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Research article

WEEE/E-WASTE AN EMERGING HEALTH HAZARD

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ABSTRACT: Waste electrical equipment and electronic/ Electronic waste (WEEE/E-waste) can be considered as a greater hazard both to humans and environment. In developing countries WEEE/E-waste collection, segregation, transportation and recycling has become a very lucrative business in unorganised sectors. But the ensuing dangers associated with it is a neglected field, which needs urgent attention. Many problems created by this waste is non-reversible and may lead to the extinction of many living things and serene environment. Composition of WEEE/E-waste components is very diverse and may contain more than 1000 different substances which are both recognised as very hazardous and non-hazardous in nature. Quantum of this waste generation is increasing tremendously and needs urgent and proper management to save our race and environment.

Health problems and environmental destruction related to WEEE/E-waste is discussed in detail in this article.

Key words: WEEE/E-waste, Environment, hazard, metals, health problems

INTRODUCTION

Development in all the fields of routine human existence is the need of the hour. As the old adage goes that every coin has two sides likewise every development has also two sides i.e. one for the betterment of human life and the other side is the ensuing hazards related to the development. Recent times the glitz of the benefits and the wealth created by the information technology revolution looms a dark reality that is the waste electronic and electrical equipments - one of the most hazardous and fast growing wastes. Electronic goods once they become obsolete is discarded as more better and modern version floods the market. In the process old, used ones have to be discarded/ disposed and if possible needs recycling to salvage some precious and non-precious metals, plastics and glass.

In developed countries it equals 1% of the total solid wastes on an average. It is expected to grow to 2.0% by 2010. The composition of WEEE is very diverse and differs in products across different categories. It contains more than a 1000 different substances which fall under hazardous and non-hazardous categories. Broadly it consists of ferrous and non-ferrous metals, plastics, glass, PVC, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitute about 50% of the WEEE/E-waste followed by plastics 21.0%, non-ferrous metals 13% and other constituents. Non-ferrous metals consist of metals like copper, aluminium, precious metals like silver, gold, platinum, palladium etc. Presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants beyond threshold quantities present in WEEE/E-waste categorises them as a hazardous waste. [1]. Beneath the glamorous surface of the benefits and the wealth created by the information technology revolution, looms a darker reality. Vast resource consumption and waste generation are increasing at alarming rate day by day. The electronics industry is the worlds largest and fastest growing industry and as a consequence of this growth combined with rapid product obsolescence, discarded electronics or E-waste is now the fastest growing waste stream in industrialized world.

The growing quantity of E-waste is beginning to reach disastrous proportions and industrialized countries all over the world are now beginning to grapple with the problem. After initially turning a blind eye to the problem governments have been forced to respond as E-waste begins to seriously inundate solid waste disposal facilities and programs. It is a crisis not only of quantity but also a crisis born from toxic ingredients, such as lead, beryllium, mercury, cadmium and brominated flame retardants that pose both an occupational and environmental health threat. But to date industry, government and consumers have only taken small steps to deal with this looming problem.

Technology has taken great strides in making our lives comfortable, allowing us to work from anywhere we please. We carry the world with us in our laptops, see the universe on our televisions and access the obscure on our home computers, enjoy the cool air of the Air conditioners, preserve the food in our refrigerators. Technology unfortunately also becomes obsolete in a remarkably short time. This means there are cathode ray monitors, keyboards, computers which are replaced with LCD screens, newer, sleeker keyboards, new computers which accommodate the new technology. In with the new and out with the old has become the gospel truth. Among the top ten consumer electronics equipment producing countries are, Japan - 29.1%, China-10.4%, South Korea-8.4%, USA - 7.8%, Malaysia - 7%, Germany -3.5%, Brazil - 3.0%, Mexico - 2.8%, Hongkong - 2.7%, Singapore - 2.6% [2], with rapid economic growth and the trans boundary movement of electronics and electrical materials have given rise to a growing waste which will test the waste management maxim of reduce, reuse and recyle. [3]

How is WEEE/E-Waste generated

WEEE/E-waste is generated at alarming rates due to obsolescence. Due to extreme rates of obsolescence, WEEE/E-waste produces much higher volume of waste in comparison to other consumer goods. Where once consumers purchased a stereo or television set with the expectation that it would last for a decade or more, the increasingly rapid evolution of technology combined with rapid product obsolescence has effectively rendered everything disposable. Consumers now rarely take broken electronics to a repair shop, as replacements is now often easier and cheaper than repair. The average lifespan of a computer has shrunk from four or five years to two years. Part of this rapid obsolescence is the result of a rapidly evolving technology. But it is also clear that such obsolescence and the throw away ethic results in a massive increase in corporate profits.

