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Management Of E-waste - A Potential Threat To The Environment

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Abstract : Electronic waste, popularly called e-waste produced by both the society and the technological industries is the biggest problem nowadays due to its harmful effect to the environment. Currently scientists and engineers are in search of new methods and technological devices to recycle and reuse the waste to its maximum level by disposing the rest to attain a sustainable development to save the environment and the society. The present paper discusses about the various types of e-waste, which is different from the normal waste due to the presence of inorganic toxic and hazardous substances in it, and different methods used to recycle the e-waste for achieving clean and green environment. The process by which hazardous substances present in the e-waste can be replaced by environmentally friendly material to save the earth is also discussed. The paper also compares the present status of e-waste in different countries emphasizing on the current Indian scenario.

Keywords - *Sustainable development, reuse, recycle, Environmental ethics, Technology.*

I. INTRODUCTION

After the industrial revolution and globalization, production of e-waste has also increased massively. The development of quality of life has led to the production of technologically advanced materials like refrigerator, washing machine, computer, mobile phones, DVDs, television and many more which unfortunately lead to the production of e-waste around the world (Babu et al., 2007). E-waste is a End-of-Life (EOL) product. The developing countries like INDIA, INDONESIA and CHINA have a higher flow of e-waste compared to the developed countries. The e waste also provides a good business for the people in the developing countries. Most of the e-waste from the developed countries comes to the developing one not only for recycling (Cui et al 2003) but also for the low price in technology. Basel convention was inspected in 1989 and was brought into force in 1992 to stop the trans-boundary movement of the hazardous material (Vats et al., 2014). Over 50 million ton of E-waste is produced every year all around the world. USA generates 3MT, China 2.5MT and India more than 1MT. The figure for India looks quite less but here most of the waste ends up in the landfill unlike the other countries where the recycling facilities are governed by the government and also provides a source of economy (Vats et al., 2014).

Recycling e-waste in India unfortunately is not a profitable business. The same is done by the people living in slums without proper protective measures for their health causing a high risk of diseases. The following main points for e-waste are discussed here:

- Types and composition
- Country wise world contribution
- Disposal and existing treatment
- The Innovation in the field of reusing and recycling
- Ethics people should share for sustainability.

II. TYPES AND COMPOSITION OF E-WASTE

E-waste is classified depending on its size and hazardous nature of the composition.

The general composition of E-waste is-

1) Metals-60.20%
2) Plastic-15.20%
3) Metal-plastic mixture-5%
4) Cables-2%
5) Screens (CRT and LCD)- 11.90%
6) PCB-1.70%
7) Others-1.40%
8) Pollutants-2.70%

2.1 Hazardous components of E-waste

•Mercury- It is mostly found in fluorescent tubes and flat screen monitors. Mercury causes severe health issues such as sensory impairment memory loss, muscle weakness and even death.

•Cadmium- It is found in light sensitive resistors, corrosive resistant alloy for marine and aviation environments and nickel cadmium batteries. It can interfere with the natural balance of the ecosystem, if not disposed properly. Inhaling cadmium causes kidney dysfunction and lung damage.

•Lead- It is found in CRT,TV, lead acid battery. Lead causes many complications like coma and even death.

•Sulphur- It is found in lead acid battery. It causes kidney damage, heart damage and even eye damage. It produces sulphonic acid when released in environment.

Other hazardous component like Chrome, Zinc, Cobalt and Selenium has their own effects on the environment (Chaney, 1980).

2.2 Non-hazardous component of E-waste

•Plastic- Found in most of the electronic devices can mostly be recycled and molded.

•Copper, Silver – Found in most of the wires and some high efficiency circuits it can be re-casted and reused.

