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Electronic Waste Management

A Review Study

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Abstract— Waste electrical and electronic equipment (WEEE) describes discarded electrical devices. Each year, around 50-million-ton e-waste is generated in the world, from which India produce 1.5 lakh ton of e-waste annually. There is lack of concurrence as to whether the term should apply to reuse, recycle, recovery and refurbishing industries. E- waste contains hazardous materials which are very harmful to human health and environment. There is lack of knowledge in disposal methods of e-waste. This is the alarming situation to find the proper path to manage and dispose the e-waste safely. This paper discusses the present scenario of e-waste management and possible handling strategies.

Keywords— Electronic waste, sources, presents scenario, impact, disposal methods, management strategies.

I. INTRODUCTION

Electronic Wastes are one of the fast-growing wastes in the world. It is a situation that prevails everywhere and it's hard to survive in this world without machines. The humans are fully influenced that machines that make our lives more comfortable. So, to satisfy the requirements of the people, electrical goods are increasing day by day and they get crowded in the market. This finally results in the generation of E Wastes.

Basel Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286, 700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead percolates into the ground water from landfills thereby contaminating it. If the tube is crushed and burned, it emits toxic fumes into the atmosphere. Disposing e wastes by burning leads to major problems and it accounts for a major part of air pollution. The unwanted chemicals produce fumes that get mixed up with the air and it destroys the nature of the air. Sequentially, it attacks human beings during respiration. So, recycling should be done to use them efficiently again.

DEFINATION OF E-WASTE:

It may be defined as, computers, office electronic equipment, entertainment devices & many other electronic or electrical devices which are unwanted, broken & discarded by their original users are known as 'Electronic Waste' or 'E-Waste'.

WHAT IS E-WASTE? :

It is the term used to describe old, end-of-life or discarded appliances using electricity and battery. E-waste is a popular, informal name for electronic products nearing the end of their "useful life." Computers, televisions, VCRs, stereos, copiers, and fax machines are common electronic products. Many of these products can be reused, refurbished or recycled.

WHY E-WASTE IS A PROBLEM:

- Composed of Hazardous Materials.
- Products are quickly obsolete and discarded.
- Electronic products are difficult to recycle.
- Discarded electronics are managed badly.
- Most e-waste goes to Landfills.
- Most recyclers don't recycle, they export.

II. GENERATION AND COMPOSITION

GENERATION OF E-WASTE IN INDIA:

The main sources of electronic waste in India are the government, Public and private (industrial) sectors, which account for almost 70 per cent of total waste generation. The contribution of individual households is relatively small at about 15 per cent; the rest being contributed by manufacturers. Though individual households are Not large contributors to waste generated by computers, they consume large quantities of consumer durables and are, therefore, potential creators of waste. An Indian market Research Bureau (IMRB) survey of 'E-waste generation at Source' in 2009 found that out of the total e-waste volume in India, televisions and desktops including servers comprised 68 percent and 27 percent respectively. Imports and mobile phones comprised of 2 percent and 1 percent respectively.

TOP TEN STATES IN INDIA GENERATING E-WASTE:

SR.NO.	STATES	WEEE(TONES)	PERCENTAGE %
1.	Maharashtra	20270.59	18.49
2.	Tamilnadu	13486.24	12.30
3.	Andhra Pradesh	12780.33	11.66
4.	Uttar Pradesh	103811.11	9.47
5.	West Bengal	10059.36	9.18
6.	Delhi	9729.15	8.87
7.	Karnataka	9118.75	8.32
8.	Gujarat	8994.36	8.20
9.	Madhya Pradesh	7800.62	7.11
10.	Punjab	6958.46	6.35
	Total	**109578.93**	**100**

Table no. 1

SOURCES OF E-WASTE:

- Household equipment's like vacuum cleaner, microwave ovens, washing machines, air conditioners etc.
- Electronic devices used for entertainment like TV, DVDs, and CD players.
- Equipment or devices used for communication like phones, landline phones, fax etc.
- Waste generated from the products used for data processing such as computers, computer devices like monitor, speakers, keyboards, printers etc.
- Audio, visual components such as VCRs, Stereo equipment etc.

TOP TEN CITIES IN INDIA GENERATING E-WASTE:

SR. NO.	CITY	WEEE (TONES)
1.	Mumbai	11017.1
2.	Delhi	9790.30
3.	Bangalore	4648.80
4.	Chennai	4132.20
5.	Kolkata	4025.30
6.	Ahmadabad	3287.50
7.	Hyderabad	2833.50
8.	Pune	2584.20
9.	Surat	1836.50
10.	Nagpur	1768.20

Table no. 2

COMPOSITION OF E-WASTE:

E-waste consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminum and precious metals like silver, gold, platinum, palladium and so on. The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants beyond threshold quantities make e-waste hazardous in nature.

