E-WASTE GENERATION AND ITS UTILISATION

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Abstract: - The problem of E-waste has forced Environmental agencies of many countries to innovate, develop and adopt environmentally sound options and strategies for E-waste management, with a view to mitigate and control the ever growing threat of E-waste to the environment and human health. E-waste management is given the top priority in many developed countries, but in rapid developing countries like India, it is difficult to completely adopt or replicate the E-waste management system in developed countries due to many country specific issues viz. socio-economic conditions, lack of infrastructure, absence of appropriate legislations for E-waste, approach and commitments of the concerned etc. E-waste is the popular name for discarded electrical and electronic equipment with all of their peripherals at the end of their life. E-waste comprises of wastes generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. Such wastes encompasses wide range of electrical and electronic devices such as computers, hand held cellular phones, personal stereos, including large household appliances such as refrigerators, air conditioners etc. The major portion of the e-waste generated domestically as well as illegally imported are recycled in crude manner leading to pollution of the environment. Lack of legislation in our country at present is aiding this hazardous form of recycling. Therefore there is urgent need to frame and implement rules for regulating this waste and to find environmentally sound, economically viable methods for recycling and disposing of this necessary evil. In this study it is mainly discussed the means of generation of E-waste and various method to utilise it in civil construction works to reduce the hazardous environmental conditions arising due to it. The methods include utilisation of E-waste as fine aggregates, coarse aggregates, fibres, pavement construction etc. The range for effective usage of E-waste in concrete is being studied and discussed

***KYEWORDS-* Electronic waste, generation, recycling, OEMs,**

I. INTRODUCTION

The electronic industry is the world's largest and fastest growing manufacturing industry in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" of electrical and electronic goods make electrical and electronic waste (e-waste) one of the fastest growing waste streams. E-waste is valuable source for secondary raw material but harmful if treated and discarded improperly as it contains many toxic components such as lead, cadmium, mercury, polychlorinated biphenyl's etc. (Bandyopadhyay, 2010). In United States alone 1,30,000 computers and 3,00,000 cell phones are trashed each day (Anderson, 2010). The developed countries use most of the world's electronic products and generate most of the E-waste (Basel Action Network, 2002). Rather than treat e-waste in an environmentally friendly manner, the developed countries are finding an easy way out of the problem by exporting these wastes to developing economies especially, South Asian countries.

"Exporting E-waste to Asia worked out 10 times cheaper than processing it in within these countries"

Much of the 40 million tonnes of E-waste produced around the world [old phones, TV's, laptops, obsolete kitchen appliances] finds its illegal ways to Asia and Africa every year, says a report by UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). Illegal trade has driven by relatively low costs of shipments and high cost of treatment in developed countries. Hence exporting E- waste to Asia has worked out 10 times cheaper than processing it within the countries.

A. MAJOR SOURCES

•Individuals and Small Businesses: The useful span of a computer has come down to about two years due to improved versions being launched about every 18 months. Often, new software is incompatible or insufficient with older hardware so that customers are forced to buy new computers.

•Large corporations, Institutions and Government: Large users upgrade employee computers regularly.

•Original Equipment Manufacturers (OEMs): OEMs generate e-waste when units coming off the production line do not meet quality standards, and must be disposed of. Some of the computer manufacturers contract with recycling companies to handle their electronic waste, which often is exported. Besides computers, other major e-waste source is the cellular phone.

II. SCENARIO IN INDIA

In developing country like India E-waste management is being reckoned as a challenging task due to unplanned discarding of E-waste along with municipal solid waste. A "systematic & scientific" trade chain of E-waste is essential to manage the present scenario both in terms of environmental protection and health perspective. The prevalence of informal E-waste handling in India has put forward several issues of concern (metals, plastic, informal recycling) that need to be addressed to protect environment and human health. One of the important aspects of current informal handling of E-waste is its recycling to minimize exposure level. However, it needs skillful protocol (formal handling) to ensure the implementation of policy. Legal frame work is another essential part that will also help in E-waste management even in grass root level. A comprehensive E-waste management plan is also needed to improve disposal practice (recycling, landfill, and reuse) to reduce the magnitude of exposure notably toxic metals and flame retardants. A multistage approach has been recommended as per policy guideline for the trade chain practitioner which will provide benefits to control exposure as well as environmental risk.

