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E-waste Management: Current Best Practices Across the Globe

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ABSTRACT

Growth has exponentially expanded the use of computer devices in the IT and communication industries. Electronics are upgraded at a very high pace and required to discharge obsolete electrical goods very fast, thus adding to the solid waste stream electronic waste (E-waste). The growing topic of E-waste demands increased focus on the recycling of E-waste. It is noted that 75% of electronic objects are projected to be retained because of confusion regarding how they will be handled. The electronic junks are located unattended and usually combined with household waste in households, offices, factories, and other locations that are eventually disposed-of at sites. This needs appropriate intervention steps.

As it is noted that E-waste is one of the world's fastest rising waste sources. It contains a wide variety of elements and compounds, all of which are either precious or dangerous or both. E-waste can contaminate the environment by inappropriate recycling and disposal methods that lead to endanger human health. It also constitutes a substantial supply of useful resources which commercially fascinating the recycling perspective of this waste.

This research offers you a rundown of E-waste technology, including sanitary sites and precious metals recycling, non-metal components, plastics, and glass. E-waste recycling has become an interesting problem due to the odd rise in E-waste production and an increased understanding of environmental conservation among citizens. The potential risk of environmental pollution, high cost, and poor performance mean that primitive treatment systems cannot fulfill the industry's future obligations. Therefore, the efficient use of reusable capital is important to the advancement of modern E-waste management technologies.

Key words : E-waste management. recycling, reuse, WEEE,

1. INTRODUCTION

AS known that the production of electronic goods is increasingly growing because of modernization.

Electronics and their luxury jobs are constantly attracted to the people. The term E-waste is used for the definition of obsolete, end-of-life or disposed-of electronic and electrical equipment. This is a general term that encompasses certain kinds of waste containing electrically driven components commonly called waste electrical and electronic equipment (WEEE)19.

Yet they become a dynamic waste and a rise in the waste after their use. It consists of various harmful heavy metals, liquids, hazardous substances, and plastics, etc. Roughly 75% of E-waste is uncertain about it or is seeking ways of using it, including renovating, rebuilding, and fixing the parts, and so on. Some electronic recyclers shipped their cheap jobs to developing countries with hazardous products such as lead, glass, mercury bulbs, etc. Poverty and wellbeing are the key reason why third-world nations ingest E-waste from Europe and the USA 14.

The method of decommissioning requires a lot of effort. Dismantling requires not just shredding, shredding, and burning. Circuits are burned to search for the precious metals of gold, silver, cadmium, etc. The wire cover and electronic equipment commonly consists of polyvinyl chloride (PVC) and printed circuit board (PCB), however, which can cause toxic smoke and carbon particles after burning that can cause lung and skin cancer and contamination of the air as well. E-waste is a national problem. Most of the technology-based items/devices that we use in our everyday lives contain E-waste of the future, hence it is a challenging problem 16. Recycling of goods is heavily polluting with nature or the person, animal, and environmental consequences.

The phenomenon of E-waste pollutes not only the garbage but also has significant health effects because of the chemical liquidation and influence on the climate and agriculture. But both the adults and child workers, as well as their families, are being put at risk of recycling methods such as burning cables for copper preservation. It is cause for millions of people around the world, particularly in Africa, Europe, China, Japan, and Asia, to be deeply worried about wellbeing.23

1.1 FACE OF PROBLEM

Every year, the world uses more than 2.5 million tons of electrical and mechanical devices. Phones, computers, toys, tablets – it is likely that it will reach a growing E-waste Mountain after usage whether it has the power or battery supply. In 2019 alone, 53.6 million tons of E-waste were produced worldwide as per seen in figure 1. It is roughly 7.3

kilograms per person and 350 cruise boats are equal in weight. The lion's share in Asia – 24.9 million tons – followed by America (13.1 million tons) and Europe (12 million tons) and 2.9 million tons respectively in Africa and Oceania. The worldwide estimate is projected to swell to 74.7 million tons by 2030, in just these sixteen years nearly twice the annual volume of fresh E-waste.