It contains over 1000 different substances, many of which are toxic, and creates serious pollution upon disposal. Obsolete computers pose the most significant environmental and health hazard among the e-wastes.

REASONS OF GENERATION OF E-WASTE:

- Changes and advancement in technology.
- Changes in fashion and style.
- Changes in configuration.
- Attractive offers from manufacturers.
- Small life of equipment.

III. ILL EFFECTS OF E-WASTE

ILL EFFECTS OF E-WASTE ON HUMAN AND ENVIRONMENT:

- 80-85% of various electronic products is discarded in landfill or incinerator which releases toxic gaseous into air & create air pollution which is harmful for human & environment.
- When e-waste disposes in landfill there is possibilities of forming leachate as water pass through-waste as it consists of hazardous material like lead, cadmium & chromium. & due to leachate surface water & sub surface water get polluted.
- Due improper disposal of e-waste possibilities of global warming which effect on eco system.
- Most of electronic waste consists of lead which causes danger to nervous system, if it is dispose improperly.
- Open burning of e-waste like computer & wire produce hydrocarbon which creates environmental hazardous. At the same time open burning creates irritation to eyes & nose & also effect on lungs & kidney.
- Metal like arsenic can create cardiac problem, cancer & diabetes if it is disposing improperly.

IMPACT OF HEAVY METAL IN E-WASTE ON HUMAN:

COMPONENTS	CONSTITUENT	HEALTH EFFECTS
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (PB)	• Damage to central and peripheral nervous systems, blood systems and kidney damage. • Affects brain development of children
Chip resistors and semiconductors	Cadmium (CD)	• Toxic irreversible effects on human health. • Accumulates in kidney and liver. • Causes neural damage. • Teratogenic.
Relays and switches, printed circuit boards	Mercury (Hg)	• Chronic damage to the brain. • Respiratory and skin disorders due to bioaccumulation in fishes.
Corrosion protection of untreated and galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr) VI	• Asthmatic bronchitis. • DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes • Reproductive and developmental problems; • Immune system damage; • Interfere with regulatory hormone
Plastic housing of electronic equipment and circuit boards	Brominated flame retardants (BFR)	• Disrupts endocrine system functions
Front panel of CRTs	Barium (Ba)	Short term exposure causes: • Muscle weakness; • Damage to heart, liver and spleen
Motherboard	Beryllium (Be)	• Carcinogenic (lung cancer) • Inhalation of fumes and dust. Causes chronic beryllium disease or berylliosis. • Skin diseases such as warts.

Table no. 3

IV. DISPOSAL OF E-WASTE

DIFFERENT METHODS OF DISPOSAL OF E-WASTE:

- **LANDFILLING:**

It is one of most widely used method of disposal of e-waste. In this, trenches are made in ground in which e-waste is filled. Finally, it is covered by thick layer of soil. In this method the major problem

is formation of leachate which pollutes surface and sub-surface water; metals like mercury, cadmium, lead is responsible for this

This is simple in operation and does not required skilled labours. It requires plenty of land. Landfilling is not environment friendly treatment.

- **INCINERATION:**

It is nothing but complete combustion of e-waste in presence of oxygen till it converts into ash. For incineration of e-waste more energy is required for process of incineration. The major problem of this method is formation of toxic gas which pollutes air. It is a practical method of disposal that saves a lot of money. Incineration has huge advantage that they can produce electricity which in the long run can help to reduce costs. Gases and leachates that are produced in landfills by waste are totally eliminated and the waste that is produced in the incineration is totally free of any environmental risk also the hazardous substances are converted into less hazardous substances.

This plant required skilled personnel for operation and continuous maintenance. The major disadvantage of this plant is dioxins which are produced in treatment and it is a cancer forming chemical.

- **REUSE:**

It is nothing but direct second hand use of product. Most of electronic products like computer, mobile phones, television etc. is available in second hand market with less cost. It is useful for low income community.

STEPS IN REUSE OF E-WASTE:

- Reuse is the environmentally preferable option for managing disposing of e-waste.
- By extending the useful life of old products, reuse conserves the energy and raw materials needed to manufacture new products and doing so reduces the pollution
- Reuse also gives people who cannot afford new products access to electronic equipment at reduced or at low cost.