Sixty-five cities in India generate more than 60% of the total e-waste generated in India. Ten states generate 70% of the total e-waste generated 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 in India. E-waste generation in top ten cities in India.

Table.1

CITY	TONNES PER YEAR
MUMBAI	11017.1
DELHI	9790.3
BANGALORE	4648.4
CHENNAI	4132.2
KOLKATA	4025.3
AHMEDABAD	3287.5
HYDERABAD	2833.5
PUNE	2584.2
SURAT	1836.5
NAGPUR	1768.9

III. CLASSIFICATION OF E-WASTE

E-waste has been categorized into three main categories, viz. large household appliances, IT and Telecom and consumer equipment. Refrigerator and washing machine represent large household appliances, personal computer monitor and laptop represent IT and Telecom, while television represents consumer equipment.

A. HEALTH EFFECTS OF SOME COMMON CONSTITUENTS IN E-WASTE

The health effects of heavy metals and certain compounds found commonly in components of e-waste are described below:

- Lead: Lead is used in glass panels and gaskets in computer monitors and in solder in printed circuit boards and other components. Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive system in humans. It also affects the endocrine system, and impedes brain development among children. Lead tends to accumulate in the environment and has high acute and chronic effects on plants, animals and micro-organisms (Metcalf & Eddy, 2003)**.**
- Cadmium: Cadmium occurs in surface mounted device (SMD) chip resistors, infra-red detectors, and semiconductor chips. Some older cathode ray tubes contain cadmium. Toxic cadmium compounds accumulate in the human body, especially the liver, kidneys pancreas, thyroid (Metcalf & Eddy, 2003, Basel Action Network, 2002)**.**
- Mercury**:** It is estimated that 22 % of the yearly world consumption of mercury is used in electrical and electronic equipment. Mercury is used in thermostats, sensors, relays, switches, medical equipment, lamps, and mobile phones and in batteries. Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes. Mercury can cause damage to central nervous system as well as the foetus. The developing foetus is highly vulnerable to mercury exposure (Metcalf & Eddy, 2003). When inorganic mercury spreads out in the water, it is transformed to methylated mercury which bio-accumulates in living organisms and concentrates through the food chain, particularly via fish (Basel Action Network, 2002).
- Hexavalent Chromium/Chromium VI: Chromium VI is used as corrosion protector of untreated and galvanized steel plates and as a decorative or hardener for steel housings. Chromium VI can cause damage to DNA and is extremely toxic in the environment. Long term effects are skin sensitization and kidney damage (Metcalf & Eddy, 2003).

- Plastics (including PVC)**:** The largest volume of plastics (26%) used in electronics has been poly vinyl chloride (PVC). PVC elements are found in cabling and computer housings. Many computer mouldings are now made with the somewhat more benign acrylonitrile butadiene (ABS) plastic. Dioxins are released when PVC is burned (Basel Action Network, 2002)
- Brominated Flame Retardants (BFRs): BFRs are used in the plastic housings of electronic equipment and in circuit boards to prevent flammability. BFRs are persistent in the atmosphere and show bioaccumulation. Concerns are raised considering their potential to toxicity (Basel Action Network, 2002).
- Barium: Barium is a soft silvery-white metal that is used protect users from radiation. Studies have shown that short-term exposure to barium causes brain swelling, muscle weakness, damage to the heart, liver, and spleen (Basel Action Network, 2002).
- Beryllium: Beryllium is commonly found on motherboards and finger clips. Exposure to beryllium can cause lung cancer. Beryllium also causes a skin disease that is characterized by poor wound healing and wart like bumps. Studies have shown that people can develop beryllium disease many years following the last exposure. It is used as a copper-beryllium alloy to strengthen connectors. Barium is a soft silvery-white metal that is used to protect users from radiation.
- Phosphor and additives Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate. Phosphor affects the display resolution and luminance of the images that is seen in the monitor. The phosphor coating on cathode ray tubes contains heavy metals, such as cadmium, and other rare earth metals, for example, zinc, vanadium as additives. These metals and their compounds are very toxic. This is a serious hazard posed for those who dismantle CRTs by hand.

