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Contaminant bioaccessibility in abandoned mine tailings in Namibia changes along a climatic gradient

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Fine-grained dust from tailing storage facilities in abandoned sulfide-ore mining areas represents an important source of environmental contamination. Fine fractions (<48 µm and <10 µm) of tailings from three old mining sites situated along a climatic gradient from hot semiarid to cold desert conditions in Namibia were studied: Kombat (Cu-Pb-Zn; rainfall ~500 mm), Oamites (Cu; ~120 mm), Namib Lead & Zinc (Pb-Zn; ~0 mm). Multi-method mineralogical and geochemical investigations were adopted to assess the solid speciation and gastric bioaccessibility of the metal(loid)s and to evaluate the associated human health risks. The total concentrations of contaminants in the tailings generally increased with the decreasing particle size (up to 134 mg As/kg, 14,900 mg Cu/kg, 8,880 mg Pb/kg, 13,300 mg Zn/kg). The mean bioaccessible fractions varied substantially between the sites and were significantly higher for the tailings from the sites with a higher rainfall (73-82% versus 22%). The mineralogical composition of the tailings, reflecting the original mineralogy and the degree of the weathering process, is the main driver controlling the bioaccessibility of the metal(loid)s. In desert environments, metal(loid)s in tailings are bound in sulfides or sequestered in secondary Fe oxyhydroxides and/or Fe hydroxysulfates, all of which are insoluble in simulated gastric fluid. In contrast, tailings from areas with higher precipitation contain metal(loid)s hosted in carbonate phases (malachite, cerussite), which are highly soluble under gastric conditions. Based on the higher contaminant bioaccessibility, the vicinity of the settlement and farmlands, and a higher percentage of wind-erodible fine particles, a higher risk for human health has thus been identified for the Kombat site, where further remediation of the existing tailings storage facility is highly recommended.

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