The above renders it now the largest growing residential resource in the world, primarily motivated by more individuals who purchase devices with shorter service life and fewer maintenance options. Those goods can raise living standards and increasingly consumers can afford them. These products continue to boost living standards. Yet increased market demand overrides our ability to safely recycle electronic goods or dispose of them. Once these items are expired and discarded, they can persist in the environment, pollute ecosystems, and damage humans and wildlife at large. Formal storage and disposal with just 17.4% of E-waste in 2019.

The production of recycled E-waste has only risen annually since 2014 by 1.8 million tons. Over the same period, the total produced E-waste grew by 9.2 million tons.

Around the exact instant of time there is a rise in the volume of unreported E-waste. New data reports Europe's highest recycling and disposal rates representing nearly 42.5% of the overall E-waste produced in 2019. Now what happened in 2019 along most of these E-waste produced by the planet (82%) is not apparent. The problem is less evident in low-income countries because E-waste is usually handled capriciously. Now the risk of harmful contaminants in the atmosphere without a trustworthy waste management system is increased and damages people who survive at electronic wasting facilities, like arsenic, brominated flame retardants, or chlorofluorocarbons. In electronic displays as well as fluorescent lights, metal mercury is used, so it can damage the brain if exposed. This E-waste sources are undocumented, which exist in that atmosphere annually, we measured approximately 50 tons of mercury as in Australian coast sides. However, E-waste is not just a health threat, but it directly contributes to global warming as well. Greenhouse gases will steadily be emitted by dumped temperature exchange systems housed in refrigerators and air conditioners. It is believed that about 98 million tons, which equates to 0.3% of world energy emissions, are hacked per year from scrap yards 7.

However, since only 17.4% of the 2019 E-waste has been processed and recycled, only ten billion USD have been reused environmentally. Recycling was equipped with just four million tons of raw materials. This is a topic that is slowly rising in the world. At the end of 2019, 78 nations, 71% of the global population, either had E-waste management policies or had laws enforced – a 5% rise from 2017. However, politics are also not legally binding in many of those countries and laws are not applied. 13

Not only the above-mentioned issue but also E-waste is detrimental to human health because it is difficult and unsatisfactory to treat. In developing countries (such as India and China) rising epidemiological and clinical data have given rise to concern about the possible danger to human health due to E-waste 21. For example, open burning as far as printed cables raise the number of dioxins in nearby environments with respect to health hazards. Such contaminants raise the likelihood that individuals and residents will be inhaled into cancer.

In the manual grinding and collection of small concentrations of precious metal, radioactive metals and toxin will also penetrate the bloodstream of the dealing person. The workers are regularly exposed to toxic substances and extremely concentrated acid fumes. Recovering re-salable copper with burning of isolated wires can destroy the kidneys and the liver and lead to acute cadmium toxicity contained in the half-conductors and chip resistors which results in bone loss.6

1.2 E-WASTE AND THE WORLD

India became the fourth most important E-waste producer in the world in 2018, annually generating approximately 2 million tons and also importing a large amount from other countries around the world. The Environmental Ministry, Delhi government, has also agreed to include rag pickers in the capital's general waste handling. The department will also include eco-clubs in this project, now run at more than 1,600 government and private schools in the city, since these are the eco-clubs that will communicate with trappers from that specific region 22. The amount of E-waste generated annually is approximately 5% in India. The U.S. is the first generator to produce E-waste with an estimated capacity of 20 million tons. With ten million tons of E-waste per year, China has placed second 3.

India is the fifth largest electronic waste generator in the world. More than 95% of E-waste is handled and processed in much of the country's city slums, where uneducated employees conduct dangerous procedures without personal protective gadgets and gears which affect their health as well as the surrounding environment. Recycling and treatment plants need significant initial investment particularly in the machinery and the processes must be equipped with advanced technology. These employees earn only Rs. 1 to 10 to uninstall one machine component. Jobs waste their lives over just a little number. These "backyard recyclers" do not provide sewage plants, waste gas recycling facilities and personal healthcare devices. Williams has noticed that the situation is apparently getting worse through considerable media coverage and some national trade prohibitions, mainly China and India 516.