Americans are buying more computers than people in any other nation. Currently over 50% of US households own computers. Data from single-day recycling collection events has revealed that more than 50% of turned-in computers are in good working order, but they are discarded to make way for the latest technology. It is expected that in 2007, one computer will become obsolete for every new one put in the market. In California alone, over $1.2 billion will be spent on WEEE/E-waste disposal over the coming years. [4]

Quantum of WEEE/E-waste

In 1998, about 20 million computers became obsolete in the United States and overall WEEE/E-waste volume was estimated to be 5-7 million tonnes. The figures are projected to be higher today and rapidly growing. European studies estimated that the volume of WEEE/E-waste is increasing 3-5% per year, which is almost three times faster than the municipal waste stream. Today electrical equipment and electronic waste likely comprises more than 5% of all municipal solid wastes. To make matters worse, solid waste agencies and recyclers are anticipating a major increase in the volume of computers and TV monitors discarded in the next five years. As cathode ray tube (CRT) monitors currently in use will be replaced by smaller and more desirable sleek liquid crystal display (LCD) screens, this could mean massive dumping of CRT monitors at an even higher rate.

Table 1: E-waste generation in selected countries by EMPA project [5]

Country	Total E-waste generated (tonnes/ year)	Categories of appliances counted as E-waste	Year
Switzerland	66042	Office and telecommunications equipment, consumer entertainment electronics, large and small domestic appliances, refrigerators, fractions	2003
Germany	1100000	Office and telecommunications equipment, consumer entertainment electronics, large and small domestic appliances, refrigerators, fractions	2005
UK	915000	Office and telecommunications equipment, consumer entertainment electronics, large and small domestic appliances, refrigerators, fractions	1998
USA	2158490	Video products, audio products, computers and telecommunications equipment	2000
Taiwan	14036	Computers, home electrical appliances (TVs, washing machines, -air conditioners, refrigerators)	2003
Thailand	60000	Refrigerators, air conditioners, televisions, washing machines, computers	2003
Denmark	118000	Electronic and electrical appliances including refrigerators	1997
Canada	67000	Computer equipment (computers, printers, etc) and consumer electronics (TVs)	2005

This leap in technology is expected to lead to a significant increase in television disposal. A 1999 study conducted by Stanford Resources, Inc. for the National Safety Council projected that in 2001, more than 41 million personal computers would become obsolete in the US. Analysts estimate that in California alone more than 6000 computers become obsolete every day. In Oregon and Washington it is estimated that 1600 computers become obsolete each day. Experts estimate that we will have more than 500 million obsolete computers in the Unites States by 2007. As this wave of electronic surges in to the waste stream, the environmental challenges will leave no community untouched. Following Table No. 1 indicates WEEE/E-waste generation around the world and E-waste generation in Asia in Table 2.

Table 2: E-waste generation in Asia [6, 7]

Country	Home appliances[a]	Personal computers	Year
China	51480000	4480000	2003
India	Unknown	Unknown	
Japan	18625000	Approx. 80000 tonnes	2003
Korea	Unknown	1710000	2003
Philippines	2379142	Unknown	2004
Taiwan	53 800 tonnes	21 100 tonnes	2004
Thailand	Approx. 2400000[b]	Approx. 300000	2001

Data are number of units unless otherwise stated
[a]TV sets, refrigerators, washing machines, and air conditioners
[b]TV sets, refrigerators, and air conditioners

Health Hazards of E-waste:

Health risks from e-waste include breathing problems, respiratory diseases, coughing, choking, pneumonitis, tremors, neuropsychiatric problems, convulsions, coma and even death. E-waste workers are also exposed to other hazards leading to physical injuries and chronic ailments such as asthma, skin diseases, eye irritations and stomach disease, inflammatory response; oxidative stress and DNA damage. [8]

Computers contain toxic chemicals like lead, cadmium, mercury, beryllium, BFR, polyvinyl chloride and phosphor compounds.

