One of the most serious problems that the world is facing today is environmental pollution due to e-waste. Though e-waste constitutes a small fraction (more than 5 percent) of all municipal solid waste globally, it is increasing worldwide over the past two decades with the rise of use of electrical and electronic products in different countries. The hazardous nature of e-waste and its disposal is one of the rapidly growing environmental problems of the world and public health issue. In this article the hazardous effect of e-waste, their disposal and some of the related issues have been discussed. Indian scenario has also been discussed.

Introduction

One of the most serious problems that the world is facing today is environmental pollution. It affects biodiversity, ecosystems, and human health worldwide. Fortunately awareness about environmental pollution is increasing day by day. But this is limited mainly to air, water, plastic and sound pollution. However, there is very limited concern over pollution due to electronic waste (e-waste). Though e-waste constitutes a small fraction (more than 5 percent) of all municipal solid waste globally, which is equivalent to 20-50 million tons a year worldwide, and is increasing worldwide over the past two decades with the rise of use of electrical and electronic products in different countries, it contains various hazardous materials that poses danger to environment and human health. At the end of the 1970s the accelerating pace of domestic consumer electronics drastically shortened the lifespan of some devices such as TVs, VCRs and audio. New innovations made older equipments obsolete. Increased complexity and sophistication of manufacture made local repair more difficult. Users discarded old devices either due to difficulty in repairing or simply out of fashion. The hazardous nature of e-waste and its disposal is one of the rapidly growing global environmental problems of the world and public health issue, as this waste has become the most rapidly growing segment of the formal municipal waste stream in the world. The ever-increasing amount of e-waste associated with the lack of awareness and appropriate skill is deepening the problem. In developing countries like India, e-waste units engage men, women and children for sorting and recovery of the materials without adopting protection and safeguards measures. This not only pollutes the environment, but also poses a serious health threat to people engaged in this occupation as well as to the people living in the proximity of e-waste management sites. There is stringent legislation designed to enforce and encourage the sustainable disposal of appliances, the most notable being the Waste Electrical and Electronic Equipment Directive of the European Union and the United States National Computer Recycling Act.2005. In India the E-Waste Management Rules, 2016 have recently been amended by the government in March, 2018 in order to streamline the recycling sectors. In this article we will discuss the hazardous effect of e-waste, their disposal and some of the related issues.

What is e-waste

In our daily life we use different electrical and electronic devices such as computer, printer, laptop, i-pad,
mobile phone, fridge, radio, television, camera, remote, charger, refrigerator, washing machine, CD, VCR, etc. When those become unsuitable for repair or broken or are discarded for any other reason (such as purchasing a new device) the discarded devices are termed as electronic waste or e-waste. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste.

**Effect on Environment and Human Health**

Although electronic and electrical equipments are indispensable in our everyday life, their hazardous effects on the environment cannot be overlooked or underestimated. Electronic scrap components contain potentially harmful materials such as lead and cadmium in circuit boards, lead oxide and cadmium in cathode ray tubes, mercury in flat-screen monitors, brominated flame retardants on printed circuit boards, and beryllium, dioxin, polychlorinated biphenyl, isotopes of radioactive substances, etc. At the same time e-wastes contains some precious metals such as silver, gold, and platinum, tantalum, palladium and have significant commercial value. Many of these materials can be recovered by recycling for use in future production and thereby can reduce the costs of constructing new systems. But the process of recycling (e.g., incineration and acid treatments) required to reclaim these precious substances may release, generate, or synthesize toxic byproducts. There are a number of specific ways in which e-waste recycling can be damaging to the environment.

Of many toxic heavy metals, lead is most widely used in electronic devices (such as CRT monitor glass, lead-acid batteries, etc.) and causes a variety of health hazards due to environmental contamination. Lead enters biological systems via food, water, air, and soil. Children are particularly vulnerable to lead poisoning. A typical computer monitor may contain more than 6% lead by weight, much of which is in the lead glass of the cathode ray tube (CRT). A typical 38 cm computer monitor may contain 1 kg of lead but other monitors have been estimated to have up to 4 kg of lead. Circuit boards contain considerable quantities of lead-tin solders that are more likely to leach into groundwater or create air pollution due to incineration. In US landfills, about 40% of the lead content levels are from e-waste.