- **RECYCLE:**

In this method most of electronic products are sold in second hand market by doing slight modification & alteration. If modification is not possible then different components are recovered from product such as plastic, glass, ferrous & nonferrous are collected such material valuable material to produce new product, by doing this we can save natural resources from nature & at same time we can save energy. Recycling creates employment locally and also helps to protect public health and environment.

- **RECOVERY:**

This technique eliminates the disposal prices. In this method if the product can not be recycled then different components are recovered. It conserves the natural resources, man power to create new products. By using this method hazardous materials can be recovered and use as it is to create new product.

V. MANAGEMENT OF E-WASTE

Waste minimization technique is basic important thing to control E-waste. This technique involves following points:

- **INVENTORY MANAGEMENT:**

Proper control over materials used in the manufacturing process is an important way to reduce waste generation. To reduce an electronic product both hazardous and non-hazardous materials are

required. So, during demanding raw material, a proper inventory should be prepared. So that excess raw material in stock get reduced all materials purchased as per inventory and at same time all material should approved a prior to purchase.

- **PRODUCTION PROCESS MODIFICATION:**

Changes can be made in process of production to minimize waste generation as far as possible mechanized system should be adopted for minimizing waste. A street maintenance program should be done periodically, so that process of production runs in proper way, which further produces waste generation. Proper training should be given to operators to minimize the waste.

- **VOLUME RUDUCTION:**

It includes those techniques that remove hazardous portion of waste from non-hazardous portion. These techniques are usually use to reduce volume and done cost disposing of waste get reduces segregation of waste is economical and simple technique of volume reduction.

- **RECYCLE AND REUSE:**

This technique eliminates waste disposal cost because most of time waste can be recovered on site or off site after dismantling product. The recycling of hazardous product has little environmental benefits if it is directly used in new product, which can save nature, electric power, man power and time. The total time required to produce product get reduced by recycling material.

- **SUSTAINABLE PRODUCT DESIGN:**

In this technique manufacturer should think to use non-hazardous material which should be sustainable and which should manufacture by using renewable energy so that ill effect of e-waste on human and nature should be minimize.

VI. LITERATURE REVIEW

Sai Lakshmi, Aishwarya Raj and T. Jarin (2017) stated that, E-waste are everywhere in our society. They are characterized by a complex chemical composition and difficulty in quantifying their flows at local and international level. The pollution caused by their irregular management has degraded the environment mostly in poorer countries, receiving them for recycling and recovery of valuable metals. Motivate them by the minimization of environmental effects caused by generated e-waste, many technological changes have to be developed.

Prof. Swati A. Patil, Prof. Neetu M. Sharma (2013) stated that, E-waste is increasing day by day more than the reuse and recycle. Modern facilities are to be established for the collection of e-waste and for disposal methods of e-waste. There also awareness programs to be conduct for the proper e-waste management. Electronic goods manufacturing companies must be legally ensured to mention the disposal methods of their product in their user manual. Some refund schemes can be taken from the government for collection of solid waste, to encourage the consumers, while the consumers return the electronic device. The export of e-waste must be minimized and recycling plants to be set up. Government has to arrange workshops, seminars also, banners can be laid everywhere and display Do's and don'ts.

In a study by **Jalal Uddin (2012),** through innovative changes in product style below EXTENDED PRODUCER RESPONSIBILITY (ERP), use of environmentally friendly substitutes for dangerous substances, these impacts can be mitigated. A legal framework must be there for imposing EPR, RoHS for attaining this goal. Adoption of environmentally sound technologies for usage and employ of e-waste at the side of EPR and RoHS offers workable answer for environmentally sound management of e-waste. Manufacturers & suppliers need to set goals for reducing electronic waste.

Encourage them to buy back old electronic products from consumers, disposing bulk e-waste only through authorized recyclers and send non-tradable e-waste to authorized private developers for final disposal.

Kuehr and Williams (2003) stated that an increasing market for reused PCs in developing countries is allowing people to own PCs and access technology at more affordable prices. Moreover, charitable organizations, such as Computer Mentor, Computer Aid, World Computer Exchange, Computers for Schools and others are expanding their boundaries and providing used and refurbished computers to organizations (e.g., schools) around the world. Furthermore, reuse also reduces the environmental impacts of technological artifacts by increasing their life spans and thereby reducing the demand for new equipment.