A study on the burning of printed wiring boards that was conducted in the year 2004 showed an alarming concentration of dioxins in the surrounding areas in which open burning was practiced.

Non-regulated recycling can lead to various occupational hazards including silicosis, glass injuries from Cathode ray tubes re-gunning and breaking;tin and lead inhalation, possible brominated dioxin, beryllium cadmium and mercury inhalation from de-soldering of Printed circuit boards. Toxicity to workers and nearby residents from tin, lead, brominated dioxin, beryllium cadmium and mercury inhalation occurs. Hydrocarbons, heavy metals, brominated substances discharged directly into river and banks lead to water pollution. Respiratory irritationdue to open burning and use of acid bath to remove final metals are the other health hazards. Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases leading to respiratory irritation to severe effects including pulmonary edema, circulatory failure and death due to Chemical stripping using nitric and hydrochloric acid and burning of chips is a very common problem. Polycyclic Aromatic Hydrocarbons (PAH) (Carcinogenic)and potential dioxin exposure occurs due to burning or shredding of plastics. [9]. Heavy metals and toxins exert their health effects over a long period of time as cumulative poisons and carcinogens.

Lead: Affects various systems including the central nervous system (organic affective syndrome), the peripheral nervous system (motor neuropathy), the hemopoietic system (microcytic anemia), the kidneys (damage to the nephrons), and the reproductive system. Lead exposure also leads to developmental damage in children exposed.

Cadmium: is a cumulative poison that accumulates in humans in the renal system. Carcinogenicity is attributed to Cadmium and Beryllium.

Zheng et al in 2008 compared blood lead levels (BLL) and blood cadmium levels(BCL) in a primitive e-waste recycling town in China (Guiyu). The authors reported significantly higher BLL and BCI in the children living in the e-waste recycling town when compared to children in another town.

The results also observed a significant increasing trend in BLLs with increasing age in Guiyu, the children were also shorter than the children in the comparator town. The risk factors related to children's BLLs and BCLs mainly included father's engagement in the work related to e-waste, children's residence in Guiyu and the amount of time that children played outside near the road every day. [10]

Mercury: causes tubular dysfunction (kidneys), affect the central and peripheral nervous system and disrupt foetal growth. Inorganic mercury in water bodies converts to methylated mercury and bioaccumulates in the living constituents of the aquatic ecosystem like fishes and gets concentrated in the food chain.

Polycyclic Aromatic Hydrocarbons (PAH): affect the lung, skin and the bladder, and are carcinogenic in nature as well. They leach into ground water bodies and pollutes the drinking water. It creates harm to the environment. Mass fish kills and complete eradication of phyto and zooplankton occurs thus complete water body is polluted with environmental effects on plants, humans and also air pollution occurs. [11].

Dioxins: are persistent environmental pollutants. They bio-accumulate in the food chain mostly in fatty tissue of animals. It causes reproductive and developmental issues, immune damage, hormonal interference and cancer. [12].

Environmental Hazards:

E-waste generates a varied group of pollutants which either in the air or through water and soil enter the various ecosystems and impact the environment. When e-waste is incinerated toxic substances are released in the atmosphere causing air pollution. The informal sector in processing e-waste use open burning of plastics, river dumping of acids and general dumping over a wide area. Consequently, pollutants are discarded into the land, air and water. Computer wastes that are disposed in landfills result in contaminated leachates which reach the groundwater and pollute it. Acids and sludge extracted from melting computer chips, disposed in the land causes acidification of soil. Excessive levels of metals, including dissolved arsenic, chromium, lithium, molybdenum, antimony, selenium, silver, beryllium, cadmium, cobalt, copper, nickel, lead and zinc, have been attributed by researchers to acid-leaching operations taking place. [13] Open-air storage raises apprehension regarding the possibility of lead and other substances leaching out into the environment.

