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Digital Waste Management and Environmental Impact

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ABSTRACT

Every year millions of electrical and electronic devices are discarded and thrown away as products break down or become obsolete. These discarded devices are considered Digital waste (D-waste) and can become a threat to health and the environment if not properly disposed of and recycled. Common items in d-waste streams include computers, cell phones, large household appliances and medical equipment. When d-waste is recycled using unhealthy activities, it can release up to 1000 different chemicals into the environment, including known neurotoxic substances such as lead. D-waste is one of the fastest growing solid waste streams in the world. Less than a quarter of the d-waste generated globally in 2022 is known to be formally recycled, but d-waste streams contain valuable and finite resources that could be reused if properly recycled. D-waste Once they become waste, these toxic substances can be released into the environment if devices are managed using environmentally unsound practices and activities. Many inappropriate practices have been observed at D-waste sites, including the following. These activities are considered hazardous to the environment and health because they release toxic pollutants and contaminate air, soil, dust and water at recycling sites and in neighboring communities. Open burning and heating are considered the most hazardous activities due to the toxic fumes generated. Once released into the environment, these toxic pollutants can travel significant distances from the point of pollution, exposing people in remote areas to hazardous substances.

1. INTRODUCTION

Electronic trash, commonly known as Digital waste (d-waste), is a type of garbage generated by electronic devices in the industrial world, and litter is one of the most diverse cult and rapidly expanding problems. D-waste consists of old or end-of-life electronic devices such as computers, laptops, televisions, generators, DVDs, cell phones, freezers and other items that are often discarded by their original owners due to their short lifespan. It contains a number of hazardous components that, if not properly managed, have a negative impact on the environment [1,2].

D-waste, is becoming a significant environmental issue. Every year, tons of obsolete gadgets like smartphones, computers, and TVs are discarded. In 2024, the problem is more pressing than ever. Advances in technology mean that devices become obsolete quickly, leading to a rapid increase in electronic waste. Most people are unaware of the harmful substances inside these devices and the damage they can cause to the environment if not properly disposed of [3].

Dumping d-waste in landfills is a dangerous practice. These devices often contain toxic substances like lead, mercury, and cadmium. When d-waste is not disposed of properly, these toxic substances can seep into the soil and contaminate water supplies. This not only harms wildlife but can also affect human health. Recycling and properly managing d-waste is crucial for protecting our planet [4,5].

In addition to environmental harm, failing to manage d-waste means wasting valuable materials. Many electronics contain precious metals like gold, silver, and copper. These materials can be recovered and reused if the devices are recycled

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correctly. By understanding and addressing d-waste, we can help preserve our environment and make the most of our resources.

According to the United Nations' (UN) 2020 global d-waste monitor, the amount of digital waste (d-waste) generated globally in 2019 reached 53.6 million tons (Mt), an increase of 9.2 million tons in five years. The UN defines d-waste as all discarded products with batteries or plugs that contain toxic and hazardous substances, such as mercury, which can pose a serious risk to human and environmental health. According to the report, 17.4 Mt of the total d-waste in 2019 was made up of small equipment, while 13 Mt was made up of large equipment and about 11 Mt was made up of temperature exchange equipment. Displays and monitors, small IT and telecommunications equipment and lamps represented 6.7 Mt, 4.7 Mt and 0.9 Mt respectively. According to the report, Asia was the biggest culprit, generating the most d-waste with nearly 25 Mt during 2019, followed by the Americas with 13 Mt and Europe with 12 Mt. Meanwhile, Africa and Oceania generated 2.9 Mt and 0.7 Mt respectively. On a per capita basis, Europe and Oceania topped the list with just over 16 kg of waste per capita, and the Americas with nearly 13 kg. Asia was at the lower end of the spectrum with 5.6 kg per capita, while Africa was only 2.5 kg. Based on per capita figures, the report found that the average man, woman and child discarded an average of 7.3 kg of d-waste per person in 2019. While the number of countries that have adopted a national d-waste policy, legislation, or regulation in the past five years increased from 61 to 78, only 17.4% of d-waste was collected and recycled in 2019, according to the report [6,7].

2. Global Status of Digital Waste Generation

In today's world, people's use of electronic gadgets is very high and this is helping the world economy in the massive expansion of new technologies. Due to the proliferation of new technological devices, there is a huge waste of electricity in our world. According to some studies, about seven billion people live on this planet, and only 5 billion of them have access to and are able to obtain their basic needs. More than 6 billion people use cell phones, which have now become a basic need and necessity [8]. This poses a threat to the ecosystem as a result of its harmful impact on human health. The large volumes of D-waste generated by the electronics industry are starting to have serious impacts. The term D-waste or electronic waste refers to old and end-of-life electronic devices such as televisions, laptops, generators, freezers, computers and other electronic appliances that are discarded by their owners.

It is predicted that access to technology along with economic growth will increase global D-waste production, Therefore, having higher income leads to more electronic goods purchase and more D-waste production. The growth of electronic devices worldwide with technological development is parallel to the rapid change in global knowledge and technological advances [9,10]. According to various estimates, garbage production will reach a new peak of approximately 53.6 million metric tons in 2019. In just a few years, there has been a 21% increase in the amount of waste produced, which has now become a serious threat. The United Nations University reported in a report published in 2015 that the global D-waste amount has reached 41.8 million metric tons. The rapid change in technologies and the demand for new developments lead to the waste of old products, which becomes D-waste.

