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E-Waste Management in the Mountainous Himalayan Region: A Case Study

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Abstract: The concept of managing electronic waste, known as e-waste, has gained prominence alongside the increasing utilization of electronic devices. The aftermath of the COVID-19 pandemic has accentuated the urgency for proper e-waste management due to a notable surge in electronic waste production. This paper sheds light on the e-waste landscape, specifically in the Garhwal region of the Himalayas. The study underscores that discarded electronics such as computers and mobile phones constitute a substantial portion of e-waste in this area. The accumulation of e-waste has significantly degraded the local environment and biodiversity of the Garhwal region, giving rise to environmental and health-related challenges. Moreover, the paper emphasizes the necessity for governmental policies tailored to ensure effective recycling of e-waste in the Garhwal region, while also considering its potential to stimulate employment opportunities within the locality. By analyzing the unique geographical and environmental factors of the region, the case study offers a comprehensive examination of e-waste generation, disposal practices, and their potential impacts on the local ecosystem. Through an exploration of innovative approaches and sustainable solutions, this research aims to contribute to the development of more efficient and environmentally conscious e-waste management strategies in similar mountainous terrains around the world.

Keywords: E-waste • Pollution, Management • Recycles • Hills

Introduction

Electronic Waste, referred to as e-waste, encompasses outdated electronic devices like computers, laptops, televisions, mobile phones, and mp3 players, which are discarded by their original users. This category involves previously utilized electronics that are destined for activities such as reuse, salvage, resale, disposal, or recycling. In regions like India, a prominent e-waste producer globally and the fifth-largest, improper and unregulated processing of e-waste can inflict harm upon human well-being and contribute to environmental contamination, particularly in developing nations. In the current context, there has been a rapid surge in the adoption of mobile phones due to the COVID-19 pandemic. People of all age groups are increasingly reliant on smartphones and various electronic devices, reflecting their indispensability in modern society. So, in addition to all the electronic appliances commonly used today, the mobile phone user is also responsible for creating a large volume of E-waste. As per the current development in mobile technology and the emergence of advanced electronic gadgets, people are all age groups and are highly attracted to these products.

Further, the rapid high consumption rate of electronic products has led to dangerous environmental consequences (vijay et al. 2014). Researchers in the latest study found that the volume of e-waste increases by 3 - 5% per year. As per the municipal waste growing, this is almost three times faster (Environmental Protection Emergency Response 2001).

E-waste refers to electronic goods that have reached the end of their usable life. Computers, televisions, VCRs, stereos, copiers, and fax machines are examples of E-waste. Owing to the pandemic circumstances, individuals are conducting a majority of their tasks online, leading to a widespread and heightened utilization of electronic devices, particularly a surge in mobile phone usage. According to findings by He et al., the global disposal of electronic waste amounts to approximately 4,000 tones every hour (He et al 2008). The pandemic situation and the rapid growth in the consumption of electronic gadgets are forming a new problem of electronic waste. After the industrial revolution, the electronic industry has grown up as the world's largest and fastest-growing manufacturing industry (Department of Information Technology, Government of India 2003). Consequently, the proportion of waste stemming from technology is witnessing a concerning escalation. Data indicates a remarkable 27% upsurge in investments within electronic product manufacturing in recent years, notably marked by the Himalayan region of Uttarakhand, where the production of mobile phones has reached a striking 28% growth rate (Development of Electronics Manufacturing Cluster in Kashipur). In India, there is no proper management for the disposal of this massive e-waste, Only 3% of the total e-waste is recycled correctly. The remaining e-waste is picked by workers who belong to low-income families. The collection and recycling of the e-waste are performed in a very unhygienic condition with bare hands and without a mask. A large part of e-waste is also related to computer-related hardware. Approximately all the electronic gadgets and computer hardware contain large to trace amounts of hazardous toxic elements. The significant elements that cause toxicity are lead, mercury, hexavalent chromium, cadmium, plastic, brominated flame retardants, PVC etc. (vijay et al. 2014). A typical computer monitor may contain up to 6% lead by weight with toxic substances, acids and toxic metals in plastics, batteries, PCBs and so on (Dimitrakakis et al 2009). Various computer components result in the formation of dioxins and heavy metals from it (Spalvins et al 2008). Improper handling and management of E-components in landfills causes a risk for the future. A significant part of heavy metals, including toxic elements such as mercury and cadmium and landfills, is found in the electrical and electronic equipment used and discarded by humans. Over an extended period, these toxic elements contaminate the groundwater and other water-bodies like glaciers in a hilly region, thereby endangering the environment and human health. Exposure to lead results in neurological, cardiovascular and reproductive function. Contamination of water and soil by lead causes problems in the blood that affect the nervous system's inadequate functioning (Pal et al 2015, Bikash et al 2019). Excessive exposure over a long period also results in the potency of males (Amadi et al 2017). Cadmium (Cd) is also a central toxic element found in E-waste spreads in the environment. Cadmium affects the respiratory tract and gastrointestinal tract majorly. Cadmium is generally transported into the bloodstream