III. COUNTRY WISE WORLD CONTRIBUTION IN E-WASTE

E-waste is a growing environmental concern worldwide. While the exact share of e-waste generated by different countries varies depending on the year and the source of data, some of the countries that are known to generate significant amounts of e-waste are (Jhariya, 2014):

1) China
2) United States
3) India
4) Japan
5) Germany
6) South Korea
7) Mexico
8) United Kingdom
9) Russia

10) France

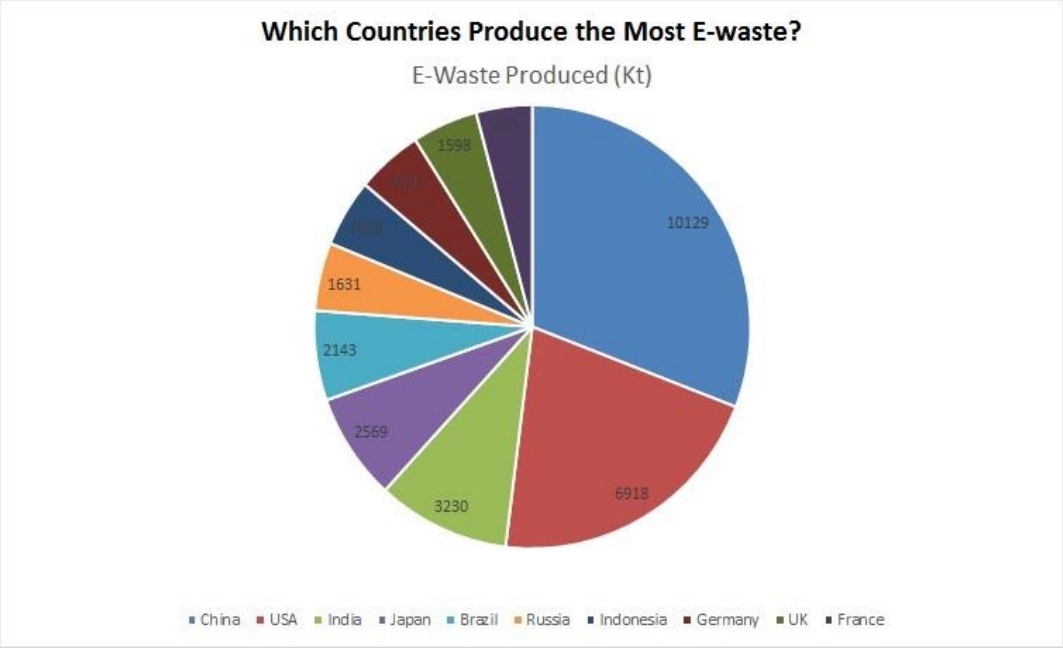

Fig. 1. Graphical Representation of the e-waste produced in the world

The proper management and disposal of e-waste are critical for protecting the environment and human health, and it's a responsibility that all countries should share (Sharma et al., 2012).

Some key facts:

- Year 2021 generated 57.4 Mt (Million Metric Tons) of e-waste where total growth is an average of 2 Mt a year.
- Year 2023 gives more than 347 Mt of un-recycled e-waste on earth.
- The highest contributors are China, US, and India.
- Quantity of e-waste known to be collected and properly recycled is only 17.4%
- The highest e-waste recycling rates are from Estonia, Norway, and Iceland.
- In 2020 the value of e-waste recycling market was $49,880 million .

The overwhelming majority of e-waste when measured by total weight comes from Asia (24.9 Mt), USA (13.1 Mt) and Europe (12Mt). Measured in terms of per person Europeans contribute 16.2 Kg, Oceania 16.1 Kg and the Americas 13.3 Kg. On the contrary, the least e-waste per capita is contributed by Africans. Unfortunately global recyleing is less than 1/5. The figure is only 17.4% of total global e-waste which are collected, recycled though it has fallen in the last 5 years in terms of percentage of total waste generated. According to the latest data Estonia, Norway, and Iceland have the best electronic waste recycling rates in terms of the percentage of waste (Shahabuddin, 2023).