E-waste generation is expected to reach 20–50 Mt every year, accounting for 1–3 percent of worldwide rubbish production [11] as shown in Fig. 1 which describes the E-waste production produced in metric tonnes every year

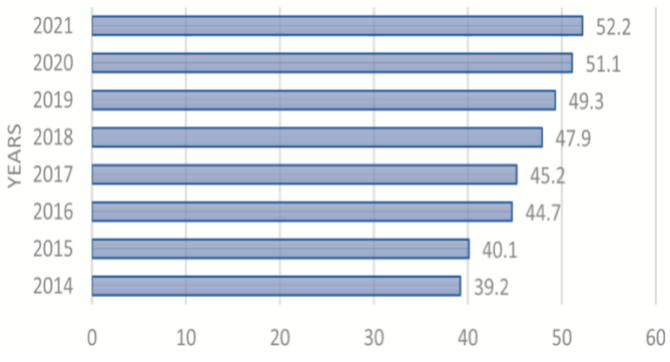

Figure 1. D- waste production in different years [12]

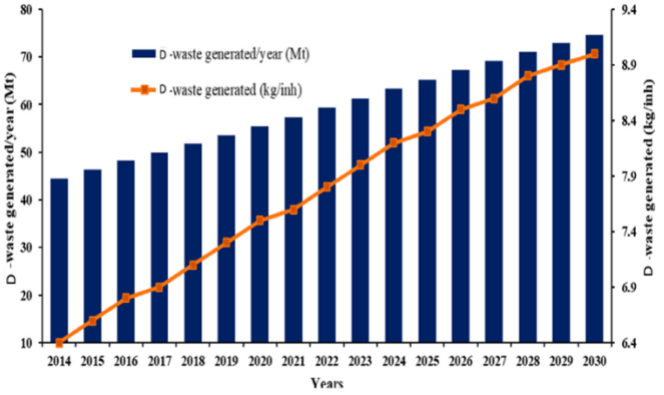

Figure 2. Global quantityof generatede-waste [13]

3. Impacts of Digital Waste

Due to the rapidly growing population, the disposal of electronic devices has posed a new challenge for the environment and the scientific community. A wide range of devices can be considered in the d-waste category, including consumer electronics d-waste such as TVs, lights, microwaves, smart watches, remote controls, etc. and information communication d-waste such as smartphones, laptops, cell phones, computers, etc. [14]. The problem arises when these electronic wastes are broken or discarded after use. The rapid industrial and technological progress in the global scenario has increased the amount of d-waste every year [15]. The improper and unscientific disposal of these wastes is not only economically unprofitable but also damaging to the lives on earth as it leads to the release of various toxic chemicals into the environment [16]. Moreover, with the advances in electronics and modern technologies, the lifespan of electronic equipment has significantly decreased. As a result, d-waste has increased in proportion to technological modernization. US Environmental Protection Agency (US EPA) research shows that an average of 125 million cell phones are destroyed each year [17].

3.1. Impact on Environment

Unplanned and unscientific disposal of d-waste not only harms people but also the environment. Conventional practices of waste management such as burning, open dumping, and landfilling can accelerate serious damage to the environment. Figure 3 shows the negative impact of unscientific d-waste management practices on the environment. As can be seen, air, water, and soil can be polluted in connection with the usual procedures of e-waste management. Disposal of d-waste through landfilling or open dumping can pollute the soil due to the presence of heavy metals and other organic pollutants in waste materials. Moreover, the leakage of these hazardous substances can lead to groundwater contamination, causing water pollution. The presence of heavy metals and organic substances in the soil can affect plants, microorganisms, crops, etc. Heavy metals can thus enter ecosystems and have harmful effects on life on earth [18].

Furthermore, the presence of toxic chemicals in the soil changes the pH of the soil, destroys micronutrients, and negatively affects growth and productivity. D- In addition to soil contamination, groundwater can also be contaminated as a result of waste being left in the open or landfilled. The presence of toxic substances in groundwater can harm water bodies and the animal kingdom. The quality of drinking water may deteriorate due to the presence of heavy metals and other toxic pollutants, thus calling into question the existence of biodiversity [33]. The management of D-waste through incineration can reduce air quality by increasing the amount of harmful chemicals in particulate matter in the air. Living organisms can be physically harmed associated with the inhalation of toxic chemicals during respiration. D-waste management therefore negatively impacts the environment and lives in the ecosystem. People, including adults, pregnant women and children, suffer greatly from d-waste pollution. In the management of electronic waste, appropriate measures need to be taken to protect the environment [34].

