An Issue on E-Waste: Pre and Post Management

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Abstract- The role of international trade on electrical and electronic components plays a vital role to determine the environmental effect. This paper discusses some issues on electronic components for manufacture and utilization after damage. The global production of e-waste can change the economic growth and new technologies to be developed. As the radiation from these components and devices is a compulsion, manufactures should take care the electromagnetic interference (EMI) with other devices as well as environment, to make EM compatible (EMC) as well as user friendly. Similarly, e-waste produced after damage of the devices comprises discarded electronic appliances. The global production of e-waste is estimated to be 30 million tons per year. Those wastes have to be recycled for further use or to useful decomposition for environment and agriculture. Due to this growing waste streams the life span of electronic appliances has dropped in many developed countries. It has the impact on soil, water, air etc. though the water can be purified, the air and the soil conservation and purification is a great question mark.

Keywords: *e-waste; Post management; electromagnetic interface (EMI); electromagnetic compatibility (EMC); electronic appliances.*

I. INTRODUCTION

Most energy forms such as X-rays, ultraviolet energy and radio waves are invisible and imperceptible to the human. Without specialized instrumentation, most frequencies cannot be detected and, as a result, people generally do not appreciate their exposure to energy fields in these ranges. Despite the lack of perception, exposure to high-frequency energy including X-rays is termed 'ionizing radiation' and is potentially damaging to human cells. By altering the atomic composition of cell structures, by breaking chemical bonds and by inducing free radical formation, sufficient exposure to ionizing radiation may inflict DNA damage or mutation, thus increasing the risk of malignancy or cell death.

Studying plant behavior under low EMF by some researchers revealed that these circumstances can affect plant growth. In addition, other researchers have found that weak EMF suppressed this growth, reduced cell division, intensified protein synthesis and/or cause disintegration in plant roots. On the other hand, other studies found an increase in plant growth such as enhancing seed growth for some species. The inconsistency and contradictory outcomes from the studies appear to indicate that the effects of EMF on plants may be dependent on species and/or EMF characteristics such as intensity and duration. While it is difficult to avoid all EMF radiation, certain precautions can be taken to avoid EMF radiation. Determining and avoiding the highest emitting items is crucial for general health [1-9].

The current global production of E-waste is estimated to be 20–25 million tons per year, with most E-waste being produced in Europe, the United States and Australasia. China, Eastern Europe and Latin America will become major E-waste producers in the next ten years. Miniaturization and the development of more efficient cloud computing networks, where computing services are delivered over the internet from remote locations, may offset the increase in E-waste production from global economic growth and the development of pervasive new technologies. E-waste contains valuable metals (Cu, platinum group) as well as potential environmental contaminants, especially Pb, Sb, Hg, Cd, Ni, polybrominateddiphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs) [8-15]. Burning E-waste may generate dioxins. The chemical composition of E-waste changes with the development of new technologies and pressure from environmental organizations on electronics companies to find alternatives to environmentally damaging materials. Most E-waste is disposed in landfills [13-24]. Effective reprocessing technology, which recovers the valuable materials with minimal environmental impact, is expensive. Such reprocessing initially results in extreme localized contamination followed by migration of the contaminants into receiving waters and food chains. E-waste workers suffer negative health effects through skin contact and inhalation, while the wider community is exposed to the contaminants through smoke, dust, drinking water and food. There is evidence that E-waste associated contaminants may be present in some agricultural or manufactured products for export [11-25].

II. E-WASTE

Electronic waste (e-waste) comprises waste electronics/electrical goods that are not fit for their originally intended use or have reached their end of life. This may include items such as computers, servers, mainframes, monitors, CDs, printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, medical apparatus and electronic components besides white goods such as refrigerators and air-conditioners. E-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery [26].