TABLE 1: The ranks of the countries in e-waste recycling

Countries	**E-waste recycled (Kilo Ton)**	**Recycling rate (in %)**
Estonia	13	76
Norway	99	72
Iceland	5	71
Sweden	141	70
Austria	116	69
Switzerland	123	63
Finland	65	61
Poland	246	60
Ireland	52	59
UK	871	57

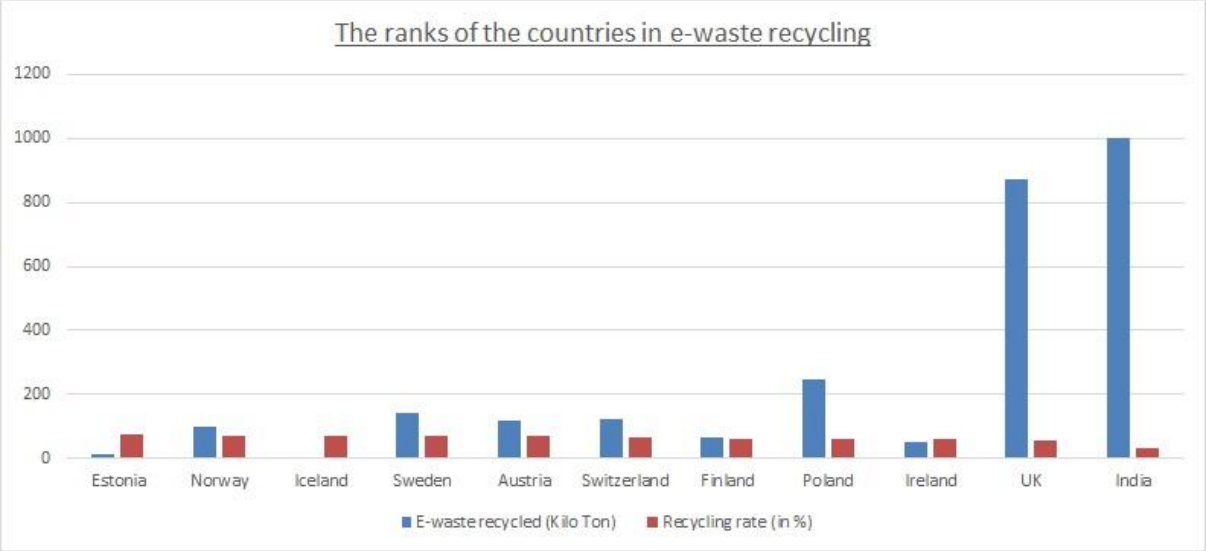

Fig. 2. Graphical representation of e-waste recyling

3.1 India's contribution to E-Waste

Recent market analysis of 2022-2027 on e-waste management (Shahabuddin,, 2023) placed India as a largest producer of e-waste after China and United States. The problem is increasing day by day as majority of this waste is managed by the private sector. Reports of Central Pollution Control Board states that India generated 1.71 million MT of e-waste whereas worldwide e-waste generation is 59.40 million MT. Up gradation of electronic products, now a days is forcing consumers to opt for new by discarding old one, which in turn, add e-waste to the nature.

A. COVID-19 Impact Analysis: After US and China the third largest e-waste generator in the world is India with rise of volume growth in an exponential manner. The main contribution is from computer equipment (70%) followed by telecom/phones (12%), electrical equipment (8%), and medical equipment (7%) as per the report of KPMG and ASSOCHAM. In terms of the Environment Performance index 2018 the rank of India is 177 amongst 180 countries and is among the bottom five countries in the world. The reason is linked to poor performance in the environmental health policy (Shahabuddin, 2023).

B. Market Influencers: The sales of electronic items are rising with rising purchasing power and a rising trend in disposable income. Additionally, new items with advance features encourage users to replace outdated products with recent models. Lack of awareness, safety concerns, and high recycling costs poses major challenges to the Indian Market. Knowledge regarding hazardous nature of e-waste components or the outcome of improper disposal is absent in most consumers (Huismann et al. 2007).

E-waste management in India, which is done by urban municipal or state government bodies, is unknown to many people. The disassembling process presents a potential threat to the workers who are exposed to dangerous elements like lead, mercury etc causing significant health impacts.

C. Steps to manage e-waste can be:

1. Regulation and Policy: Governments can make laws and regulations to govern collection, handling, and disposal of e-waste. This can include requirements for manufacturers to take responsibility for the outdated gadgets, establish programs to ensure proper disposal.
2. Collection and Recycling by microbiological process: Countries can establish e-waste collection and recycling programs to divert electronic waste from landfills and encourage responsible disposal. These programs can be drop-off locations or curbside collections.

