Chapter 10
Impact of E-Waste Processing on Health and Environment

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ABSTRACT

This chapter explores innovative e-waste management solutions focusing on technology and sustainability. It introduces the universal risk assessment framework (URAF) for e-waste sites, a model to evaluate contamination. The chapter highlights urban mining as a sustainable alternative to traditional resource extraction, along with supercritical water oxidation (SCWO) and thermal plasma technology, which transform hazardous e-waste into harmless byproducts and clean energy sources. Technological advancements, including blockchain-enabled waste tracking, AI-powered automated sorting, and IoT-integrated smart waste bins are revolutionizing e-waste management efficiency. Additionally, policy-driven strategies such as right-to-repair legislation and modular electronics design aim to extend product lifespans and reduce overall waste. However, challenges remain in implementation, particularly in developing nations where regulatory enforcement and economic viability pose obstacles to formal recycling.

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INTRODUCTION

Electronic waste (e-waste) is one of the fastest-growing global waste streams, posing significant environmental and public health challenges. The rapid expansion of consumer electronics shortened product life cycles, and limited repairability have resulted in an unprecedented increase in discarded electronic devices (Forti et al., 2018). A record 62 million tonnes (Mt) of e-waste was produced in 2022, Up 82% from 2010; On track to rise another 32%, to 82 million tonnes, in 2030; Billions of dollars worth of strategically valuable resources squandered, dumped; Just 1% of rare earth element demand is met by e-waste recycling, highlighting a significant gap in sustainable e-waste management. Europe has the highest documented formal e-waste collection and recycling rate. In other continents, the e-waste documented as formally collected and recycled is substantially lower than the estimated e-waste generated. Despite its hazardous composition, e-waste also contains valuable materials driving both formal and informal recycling efforts. However, a significant portion of e-waste is mishandled, exported to developing nations, or processed using unsafe methods, leading to severe health and environmental consequences.

E-waste contains a complex mix of hazardous substances, including heavy metals (lead, mercury, cadmium, chromium), persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs), and brominated flame retardants (Eguchi et al., 2013). E-waste also contains valuable resources such as gold, silver, copper, and rare earth elements, yet its informal processing releases toxic chemicals, heavy metals, and persistent organic pollutants (POPs) into the environment, posing severe risks to workers, surrounding communities, and ecosystems (Parvez et al., 2021). The health consequences of prolonged exposure to e-waste pollutants include neurodevelopmental disorders, respiratory diseases, endocrine disruption, and cancer risks (Heacock et al., 2022; Huo et al., 2019). The economic and environmental paradox of e-waste recycling serves as both a resource recovery opportunity and a major pollution source demanding a multidisciplinary, policy-driven approach for effective management (Agrawal & Sahu, 2010).

Improper disposal and informal recycling methods, such as open burning, acid leaching, and manual dismantling, expose workers and surrounding communities to toxic fumes, contaminated soil, and polluted water sources (Parvez et al., 2021). These practices are particularly prevalent in low-income countries, where weak regulatory enforcement, economic pressures, and a lack of proper waste management infrastructure contribute to unsafe recycling activities (Gollakota et al., 2020). To mitigate the risks associated with e-waste, various international regulatory frameworks have been established. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal aims to prevent the illegal export of hazardous waste from developed to developing nations, yet loopholes and