- IT and Telecom equipment like computers, laptops, tablets and the systems used in the BPO call centers.
- Large household appliances like washing machines, microwave ovens, refrigerators, television etc.
- Small household appliances like PC's, mobile phones, MP3 players, I-Pods, Tablets etc.
- Consumer and lighting equipment like bulbs, CFL, fluorescent tube lights. Toys, leisure and sports machines.
- Medical devices like CT scan machine, MRI etc.
- Monitoring and control devices

E-waste is not hazardous. However, the hazardous constituents present in the e-waste render it hazardous when such wastes are dismantled and processed, since it is only at this stage that they pose hazard to health and environment. Electronics and electrical equipment seem efficient and environmentally- friendly, but there are hidden dangers associated with them once these become e-waste. The harmful materials contained in electronics products, coupled with the fast rate at which we're replacing outdated units, pose a real danger to human health if electronics products are not properly processed prior to disposal. Electronics products like computers and cell phones contain a lot of different toxins. For example, cathode ray tubes (CRTs) of computer monitors contain heavy metals such as lead, barium and cadmium, which can be very harmful to health if they enter the water system. These materials can cause damage to the human nervous and respiratory systems. Flame-retardant plastics used in electronics casings, release particles that can damage human endocrine functions. These are the types of things that can happen when unprocessed e-waste is put directly in landfill.

III. ELECTROMAGNETIC WAVE EFFECT

While medical studies correlating EMF with adverse health outcomes have sometimes yielded apparently contradictory results, recent research reported in respected medical journals has uncovered evidence about potential risk. Studies looking at reproductive dysfunction, cancer potential and CNS disorders appear to support previous suspicions that EMF exposure may present a health risk. Basic scientific study of the human body has demonstrated that most physiological functions in living organisms are electrochemical in nature. Living cells are made up of molecules and atoms, which in turn are made up of electrons, neutrons and protons. The intrinsic functioning of these atoms and molecules with homeostasis of cells, tissues and organs is entirely dependent on ordered chemical and electrical activity. Disturbance of intrinsic electrical or chemical processes within cell structures has the potential to disrupt cell functioning, leading to malfunction of organ systems and ultimately to clinical illness [5-17].

Electromagnetic radiation from Cell phone and cell tower affects the birds, animals, plants and environment. When birds are exposed to weak electromagnetic fields, they disorient and fly in all directions, which harm their natural navigational abilities. A large number of birds like pigeons, sparrows, swans are getting lost due to interference from the "unseen enemy" , i.e. mobile phone masts. It has also been noted of late that animals used near mobile towers are prone to various dangers and threats to life including still births, spontaneous abortions, birth deformities, behavioral problems and general decline on overall health. Electromagnetic pollution is a possible cause for deformations and decline of some amphibian populations too. Apart from birds and animals, electromagnetic radiation emanating from cell towers can also affect vegetable, crop and plants in its vicinity. This study aims at studying the possible effects of Electromagnetic Radiations on all the above mentioned living beings.

Preliminary reading in [1], states "The overall evidence suggests that mobile phone usage of less than 10 years does not pose any increased risk of brain tumor. The effect of still longer use is unclear due to non-availability of data. Any conclusion therefore is uncertain and tentative. Available studies suggest that self-reported symptoms are not correlated to an acute exposure to RF (radio frequency) fields, but considering that the studies are carried out over a rather limited duration, it is very difficult to draw any firm conclusions".

Limited information on the effect of EMF on plants is available. Most researchers focus on strategic crop plants leaving a knowledge gap on other species such as wild plants. Considering possible consequences, including economic and ecological impacts, more work is needed to clarify the basics of biological effects by electromagnetic fields. Modern civilization depends heavily on the widespread use of high voltage transmission lines for industrial, agricultural, and domestic purposes. This has enhanced the exposure to the EMF that has adverse biological effects on living organisms. Plants play an important role in the living world as main producers of food and oxygen; therefore, it would be beneficial to examine their relations with today's increased exposure to electromagnetic fields. All living organisms generate and conduct electrochemical impulses all the way through their different tissues and organs. Properties of temperature sensing in plants has been demonstrated experimentally (Plieth, 1999).

