Vol 2 Issue 11 May 2013

Impact Factor : 0.1870

ISSN No :2231-5063

Monthly Multidisciplinary Research Journal

GoldenResearch Thoughts

IMPACT FACTOR : 0.2105

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RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

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Golden Research Thoughts
Volume 2, Issue. 11, May. 2013
ISSN:-2231-5063
Available online at www.aygrt.isrj.net

ORIGINAL ARTICLE

WEEE WASTE: AN EMERGING ENVIRONMENTAL THREAT

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Abstract:

Waste electrical and electronic equipments (WEEE) waste is one of the most hazardous and fast growing waste. The WEEE/ E-waste crisis has reached epic proportions due of two primary characteristics: E-waste is hazardous and E-waste contains over 1000 different substances many of which are toxic and create serious environmental pollution problems upon disposal. One of the sources of e-waste is condensers, cooling units' insulation wires, older floppy and transmitters which on disposal leaches out certain toxic chemicals which reaches water bodies. They exert toxicity on fauna and flora. Mostly the fish community gets affected, gets bio-accumulated in their tissues and ultimately leads to bio-magnification. They cause cancer and affect the reproductive system of fish. In the process gradually the fish population will decrease and ultimately perish if it is not controlled. The e-waste compounds may also cause mutagenicity in plants and humans. E-waste/ WEEE waste can be managed by following few methods: Incineration/ Pyrolysis, Recycle/ reuse/ recovery facility, Secure landfills. Recycling and reuse of the waste helps in reduction of the volume of waste for disposal. Resource recovery is a method to turn wastes into resources by recovering usable products both materials (like metals) and energy.

KEYWORDS:

E-waste,electronic equipment, Toxic, pyrolysis, recycling

INTRODUCTION

Beneath the glitz of the benefits and the wealth created by the information technology revolution looms a dark reality.Waste electrical and electronic equipments (WEEE) waste is one of the most hazardous and fast growing waste. Resource consumption and waste generation are escalating at alarming rates by the day.The electronics and electrical industry is the world's largest and fastest growing manufacturing 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 the industrialized modern world.

The growing quantity of WEEE/ E-waste is beginning to reach disastrous proportion and industrialized countries all over the world are now beginning to grapple with this enormous problem. After initially taking this problem very casually, governments/ enforcement authorities have been forced to respond, as E waste / WEEE 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 the lead, mercury, beryllium, cadmium, copper, chromium, arsenic, selenium and brominated flame retardants that pose both an occupational and environmental health problems. But to date, industry, government and

Title : WEEE WASTE: AN EMERGING ENVIRONMENTAL THREAT Source:Golden Research Thoughts [2231-5063] SANJEEV SATYANARAYAN AND AHANA SATYANARAYANI yr:2013 vol:2 iss:11

consumers have only taken small steps to mitigate this problem.

United Nations Environmental Programme (UNEP) has predicted that by the year 2020, E waste/ WEEE waste problem would grow by 400% due to computer waste only (UNEP Report). Another report says that computer waste will increase by 500% in India alone (Hitavada). In developing countries E-waste generation ranges from 0.01% to 1.0% of the total municipal solid waste generation in countries like India and China (UNEP Report).

As the population grows there is a corresponding increase in per capita generation of waste which is less than 1.0 kg at present.

COMPONENTS OF WEEE/ E-WASTE

Electronic waste encompasses a broad and growing range of electrical, electronic devices ranging from large household appliances such as refrigerators, air conditioners, handheld cellular phones, induction burners, personal stereos and consumer electronics to computers. The WEEE/ E-waste crisis has reached epic proportions due of two primary characteristics: E-waste is hazardous and E-waste contains over 1000 different substances many of which are toxic and create serious environmental pollution problems upon disposal. A concise list of the important pollutants is given below:

Category	Metals	Quantity
1. Non ferrous metals	Copper, aluminum	13%
2. Precious metals	Gold, silver, platinum, palladium	Very insignificant quantity
3. Toxic metals	Lead, mercury, chromium, cadmium, selenium	
4. Plastic	--	21.0%
5. Iron and steel	--	50.0%
6. Other insignificant materials viz. glass, wood, circuit board, ceramic, cement, rubber, leather, chemicals like polychlorinated biphenyl	--	16%