A massive amount of E-waste was produced globally in 2019 (53.6 million tons, with an average of 7.3 kilograms per capita). It is estimated that by 2030 this will rise to 4.7 MT. Asia is the major contributor to a significant amount of electrical waste at 24.9 meters above sea level, followed by the Americas (13.1 meters above sea level), Europe (12 meters

above sea level) and Oceania and Africa at 2.9 meters. At 2.5 kg Africa is the least E-waste producer per person. Of the 53.6 tons of metric waste produced worldwide, 9.3% was officially extracted and recovered and 44.3% was unknown, with environmental effects and their position in the various regions of the world as shown in figure.1 20. However, since 2014, there have been increases of 61 to 78 in the quantity of E-waste national regulation countries, rules, otherwise policies. A significant portion of undocumented industrial and household waste is blended along with other sources of waste, such as plastics and metal waste, which implies that fractions that can be quickly recovered can be recycled, without contamination under considerable circumstances, and with the recycling of all useful products. It is also not the recommended recycling type. In medium- and low-income nations, the E-waste management framework is still intact and is in some cases missing. The informal sector is responsible for administration, at the expense of inferior recycling conditions that can have dire implications on the welfare of staff and their children living, playing, and working next to E-waste management sites 7.

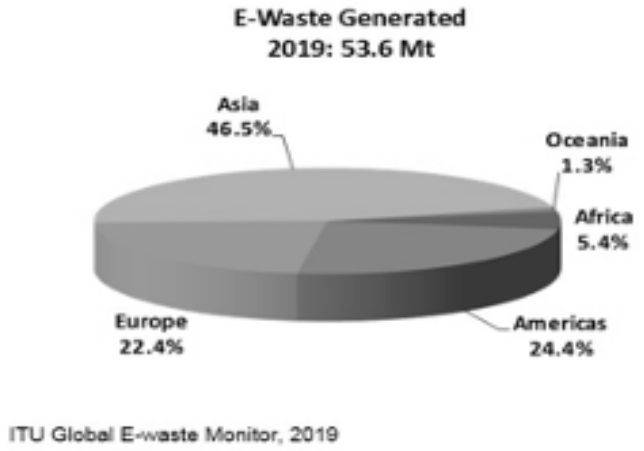

Figure 1: Global E-waste Monitor report issued by the ITU for the year 2019 of the region maximum generating E Waste.

2. MANAGEMENT OF E-WASTE

As 80% of devices are held out of uncertainty as to how they can be managed. It is estimated. These electronic junks are stored in households, workplaces, and other storage unattended and are typically combined with household garbage, which eventually is disposed of at the sites. This could be done through waste minimization and efficient product development techniques. The elimination of waste in industry includes material control, improvements in the manufacturing process, reduction in volume, recovery, and reuse. The components used in the welding process are tracked correctly in the inventory control. That quantity that wastes produced could to almost the same extent become reduced by reducing that both volume of hazardous material through use as well as abundance for raw resources stored throughout the method 22. And for this many countries initiated their roles in collection and recycling of this E Waste shown by Figure 2.

Many United States retailers provide customer recycling options for outdated computer appliances. The consumer electronics association (CEA) encourages customers, by retreating its scheme, to discharge the electronics at the final moment. This list covers only fabricator and retail projects using rigorous criteria and approved recycling sites by third parties, to ensure customers that their goods are recycled safely and responsibly. This study gave 58% customers knowledge about where to get their electronics end of life and that this degree of knowledge is highly valued by the electronics industry.

Products distributors and suppliers have been funding or running more than 5,000 recycling sites around the country and pledging 1 billion pounds a year by 2016, up from the 300 million pounds recycled in the 2010 sector. In 2012, the U.S. environmental protection agency (EPA) developed the sustainable materials management electronic competition. The challenge members are electronics producers and dealers. They gather and submit electronics to accredited third-party recyclers in different areas at the end-of-life (EOL) 21. Program members will also openly endorse and monitor 100% of their businesses conscientious recycling. To protect human health and to reduce environmental impacts, electronics are made, used, and disposed of in the electronics take-back coalition (ETBC). The ETBC seeks, by neighborhood promotions and legal compliance programs, to delegate responsibility to electronic production firms and brand owners for the disposal of technology goods. It gives customer recycling guidelines and a list of recyclers that are assessed as environmentally friendly 17.