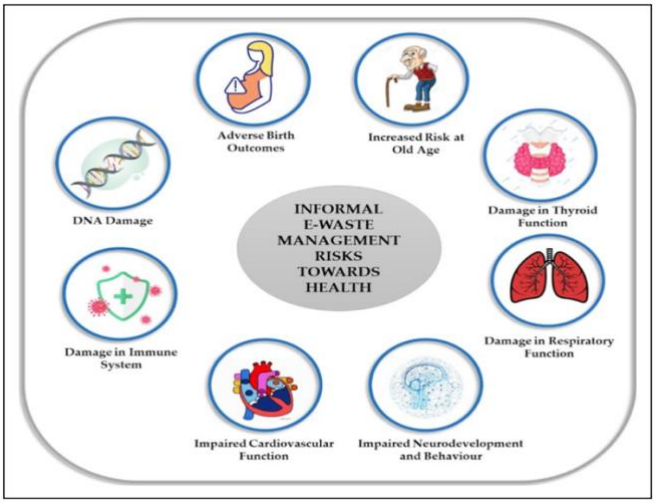

Figure 3. Impact of informal D-waste management towards human [18, 20].

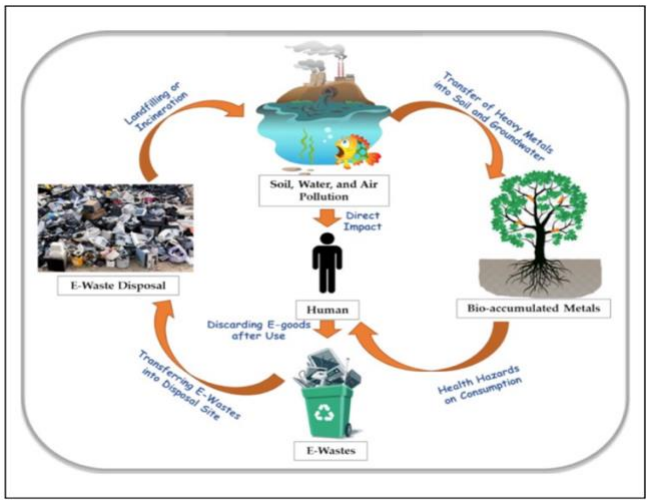

Figure 4. Impact of informal D-waste management towards environment [21].

4. Management of D-waste

The end usage of electronic wastes necessities the management of these accumulated wastes to minimize its harmful effects towards the environment and the lives on the earth. Sustainable management of d-waste requires appropriate planning and strategies by policy makers worldwide [22]. The strategies should include appropriate use of available technologies, easy and economically applicable procedure, minimization of environmental pollution and consumer awareness. Advanced technologies used to recover metals from d-waste such as pyrometallurgy, hydrometallurgy, biometallurgy should be incorporated into sustainable waste management procedures. The main challenge in e-waste management is the collection of different e-waste materials from different sources and their proper separation. An interesting study by Forti et al. [23]. suggests that only 17.4% of the total e-waste generated globally is collected while the remaining 82.6% remains abandoned. This fact indicates that there are significant gaps in d-waste management policies. Therefore, success in sustainable d-waste management lies in the sincerity and responsibility of each and every stakeholder associated with it. The government should take the initiative to formulate appropriate guidelines for consumers, manufacturers, traders and recyclers. The appropriate regulatory body should be there to oversee every step of the management and ensure that d-waste materials are recycled properly to maintain environmental peace. Local bodies can play a significant role in the collection and segregation of d-waste. Transportation of e-waste has always remained a major challenge due to the uncertain amount of d-waste coming from different cities. To get rid of the associated hazards, e-waste from developed countries is transferred to developing countries where the legislation regarding e-waste is lax and thus e-waste is processed informally, causing serious damage to the ecosystem. Sustainable transportation of e-waste can only be achieved by developing appropriate collection channels and transferring the segregated waste to the relevant recycling stations. All stakeholders, namely producers, consumers and recyclers, play a vital role in the smooth functioning of d-waste management.

5. Conclusion

The vast majority of D-waste poses a threat to the environment and human health, particularly in developing countries. Despite the adoption of legislation regulating D-waste management and disposal, many developing countries appear to have failed to implement effective formal recycling systems. Therefore, more rigorous life cycle assessment models, such as those used successfully in developing countries, should be promoted and adopted in their countries. Protecting society from D-waste risks in the environment should be a top priority. While the disadvantages of informal D-waste recycling have long been recognized, the health risks to those exposed are only now becoming apparent. A global work plan focusing on a wide range of issues and groups should be designed to better understand the environmental impacts of D-waste exposure.

The international health community, researchers and policy makers, as well as civil society organizations and national governments, should work together to address D-waste exposure and its consequences on the environment. In addition, significant research focus has been placed on the harmful effects of d-waste, the recovery of heavy and precious metals from d-waste, and the processes and policies associated with systematic d-waste management. Informal and unscientific management of d-waste has led to serious health and environmental hazards. Traditional waste management methods such as landfilling and incineration release significant amounts of heavy and toxic chemicals into the environment, leading to serious air, water and soil pollution. Therefore, the increase in d-waste production has outpaced the increase in formal recycling by almost 5 times, driven by technological advancement, higher consumption, limited repair options, short product life cycles, increased electronification and inadequate d-waste management infrastructure, thus outpacing the increase in formal and environmentally friendly collection and recycling.

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