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Research Article

STUDY ON E-WASTE, THEIR HEALTH EFFECTS AND DISPOSAL PRACTICE

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ABSTRACT
This paper deals the types of e-waste, current situation in e-waste production, their estimated life cycle and environmental problems related with the disposed electronic appliances, known as e-waste. The increased production of electronics has lead to a rapid growth in electronic waste which, when improperly disposed of, is associated with health risks and environmental pollution from toxic components like lead, cadmium, nickel, manganese and mercury found in most computers, monitors, batteries and other electronic appliances. These toxic compounds enter the living system via food, water, air and soil resulting in a variety of health hazards. Moreover ,the current and the future production of e-waste, the potential environmental problems associated with their disposal monitoring and management practices are discussed whereas the existing e-waste management schemes in India and other countries are also mentioned.

Keywords: *Electronics, Mercury, Lead, Pollution, Recycling*

INTRODUCTION
In current years we have witnessed the rapid increase of number of mobile subscribers, mobile services providers, internet service providers, data operators and internet users. This is primarily caused by lifting of ban imposed by government on importation of computers and its peripherals in government entities, government decision to remove all taxes and duties on those electronic products and flexibility on regulations for establishment of media and telecommunication companies (Betts, 2008). All these steps have contributed much on inflow of electronic products particularly computers and its peripherals, mobile phones and television sets. This pose challenges on appropriate methods to dispose end of use electronic products without destroying environment, jeopardize people health and without loss of data and information stored in these products (Bertram *et al.,* 2002).

Computers and televisions are most important part of the consumer electronics waste stream which also includes VCRs, radios, small & larger batteries, cell phones, and small appliances. Collectively, they are referred to as electronic waste or "e-waste" (See figure 1) and are one of the very fastest growing portions of our waste stream. As new electronic equipment becomes faster, cheaper and more efficient, especially computers, will find their way from the desktop to the bottom of the closet (Freeman, 1989). For each new product that is introduced to consumers, one or more products become outdated or obsolete. In 2005, EPA estimated that 26 to 37 million computers became obsolete amounting to approximately 1.9 to 2.2 million tons of waste nationally. Careful disposal of these items is important because many electronic products contain hazardous components. Computer monitors and televisions can contain leaded glass. Materials such as beryllium, mercury, cadmium, nickel, zinc, silver and gold can be found in printed circuit boards. Cadmium can also be found in batteries and mercury can be present in relays and switches. If it is not recovered for recycling, it will likely end up in a waste-to-energy facility, where most of our trash is disposed in Connecticut. Incineration of e-waste can produce dioxin and contribute to heavy metal contamination in the atmosphere (Gullett *et al.*, 2007).

Responsible recycling and disposal of e-waste can help prevent exploitation of people in lesser developed countries where much of the e-waste from the U.S. has historically been disposed. Media exposés of companies that sent e-waste overseas where unprotected workers rummage through vast mountains of smoldering electronics to recover bits of recyclable metals served to shed light on the problem that our e-waste was causing elsewhere (Huisman and Magalini, 2007). This, among other reasons, prompted states, including CT, to pass e-waste recycling laws that help to ensure responsible recycling and disposal of these items.

E-Waste Production-Current Situation

The global e-waste production is assessed at 20-50 Mt/year (UNEP, 2006), equal to 1-3% of the estimated global urban waste production (1636 Mt). PCs, cell phones and TVs will contribute 5.5 Mt in 2010 and will amount to 9.8 Mt in 2015. In wealthier countries, e-waste will stand for 8% of the urban waste volume (OECD, 2008). Each electronic item's participation in the annual e-waste production, E (kg/year), depends on each electronic item's mass, M (kg), its quantity (number) in the market and consumption, N, and its average life cycle, L (year).

Electronic computers with an average 3-year life cycle (Widmer *et al.*, 2005) contribute to a greater extent to the total e-waste flow compared to refrigerators and electrical cook-stoves, having an average life cycle of 10-12 years. Certain e-waste types along with their mass and estimated life cycle are summarized in Table 1.