and severely affects the kidney, renal and hepatic dysfunction in later stage (Satarug et al 2018, Tinkov et al 2018). In India, the primary source of north Indian rivers is the glaciers of the Himalayas. These rivers have 30–50% annual flow from glacier melt runoff (Chauhan et al 2012). The temperature in the Himalayan region is generally between 20°C and -20°C. These freezing conditions make it challenging to compost processes in the hilly regions, leading to improper disposal of E-waste in the region (Hou et al. 2017) . This mismanagement of E-waste leads to toxic elements in soil and water bodies (Tian et al 2013). In context to Himalaya in Uttarakhand state, the world-famous Hindu pilgrims Badrinath, Kedarnath, Gangotri and Yamunotri have always attracted tourists worldwide. Also, there are a large number of trekking paths for adventures. In contrast, the remote and rural places in the lap of the Himalayas are crowded with people throughout the year. In the last few years, the e-waste consumed by people in rural areas of the Himalayas has increased. Managing electronic trash is one of the world's fastest-growing pollution issues. The geographical and social aspects also make it challenging to manage the large spread e-waste in the region. Manage e-waste on a personal level is less profitable economically to waste collectors, shopkeepers and manufacturers. Due to the lack of a proper recycling system, the collection and treatment of e-waste are entirely dependent upon the voluntary response of the visitor and locals (Williams et al 2003, Jagdish et al 2005) . Our primary objective is to underscore the detrimental effects of these wasteful electronic devices, which pose significant harm to our society. We derive relevant conclusions and recommendations from a survey conducted among individuals of different age brackets in the mountainous expanse of Uttarakhand. These recommendations hold considerable value in addressing and ameliorating the diverse array of challenges stemming from electronic waste. The Uttarakhand E-Waste Management Rules-2023 is a policy framework that aims to bring together the public, government, and industry to adopt responsible measures for sustainable electronics that are responsive to environmental needs. The policy focuses on the principles of “Reduce, Reuse, and Recycle”. The rules outline clear responsibilities for manufacturers, producers, consumers, bulk consumers, refurbishers, collection centers, dismantlers, recyclers, state governments, and urban local bodies. The state government aims to complement these rules by promoting refurbishing and recycling of electronic products through the right channels.

In addition to the policy framework, there are several initiatives in Uttarakhand that aim to manage e-waste. For instance, the Dehradun Municipal Corporation has inaugurated an e-waste management system and minimization campaign in collaboration with the Society of Pollution and Environmental Conservation Scientists (SPECS), Uttarakhand State Council of Science and Technology, and National Missions on Himalayan Studies. Green Hills, an NGO in Almora, has launched a campaign to collect all kinds of electronic waste such as discarded computers, laptops, printers, fax machines, mobile phones, chargers, electronic toys, batteries, television sets, calculators etc. so that the waste can be recycled. There are several possible reasons for the surge in electronic waste production in Uttarakhand. Some of them are:

- The rapid growth of the IT sector and the increasing demand for electronic products in the state.
- The lack of awareness and proper disposal facilities for e-waste among consumers and businesses.
- The influx of tourists and pilgrims who bring and discard electronic gadgets such as mobile phones, cameras, batteries, etc.
- The natural disasters such as floods and landslides that damage electronic infrastructure and equipment.