Source: UNEP Report

Sources of E-waste generated

E-waste is generated in enormous rates due to obsolescence which produces much higher volumes of waste in comparison to other consumer goods. As new modified versions invade the market, the consumer is tempted to dispose the old for the new. Consumer prefers to exchange the existing model with a new purchase rather than repairing the old version. This is probably easier for the consumers.Early model computers had a usage span of four to five years but now the life span has shrunk to less than two years.Part of this obsolescence is the result of a rapidly evolving technology.

The major PCB usedcurrently is as a dielectric in the electrical equipment servicing industries with large electrical power distribution and consumption where they continue to pose potential threat to the environment in the event of its release.This situation is particularly encountered in the mining industry because mines generally penetrate the water table. When PCBis spilled or PCB equipment is discarded / abandoned underground, the PCBs can be expected to leach in to the groundwater with no source to recover

it (Bench, 2003).

The human epidemiology and animal toxicity of PCB exposure have been reported and reviewed (Cordle et al. 1982).

QUANTUM OF E-WASTE

In 1998 about 20 million computers became obsolete in USA. In 2007 E-waste generation was quoted at 330,000 MT and apart from this illegal import of 50,000 MT has also been reported (MPCB Report, 2011) Manufacturers Association of Information Technology has estimated that in 2011 E-waste in India would touch an alarming volume of 470,000 MT. Out of this total quantity 10,000 MT of e-waste generated gets ultimately processed by the conventional recycling centres (Creagh, 2012).

European studies estimate that the volume of e-waste is on an increase by 3% to 5% per year, which is almost three times faster than the municipal solid waste stream. In Europe electronic waste comprises more than 5% of all municipal solid wastes.

INDIAN SCENARIO OF E-WASTE

There is no accepted definition of e-waste in India. Broadly e-waste has been defined as a waste item from relatively expensive and essentially durable products, used for data processing, telecommunication or entertainment in private households and businesses including computers, printers, fax machines, telephones, microwave ovens, television sets, radios, VCRs, DVDs, CD players etc.

The electronic industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. Mobile phones and TV sets have reached every corner of the country. The IT industry is the prime mover with an annual growth rate of 42.4% between 1998 and 2000. By the end of 2000 India had an installed base of 5 million personal computers (PCs). As per IT industry's estimates about 1.65 million PCs were sold in the year 2001-2002. (SatyanarayanSatyanarayan, 2009).

Electronic video games have become a craze among the youth and adults equally. The increased demand for the electronic gadgets is leading to generation of e-waste and poses environmental pollution problems.This growth has significant economic and social impacts. The growing rate of electronic products consumption and higher obsolescence rate leads to higher generation of electronic waste (e-waste). This added to the huge imports of junk electronics from other countries, is making it more complex for solid waste management in India.

Environmental and Health Impacts of WEEE/ E-waste

Forthe layman, it may seem like broken, dismantled and discarded pieces of electronic waste but in reality they are extremely toxic and hazardous in nature. Table 1 shows the health hazards due to E-waste/ WEEE waste.

Table 1: Health Hazards

Components	E-waste product	Threshold limit	Adverse Effects
Beryllium	Phones, computers	0.1%	May cause cancer due to inhalation
Cadmium	Paints on toys	0.1%	Carcinogenic, harmful for aquatic organisms.
Copper-beryllium alloys	Toys and household appliances	0.1%	Toxic, can cause suffocation
Lead	Electronic circuits and toys	NA	Harms the DNA, can cause genetic mutation
Mercury	Battery and plastic components	25%	Causes poisoning, harms nerve system

Source: Times of India Report by Viju, 2012

One of the sources of e-waste is condensers and transmitters which on disposal leaches out polychlorinated biphenyl and reaches water bodies. They exert toxicity on fauna and flora. Mostly the fish community gets affected, gets bio-accumulated in their tissues (Bagade, 2012) and ultimately leads to bio-magnification. They cause cancer and affect the reproductive system of fish. In the process gradually the fish population will decrease and ultimately perish if it is not controlled. Likewisepolybrominated biphenyls and polybrominateddiphenyl ethers which form a constituent of insulation wires are also very toxic and leads to chronic toxicity when burnt. Chlorofluorocarbons from cooling units are being now replaced as it is well known fact that they lead to global warming. Older floppy discs on disposal, are acutely toxic and causes allergic reactions (Satyanarayan and Satyanarayan, 2008).