Mobilization of metals from the waste is needed for reusing, refurbishing the scrap. This can be done by different microbiological processes which cause formation of inorganic and organic acids (Shuchi Patel et al. , 2014). It is found that metals like Cu and Sn are mobilized by 65% whereas Al, Ni, Pb and Zn by more than 95% by fungal strains of the scraps.

Many hazardous wastes can be degraded by the microbes, which cannot be readily biodegraded using adapted activated sludge technology, as it's a convenient, cost-effective method of removing potential pollutants. Patents are published regarding this issue earlier (King, Michael R. et al 2019)

Lithium is a hazardous element. Now a day's lithium ion battery is one of the most wanted components for many industries particularly electrical vehicle which is a growing industry now-a-days. But disposing of EV batteries is a waste management problem. Lithium is lost as slag and is difficult to extract even from post-processing due to incinerated plastics, hazardous slags

and toxic gas emissions. But on the other side there is an opportunity for producing a sustainable secondary stream of critical materials (Hanne Flaten Andersen 2018)

3. Public Awareness and Education: Governments and NGOs can help raise public awareness regarding proper e-waste management and the risks associated with improper disposal.

4. International Cooperation: Countries need to work together to address this global issue of e-waste. This can involve sharing best practices for e-waste management, collaborating on research, and coordinating efforts to prevent the illegal export of e-waste to developing countries. Overall, participation in e-waste management requires a multi-faceted approach involving many different stakeholders, including governments, manufacturers, consumers, and recycling companies (Sharma et al., 2012).

India's management programs with e-waste: India, one of the largest developing countries has been grappling with the problem of e-waste management for several years and has taken several steps to address this issue in recent years.
Some of the notable contributions are given below:

1) The E-waste (Management) Rules, 2016: The Ministry of Environment, Forest and Climate Change (MoEFCC) notified the E-waste (Management) Rules, 2016 in March 2016. The rules have been framed to manage e-waste and reduce its impact on the environment and human health.
2) Extended Producer Responsibility (EPR): The EPR concept has been introduced stating that producers, manufacturers, and importers of electronic products are responsible for managing their products at the end of their life in an environmentally sound manner.
3) E-waste collection and recycling: India has also taken steps to establish e-waste collection and recycling facilities across the country through state governments.
4) Public awareness: India has launched several public awareness campaigns to educate people about the importance of e-waste management. The government has also taken initiatives to involve the informal sector in the same.
5) International cooperation: India has been working closely with international organizations such as the United Nations Industrial Development Organization (UNIDO) and the Global Environment Facility (GEF) to address the e-waste problem (Shahabuddin, 2023). Thus, India has made significant progress in e-waste management in recent years. However, more needs to be done to ensure that e-waste is managed in an environmentally sound and sustainable manner.

D. The role of big companies: Big companies play a significant role in the production of e-waste, as they are often the manufacturers of electronic devices and equipment that eventually become obsolete and discarded. These companies are also responsible for the design and production of devices that are difficult or impossible to repair or recycle, contributing to the growing e-waste problem. Many corporations have started taking responsibility for the disposal and management of their products at the end of their useful life. This includes offering recycling programs for their products, implementing environmentally-friendly production practices, and investing in research and development to create more sustainable products.

Additionally, big companies can influence consumer behavior by designing products that are easier to repair, upgrade, and recycle, and by promoting responsible e-waste disposal among their customers. They can also support initiatives and policies aimed at reducing e-waste. Overall, big companies have both contributed to and can help solve the e-waste crisis through responsible production and disposal practices, as well as promoting sustainable behavior among their customers.

IV. DISPOSAL AND EXISTING TREATMENT OF E-WASTE

E-waste management refers to the collection, treatment, and disposal of electronic waste, which includes a range of products such as computers, televisions, cell phones etc. As technology continues to advance and evolve, the amount of e-waste generated has become a significant concern for the environment and human health.

There are a number of benefits of implementing an e-waste management project. For example, it can reduce the amount of waste that ends up in landfills, where it can harm the environment and pose a threat to human health. It can also conserve natural resources by recovering valuable materials from e-waste, which can then be used to produce new products. Additionally, it can create jobs and stimulate economic growth in the waste management and recycling sectors.