E-waste, or electronic waste, is a growing problem that needs to be addressed. Every year, over 50 million metric tons of e-waste are produced throughout the world. E-waste contains toxic components that are dangerous to human health, such as mercury, lead, cadmium, polybrominated flame retardants, barium, and lithium. These can cause damage to the human body and affect the brain, heart, liver, kidney, and skeletal system. Workers who handle e-waste in developing countries are particularly vulnerable to these harmful substances. In addition to the negative health effects on humans, e-waste also has a significant impact on the environment. E-waste releases toxic chemicals into the air and soil, causing air pollution and negatively impacting soil and water quality. It also contributes to climate change by releasing greenhouse gases into the atmosphere.

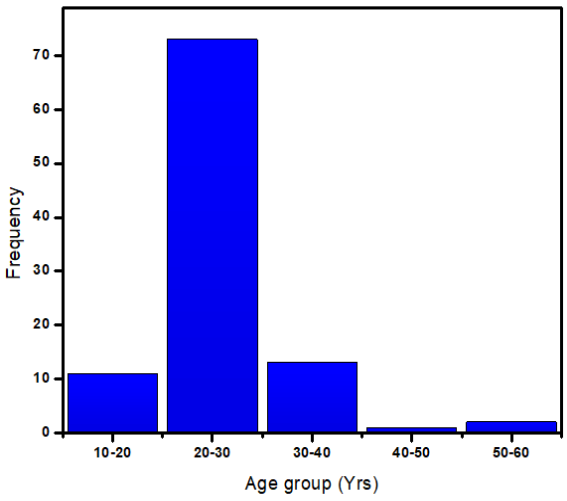
Methodology and Findings

An endeavor has been undertaken to formulate a strategy aimed at shedding light on the E-waste scenario in the Garhwal Himalayan region. For this purpose, an online questionnaire was employed to elucidate the pattern of electronic waste (E-waste) within the area.

Respondent age group and use of electronic gadgets

Conducting an online survey, we distributed questionnaires to diverse age cohorts ranging from 10 to 60 years in the mountainous terrain of Uttarakhand. The analysis of these surveys revealed a greater involvement of the younger demographic, specifically within the 20-30 age bracket, while comparatively lower enthusiasm was observed among individuals aged 40-50. This trend is visually represented in Figure 1, showcasing heightened frequency and participation interest among the younger generation.

Among all 100 respondents, around 57% feel that electronic gadgets, the mobile phones and laptops used by them, create the E-Waste problem in the Himalayan region. As we see from the fig. 2, the average life of electronic gadgets becomes shorter, impacting the advancement of fast-growing technology. With the advancement, a user only wants to use his gadget only for a few months after exchanging it or disposing of it. The data taken from the respondents shows 73% find that the average life of electronic gadgets ranges from 2-5 years. And this lifetime of the electronic gadgets needs to be taken care of by the companies manufacturing the products by increasing the use-life of the products.



Figu 1. Participation of different age

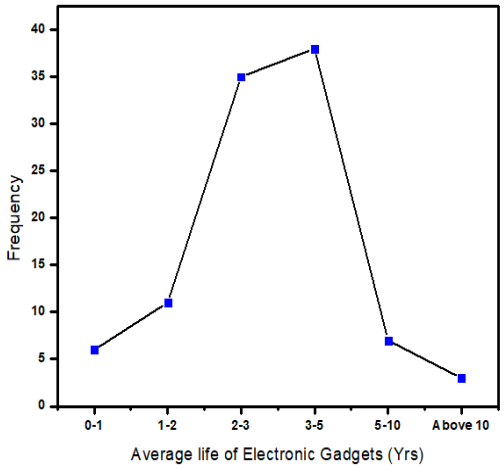


Figure 2. Average life of electronic gadgets (Yrs) group with frequency mostly used by the respondents

Among the data collected from 100 respondents mostly, 73% are from the age group of 20-30, then 13% respondents are from the age group of 30-40, and 11% are from 10-20 age, so we can conclude that the respondents are young and active users of mobile phone and Laptop. Regarding electronic devices, the majority of participants make use of laptops and mobile phones, as depicted in Figure 3. Due to the prevailing circumstances of the COVID-19 pandemic, mobile phone usage has significantly overshadowed other electronic gadgets among the respondents. This data unequivocally highlights that the predominant contributors to E-Waste are mobile phones or smartphones, exerting a noteworthy impact on both environmental and health-related concerns in the Himalayan hilly region.