III. LITERATURE REVIEW

(1) Chen et al (2006) demonstrated that use of E-glass waste in concrete as fine aggregate replacement. The compressive strength of specimen with 40% E-waste glass is 17%, 27% and 43% higher than control concrete at the ages of 28, 91 and 365 days. The E-waste particles act as crack resistors in concrete.

(2) Laxmi Nagan (2012) did an experimental study is made on the utilization of E-waste particles as coarse aggregates in concrete with a percentage replacement ranging from 0 % to 30% on the strength criteria of M20 Concrete. Compressive strength, Tensile strength and Flexural strength of Concrete with and without E-waste as aggregates was observed which exhibits a good strength gain. She concluded that he compressive strength and split tensile strength of concrete containing e plastic aggregate is retained more or less in comparison with controlled concrete specimens. However strength noticeably decreased when the e plastic content was more than 20%. It was also observed that concrete with fly ash gave better results for 25% replacement rather than in conventional concrete.

(3) Tung Chai Ling (2011) assessed the feasibility of utilizing CRT glass as a substitute for natural aggregates in cement mortar. The CRT glass investigated was an acid-washed funnel glass of dismantled CRT from computer monitors and old TV sets. The mechanical properties of mortar mixes containing 0%, 25%, 50%, 75% and 100% of CRT glass were investigated. The results obtained were as like incorporating CRT glass increased the workability (flow table value) but reduced the water absorption and drying shrinkage values. These were mainly attributed to the lower water absorption capability of CRT glass than that of sand. The hardened density increased with increasing CRT glass content because of its higher specific gravity compared to that of sand. Inclusion of CRT glass in the mortar caused a reduction in both flexural and compressive strengths. The reduction was due to the loss of bonding strength between the smooth surface of CRT glass and cement paste. The overall test results of this study have demonstrated that it may be feasible to utilize CRT glass as fine aggregates in the production of cement mortar. However, further studies are needed to ascertain the complete safeness regarding the use of CRT glass in cement mortar before it can be introduced to the construction industry.

(4) Baron W. Colbert (2012) carried out a study to investigate utilization of plastic from E-waste into asphalt roads. This research investigation utilized two approaches for incorporating electronic waste plastics into asphalt pavement materials. The first approach was blending and integrating recycled and processed electronic waste powders directly into asphalt mixtures and binders; and the second approach was to chemically treat recycled and processed electronic waste powders with hydro-peroxide before blending into asphalt mixtures and binders. The chemical treatment of electronic waste (e-waste) powders was intended to strengthen molecular bonding between e-waste plastics and asphalt binders for improved low and high temperature performance. Electronic waste plastic powders and particles were successfully blended within asphalt binders and mixtures as a modification agent. Compared with conventional asphalt binders and mixtures electronic waste modified asphalt binders and mixtures exhibited promise towards improving asphalt pavement material performance.

(5) Iftekar Gull (2014) reported E- plastic waste can be used in the form of fibers in the concrete. His research paper seeks to optimize the benefits of using E Plastic Waste in the fiber form in concrete. The E Plastic waste (insulation wires) is shredded into fibers of specific size and shape. Several design concrete mixes with different percentages of waste plastic fibers for three aspect ratios, are casted into desire shape and size as per requirement of the tests. Each specimen was cured for 7, 14 and 28 days. The workability, compression, split tension and flexure strength tests were carried out. The results are compared with control concrete. The improvement in mechanical properties of concrete was observed. He concluded that with use of 4cm to 5cm of fibers, there can be increase in overall hardened properties by around 5-10%

(6) P. Gomathi (2014) examined the possibility of reusing the non-metallic portions of E-waste in concrete to increase its mechanical properties. Compressive strength test result shows concrete containing E-fiber exhibits a good strength gain than the control mix concrete.