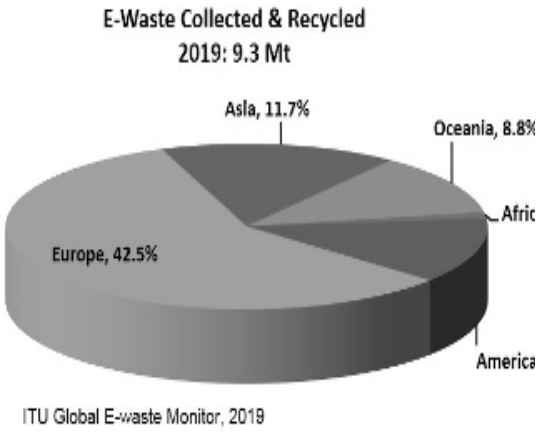

Figure 2: Global E-waste Monitor report issued by the ITU for the year 2019 for E Waste collected and recycled by different countries

E-waste recycling typically requires, first in many developing

countries, the removal of the machines, sometimes in person, but progressively by automated screw-in systems, in separate sections. Usually, NADIN is in Novi Iskar, Bulgaria, the largest of its kind in Eastern Europe, E-waste recycling plants. The rewards are the capacity of the human employee to identify and secure operating and reworkable materials, including processors, transistors, RAMs, etc. The downside is that with the lowest health and welfare requirements the population is cheapest.8. About 8% of E-dust is estimated to be dumped in high income countries such as Australia as seen in figure 3 in waste container tanks, while 7% - 20% is shipped. That benefits through recycling were enhanced as sustainable recycling techniques were being used. Conscious recycling throughout the U.S tries to lessen potential risks to public health as well as the atmosphere involved with storage including destruction of appliances 2.

Figure 3: E-waste Recycling containers for shipping purpose

Conscious recycling guarantees sound control of electronics and health and wellbeing of workers throughout the domestically and overseas, along with care for the environment. That factories from origin were recovered with reduced prices across Europe with renewable sources. Producers are forced to make their goods more competitive by way of a committed recycling scheme in Japan. In the United States, farmers are frustrated with the shortage of available knowledge about operation, specialist equipment and new parts for their high-tech farming machines. However, the campaign reaches further beyond farm equipment and criticizes Apple for example, the small repair choices. Manufacturers also oppose safety issues arising from illegal repairs and improvements 16.

A research from the Basel action network (BAN), which is working on the deterrence of the globalization of hazardous chemicals, states that 50 - 80% of the electrified waste collected in the US will be transported into India, China, Pakistan, Taiwan, and other African countries. After the first level of economic liberalization in 1990, issues associated with E-waste began to grow in India. E-waste management can be divided into three principal sections: collection, recycle and recovery and disposal, according to the Indian scenario. To maximize the use of services and facilities available for informal and formal stakeholders, some recommendations are mentioned, so that their capacity can be completely used for E-waste management in an environmentally sound way; they are used for the Indian scenario. The following parts are divided according to the other activities concerned 18.

In certain countries, life cycle evaluation is widely used for handling E-waste. The product life cycle evaluation is expected through identifying purchased goods as well as environmental pollutants that measure environmental constraints of a commodity, process as well as utility. In addition, alternative methods of changing the atmosphere may be calculated 20. This method can be used to design ecofriendly products during the design process of latest electronic products and to reduce waste produced at end-of-life (EoL). Several experiments have been studied by lifecycle assessment in Europe to determine the environmental impact of EoL E-waste disposal. It proposed that the EU should change the WEEE directive to ensure its effect on its life cycle 12. The EoL's ecological impacts on four items of electrical and electronic appliances in Europe were analyzed by Barva-Gutierrez et al. (2008) the life cycle assessment. They show that the distance travelled to collect E-waste is important for the design of recycling networks and environmental effectiveness, along with where the processing facilities are situated 4. The effect of E-waste and E-waste management in Asian countries was considered in the life cycle assessment's prediction used, for example, life cycle assessment in Korea to test environmental and financial recycling operations of waste home appliances 15. The findings found that glass and circuit boards constitute the top scoring in environmental terms followed by iron, copper, aluminum, and plastic. With respect to the financial factor, copper recycling was the largest prospect of recycling, followed by iron, glass, plastic and aluminum. The proportion of the machine used recycled, and the environmental impact was measured by the research 1.