The EMF from high power transmission lines affects the growth of plants. Extensive biological, geological, and oceanographicresearches has been carried out to investigate the effects of high voltage fields on the environment (Cherry, 2001; and Demir, 2010). In electrical power transmission engineering high voltage is usually considered as any voltage above 35 KV. The voltage of these magnitudes can affect the plant in one way or the other as the most vital physical signal in any organism is electrical signal. In comparison to chemical signals (e.g. hormones) the electrical signal is able to transmit signals more rapidly over long distances [13-24].

Recently, biologists have revealed that electrical signals are significant in many physiological activities of plants. The electrical signaling in fruit trees in response to water and darkness conditions was studied by Trebacz*et al.*, (2006), Gurovich, and Hermosilla (2009) and Paul *etal.*, (2006). In addition, Desrosiers and Bandurski, (1988) investigated the effect of longitudinally applied voltage on the growth of *Zea Mays* seedlings. Electrical signals are involved in many processes in plants life including respiration, water uptake, and leaves movements (Fromm and Lautner, 2007). Various changes regarding to plant growth parameters such as meristem tic activities, cell differentiation, shoot length, root length, leaf area, specific leaf weight, total biomass content, total water content, chlorophyll, carotenoids, soluble sugar, soluble starch, soluble protein content, biochemical, and antioxidant system has been shown to be affected by environmental electric and magnetic fields (Walter *et al*., 1997; Hanafy*et al*., 2006; and Fromm and Lautner, 2007).
The electric field treatment has also been used to control invasive plants by affecting their tissues. It can be also usedfor allowing and avoiding many undesirable changes in products, pigments, vitamins, and flavoring agents, which are typical for other pre-treatment techniques, including thermal, chemical, and enzymatic ones. Electric field treatment is also capable of microbial inactivation (Vorobiev and Lebovka, 2008). As the resistance of the plant tissue varies considerably from plant to plant, hence, a clear idea of plant tissue electrical properties is essential for the assessment.

The impacts of EMFs on plants is a question being explored since plants are just as readily exposed to low-level magnetic fields as humans as a consequence of power lines and other industrial technology (Martinez *et* al., 2004). It appears that a magnetic field does have an effect on the growth of plants. Belyavskaya (2004) found that weak electromagnetic fields suppressed the growth of plants, reduced cell division, intensified protein synthesis and cause disintegration in plant roots. Conversely, other studies such as those of RamezaniVishki*et al.*, (2012a& b) found an increase in plant growth while other studies like those of Davies (1996) found some seeds increased in growth and others showed no change.

IV. PRE-MANAGEMENT OF ELECTRONICS DEVICES DEVELOPMENT

Electromagnetic compatibility (EMC) is the branch of electrical engineering concerned with the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage in operational equipment.The goal of EMC is the correct operation of different equipment in a common electromagnetic environment.EMC pursues two main classes of issue. Emission is the generation of electromagnetic energy, whether deliberate or accidental, by some source and its release into the environment. EMC studies the unwanted emissions and the countermeasures which may be taken in order to reduce unwanted emissions. The second class, susceptibility is the tendency of electrical equipment, referred to as the victim, to malfunction or break down in the presence of unwanted emissions, which are known as Radio frequency interference (RFI). Immunity is the opposite of susceptibility, being the ability of equipment to function correctly in the presence of RFI, with the discipline of "hardening" equipment being known equally as susceptibility or immunity. A third class studied is coupling, which is the mechanism by which emitted interference reaches the victim.
Interference mitigation and hence electromagnetic compatibility may be achieved by addressing any or all of these issues, i.e., quieting the sources of interference, inhibiting coupling paths and/or hardening the potential victims. In practice, many of the engineering techniques used, such as grounding and shielding, apply to all three issues.
While electromagnetic interference (EMI) is a *phenomenon* - the radiation emitted and its effects - electromagnetic compatibility (EMC) is an equipment *characteristic* or *property*- not to behave unacceptably in the EMI environment.