(7) Prasanna and Rao (2014) investigated the use of E-waste in concrete as partial replacement of concrete. The strength loss was 33.7% when 20% of E-waste is used to replace coarse aggregate, it is reduced by 16.86% when coarse aggregate is replaced by 20 % of E- waste plus 10% Fly ash.

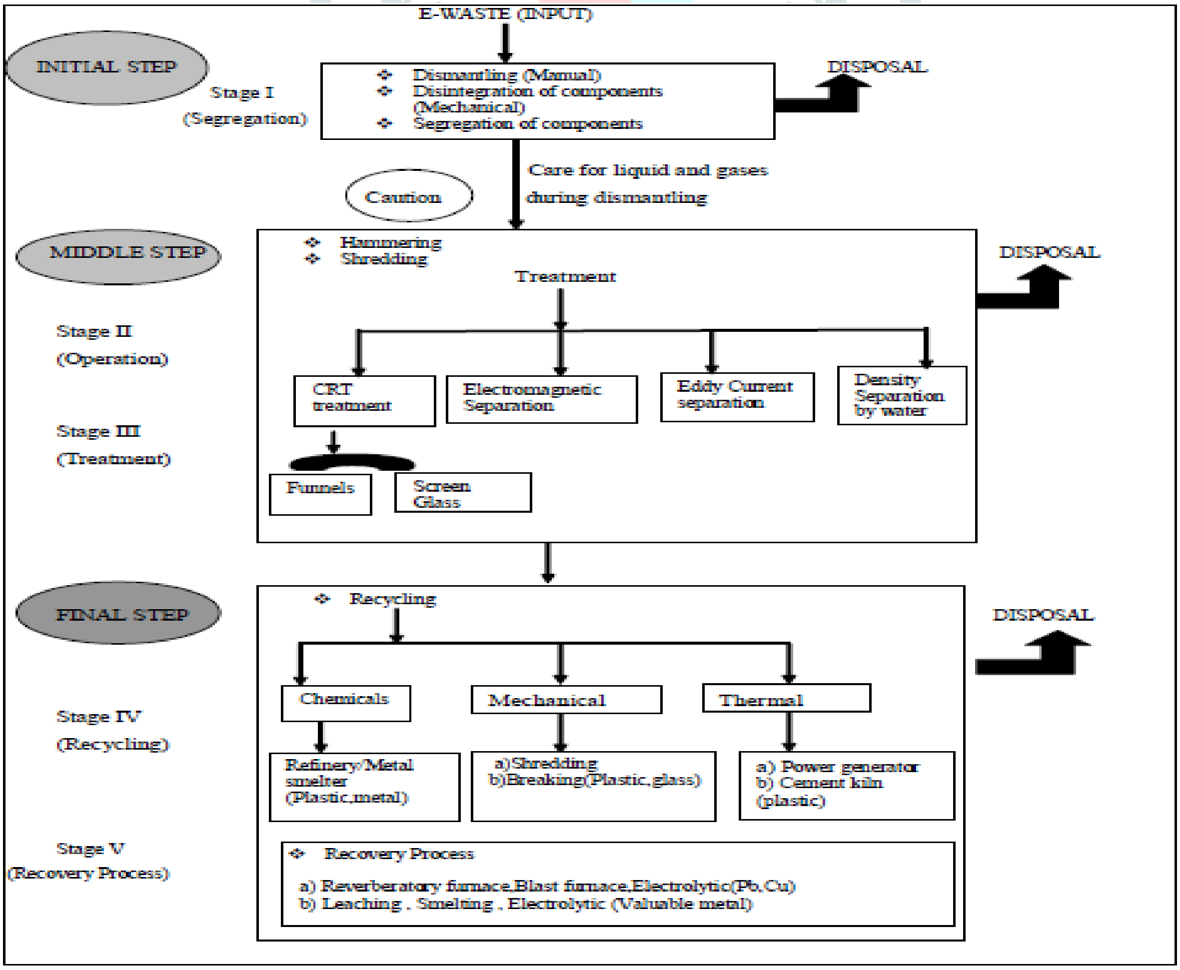
(8) Nagajothi and Felixkala (2014) reported that utilising E-fiber waste as additive in concrete till 2.5% resulted in almost twice compressive strength as compared to control mix. The compressive strength increased constantly with addition of E-fiber waste.