Two alternatives were considered: landfill or disposal recycling. Their findings concluded that recycling is a better option than sending waste to waste disposal. In Taiwan, researched multiple alternatives for maintaining discharge planning machines including ecological and financial concerns (e.g., secondhand retail purchases, conservation practices, burning or landfill). They recommended that businesses pay attention rather than concentrate on recovery and recycling should increase the recycling and shift their attitudes towards product design. Individuals accomplished this waste disposal is better than recycling, but that waste disposal is more harmful for the atmosphere and emissions. It was proposed that a proper assembly design should be

implemented to minimize disposal costs. A life cycle assessment in China applied to determine the global effect on the ecosystem of electronic goods 7, 9. A personal desktop computer device has been studied to show the reliability of the proposed life cycle assessment process 11.

Extended producer responsibility (EPR) is viewed as an environmental conservation mechanism for mitigating the environmental effects of a product, by offering benefits for the producer of the EoL product, the take-back, recycle or disposal schemes. EPR is aimed at fostering corporate responsibility by encouraging producers to control EPR during the product design process. EPR has been applied effectively in some countries in the world such as Japan, European Union, Switzerland, Asian countries, and some USA 10.

3. CONCLUSION

Many employees engage in the coarse removal of these electronic products for their livelihood and their health is at stake. Hence, a prevention policy for E-waste health risks among these workers in India is urgently needed. There is, sadly, another option for E-waste reduction worldwide. Most of the E-waste is exported to developed countries in developing nations. There is regulation in many developing countries to avoid this, but E-waste is still commonly exported. Most of the E-waste in the world is exported to, among others, Nigeria, Ghana, Pakistan, India, and China. Though it appears unlikely for a country to import another's waste freely, E-waste is transported, often unlawfully.

This profession offers valuable work and scraps. A spring of precious metals such as gold, nickel, copper, iron, and silicon is amalgamated in the E-waste. The countries that receive this pollution have inadequate regulations that safeguards their employees or the environment.

Most staff are children or work endless hours a day. It is also correct that most of the computer equipment refuse is risky. Following scrap harvesting, dumping these products will lead to soil or water pollution, destroying the atmosphere and possibly the supply of food. Details on the safe handling of E-waste and personal security needed should be supplied to such employees.

Many technological options for E-waste management are available, but specifications such as regulations, recycling processes, logistics, and workforce should be prepared to be implemented in the management framework. Operational analysis and assessment studies may be needed.