Use of electronic gadgets and their side effects

The findings of the study indicate that a significant proportion of participants, approximately 56%, tend to retain obsolete and antiquated electronic devices within their households, as visually depicted in Figure 4. A mere 6% of the respondents choose to discard these devices outdoors, thereby contributing directly to the imminent issue of E-Waste. A smaller percentage, roughly 12%, opt to gift their outdated items to others. Merely 26% of the respondents engage in exchanging their devices with retailers, who might subsequently either dispose of them or subject them to recycling processes

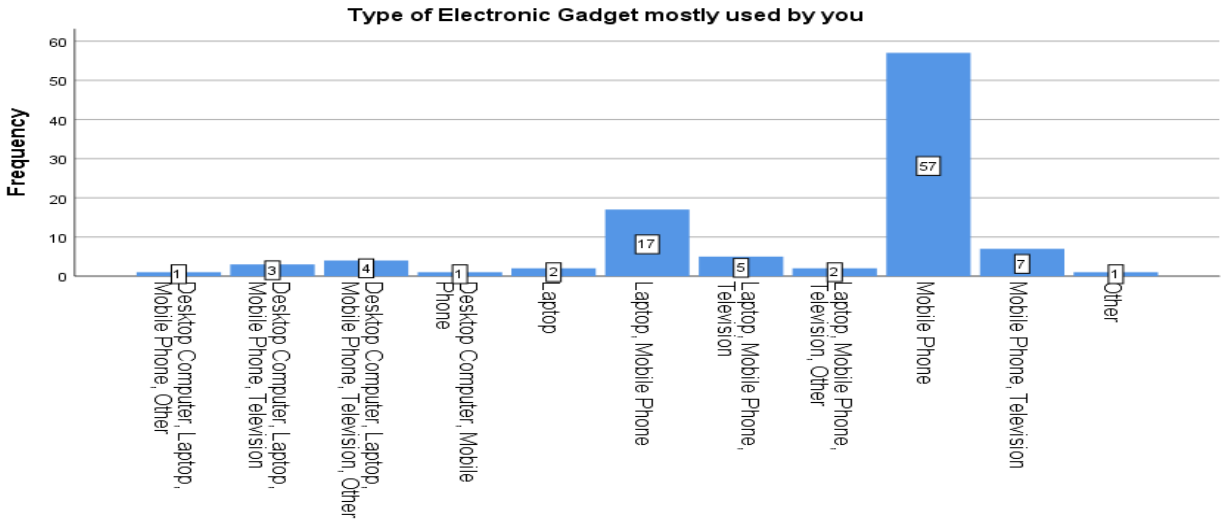


Figure 3. Type of Electronic Gadget mostly used by the respondents

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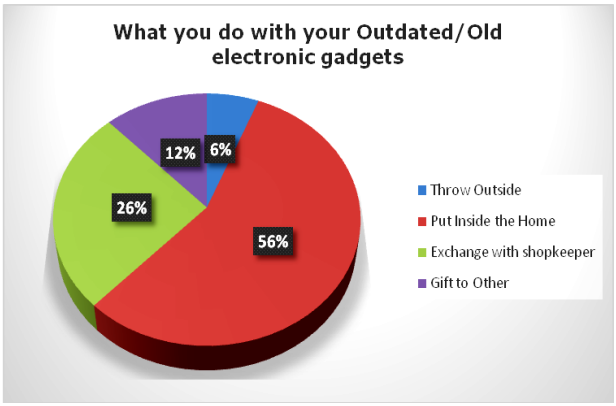

Table 1. Awareness about the toxic materials used in electronic gadgets

Yes	No	No response	Total
78	21	01	100

Figure 4. Reaction of Respondents with outdated and old electronic gadgets

As indicated in Table-1, a substantial majority of respondents, approximately 78%, demonstrate awareness of the E-Waste predicament. This awareness encompasses the recognition of the toxic substances present in electronic devices, a recognition that persists despite their extensive interaction with these gadgets. The most pernicious component within e-waste possesses the capacity to adversely impact nearly all systems within the human body. For instance, cell phone batteries contain cadmium, which can impair learning, cognition, and other behavioral attributes, particularly in children. Additionally, cell phones may contain arsenic, a hazardous element affecting various bodily systems. The survey findings, as depicted in Figure 5, undeniably affirm that a significant number of respondents acknowledge the role of E-Waste in engendering health concerns within society.