(9)Amiya Akram (2015) reported that on the utilization of e-waste plastic particles in concrete as partial replacement of coarse aggregate, it was observed that when e-plastic alone was used, there was a decrease in strength but when 10% fly ash was added results comparable to control specimen were obtained. It is thereby suggested that utilization of this e-waste in concrete will reduce the requirement for conventional coarse aggregates thereby resulting in conservation of natural resources. The specific gravity of e-plastics is much less, if used in concrete, they can reduce selfweight of the mix. Introduction of plastics in concrete also make concrete ductile, hence increasing the ability of concrete to significantly deform before failure.

(10)Pravin A. Manatkar et al. (2015) did analysis of compressive strength of M20 and M25 grade of concrete by replacing coarse aggregate by adding non-metallic e-waste in 0% to 20% and it is observed that some percent non-metallic e-waste can be used as a coarse aggregate in concrete. It is observed that compressive strength decrease with increasing e- waste percentage for both grade. Up to 5%, it is nearly same to normal concrete but after 15%, it reduces maximally. Strength reduce because of bonding of e-waste reduces. Volume of e-waste increase then bonding problem occurred in concrete that affect the on strength of concrete.

IV. METHOD OF UTILISATION

INITIAL STEP [Stage I, (Segregation)] is the starting process where E-waste input has been given various unit operation e.g. Dismantling (Manual) followed by disintegration of components (mechanical), later on systematic "Segregation" of the component.



During the unit operation a caution will be recommended to care for the hazardous emission in any forms. The offshoot components (DISPOSAL) have to be taken care off.
The MIDDLE STEP is the backbone of proposed management plan. Multistage phenomena are going on in several stages e.g. Stage-II (Operation Stage II (Operation) consists of several operations such as Hammering and Shredding.)
The most crucial part is the Stage III (Treatment). In this stage several treatment options are recommended such as CRT Treatment, Electromagnetic Separation, Eddy Current Separation and finally Density Separation
The FINAL STEP consists of Stage IV (Recycling) and Stage V (Recovery Process).The Stage IV (Recycling) has several options such as Chemical, Mechanical and Thermal. In Chemical option recycling is opted for plastic and metal whereas Mechanical accommodates shredding and breaking. In the Thermal option E-waste can be used for power generation and cement production.
In Stage V (Recovery Process) several steps are employed to recover metals notably valuable metals.

V. GENERAL PROCEDURE

A. Batching: Batching was done method of weight batching by using weighing balance having accuracy 0.001gm.

B. Mixing: Mixing of concrete can be done manually or by machine. The percentage of E-waste added to the concrete can be from the range of 0% to 20%. Admixture may be added depending upon the working condition and mix design of the concrete

C. Casting and Curing: The casting and curing should be done according to the IS 10262-2009.

VI. CONCLUSION

Form experimental analysis it is to be observe that e-waste can be used up to some extent in concrete as coarse aggregate. Following points, give idea about it.

- It is identified that e-waste can dispose in concrete as a coarse aggregate.
- Up to 5-15% replacement of e-waste is suitable to use up to (G+2) building construction, road construction.
- Up to 20% replacement of e-waste is use in construction where low strength required such as garden wall construction etc.
- More than 20% is not considerably useful for construction field because of strength decreases.
- Chemical treatments on the E-waste can make it feasible to be used in asphalt road constructions. With use of 4cm to 5cm of fibers, there can be increase in overall hardened properties by around 5-10%

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