Most electronic waste is sent to landfills or incinerated. Landfill causes groundwater pollution due to transfer of toxic substances such as lead, mercury, or cadmium into the soil. Incinerations cause air pollution due to combustion of e-waste that emits toxic gases into the environment. Recycling and disposal of e-waste may involve significant risk to health of workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaking of materials such as heavy metals from landfills and incinerator ashes. Burning to recover metal from wires and cables leads to emissions of brominated and chlorinated dioxins, causing air pollution. Again, burning away wire insulation and acid baths to resell circuit boards pose environmental and health hazards, as toxins are released into the air and acid bath residue can enter the water supply.

The concentration of dioxins in the surrounding areas increases when printed wiring boards are burnt openly and causes increased risk of cancer if inhaled by the workers and local people. During manual extraction and collection of tiny quantities of precious metals, toxic metals and poison can also enter the bloodstream and the workers are continuously exposed to poisonous chemicals and fumes of highly concentrated acids. Recovering copper by burning insulated wires causes neurological disorders. Exposure to cadmium in semiconductors and chip resistors can damage the kidneys and liver and cause bone loss. Processing of e-waste such as dismantling components, wet chemical processing, and incineration, without using safety equipment such as gloves, face masks, and ventilation fans results in direct exposure and inhalation of harmful chemicals affects the health of the workers. During the recycling process in the informal sector, toxic chemicals having no economic value are simply dumped. The toxic industrial effluent is poured into underground aquifers and seriously affects the local groundwater quality, thereby making the water unfit for human consumption or even for agricultural purposes. Even due to dismantling the components of e-wastedust particles, loaded with heavy metals and flame retardants, enter the atmosphere. These particles either redeposit near the emission source or may be transported over long distances. The dust particles can also enter the soil or water systems and can leach into the ground which causes both soil and water pollution.

Due to breaking and removal of yoke of Cathode ray tubes (used in TVs, computer monitors, ATM, video cameras, etc.) lead, barium and other heavy metals leach into the ground water and release of toxic phosphor.

Due to chemical stripping using nitric and hydrochloric acid and burning of chips and other gold-plated components heavy metals, brominated flame retardants are discharged directly into rivers acidifying fish and flora. Further, tin and lead contaminate surface and groundwater. De-soldering and removal of chips and other...
electronic components from printed circuit boards; open burning and acid baths to remove metals after chips are removed pollutes air and glass dust, tin, lead, brominated dioxin, beryllium cadmium, and mercury discharge into rivers. Some e-waste sources, their constituents, and their impacts on health are given in Table 1.

**Computer Recycling**

The disassembly and separation of components and raw materials from e-waste is called computer recycling, electronic recycling or e-waste recycling. Although consumer electronics such as the radio have been popular since the 1920s, recycling was almost unheard of until the early 1990s. In 1991, the first electronic waste recycling system was implemented in Switzerland, beginning with collection of old refrigerators but gradually expanding to cover all devices. Since then more and more devices are recycled worldwide due to increased awareness and investment. Obsolete computers and old electronics are valuable sources for secondary raw materials if recycled; otherwise, these devices are a source of toxins and carcinogens. Computer recycling occurs primarily in order to recover valuable rare earth metals and precious metals, such as copper, gold, silver, platinum, etc., in computers and other electronic devices. These are resold or used in new devices after purification. However one can also make use of the useful components of the dead computers that may be damaged beyond repair so as to use the parts on new computers which reduces the cost of new computers. However, care must be taken that the heavy metals do not infiltrate in landfills and the materials such as ashes, emitted gases and minute particles released due to incineration and acid treatment are removed before those released in air.