When brominated flame retardant plastic or cadmium containing plastics are land filled, both Poly Brominated Diphenyl Ethers (PBDE) and cadmium may trickle into the soil and groundwater. It has been found that major amounts of lead ion are dissolved from broken lead containing glass, such as the cone glass of cathode ray tubes, gets mixed with acid waters in landfills. The most dangerous form of burning e-waste is the open-air burning of plastics in order to recover copper and other metals. The toxic result from open air burning changes both the local environment and global air currents. Evidence from several studies in China have established that the primitive recycling techniques coupled with the amounts of e-waste processed have resulted in undesirable environmental and human health impacts, including contaminated soil and surface water. The unregulated sector e-waste activities are also a fundamental source of environment-to food-chain pollution, as contaminants are likely to be accumulated in farming lands and become accessible for uptake by grazing domestic animals. Additionally, most chemical wastes have a slow metabolic rate in animals, and may bio-accumulate in the animals and may be passed on to humans in edible products such as eggs and milk. E-waste-related dangerous effects can be aggravated throughout the lifetime and succeeding generations. Table 3 indicates the presence of hazardous substances, metals, their occurrence and impacts.

Indian Scenario of WEEE/E-waste

India is a booming electronic consumer goods market. It has also seen tremendous growth in the IT sector with new companies and research facilities setting up shops. By the end of financial year 2005-06, India had 4.64 million desktops, about 431 thousand notebooks and 89 thousand servers. As per MAIT estimate, the Indian computer industry is growing at a 25% compounded annual growth rate. Both of these mean that the Indian household and industry now churn out e-waste at a fast pace. The increase in electronic products, consumption rates and increased obsolescence rate has led to higher generation of electronic waste (e-waste). Add to this the e-waste is being imported for processing. It makes a challenging situation vis-a-vis solid waste management. [14] It is reported that in India about 800000 MT of E-waste is generated annually. It is been estimated that E-waste generation in India is expected to exceed 1,200,000 tons by 2015 [15].

In India about ten states generate approximately 70% of the total e-waste 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. Of the total e-waste generated in the country, western India accounts for the largest population at 35%, while the southern, northern and eastern regions account for 30, 21 and 14%, respectively. [16]

Table 3: E-waste: Hazardous substances, their occurrence and their impacts [14]

Substance	Occurrence in E-waste	Environmental and Health Relevance
Halogenated Compounds:		
PCB (polychlorinated biphenyls)	condensers, transformers	Cause cancer, effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. Persistent and bioaccumulatable
• TBBA (tetrabromo-bisphenol-A) • PBB (polybrominated biphenyls) • PBDE (polybrominateddiphenyl ethers)	fire retardants for plastics (thermoplastic components, cable insulation) TBBA is presently the most widely used flame retardant in printed wiring boards and covers for components	can cause long-term period injuries to health acutely poisonous when burned
Chlorofluorocarbon (CFC)	cooling unit, insulation foam	Combustion of halogenated substances may cause toxic emissions.
PVC (polyvinyl chloride)	cable insulation	High temperature processing of cables may release chlorine, which is converted to dioxins and furans.

Heavy Metals and Other Metals:

Arsenic	small quantities in the form of gallium arsenide within light emitting diodes	acutely poisonous and on a long-term perspective injurious to health	
Barium	getters in CRT	may develop explosive gases (hydrogen) if wetted	
Beryllium	power supply boxes which contain silicon controlled rectifiers, beamline components	harmful if inhaled	
Cadmium	rechargeable NiCd-batteries, fluorescent layer (CRTscreens), printer inks and toners, photocopying -machines (photo drums)	acutely poisonous and injurious to health on a long-term perspective	
Chromium VI	data tapes, floppy-disks	acutely poisonous and injurious to health on a long-term perspective causes allergic reactions	
Gallium arsenide	light-emitting diode (LED)	injurious to health	
Lead	CRT screens, batteries, printed wiring boards	causes damage to the nervous system, circulatory system, kidneys, causes learning disabilities in children	
Lithium	Li-batteries	may develop explosive gases (hydrogen) if wetted	
Mercury	is found in the fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches	acutely poisonous and injurious to health on a long-term perspective	
Nickel	rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT	may cause allergic reactions	
Rare earth elements (Yttrium, Europium)	fluorescent layer (CRT-screen)	irritates skin and eyes	
Selenium	older photocopying-machines (photo drums) """	exposure to high levels may cause adverse health effects	
Zinc sulphide	is used on the interior of a CRT screen, mixed with rare earth metals	toxic when inhaled	
Others:			
Toxic organic substances	condensers, liquid crystal display		
Toner Dust	toner cartridges for laser printers/ copiers	Health risk when dust is inhaled, of explosion	risk
Radioactive substances (Americium)	medical equipment, fire detectors, active sensing element in smoke detectors	May cause cancer when inhaled	

Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore,Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. As per country level Waste Electrical and Electronic Equipment (WEEE) assessment study, Mumbai and Pune fallsunder the top ten cities that are generating e-waste and Mumbai alone generates the most among all the cities of India. Total WEEE generation in Maharashtra is 20270.6 tons, out of this Navi Mumbai contributes 646.48 tons, Greater Mumbai 11017.06 tons, Pune 2584.21 tons and Pimpri – Chinchwad 1032.37 tons. [17]

Besides domestic e-waste produced, about 50,000 MT of e-waste each year is illegally imported into the country. Approximately 30,000 computers become outdated every year from the IT industry in Bangalore alone. It is home to more than 1200 foreign and domestic technology firms, Bangalore figures significantly in the list of cities faced with e-waste risk. As many as 1000 tonnes of plastics, 300 tonnes of lead, 0.23 tonnes of mercury, 43 tonnes of nickel and 350 tonnes of copper are annually generated in Bangalore. [16]

There are only few small scale units which carryout WEEE/e-waste dismantling and recycling facilities. These facilities are M/s Trishiraya recycling at Chennai and M/s E. Parisara at Bangaluru, India. [15] There does not exist properly organized WEEE/E-waste facility in India. In many places unorganized WEEE/E-waste recycling does exist leading to health and environmental problems. Over a million people in India are involved in the manual recycling operations. Particularly northern India is a leading processor of WEEE/E-waste in the country. This informal and illegal sector employs mostly women and poor children in the recycling processes. A survey carried out in 2003 reports that there are about 200 recycler in the city. Through a massive effort by Indo-German-Swiss E-waste Institute and M/s Paradigm Environmental Strategies Private Limited the recyclers were brought together to form a company named 'The Edward and Co.' The mandate was to integrate recyclers in transparent and fully organized system.

The second Nordic Council report—*Environmental Consequences of Incineration and Landfilling of Waste from Electronic Equipment* says [18]:

- Some materials in WEEE are hazardous to the environment. Other substances are not hazardous in the concentrations present. The amount of material has to be considered when discussing environmental impacts. Some substances in WEEE are in small quantities, but can be very poisonous.
- When WEEE is mixed with other types—especially organic waste—in landfills, the substances change their mobility and toxicity. Generally, emissions will increase.
- The processes in landfills are very complicated and run over a wide time span. Therefore, it is impossible to quantify environmental consequences of WEEE in landfills.
- Degradation of CRT-glass in landfills is a very slow process, but eventually barium and lead will be leached from the glass. If CRT-glass contains cadmium as a pigment, the cadmium may also be leached.
- Sorting waste from electric and electronic equipment and extracting of as many metals as possible especially copper, nickel, lead, and mercury before incinerating and landfilling should be recommended.

Substances Present in WEEE/E-waste

Lead

Apart from batteries, lead is used widely in solders, as an alloying element for machining metals, printed circuit boards, components, incandescent light bulbs, and weighting. Lead oxides occur in leaded glass in cathode ray tubes, light bulbs and photocopier plates, and in batteries. Lead-based solder (typically a 60:40 ratio of tin to lead), which is used to attach electrical components, represents the major solder type used in most EEE applications and typical motherboards have been reported to contain approximately 50 g/m^2 lead. In CRTs, leaded glass provides shielding from X-rays generated during the picture projection process. Colour CRTs contain 1.6 kg to 3.2 kg of lead on an average (Microelectronics and Computer Technology Corporation, 1996). A TV set glass contains about 2 kg lead. The lead oxide in CRT tubes constitutes the largest share of lead, where it is present in the form of silicates. A light bulb contains between 0.3 and 1.0 g of lead in lead-tin solder and 0.5 to 1.0 g of lead silicates in the glass (on average 1.5 g lead in solder and glass). The main areas of the body affected by lead are the brain, kidney and nervous system. [19] Once the body is exposed to the lead it remains in the human tissues / gets bioaccumulated. [20]