Numerous toxic metals are released during incineration and during recycling which are toxic to the workers involved in this process. They suffer from chronic allergies, ulcers on the hands, lung infections; long term exposure can cause cancer. (Nordic Report, 1995).

Some WEEE is hazardous to the environment if present in considerable quantities. Some substances in WEEE are in miniscule quantity but they can be extremely toxic and can create chronic toxicity and lead to bioaccumulation. Moreover the toxic substances present in thee-waste may persist in nature for many years particularly polychlorinated biphenyls and its related halogenated compounds. The e-waste compounds may cause mutagenicity in plants and humans. In many water bodies mass fish kills have been reported, which may be due to PCB leaching from discarded batteries from automobile emissions and pigment manufacturing.

Many toxic heavy metals both ferrous and non-ferrous including precious metals leach into ground water causepollution.These heavy metals are known to occur in both free and combined forms. Heavy metals pollution can induce two major effects in the ecosystem i.e. they get bioaccumulated in the tissues of aquatic/ terrestrial animals and get biomagnified in other organisms which are predators. Metals have been shown to cause mortality (Patrick et al. 1996) and reduce fertility. Organically bound metals are less toxic than free form of metals. According to Steeman and Anderson (1970) the ionic form of copper is far more toxic to aquatic organisms than the complex copper.

Metal toxicity ultimately reaches higher trophic levels and humans are affected. Leukemia and general in cancer are common due to e-waste. Heavy metal like arsenic makes a man completely ulcerated and life becomes hell.

E-WASTE MANAGEMENT

First and foremost the E-waste/ WEEE waste needs segregation before its management. Based on the severity of toxic content, recyclable nature, complete disposal nature etc. the waste needs segregation. E-waste/ WEEE waste can be managed by following few methods:

1)Incineration/ Pyrolysis
2)Recycle/ reuse/ recovery facility
3)Secure landfills

Incineration means burning which is carried out in furnaces. This method is followed when dumping sites are very limited. In this combustible are segregated and incinerated. Incineration also leads to emission of toxic gases and need pollution control devices.

Pyrolysis: The chemical constituents and chemical energy of some part of e-waste can be recovered by destructive distillation (Pyrolysis) of the solid waste. In this process the combustible constituents of the waste fraction are heated in a special reactor like known as a pyrolysis reactor at 60 – 1000oC in low oxygen or no oxygen environment. This is an endothermic process and thus differs from the conventional incineration.

Pyrolysis yields tar, oil, melted metals and some organic solvents. Gases products available include CH4, CO, CO2 and H2. This process is preferred because it reduces the volume of waste by 90% and is comparatively safe in nature. This method is pollution free.

Secure Land filling: The practice of disposing some detoxified hazardous waste under carefully controlled conditions is disposed on land. This land or secure landfills are meant to accept and retain concentrated waste for indefinite period of time.

The secure landfills are the ultimate repository for all non-degradable and hazardous wastes and it should be considered as the last option when all other techniques for the e-waste management fail. But this technique is very cost intensive, needs large land area and where water table is below 1.5 meters below the bottom of the landfill site (Dara, 2001).

