wastes

Disposal of e-wastes is a particular problem faced in many regions across the globe. E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates. These heavy metals enter in biological system via food, water, air and soil. Long-term exposure to these substances damages the nervous, circulatory, reproductive and endocrine systems along with kidney and bones also. Some of them are carcinogenic and neurotoxic. The residents of that area where e-waste recycling activities continue had a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers (Qui *et al.*, 2004).

Disposal of e-wastes is a critical problem faced and poses a threat to both health and vital components of the ecosystem. Disturbances in ecosystem affect the biodiversity and human survival (Verma, 2015, 2017, 2018) [19, 20, 21]. There are a number of channels through which e-waste goes to the environment. It also influences the overall climate. The climate change has a huge impact on biodiversity (Prakash and Srivastava, 2019). The biodiversity conservation is required for sustainable development (Verma, 2019) [22] and survival of plants and animals because biodiversity is the foundation of human life (Verma and Prakash, 2020) [23]. E-waste that is land filled produces contaminated leachates, which eventually pollute the groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil, leading to contamination of water resources.

Incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. Improper recycling and recovery methods can have major impacts on the environment. Crude forms of dismantling can often lead to toxic emissions, which pollute the air and thereby also expose the workers to the harmful materials. The most dangerous form of recycling and recovery from e-waste is the open air burning of circuit boards in order to recover copper and other metals. Extraction of metals through acid bath method or through mercury amalgamation also contributes to environmental degradation (Jahan and Begum, 2013) [6]. Of many toxic materials like lead, mercury and polychlorinated biphenyls (PCBs) were responsible for causing a variety of health hazards due to environmental contaminations. 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) [14]. The waste rechargeable batteries contain toxic substances that can contaminate the environment when burned in incinerators or disposed of in landfills. The cadmium from one mobile phone battery is enough to pollute 600m^3 of water (Trick, 2002) [17].

Phthalates such as DEHP in its monomer form effects the development of testis, Butybenzyl phthalate (BBP) and dibutyl phthalate (DBP) also hazardous to reproduction exposure ro phthalates in pregnancy reduces ano-genetal index in male child (distance between anus and genitals) (Swan *et al*., 2005) [16]. DINP and DIDP (diisodecyl phthalate) effects liver and kidneys.

Chlorobenzene causes acute and chronic effects on central nervous system (CNS: brain and spinal cord), liver, thyroid, kidney and immune system of mammals (Van Birgelen, 1998) [18]. When brominated flame retardant plastic or cadmium containing plastics are land filled, both polybrominated diphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater that clearly damaging to human health and the environment. The PBDE is an environmentally persistence compound and bioaccumulated. It causes abnormal brain development during the initial development of fetus; it also associated with impacts on learning, memory, behavior, immune and endocrine system (Legler and Brouwer, 2003) [10]. A Triphenyl phosphate (TPP) is a potent inhibitor of an enzyme, monocyte carboxyl esterase in human blood cells (Amini and Crescenzi, 2003) [1].

The important hazardous substances their occurrences and impact on environment and human health is given in table.

Table 1: Hazardous substances, their sources and impacts

Hazardous substance	Source of e-waste	Effects on environment and health
PCB (polychlorinated biphenyls)	Condensers, Transformers	Persistence and bioaccumulation. Effects on the immune, reproductive, nervous system, endocrine systems and other health effects. Causes tumors and cancer.
CFC (Chlorofluorocarbon)	Cooling unit, insulation foam	Combustion of halogenated substances may cause toxic emission
PVC (polyvinyl chloride)	Cable insulation and computer housing	High temperature processing of cables may release chlorine, which is converted to dioxins and furans. It causes reproductive and developmental problems; immune system damage; interferes with regulatory hormones.
Lead (PB)	Cathode ray tube (CRT) screens, batteries, solder in printed wiring/ circuit boards, glass panels and gaskets in computer monitors.	Damage the central and peripheral nervous systems, circulatory systems and kidney damage. Affects brain development in children. It is a carcinogen and causing lung cancer.
Cadmium (Cd)	Chips resistors and semiconductors, rechargeable NiCd-batteries, fluorescent layer (CRT screen), printer inks and toners.	Acute poisonous and causes irreversible effects on human health. Accumulates in kidney and liver. Causes neural damage. Teratogenic.
Mercury (Hg)	Relays and switches, printed circuit boards, alkaline batteries	Acutely poisonous and damage to the brain. Respiratory and skin disorders due to bioaccumulation in fishes.
Chromium VI	Data tapes, floppy-disks, Corrosion protection of untreated and galvanized steel plates	Acutely poisonous and damage the DNA. It causes Asthmatic bronchitis / allergic reactions.
Barium (Ba)	Front panel / Getters in CRT	May develop explosive gases (Hydrogen) if wetted. Short term exposure causes muscles weakness; damage to heart, liver and spleen.
Beryllium (Be)	Motherboard, power supply boxes which contain silicon controlled rectifiers, beam line components.	Harmful if inhaled the fumes and dust. Causes lung cancer, beryllium disease or beryllicosis and skin diseases such as warts.
Arsenic (As)	Small quantities in the form of gallium arsenide within light emitting diodes.	Acutely poisonous and injurious to health on a long term exposure.
Gallium arsenide	Light-emitting diode (LED)	Injurious to health
Lithium (Li)	Li-batteries	May develop explosive gases (hydrogen) if wetted.
Nickel (Ni)	Rechargeable NiCd-batteries or NiMH batteries, electron gun in CRT	May cause allergic reactions.
Antimony (An)	Flame-retardant materials, batteries and cable sheathing.	It is a toxic compound and causing dermatitis, affecting skin cells and respiratory tract and affects the immune mechanism.
Zinc sulphide	It is used on the interior of a CRT screen, mixed with rare earth metals.	Toxic when inhaled
Toner dust	Toner cartridges for laser printers / copiers.	Health risk when dust is inhaled risk of explosion

