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A review on the sources, occurrence and health risks of per-/poly-fluoroalkyl substances (PFAS) arising from the manufacture and disposal of electric and electronic products

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ABSTRACT

Electric and electronic waste materials (e-waste) serve as a reservoir of highly persistent and extremely toxic inorganic and organic hazardous materials, including per-/poly-fluoroalkyl substances (PFAS) compounds. Besides the electric and electronic industry, PFAS remain an important industrial chemical class because PFAS coating on consumer goods increases their mechanical and thermochemical resistance as well as to tune their liquid repellence properties to oil and water. The release of PFAS from e-waste processing sites and storage landfills into wastewaters was reviewed. It appears that e-waste materials in landfills serve as important nodes for PFAS diffusion to water, soil, hence exerting ecotoxicity on exposed human populations. Evidence from cross-sectional, case-control, and longitudinal studies show that co-occurrence of PFAS and other e-waste toxicants in body fluids and organs of humans act synergistically in causing several health disorders. Based on holistic analyses, the review highlights that PFAS compounds significantly contribute to e-waste pollution, which needs immediate attention from policymakers.

1. Introduction

Globally expanding electronics and electrical industries constitute a major source of organic pollutants in the environment, posing a significant risk to environmental security and industrial sustainability [1,2]. An increase in purchasing power and associating self-esteem with e-products has further accelerated the generation of e-waste by the individuals [3,4]. In addition, within the past decade, the fast rate of innovation within the e-industry has led to paradigm technological changes leading to substantial leaps in e-waste volumes generation. Over 50 million metric tons of e-waste, discarded electronics, and electrical equipment or their subparts are generated annually [5].

Landfills dumped with electrical and electronic waste and e-waste processing sites leach a cocktail of persistent organic pollutants (POPs) into the environment, including per-/poly- fluoroalkyl substances (PFAS), which has not received due attention [6,7]. PFAS, fluorinated organic compounds (–C_nF_{2n+1}), are widely used as additives within the electronic, metal finishing, and packaging or surface treatment industries [8,9] for their outstanding thermo-chemical resistance and stability, imparting unique properties to goods and materials. The amphiphilic nature of PFAS compounds offer them tunable liquid repellence, facilitating the development of self-cleaning technologies, while the great stability of the C–F bonds within PFAS materials dramatically enhances the chemicals tolerance to photo, thermal,

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