According to **Vijay N. Bhoi et al. (2014),** most of the waste is inherently dangerous. It will degrade to provide leachate, which can contaminate water, and make lowland gas, that is explosive. Additionally, owing to the risks related to lowland sites, there are currently terribly strict needs on the development, operation and medical care of such sites. Most designing authorities desire a figured-out quarry to be used for landscaping instead of a lowland web site that nobody desires in their "back yard". Product style should be used to assist to reduce not solely the character and quantity of waste, however conjointly to maximize end-of-life utilization. Makers, retailers, users, and disposers ought to share responsibility for reducing the environmental impacts of merchandise. A product-centered approach ought to be adopted
to preserve and shield setting.

Ramzy Kahhat, et al., (2008) stated in his article that some states are adopting e-waste regulations, but so far, the U.S. does not have a federal regulation that addresses the complete e-waste situation, including residential and non-residential sectors. Federal level policies and regulations present the best way to address the e-waste situation (U.S. GAO, 2005) as they will overcome the lack of regulations in most states and will standardize regulations and policies in the country. This will create a more efficient national e-waste management system. In this scenario, the e-Market for returned deposit system will be the mechanism for residential customers to dispose of their devices in a way that motivates collection, recycle and reuse of e-waste.

Sivakumaran Sivaramanan (2013) confirmed that the public awareness and cooperation of manufactures are essential for the advancement of e-waste management system. And also, it is the responsibility of government to allocate sufficient grants and protecting the internationally agreed environmental legislations within their borders. Licensing of certification like stewardship may ensure the security to prevent illegal smugglers and handlers of e-waste. As e-wastes are the known major source of heavy metals, hazardous chemicals and carcinogens, certainly diseases related to skin, respiratory, intestinal, immune, and endocrine and nervous systems including cancers can be prevented by proper management and disposal of e-waste.

According to **Peeranart Kiddee et al. (2013)** e-waste can be managed by developing eco design devices, properly collecting e-waste, recover and recycle material by safe methods, dispose of e-waste by suitable techniques, forbid the transfer of used electronic devices to developing countries, and raise awareness of the impact of e-waste. No single tool is adequate but together they can complement each other to solve this issue. A national scheme such as EPR is a good policy in solving the growing e-waste problems.

Yamini Gupt & Samraj Sahay (2015) suggested that financial responsibility of the producers and separate collecting and recycling agencies contribute significantly to the success of the extended

producer responsibility-based environmental policies. Regulatory provisions, take back responsibility and financial flow come out to be the three most important aspects of the extended producer responsibility. Presence of informal sector had a negative impact on the regulatory provisions.

In **Sukeshini Jadhav (2013)** observed that proper e waste management will help efficient sourcing and collection right up to extraction and disposal of material, ensuring that e-waste will turn into lucrative products and business opportunity. The manufacturers have to take responsibility for adopting the guideline for manufacturing sound environment product and sustainability management should be started from the product manufacturing stage i.e. raw material selection, product and process design can be the important factors for the designed for environment practices, which can facilitate the recycling and reuse. Manufacturer should also try and initiate a take back program to handle the waste so that proper management and disposal of e-waste can be done. This way as 60% e-waste is coming from industry, can contribute to a very large part of Electronic waste management collection and establishing clean e-waste channels.

Samarkoon M.B. (2014) in his study states that improper handling of e-waste can cause harm to the environment and human health because of its toxic components. Although the current emphasis is on end-of-life management of e-waste activities, such as reuse, servicing, remanufacturing, recycling and disposal, upstream reduction of e-waste generation through green design and cleaner production must be introduced to enhance a sustainable e-waste management system.

Shubham Gupta et al. (2014) studied that in developing countries like India, China, Indonesia, Brazil, commercial organizations tend to focus more on economic aspects rather than environmental regulations of e- waste recycling. So, for the profitable recovery of reusable materials and sustainable environment, the efficient recycling of this waste has been rendered indispensable, and is considered as a challenge for today's society.

VII. CONCLUSION

Based on the literature survey, the following are the salient conclusions:

- As far as e-waste is concerned, it has emerged as one of the fastest growing waste streams worldwide today.
- Electronic equipment is one of the largest know sources of heavy metals without effective collection, reuse, and recycling systems, they will be dangerous to environment as well as dangerous to human being.
- Reuse and recycling of electronic equipment is a beneficial alternative than disposal.
- Product design by using safe and environment friendly raw materials and most emerging technologies.
- Product design by using safe and environment friendly raw materials and most emerging technologies.
- Implementation of legislation should be mandatory.
- Preparation of Guidelines for Environmentally Sound Management of e-waste.
- Conduct assessment of e-waste generation and processing.
- Recommend standards and specifications for processing and recycling e-waste.
- Conducting training & awareness program for electronic user during purchasing an electronic product.
- Incentives and certification for green products.

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