Particularly for the European Union, the e-waste quantities increase by 3-5% per year, a rate three times faster than the urban solid waste. During the 1990-1999 periods the quantities produced in EU-15 were approximately 3.3-3.6 kg/resident, while estimated quantities for the 2000-2010 periods vary between 3.9-4.3 kg / resident. Using the equation (1), Swiss is estimated to produce 9 kg/person/year (Betts, 2008), the European population 14 kg/person/ year, with the total EU-15 production amounting to 5.5 Mt/ year and, in case of EU-27, 8.3-9.1 Mt/year.

USA produced approximately 2.6 Mt, while China produced 2.5 Mt in 2005. There are no available data for poorer countries, but it was assessed that India and Thailand produced 0.3 and 0.1 Mt of e-waste in 2007.

Figure 1: Different form of E-waste collection

According to another calculation based on the equation, and available data for the total number of PCs (0.78 billion units), cell phones (3.4 billion units), stationary phones (1.2 billion units), TVs (1.4 billion units), and radios (2.5 billion units), the total production amounts to 11.7 Mt / year. Moreover, considering the constantly increasing production of e-waste and the fact that the relatively large-mass electrical appliances (refrigerators, air-conditioners etc.) are not included in the aforementioned calculation, it is estimated that the total e-waste quantities will be rather larger. If the global increase of GDP by approximately 20% in the last 6 years is also considered, then the aforementioned estimate of 20-50 Mt/year is justified.

Table 1: E -waste types and their estimated life cycle

Item	Estimated item (kg)	Mass of life (years)
Cell phone	0.1	2
Electronic games	3	5
Photocopier	60	8
Radio	2	10
Television (TV)	30	5
Video recorder/DVD Player	5	5
Air-conditioner	55	12
Dish washer	50	10
Electric cooker	60	10
Food mixer	1	5
Freezer	35	10
Hair-dryer	1	10
Iron	1	10
Kettle	1	3
Microwave	15	7
Refrigerator	35	10
Tumble Dryer	35	10
Vacuum cleaner	10	10
Washing machine	65	8
Personal Computer (PC)	25	3
Fax machine	3	5

Health Impacts

Electronic equipments contain many health impact hazardous metallic contaminants such as lead, cadmium, and beryllium and brominated flame-retardants [Table 2]. The fraction including iron, copper, aluminum, gold, and other metals in e-waste is over 60%, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70%. Of many toxic heavy metals, lead is the most widely used in electronic devices for various purposes, resulting in 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 – more so than adults because they absorb more lead from their environment and their nervous system and blood get affected. It is found that the e-waste recycling activities had contributed to the elevated blood lead levels in children living in China, which is one of the popular destinations of e-waste. This was due to that fact that the processes and techniques used during the recycling activities were very primitive.

Table 2: E-wastes their heavy metals and health effects

Source of e–wastes	Constituents	Health effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (Pb)	• Affects Brain development • Kidney damage • Affects CNS
Chip, resistors and semiconductors	Cadmium (Cd)	• Neural damage • Affects Kidney and Liver
Relays, switches and printed circuit boards	Mercury (Hg)	• Respiratory and Skin disorders
Corrosion protection, of untreated and galvanized steel plates, decorator or hardener for steel housings	Chromium (Cr)	• DNA damage • Stroke
Cabling and computer housing	Polyvinyl chloride (PVC)	• Disrupts hormone secretion • Immunity loss
Plastic housing of electronic equipments and circuit boards	Brominated flame retardants (BFR)	• Disrupts Endocrine system
Front panel at CRT	Barium (Ba)	• Muscle weakness • Reduced Lung and Spleen development
Mother board	Beryllium (Be)	• High blood pressure • Lung cancer • Warts • Beryllicosis • Asthma