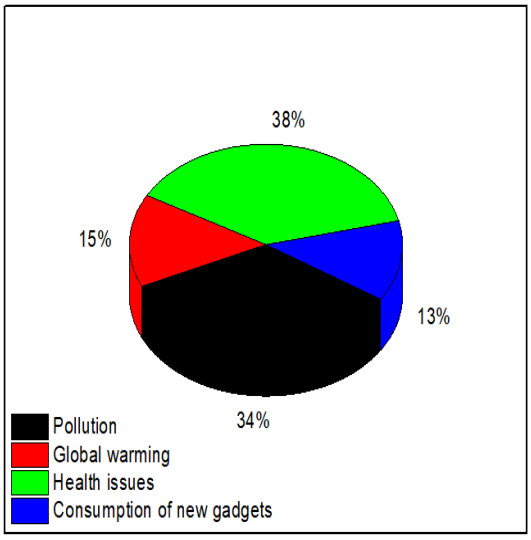

Figure 5. Effect of E-Waste on Society

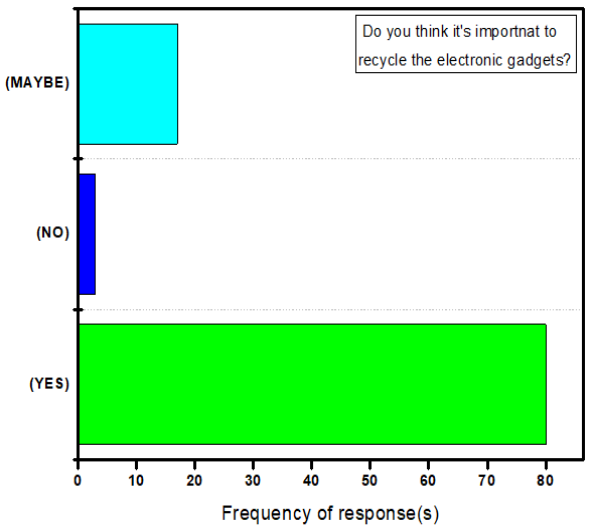

Figure 6. Responses towards recycling of E-Waste

Need for Recycling of E-Waste

According to the data illustrated in Figure 6, approximately 80% of respondents are well aware of the significance of E-waste recycling, while 17% lack understanding of proper e-waste recycling practices. In the hilly expanse of the Himalayas, only a negligible fraction of E-waste undergoes correct recycling procedures; the majority is disposed of in landfills and incinerators, despite the presence of hazardous chemicals that can seep into groundwater and water courses from these sites. The secondary breakdown of materials derived from e-waste processing, such as the dismantling of cathode-ray tubes (CRTs) and metal extraction, constitutes a segment of the management of these discarded items. This waste adversely affects various rivers in the Himalayan hilly region, including Alaknanda, Bhagirathi, Yamuna, Koshi, Kali, among others, thereby precipitating environmental predicaments. Referring to Figure 7, it is evident that a predominant 51% of respondents perceive mobile phones as the principal catalyst for the E-Waste predicament in the area. Despite diverse sources of E-waste, most respondents opine that mobile phones serve as the most rapidly expanding repository of electronic waste materials in contemporary times.

Table-2 shows that 66% of the respondents feel that they are aware that E-Waste is a problem, while around 33% don't see E-waste as a problem because they go for the exchange of outdated electronic gadgets. Lack of management makes it dangerous for the health of people and the environment.