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REFERENCES

1. Alam, M., & Bahauddin, K. M., "**Electronic waste in Bangladesh: Evaluating the situation, legislation and policy and way forward with strategy and approach"**. *Present Environment and Sustainable Development*, 9(1), 81–101, 2015.
2. A.L. Araina, R. Pummill, J.Adu-Brimpong, S.Becker, M.Green, M.Ilardi, E.Van Dam, R.L.Neitzel, "**Analysis of e-waste recycling behavior based on survey at a Midwestern US University",** *Waste Management*, Volume 105, Pages 119-127, 2020.
3. Awasthi, AK, Li, J, "**Management of electrical and electronic waste: a comparative evaluation of China and India".** *Renewable and Sustainable Energy Reviews* 76, 434–447, 2017.
4. Awasthi, AK, Zeng, X, Li, J, **Relationship between electronic waste recycling and human health risk in India: A critical review.** *Environmental Science and Pollution Research* 23, 11509–11532, 2016.
5. Badoni, P. D. **Electronic waste management in India.** *Electronics.* Accessed 16th Oct 2019.
6. Bakhiyi, B., Gravel, S., Ceballos, D., Flynn, M. A., & Zayed, J. "**Has the question of electronic waste opened a Pandora's box? An overview of unpredictable issues and challenges".** *Environment International*. 110, 173–192, 2018.
7. Balde, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P, **The global E-waste monitor – 2017**, United Nations University (UNU), *International Telecommunication Union (ITU) & International Solid Waste Association* (ISWA), Bonn/Geneva/Vienna, Pages 120, 2020.
8. Barba-Gutiérrez, Y., Adenso-Diaz, B., & Hopp, M, **An analysis of some environmental consequences of european electrical and electronic waste regulation. Resources,** *Conservation and Recycling*, 52, 481–495, 2008.
9. Duan, H., Eugster, M., Hischier, R., Streicher-Porte, M., & Li, J. **Life cycle assessment study of a Chinese desktop personal computer.** *Science of The Total Environment*, 407(5), 1755–1764, 2008.
10. Fang Tian, Greys Sošić and Laurens Debo, "**Stable recycling networks under the Extended Producer Responsibility"**, *European Journal of Operational Research*, Volume 287, Issue 3, , Pages 989-1002, 2020
11. Garlapati, VK, "**E-waste in India and developed countries: management, recycling, business and biotechnological initiatives".** *Renewable and Sustainable Energy Reviews*, 54, 874–881, 2016.
12. Giovanni Francesco Cardamone, Filomena Ardolino and Umberto Arena, "**About the environmental sustainability of the European management of WEEE plastics",** *Waste Management*, Volume 126, Pages 119-132, 2021.
13. Ilankoon, I.M.S.K., Ghorbani, Y., Chong, M. N., Herath, G., Moyo, T., & Petersen, "**Electronic waste in the international context – A review of trade flows,**

regulations, hazards, waste management strategies and technologies for value recovery". *Waste Management*, 82, 258–275, 2018.

14. Ingole, A. **"E-waste. Its advanced collection system and innovative applications in the field of civil and environmental engineering".** *Lap Lambert Academic Publishing, Mauritius*, 2018.
15. Kim, J., Hwang, Y., Matthews H. S., & Park K., "**Methodology for recycling potential evaluation criterion of waste home appliances considering environmental and economic factor".** *IEEE International Symposium on Electronics and the Environment, Conference Record.* Scottsdale, AZ, USA, pp., 68–73, 2004.
16. Kumar, A., Holuszko, M., & Espinosa, D.C.R. "**Electronic waste: An overview on generation, collection, legislation, and recycling practices. Resources,** *Conservation and Recycling"*. 122, 32–42, 2017.
17. Kunz, N., Mayers, K., & Van Wassenhove, L. N. **Stakeholder views on extended producer responsibility and the circular economy.** *California Management Review*, 60(3), 45–70, 2018.
18. Lakshmi, S., Raj, A., & Jarin, T. "**A review study of electronic waste management in India".** *Asian Journal of Applied Science and Technology (AJAST)*, 1(9), 33–36, 2017.
19. Olanrewaju S. Shittu, Ian D. Williams and Peter J. Shaw, **Global E-waste management: Can WEEE make a difference? A review of e-waste trends, legislation, contemporary issues and future challenges,** *Waste Management*, Volume 120, Pages 549-563. 2021,
20. Rajesh Ahirwar and Amit K. Tripathi," **E-waste management: A review of recycling process, environmental and occupational health hazards, and potential solutions",** *Environmental Nanotechnology, Monitoring & Management*, Volume 15, 100409, 2021.
21. Shari K. Grossarth and Alan D. Hecht**, "Sustainability at the U.S. Environmental Protection Agency: 1970–2020",** *Ecological Engineering*, Volume 30, Issue 1, Pages 1-8, 2007.
22. Shivkumar, T., Vijayaraghavan, G., & Kumar, A. V., **Global challenges in electronic waste management: Indian scenario.** *International Journal of Advanced Engineering Technology*, II(IV), 10–15, 2011.
23. Singh, N., Li, J., & Zeng, X., **Global responses for recycling waste CRTs in electronic waste.** *Waste Management*, 57, 187–197, 2016.
24. Singh, R., Khan, S. A., & Siddiqui, S. Fastest., **Growing Waste: E-waste.** *Asian Journal of Advanced Research and Reports*, 11(1), 20–24, 2020.