Mercury

The global man-made release of mercury to the atmosphere is approximately 2000-3000 tonnes per year. It is estimated that of the yearly world consumption of mercury 22% is used in electrical equipments and electronics (EEE). Mercury is basically used in thermostats, sensors, relays and switches (on printed circuit boards and in measuring equipment and discharge lamps). It is also used in medical equipment, data transmission, telecommunications, and mobile phones. In the EU, 300 tonnes of mercury are used in position sensors alone.

Cadmium
In Printed Circuit Boards, cadmium occurs in certain components, such as chip resistors, infrared detectors and semiconductors. Older types of CRT's contain cadmium. Cadmium metal or powder is still used as part of the negative electrode material in nickel-cadmium (NiCad) batteries, as deposited coating on iron, steel, aluminium-base materials, titanium-base alloys or other non-ferrous alloys, and as an alloying element in soldering and specialty alloys. Cadmium oxide forms part of the negative cadmium electrode in nickel-cadmium batteries, and cadmium sulphide is found widely in CRT and electronic devices.Cadmium toxicity can lead to kidney, bone and pulmonary problems. Cadmium toxicity spreads through skin exposure, water and air. [21, 22].

Hexavalent Chromium and Barium Compounds
Hexavalent chromium is used in the plastics of personal computers, cabling and packaging. Chromium VI is typically used as a hardener or stabilizer for plastichousings and as a colorant in pigments. References to quantities of chromium VI in these components are poor. The use that is occurring seems to be in trace amounts, between 0.2 and 0.3 grams per component. As a colour pigment, the European Union is moving to restrict the use of chromium VI. Hexavalent chromium may also be present on the surface of metal parts that have been protected from corrosion with chromate conversion coatings.

Beryllium
Traditionally, copper-beryllium alloys were used in motherboards on personal computers. Beryllium is rarely used in this form anymore, but its use in combination with copper as an alloy is increasing. Beryllium improves the properties of copper contact springs because of its high strength, high conductivity and high elastic quality. Between 2-4% of these copper alloys is beryllium metal. It is used amongst other things, in electrical insulators and resistors, microwave tubes, photographic equipment, rotating mirrors in laser printers. When crude methods and improper handling are followed during recycling of E-waste, beryllium dust is generated which causes cancer and lung diseases. [23]

Brominated Flame Retardants
Brominated flame retardants (BFRs) are today regularly designed into electronic products as a means for ensuring flammability protection. BFRs are used in a wide range of products including plastics, white goods, car interiors, carpets and carpet underlay, polyurethane foams in furniture and bedding. They occur in mainly four applications; PCB's, components such as connectors, plastic covers, and cables, and their use has increased markedly over the past two decades, with worldwide production over 200,000 tonnes per year. According to a Danish estimation, WEEE represents about 78% of the total content of brominated flame retardants in waste. Illegal and crude recycling methods leads to health hazards and environmental degradation. Thus it leads to serious health problems and may also lead to mutagenic changes in future generation. Thus proper and scientific management methods of e-waste is the need of the hour.

Tetrabromobisphenol-A (TBBPA) is the largest volume brominated flame retardant in production today. It is used as a reactive or additive flame retardant in polymers, such as epoxy and poly-carbonate resins, high impact polystyrene, phenolic resins, adhesives, and others. Its main use in EEE is as a reactive flame retardant in printed circuit boards.

PVC
Many different types of plastics are used in the manufacture of electronic equipment. PVC is ubiquitous in electronics, forming the structure of computer housings, keyboards and cables. Estimated quantities of PVC in different products range from 37.1 grams in a keyboard to a total of 314 grams in all of the cables connecting different component pieces together. Outwardly it may look harmless but its recycling or even secured land filling may lead to environmental degradation. [24]

Phosphors
Phosphors are found in all CRT screens as well as fluorescent lights. Many phosphors used in CRTs contain zinc, although only small quantities of phosphors are used in electrical and electronic products. Some old monitors contain phosphors that include arsenic.