Today, we have the technology to make the most out of our e-waste by extracting useful resources from it

<table>
<thead>
<tr>
<th>e-waste sources</th>
<th>Hazardous constituents</th>
<th>Impact on health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solders, printed circuit boards, glass panels</td>
<td>Lead</td>
<td>Damage to central and peripheral nervous systems, blood systems, reproductive system and kidney;</td>
</tr>
<tr>
<td>Relays and switches, and printed circuit boards</td>
<td>Cadmium</td>
<td>Adverse effects on brain development of children; causes damage to the circulatory system and kidney;</td>
</tr>
<tr>
<td>Cabling and computer housing</td>
<td>Mercury</td>
<td>The accumulation of lead in the environment results in both acute and chronic effects on human health.</td>
</tr>
<tr>
<td>Electronic equipment and circuit boards</td>
<td>Plastics and PVC</td>
<td>Risk of irreversible impacts on human health, particularly the kidney and liver; Causes neural damage</td>
</tr>
<tr>
<td>Front panels of CRTs</td>
<td>Brominated flame-retardants</td>
<td>Chronic brain damage; Respiratory and skin disorders due to bioaccumulation in fishes</td>
</tr>
<tr>
<td>Copper wires, Printed circuit board tracks.</td>
<td>Barium, phosphorus, and heavy metals</td>
<td>Burning produces dioxin that causes reproductive and developmental problems</td>
</tr>
<tr>
<td>Nickel–cadmium rechargeable batteries</td>
<td>Copper</td>
<td>Cause muscle weakness and damage to heart, liver, and spleen</td>
</tr>
<tr>
<td>Lithium-ion battery</td>
<td>Nickel</td>
<td>Allergy of the skin to nickel results in dermatitis while allergy of the lung to nickel results in asthma</td>
</tr>
<tr>
<td>Motherboard, Relays</td>
<td>Lithium</td>
<td>Lithium can pass into breast milk and may harm a nursing baby; Inhalation of the substance may cause lung edema</td>
</tr>
<tr>
<td>Gallium arsenide used in light emitting diodes</td>
<td>Beryllium</td>
<td>Exposure to beryllium can lead to chronic beryllium disease or berylliosis, lung cancer and skin.</td>
</tr>
<tr>
<td></td>
<td>Arsenic</td>
<td>It has chronic effects that cause skin disease and lung cancer and impaired nerve signaling</td>
</tr>
</tbody>
</table>
before disposing of in a safe manner. But according to a recent UN report, only 20% is formally recycled. Much of the rest ends up in landfill, or is recycled informally in developing nations. Recycling is considered environmental friendly because it prevents hazardous waste, including heavy metals and carcinogens, from entering the atmosphere, landfill or waterways. It is the most effective solution to the growing e-waste problem. Another benefit of recycling e-waste is that many of the materials can be recycled and re-used again.

**Basel Convention**

In the 1970s environmental laws, such as the Resource Conservation and Recovery Act enacted in 1976 in the United States governing the disposal of solid waste and hazardous waste, were tightened. As a result, the costs of disposal of hazardous waste increased dramatically. This act led to the illegal dumping of e-waste in less developed countries. And in order to earn more profit businessmen of many developed countries, instead of proper disposal of e-wastes in their countries, started exporting the e-wastes in less developed countries and Third World countries where the environment laws are not strict, sometimes without their consent. On the other hand some less developed countries, in order to earn foreign exchange, were eager to import the e-waste. They do not care for the health of the people. So the human health of these countries and the health of the workers who recycle the waste are at risk because they are not provided with necessary safety equipments (such as mask, etc.) and also environment is polluted. For example, when the workers smash discarded electronic goods toxins go to the ground, contaminating the soil and putting those who do not wear shoes in danger.