Table 2. Problem related to disposal of E-waste

		Frequency	Percent
	Yes	66	66.00
	No	33	33.00
	No Response	01	01.00

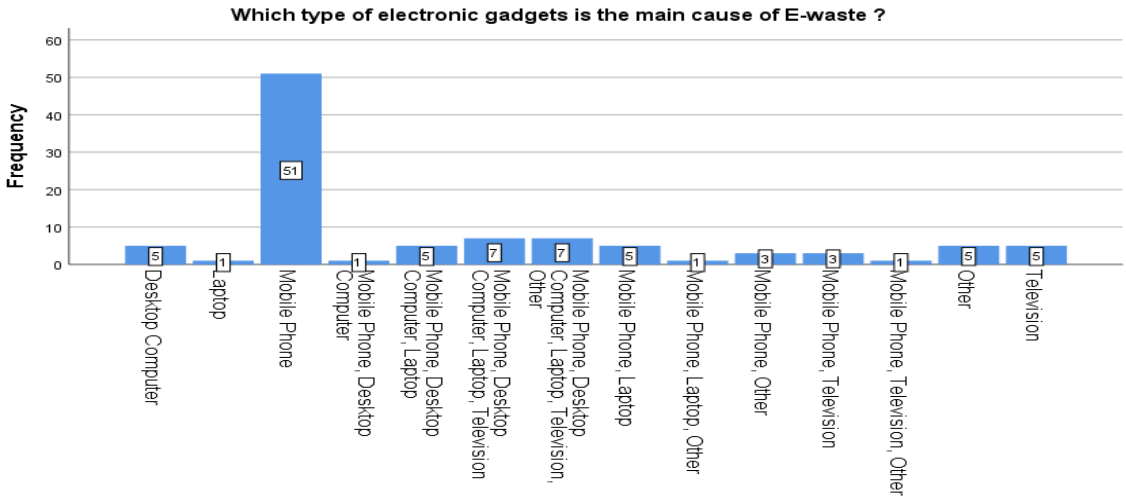

Figure 7. Main causes of E-Waste with frequency of respondents

Conclusion

Based on the conducted survey within Uttarakhand's hilly terrain, a predominant participation from the age group of 20-30 years, most notably the younger demographic, has been observed. The data shows that the mean lifespan of various electronic devices hovers around 3-5 years, with mobile phones securing the lead as the most extensively employed electronic gadget, accounting for 57% of utility. The survey outcomes highlight that a notable 56% of respondents retain outdated electronic devices within their homes, while 26% opt for the exchange of alternatives with local vendors. It's worth noting that the survey pool primarily comprised the younger age bracket, individuals who exhibit a strong awareness of the toxicity associated with e-waste. Evidently, pollution and health concerns emerge as the most severe consequences of e-waste. Given the eco-sensitive nature of Uttarakhand's hills and rivers, the extensive prevalence of e-waste poses substantial peril to the Himalayan ecosystem. The survey unequivocally underscores that both disposal and recycling stand out as pivotal issues for the local populace. There exists a deficiency in awareness and effective management concerning the collection, disposal, and recycling of e-waste. This insufficiency in management is contributing to the degradation of the environment and biodiversity of the Garhwal region, subsequently triggering environmental and health-related predicaments. Furthermore, the integration of e-waste management with employment generation holds promise for the region's development. A pressing need arises to institute a proficient e-waste recycling system in order to preserve the biodiversity encompassing the land, forests, and aquatic life within the Himalayan hilly domain. To effectively tackle the e-waste management challenge in the Garhwal region of the Himalayas, a comprehensive strategy is essential. The existing framework of e-waste management guidelines in India, including the 2016 guidelines, provides a foundation for overseeing e-waste practices. National policies dedicated to e-waste management guide the collection and recycling procedures. However, these policies should be fortified to ensure stakeholders' accountability for preventing e-waste contamination. An effective mechanism should be established to engage the general public in the effort, potentially through the establishment of a special task force by the government, aimed at both minimizing e-waste and generating employment opportunities.

There are several ways to dispose of electronic waste (e-waste) responsibly. Here are some options:

1. **Sell your electronics**: If electronic device is still in good condition, consider selling it to someone who can use it. This way, you can extend the life of the device and prevent it from ending up in a landfill.
2. **Donate your electronics**: If you don’t want to sell your electronics, consider donating them to a charity or non-profit organization that accepts electronic donations. This way, you can help someone in need while also keeping e-waste out of landfills.
3. **Recycle your electronics**: Recycling is one of the best ways to dispose of e-waste responsibly. Many manufacturers and retailers offer recycling programs for electronic devices. You can also check with your local government or recycling center to see if they accept e-waste.
4. **Find an e-waste collection event**: Many communities hold e-waste collection events where you can drop off your old electronics for recycling. Check with your local government or recycling center to see if there are any upcoming events in your area.

5. **Use a certified e-waste recycler**: If you have a large amount of e-waste to dispose of, consider using a certified e-waste recycler. These companies specialize in the safe and responsible disposal of electronic devices and can ensure that your e-waste is recycled properly.

Remember that e-waste contains toxic components that are dangerous to human health and the environment. Therefore, it's important to dispose of e-waste responsibly and avoid throwing it in the trash.

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