RECYCLING/ REUSE

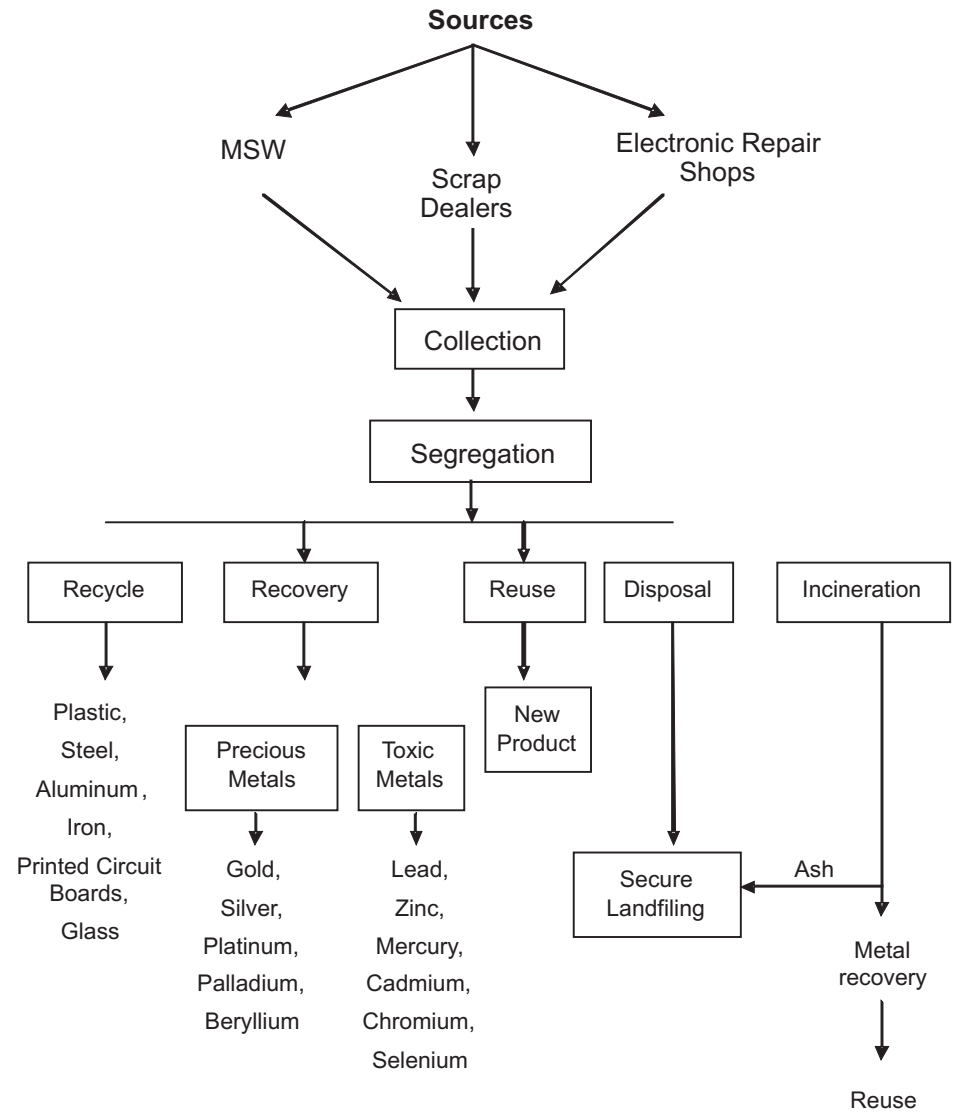
This technique is generally used for the printed circuit boards. Around 60 million printed circuit boards are produced around the world each year. Each circuit board has a metal content up to 30% by weight. The metals present in the majority of cases are gold, silver, copper, tin, lead etc. Many of the processes used to recover non-precious metals are based on mechanical, pyrometallurgical and hydrometallurgical techniques in which the value of electronic components 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 (Satyanarayan and Satyanarayan, 2009).

Recycling and reuse of the waste helps in reduction of the volume of waste for disposal. Resource recovery is a method to turn wastes into resources by recovering usable products both materials (like metals) and energy.

CONCLUSIONS

E-waste/ WEEE waste posses a great environmental problem in developing countries. Most suitable management system for this waste is recycling, recovery and reuse. Apart from these 'R' one more important R is reduce/ reduction methods using cleaner technologies.

Some new technologies have to be looked into to curtail this mounting problem.



General Schematics of E-waste/ WEEE Waste Management

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