In 1988 two severe incidents gave the world a rude awakening of e-waste crisis. One was the Khian Sea waste disposal incident, in which a ship was carrying more than 14,000 tons of toxic incinerator ash from Pennsylvania in the United States. The original destination of the e-waste was New Jersey which refused to take it. Six other states also rejected incinerator ash shipments. It was then decided to send it offshore to countries with less stringent environmental standards. The ship sailed for 16 months, changing its name several times, searching for a place to unload the waste and finally dumped it under the pretense of “topsoil fertiliser” near Gonaives in Haiti and in the Indian and Atlantic Oceans by November 1988. Another is the 1988 Koko case in which approximately 3,500 tonnes of toxic waste from Italy was dumped in the small town of Koko in Nigeria. These events led to the Basel Convention, 1989 which was convened at Basel from 20 to 22 March 1989. It is an international treaty designed to control of trans-boundary movements of hazardous wastes and their disposal and to control the international trade in hazardous wastes between countries, and specifically to prevent the transfer of hazardous waste from developed to less developed countries. In accordance with its article 21 the Convention was opened for signature on 22 March 1989 until 22 March 1990. It came into force on 5 May 1992. Currently 187 countries are parties to the treaty. Since then, recycling plants have opened up around the world, particularly in Asia.

**Indian Scenario**

Electronic waste is emerging as a serious public health and environmental problem in India. In India approximately 2 million tons of e-waste is generated annually and an undisclosed amount of e-waste is imported from other countries around the world. India is ranked fifth among top e-waste producing countries in the world after USA, China, Japan and Germany. India has also become a dumping ground for many developed nations such as USA, European Union, Germany. 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. In India Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab contribute about 70% of total e-waste. Regarding the current status of e-waste in the country Sunita Narain, Director General, Centre for Science and Environment, submitted a report on e-waste management in 2018 to Hon’ble Delhi High Court in compliance with the order of the Hon’ble Court. In the report it has been stated, “India does not have an updated inventory of e-waste generation, which makes it difficult to say how much waste is recycled and how much is disposed off and how. The Central Pollution Control Board (CPCB) had done the last comprehensive inventory in 2005 – over a decade ago and in that report future projections of e-waste generation were provided where computer equipment account for almost 70 per cent of e-waste, followed by telecommunication equipment – phones (12 per cent), electrical equipment (8 per cent) and medical equipment (7 per cent) with remaining 4 per cent coming from household e-waste.... According to a study conducted in May 2017 the volume of waste is growing at an estimated 21 percent annually. This report predicts that by 2020, e-waste from old computers in India will increase by 500%; from discarded mobile phones will be about 18 times higher;
from televisions will be 1.5 to 2 times higher; from discarded refrigerators will double or triple; than their respective 2007 levels. So, the problem of e-waste is clearly much bigger than what is estimated by government today. What adds to e-waste challenge is just not the fact that India generates massive domestic e-waste for which it has no inventory; but also that it may just be importing vast quantities of e-waste – both legally and illegally. Officially, Indian government says it has banned the import of e-waste for disposal into the country as per Hazardous and Other Wastes (Management and Transboundary) Rules, 2016. But there are many ways the same rule can be flouted – both legally and illegally. According to the report 95% of e-waste is recycled in the informal sector and in rather crude manner under abjectly poor working conditions and environmental safeguards which are not only very harmful for the environment but potentially dangerous for the people employed in the sector. This is how the costs are kept low. This is why countries like India are the preferred destination for large quantities of such waste – our poor people provide the labour needed to dismantle and then to reuse the materials.

**Conclusion**

Uses of electronic and electronic devices are increasing day by day throughout the world and naturally the amount of e-waste is increasing. But there is lack of proper awareness about its potential danger to environment and human health. Further, there is lack of proper facilities for safe disposal of e-waste. Many workers who are engaged in dismantling the obsolete electronic devices to earn their livelihood do not take necessary safety measures resulting their health at risk. In many cases the businessmen who deal with e-waste do not provide their workers necessary safety equipment and working ambience in order to earn more profit. So in order to save the environment there is urgent need for the governments to look into the matters and at the same time to aware people on the hazardous effect of e-waste. At the same time if we take steps for ensuring the safe disposal of personal e-waste, we can look forward to a better future and guarantee the safety of our environment.

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