Toxicity, Man and the Environment
Any substance is potentially toxic if the dose and duration of exposure are sufficiently high. There are many ways in which chemicals might disrupt the functioning of an organism, including *corrosive* or *irritant effects, acute and chronic toxicity, effects on the nervous system (neurotoxicity), impairment of the reproduction of cells or organisms* (by carcinogens, mutagens or reproductive toxins), or *damage to hormone systems,* for example, the effects resulting from endocrine-disrupting chemicals. Tests have been devised to assist in determining toxic doses—*i.e.*, doses required to cause a specified impact on health of humans or other living organisms.

It is well-documented that toxicity is not solely a characteristic of synthetic chemicals. Some of the most toxic substances known, occur naturally in organisms, where they usually form part of a defence mechanism. For example, clovers produce hydrogen cyanide when damaged, and a number of Australian plants produce fluoroacetate, a respiratory inhibitor which is highly toxic to sheep, but to which red kangaroos have adapted.
In WEEE-relevant substances, it is important to note that the form of the waste and the conditions of its storage or burial will be important in determining both the dose and the response. As there are a wide variety of landfill conditions, the determination of dose-response across these varying conditions is not simple, and even if it could be determined, it would vary across various conditions. A common approach is therefore to set 'guideline' levels of concentrations of known toxic substances. Where dose-response relationships are unknown, it is appropriate to take a precautionary approach and set exposure levels to as low as reasonably practicable.

Management of E-Waste in nutshell would include the following three items:

- *Precautionary principle*—where theory or circumstantial evidence suggests damage potential exists, in the absence of fuller evidence, it is prudent to assume the worst case and legislate accordingly;
- *Prevention is better than cure—ii* is cheaper in the long run to prevent risks and impacts from occurring rather than to concentrate entirely on cleaning up problems, so eco-design mechanisms to minimise generation is a logical approach;
- *Polluter pays principle*—those who create the risks should incorporate the costs of dealing with them into their operating costs.

Recycling Printed Circuit Boards

Around 60 million PCBs are produced around the world each year. Each circuit board has a metal content of up to 30% by weight. The metals present in the majority of cases are gold, silver, copper, tin and lead. Many of the processes used to recover non-precious metals are based on mechanical, pyrometallurgical and hydrometallurgical techniques, in which the value of the electronic component is totally lost and maximum metal recovery is not possible. A newly developed integrated approach at Cambridge University enables the components to be separated and resold, the solder leached and re-deposited as a solder alloy and the shredded boards to be reused as a binder in aggregate use.
The key to the new process is the development of a selective leaching agent that is highly effective at dissolving solder used in the circuit boards yet has no effect on the performance of the electronic components. The selective leachant that has been developed is composed of fluoroboric acid containing a titanium redox couple. The leachant dissolves the lead and tin content in exactly the same ratio as the solder, leaving the copper content of the boards intact. The same process can also be applied to shredded boards after they have been treated to remove aluminium and ferrous scrap. The solder is then electroplated from the leaching agent, which is then regenerated.
Another clean process for recovering nearly all precious metals and heavy metals from electronic waste exploits the ability to dissolve all the recoverable metals non-selectively and then recover them selectively or non-selectively. The process uses two reactors, a leach reactor and an electrochemical reactor. Using anodically generated chlorine, the leach reactor dissolves the metals, while the electrochemical reactor has two functions. It not only generates the reagent for dissolving the metals, but also recovers, from solution, the metals dissolved in the leach reactor. The overall process involves inputting electrical energy to move the metals from the scrap to the reactor's cathode, which produces only de-metallised waste. Recycling is the best option for the E-waste management, if followed properly.

CONCLUSION

WEEE/E-waste is very hazardous in nature. This waste has to be properly managed. This waste possess a great environmental and health problems in developing countries. Most suitable and scientifically sound management systems for this waste is recycling, recovery and reuse. Side by side awareness about the waste has to be taught at both urban and rural levels by increasing the literacy rate. Some new cleaner technologies are needed to be developed to curtail this mounting and unending problem. Recyclers have to be provided with safety gadgets to prevent them from direct contact with the toxic metals to save their life. At present recycling, incineration and secured land filling are followed in many small pockets of the country.

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