(**Source:** Kim *et al*., 1999; DHHS, 2005; Jahan and Begum, 2013; Monika and Kishore, 2020) [9, 5, 6, 11]

E- waste Management in India

Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes. Establishment of e-waste collection, exchange and recycling centers should be encouraged in partnership with private entrepreneurs and manufacturers.

The current practices of e-waste management in India suffer from a number of drawbacks like the difficulty in inventorization, unhealthy conditions of informal recycling, poor awareness and reluctance on part of the corporate to address the critical issues. Despite the number of legislation related to environmental protection in India there are lack of adequate legislation or specific laws or guidelines for electronic waste or computer waste. As per the Hazardous Waste Rules (1989), e-waste is not treated as hazardous unless proved to have higher concentration of certain substances. Though PCBs and CRTs would always higher the normal level. In India the collection and re-cycling of electronic wastes is being done by the informal sector. Only 10% of total e-waste recycled due to absence of an efficient technique, facilities and scheme in India. The public awareness and cooperation of manufacturers are essential for the advancement of e-waste management system. It is the responsibility of governments to allocate sufficient

grants and protecting the internationally agreed environmental legislations within their borders.

The Government has taken the following steps to enhance awareness about environmentally sound management of electronic waste (CII, 2006) [2]:

- Several Workshops on Electronic Waste Management was organized by the Central Pollution Control Board (CPCB).
- Action has been initiated by CPCB for rapid assessment of the E-Waste generated in major Cities of the country.
- A comprehensive technical guide on 'Environmental Management for Information Technology Industry in India' has been published and circulated widely by the Department of Information Technology (DIT), Ministry of Communication and Information Technology.
- Licensing of certification like stewardship may ensure the security to prevent illegal smugglers and handlers of e-waste.

In spite of above steps taken by Government the following steps also should be taken for the proper management of e-waste:

- Governments should set up regulatory agencies in each district, which are vested with the responsibility of coordinating and consolidating the regulatory functions of the various government authorities regarding hazardous substances.
- Governments should be responsible for providing an adequate legislation and administrative procedures for hazardous waste management. Existing laws concerning e-waste disposal be reviewed and revamped. A comprehensive law that provides e-waste regulation and management and proper disposal of hazardous wastes is required.
- Governments must encourage research towards the development and standard of hazardous waste management, environmental monitoring and the regulation of hazardous waste-disposal.
- Governments should enforce strict regulations against dumping e-waste in the country by outsiders.
- Governments should enforce strict regulations and heavy fines levied on industries, which do not practice waste prevention and recovery in the production facilities.
- Governments should encourage and support NGOs and other organizations to involve actively in solving the nation's e-waste problems,
- Uncontrolled dumping is an unsatisfactory method for disposal of hazardous waste and should be phased out.
- Governments should explore opportunities to partner with manufacturers and retailers to provide recycling services.

Conclusion

Waste electrical and electronic equipment (WEEE) is becoming major threat to the whole world. Its toxic emissions mixed with virgin soil and air and causing harmful effects to the entire biota either directly or indirectly. Direct impacts include release of acids, toxic compounds including heavy metals, carcinogenic chemicals and indirect effects such as bio magnification of heavy metals. As a consequence, toxic materials enter the waste stream with no special precautions to avoid the known adverse effects on the environment and human health and the resources are wasted when economically valuable materials are dumped or unhealthy conditions are developed during the informal recycling.

Criteria are to be developed for recovery and disposal of e-wastes. Policy level interventions should include development of e-waste regulation, control of import and export of e-wastes and facilitation in development of infrastructure. An effective take-back program providing incentives for producers to design products that are less wasteful, contain fewer toxic components, and are easier to disassemble, reuse, and recycle may help in reducing the wastes. It should set targets for collection and reuse/recycling, impose reporting requirements and include enforcement mechanisms and deposit/refund schemes to encourage consumers to return electronic devices for collection and reuse/recycling. End-of life management should be made a priority in the design of new electronic products.

Basel Action Network is now working at their best to stop or control trans boundary e-waste movements, they also involved in conducting public awareness programs to enlighten the world community and opening research areas to find better methods or alternatives. As e-wastes are the known major source of heavy metals, hazardous chemicals and carcinogens, certainly diseases related to skin, respiratory, intestinal, immune, and endocrine and nervous systems including cancers can be prevented by proper management and disposal of e-waste.

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