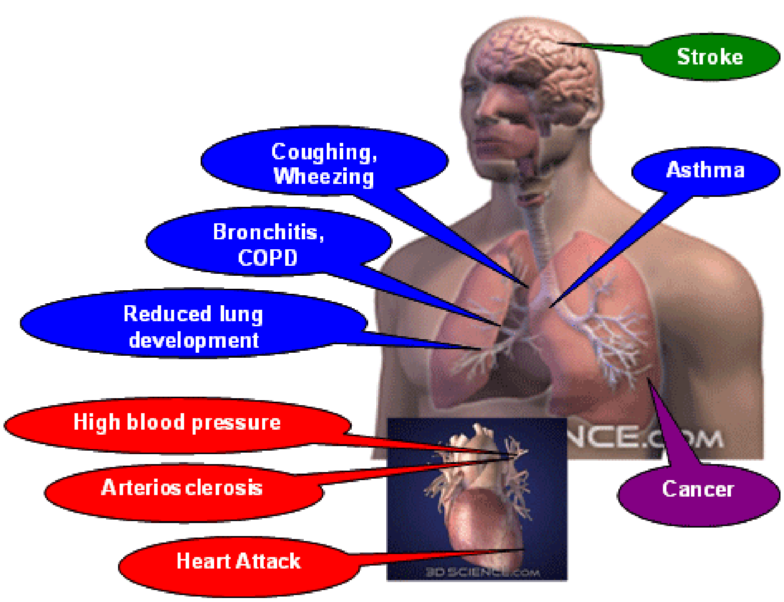

Figure 2: Possible health effects due to E-waste pollution

Various studies have reported the soaring levels of toxic heavy metals and organic contaminants in samples of dust, soil, river sediment, surface water, and groundwater of Guiyu in China. In the same areas, the residents had a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers (See figure 2). Further it was found that the blood lead levels of children were higher than the mean level in China, and there was no significant difference between boys and girls. It was found that e-waste recycling operations were causing higher levels of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) in the environment as well as in humans.

Body burdens of people in hair, human milk, and placenta from the e-waste processing site showed significantly higher levels of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) than those from the non-processing site. There is paucity of data on burdens of heavy metal exposure on human body in India.

A large number of workers including small children are exposed to different dismantling activities of e-waste. Although findings of these studies cannot be generalized to India but these are enough to alarm and strongly suggest to be replicating in occupational settings in India. There are no data available about the health implications of these workers. They might be ruining their lives in the lack of appropriate knowledge. In another study from China, human scalp hair samples were collected to find out heavy metal exposure to workers from intense e-waste recycling sites. Higher concentrations of Pb, Cu, Mn, and Ba metals were found in hair of exposed as compared to the hair in control group.

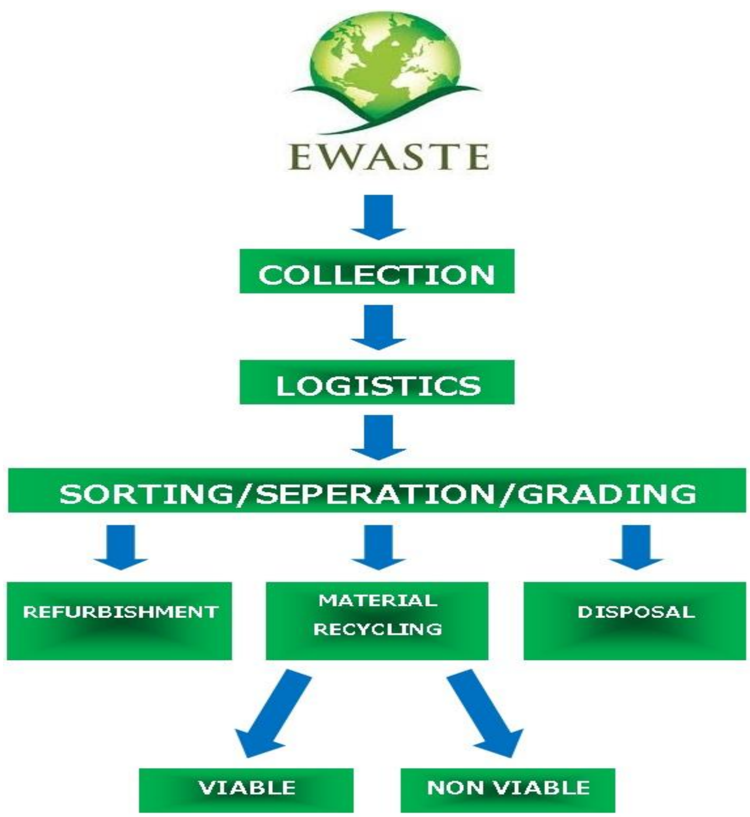

Figure 3: E-waste disposal

Environmental Pollution Caused by E-Waste Disposal and Recycling

The most of e-waste is led to (sanitary) landfill sites. The implementation of the appropriate, in this case, TCLP (Toxicity Characteristic Leaching Procedure) test has showed that e-waste discarded at urban waste dumping sites do not produce leachates with heavy metals concentrations exceeding the environmental limits (Spalvins *et al.*, 2008). Nevertheless, this chemical cocktail generated as leach ate following the

