

Multimedia assessment of heavy metal pollution and health risks in a riverine agro-mining landscape

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Abstract

Heavy metal pollution in agro-mining zones threatens ecosystems and human health through bioaccumulation and food-chain transfer. This study assessed heavy metal pollution and associated health risks in the Likuyu River catchment by measuring concentrations of zinc (Zn), cadmium (Cd), nickel (Ni), copper (Cu), and lead (Pb). During the rainy season, samples of water, sediment, soil, and locally cultivated vegetables were systematically collected along a 22.7 km stretch of the river. Heavy metal concentrations were analyzed by flame atomic absorption spectroscopy (FAAS), providing a multi-media view of contamination and exposure pathways. Although water showed low ionic concentrations, Cd exceeded the WHO limit (0.01 mg/L). Sediments revealed elevated Zn at Site A (108.0 mg/kg) and Ni at Site E (35.97 mg/kg), with Ni surpassing the threshold effect concentration (TEC) of 22.7 mg/kg. However, overall sediment pollution was low: Zn enrichment was slight (CF = 1.14), and a negative Igeo with PLI < 1 indicated unpolluted conditions. Soil from Site D had Ni at 107.2 mg/kg, exceeding the Tanzania Bureau of Standards (TBS) limits, with CF = 1.58 and Igeo = +0.07, indicating moderate pollution. Other sites showed CF < 1, negative Igeo, and low PLI, reflecting minimal contamination. Cowpea (*Vigna unguiculata* (L.) Walp.) and Napa cabbage (*Brassica rapa* subsp. *pekinensis* (Lour.) Hanelt) accumulated high levels of Ni and Pb, with Pb exceeding the Codex Alimentarius limits and Ni surpassing the European Food Safety Authority (EFSA) limits. Bioaccumulation was evident (BAF > 1), and health indices indicated noncarcinogenic (HI > 1) and carcinogenic risks (CR > 10⁻⁴), especially in cowpea (CR = 0.347). Elevated Ni and Pb in soils and vegetables indicated localized exposure risks, highlighting the need for targeted monitoring, informed vegetable selection, and coordinated mitigation in agro-mining areas.

Keyword

Heavy metals; Multimedia assessment; Bioaccumulation; Health risk; Agro-mining areas; Tanzania