EMC ensures the correct operation, in the same electromagnetic environment, of different equipment items which use or respond to electromagnetic phenomena, and the avoidance of any interference effects. Another way of saying this is that EMC is the control of EMI so that unwanted effects are prevented.

Besides understanding the phenomena in themselves, EMC also addresses the countermeasures, such as control regimes, design and measurement, which should be taken in order to prevent emissions from causing any adverse effect.
The damaging effects of electromagnetic interference pose unacceptable risks in many areas of technology, and it is necessary to control such interference and reduce the risks to acceptable levels.

The control of electromagnetic interference (EMI) and assurance of EMC comprises a series of related disciplines:

- Characterising the threat.
- Setting standards for emission and susceptibility levels.
- Design for standards compliance.
- Testing for standards compliance.

For a complex or novel piece of equipment, this may require the production of a dedicated *EMC control plan* summarizing the application of the above and specifying additional documents required.

Characterisation of the problem requires understanding of:

- The interference source and signal.
- The coupling path to the victim.
- The nature of the victim both electrically and in terms of the significance of malfunction.

The risk posed by the threat is usually statistical in nature, so much of the work in threat characterization and standards setting is based on reducing the probability of disruptive EMI to an acceptable level, rather than its assured elimination. Figure 1 shows the radiation due to EM waves affecting the victim.

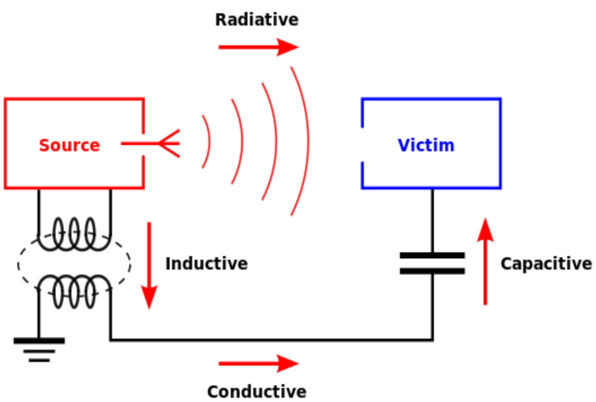

Fig 1: Electromagnetic radiation affecting the victim

V. Post-Management for E-Waste Utilization

E-waste recycling involves the disassembly and destruction of the equipment to recover new materials (Cui and Zhang, 2008). Recycling can recover 95% of the useful materials from a computer and 45% of materials from cathode ray tube monitors (Ladou and Lovegrove, 2008). In rich countries, such as Japan, high tech recycling operations function well with little environmental impact (Aizawa et al., 2008). Modern techniques can recover high-Pb glass from discarded CRT with minimal environmental impact (Andreola et al., 2007). Any ecological benefits of recycling are more than offset if the waste has to be transported long distances due to the negative environmental effects of fossil fuel combustion (Barba-Gutierrez et al., 2008). However, recycling always has a lower ecological impact than landfilling of incinerated E-waste (Hischier et al., 2005). Mechanical separation of components is the first step in E-waste recycling. Components may be separated for reuse or metallurgical processing (He et al., 2006). This process can be automated or carried out by hand. In poor countries, there is a risk that children may be employed to separate E-waste components (Ladou and Lovegrove, 2008). An open flame is often used to free components (Manomaivibool, 2009), which may result in exposure to volatilized contaminants. Valuable metals may be recovered from E-waste by pyro- hydro- and bio-metallurgical processes (Cui and Zhang, 2008). Pyro metallurgical processing includes incineration of the matrix and smelting of the target metals. The efficacy of this process depends on investment. Shoddy operations have the potential to emit dangerous compounds into the environment. Copper is a catalyst for dioxin formation when flame retardants are incinerated, in particular the low-temperature incineration of brominated flame retardants (Cui and Zhang, 2008). Hydrometallurgical processes involve the dissolution and recovery of the target metals with acids, cyanide, halides, thiourea or thiosulphate.