TCLP test from several electronic items was toxic for aquatic organisms (Dagan *et al.*, 2007). Moreover, the usual management practice of e-waste compression before or during discarding in landfills may increase the leach ate volumes due to the disturbance of the several electronic circuit parts and, for that reason, it is proposed to perform cement solidification on e-waste that increases pH and decreases the aqueous solutions' flow in the waste discarded (Niu and Li, 2007). Burning before discard at landfill sites (Solid Waste Management) increases heavy metals mobility contained in circuits covered with a plastic grid and, for that reason, while not being bio available following wash-out, they are released to the atmosphere and lithosphere during burning. Similarly, e-waste recycling includes disassembling and destroying the individual parts to retrieve several materials (See figure 3).

Through recycling, 95% of a computer's useful materials and 45% of a cathode ray tubes materials can be retrieved. Recycling methods have least environmental impact when combined with the application of appropriate technology, such as in Japan, while, on the contrary, when using the practices followed in developing countries (e.g. child labour, e-waste burning and emission of several pollutants to the air, leach ate seepage in underground and surface aquifers etc.), the final environmental benefit- impact balance is not always positive (Liu *et al.,* 2006). It must be also stressed out that any environmental benefit from recycling vanishes when the waste to be recycled is transported to great distance due to the adverse environmental impact of the energy consumed for its transportation, while, recycling, in any case, has smaller ecological footprint than e-waste dumping and burning (Gullett *et al.,* 2007).

In the Asian and European Union, e-waste has been targeted regarding the prevention of environmental pollution, for the exploitation of resources and the reduction of landfill use. The legislation developed by the European Parliament is based on three axes, the prevention, recycling and re-use of e-waste, so that the amount of the waste electrical and electronic equipment (WEEE) available is reduced (Hischier *et al.*, 2005).The below are elaborated in two relative Directives:

1. Directive 2002/95/EC restricts the use of hazardous substances introducing the requirement for change of substances causing the main environmental problems during the emplacement and recycling of the waste electrical and electronic equipment. According to this directive, the most effective way to ensure the substantial reduction of health and environmental hazards relating to hazardous substances is their replacement with other, safer substances. The prohibition of use of hazardous substances is most likely to increase the possibilities and the financial profit from recycling electrical and electronic equipment.
2. Directive 2002/96/EC on waste electrical and electronic equipment has been developed particularly to assist in reducing the waste electrical and electronic equipment available in the landfills and encourage the more efficient use of resources through recycling and re-use. The specific directive measures for collection, management, recovery and recycling of all electrical and electronic products and focuses on the Extended Producer Responsibility (EPR). Its main points are:

The study and production of electronic equipment should facilitate the disassembly and recovery for posterior use and recycling of e-waste. The collection of e-waste should be separately from other forms of waste and their collection should not burden households. The target price to integrate in the management system is 4 kg/year/resident. By the end of 2006, producers should be able to recover and reuse a certain target percentage for each of the 10 categories of the Directive ranging between 50-80%. Producers are responsible for financing e-waste collection disposal and management.

CONCLUSION

Electronic appliances everywhere in our world in the form of e-waste. These are characterized by a cumulative chemical composition and difficulty in quantifying their flows at a regional and international level. The pollution caused by their irregular management substantially degraded the environment mostly in poorer countries, receiving them for recycling and recovery of their valuable metals. As for the consequences on ecosystems, human health and environmental restoration of areas burdened by certain polluters generated by e-waste (e.g. Li and Sb), there are no sufficiently documented scientific studies. Motivated by the minimization of environmental effects caused by the generated e-waste, many technological changes have been effectuated. E-waste separation from the solid waste and their recycling for the recovery of valuable raw materials and basic metals is essential. The management system has to be rationally designed so that the environmental benefits from the Collection, transportation, management and the financial benefits from the recovery are not set-off by the required resources and energy consumptions for the system operation.

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