Thus, e-waste management is a critical issue that requires a comprehensive and coordinated approach to protect the environment and human health, conserve resources, and promote economic growth (Chatterjee, 2012).

V. INNOVATIVE WAYS OF MANAGING AND RECYCLING E-WASTE

There are some innovative waste management technologies to assist in managing digital garbage and maximizing the usefulness of an object (Borthakur, 2018).

5.1 Robotic e-waste monitoring system

With the help of robotic e-waste monitoring system, the organizations can track amount of waste gathered in containers. Based on the gathered information, it is possible to plan e-waste disposal routes, ensuring the waste collection vehicles to follow an energy efficient route that saves cash and effort.

5.2 Robotic Process for e-waste sorting

AI technology can assist in recycling efficiently and affordably to eliminate extremely damaging blunders thus converting the lifestyles to a zero waste one.

5.3 Buy-back Programs

The inconvenient nature of processing e-waste has resulted in garbage pilling which forces scientists and engineers to design creative e-waste management methods. Buy-back programs, a new method, will pay consumers cash each time they deposit unwanted digital products.

5.4 Increasing use of scrap metals

Presently the natural resources are decreasing, and on the contrary metals are in high demand for laptop, smart phone and electric vehicle batteries. Metals melted from recycled one use 2 - 10 times less energy than metals milted down from virgin one. So, increasing use of scrap metals in electronic goods might significantly aid in achieving sustainable development (Thakur, 2016).

5.5 E-waste can be repurposed into new products

1) DIY Robot: E-waste like old motors, sensors etc can be used to create a robotic arm or a self-driving car.
2) Solar-Powered Charger: Old solar cells can be repurposed from broken electronic devices to create a solar-powered charger for phone or other small devices.
3) Electronic Musical Instruments: Old electronic components can be used to create unique musical instruments like synthesizers or drum machines.
4) E-Waste Jewellery: Old computer parts like circuit boards or hard drive disks can be turned to earrings or necklaces.
5) Home Decor: Old electronic components can be repurposed to unique home decor items like clock or lamp.

5.6 E-WASTE CAN BE USED TO CREATE EDUCATIONAL TOOLS FOR STUDENTS

1) Robotics kits: E-waste like motors, sensors, and circuit boards can be used to create robotics kits to teach students.
2) Circuit building: E-waste can be used to create circuit building kits to teach students.
3) Computer building: E-waste can be used to assemble computer components to teach students about the hardware components.

5.7 DONATION OR SALE OF E-WASTE COMPONENTS

Electronic Cemetery E-Waste Management is a non-profit organization which accept old electronics for refurbishment or donation to those in need. E-wastes are disassembled and sold for parts through online market places or specialized electronics recycling companies.

5.8 TRADE-IN PROGRAMS:

Some electronic retailers offer trade-in programs where exchange of old device for a discount to a new one is available which can help to extend the life of the product.

VI. ETHICS PEOPLE SHOULD SHARE FOR SUSTAINABILITY

The three main principle of sustainable development are economy, society, and the environment. All are responsible to keep the earth clean and maintain a sustainable development by recycling and reusing while rejecting old technology before buying new one which not only benefits the earth but also the future generation to live a cleaner life.

VII. CONCLUSION

E-waste has grown to a global problem and until and unless proper care is taken it will lead to a devastating future. For a sustainable development of the society there should be recycle and reuse of the e-waste where microbiological process plays a big role. In India e-waste management is a growing industry which can increase the economy and provide jobs to certain section of people. To effectively manage e-waste, it is important to implement policies and regulations that promote proper disposal and recycling practices. This includes encouraging manufacturers to produce more environmental-friendly products, establishing recycling programs, and promoting awareness and education on proper e-waste disposal. Different mobile applications can be created to get in touch with manufacturer for refurbishing or selling along with information about the cashify centres which have both pros and cons. Materials scientist can help to convert heavy hazardous material to non-heavy non hazardous one. The proper management of e-waste, which is the most recent potential threat, is crucial to protect the environment for sustainable development. It requires a collaborative effort from all stakeholders, including governments, manufacturers, consumers and recycling facilities, to ensure that electronic waste is managed in a responsible and sustainable manner.

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