Soils from a site where acid leaching was used to recover valuable metals, contained up to 4250 ng /g PBDEs (Leung et al., 2007). There are elevated concentrations of PCBs, PAHs (Shen et al., 2009a) and PBDEs (Cai and Jiang, 2006) in Chinese agricultural soils proximal to E-waste reprocessing sites. Luo et al. (2009b) reported PBDE concentrations of 191 to 9156 ng /g (dry weight) in farmland soils 2 km from an E-waste recycling workshop. Soils from this region also contain poly chlronateddibenzo-p-dioxins and dibenzofurans (PCDD/Fs), PCBs and PAHs at concentrations up to 100, 330 and 20,000 ng/g, respectively (Shen et al., 2009b).

Liu et al. (2008) reported elevated concentrations of PBDEs and PCBs in soils, plants and snails from the town of Guiyu and the surrounding areas. PBDEs are translocated from soils to plants. Leaves of bracken fern (Pteridiumaquilinum L.), spider fern (PterismultifidaPoir.), sorghum (Sorghum bicolour L.), Japanese dock (Rumexjaponicas Houtt.) and Eastern daisy fleabane (Erigeron annuus L.) contained PBDEs at concentrations of 144, 116, 162, 278 and 326 ng/g (dry matter), respectively, when growing in soil containing 25,479 ng/g PBDE (Yang et al., 2008). Although the bioaccumulation coefficients are small (<0.01) plant uptake may facilitate the entry of these contaminants into food chains.

Soils at an E-waste recycling slum in Bangalore contained up to 39 mg/kg Cd, 4.6 mg/kg In, 957 mg/kg Sn, 180 mg/kg Sb 49 mg/kg Hg, 2850 mg/kg Pb, and 2.7 mg/kg Bi (Ha et al., 2009). These concentrations are some one-hundredfold higher than those found at a nearby control site in the same city.

Analysis of rice samples from another E-waste processing town in Eastern China, Taizhou (Zhejiang province) revealed concentrations of Pb and Cd in polished rice to be 2–4 times in excess of 0.2 mg/kg, the maximum allowable concentrations of these elements in foodstuffs in China (Fu et al., 2008). In the same town, Liang et al. (2008) measured elevated levels (up to 18 ng/g) of PBDEs in chicken tissues and concluded that these toxins may pose a threat to humans and ecosystems. Rice paddy soils adjacent to E-waste recycling areas in the Zhejiang province were shown to reduce the germination rate of rice (Zhang and Min, 2009). A micronuclei assay using Viciafabia indicated that the contaminants in these soils also promote DNA damage.

E-waste contaminants can enter aquatic systems via leaching from dumpsites where processed or unprocessed E-waste may have been deposited. Similarly, the disposal of acid following hydrometallurgical processes into waters or onto soils, as well as the dissolution or settling of airborne contaminants, can also result in the contamination of aquatic systems. Luo et al. (2007b) reported that carp from the Nanyangriver, near Guiyu, were bioaccumulatingPBDEs to concentrations of up to 766 ng/g (fresh weight). Unsurprisingly, the same authors (Luo et al., 2007a) reported elevated PBDE concentrations in the sediments (up to 16,000 ng/g) of the same river. In an aquatic ecosystem near an E-waste recycling plant, Wu et al. (2008) reported that the water snake, the top predator, had on average 16,512 ng/g PCBs and 1091 ng/g PBDEs on a wet weight basis. Mud carp, crucian carp and prawns from the same area also had elevated concentrations of these contaminants. The ambient water contained just 204 ng/L
PCBs. Waterfowl from downstream areas in the Pearl River Delta also contained elevated PCB and PBDEs (Luo et al., 2009a). Brominated flame retardants other than PBDE, namely 1,2-bis(2,4,6-tribromophenoxy) ethane, decabromodiphenyl ethane and tetrabromobisphenol A bis (2,3-dibromopropyl) ether, are widespread in various biota of the Pearl River Delta, downstream from E-waste recycling towns (Shi et al., 2009).

Wang and Guo (2006) found up to 0.4 mg/L Pb in river water downstream of a recycling plant in Guiyu, some 8 times higher than the local drinking water standard (0.05 mg/L). Similarly, Wong et al. (2007) reported elevated concentrations of Ag, Cr, Li, Mo, Sb and Se in the nearby Lianjiangriver.
Many E-waste contaminants are spread into the air via dust. This is a major exposure pathway for humans through ingestion, inhalation and skin absorption (Mielke and Reagan, 1998). Air samples taken near Guiyu contained polychlorodibenzo-p-dioxins between 65 and 2765 pg/m3, the highest level of atmospheric dioxins ever reported (Liet al., 2007).

Combustion of E-waste containing flame retardants has resulted in concentrations of total PBDEs of up to 16,575 pg/m3 in aerial samples near Guiyu, some 300 times higher than in nearby Hong Kong (Deng et al., 2007). Aerial contamination of PBDEs in the city of Guiyu exceeds 11,000 pg/m3 during the daytime, dropping to under 5000 pg/m3 at night (Chen et al., 2009a). Similarly, high aerial concentrations of particulate PAHs, Cr, Cu and Zn have also been reported (Deng et al., 2006).

A set of interrelated and mutually supportive strategies are proposed to support the concrete implementation of the activities as indicated in the website (www.basel.int/DraftstrateKJcpian4Seot.pdf) is described below:

1. To involve experts in designing communication tools for creating awareness at the highest level to promote the aims of the Basel Declaration on environmentally sound management and the ratification and implementation of the Basel Convention, its amendments and protocol with the emphasis on the short-term activities.
2. To engage and stimulate a group of interested parties to assist the secretariat in exploring fund raising strategies including the preparation of projects and in making full use of expertise in non-governmental organizations and other institutions in joint projects.
3. To motivate selective partners among various stakeholders to bring added value to making progress in the short-term.
4. To disseminate and make information easily accessible through the internet and other electronic and printed materials on the transfer of know-how, in particular through Basel Convention Regional Centers (BCRCs).
5. To undertake periodic review of activities in relation to the agreed indicators;
6. To collaborate with existing institutions and programmes to promote better use of cleaner technology and its transfer, methodology, economic instruments or policy to facilitate or support capacity-building for the environmentally sound management of hazardous and other wastes.

The Basel Convention brought about a respite to the transboundary movement of hazardous waste. India and other countries have ratified the convention. However United States (US) is not a party to the ban and is responsible for disposing hazardous waste, such as, e-waste to Asian countries even today. Developed countries such as US should enforce stricter legislations in their own country for the prevention of this horrifying act.

Industry Responsibility and Role

1. Generators of wastes should take responsibility to determine the output of wastes and if hazardous, should provide management options.
2. All personnel involved in handling e-waste in industries including those at the policy, management, control and operational levels, should be properly qualified and trained.
3. Companies can and should adopt waste minimization techniques, which will make a significant reduction in the quantity of e-waste generated and thereby lessening the impact on the environment. Earth will be mined for raw materials, and groundwater will be protected.
4. Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products.
5. Manufacturers of computer monitors, television sets and other electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products.

Citizen Responsibilities

Waste prevention is perhaps more preferred to any other waste management option including recycling. But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford.

E-wastes should never be disposed with garbage and other household wastes. NGOs should adopt a participatory approach in management of e-wastes.

VI. CONCLUSION

E-waste is omnipresent. Contamination associated with E-waste has already caused considerable environmental degradation in poor countries and negatively affected the health of the people who live there. Cleansing of such sites is unfeasible, many of which are poorly studied. However, the negative effects of the contaminants at these sites may be reduced using standard remediation technologies. There is limited knowledge on the ecological effects, human health risks and remediation options for some E-waste contaminants. They are not normally environmental pollutants. Rich countries have self-interest in mitigating the negative environmental effects of E-waste because it will negatively affect the quality and quantity of food and manufacturedgoods that are imported from poor countries.Electronic equipment and therefore e-waste are everywhere in our society. 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. E-waste separation from the rest of 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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