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Assessing soil contamination sources and pathways in mining area using Cu, Pb, Zn, and S isotopes

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Investigation technologies using reliable methods are essential components of environmental forensics for soil contamination sources and pathways. Areas surrounding the studied mine in South Korea were contaminated by As and Cu and there are a tailings dump and a creek contaminated by adit seepages. Soil, ore, and surface water samples were analyzed for Cu, Zn, Pb, and S isotopic ratios. δ^{65}Cu in the soil downstream of the adit seepages and the tailings dump exhibited higher and lower values than 0.3‰, respectively, showing a clear differentiation. δ^{65}Cu of the adit seepages increased to 2.3–3.1‰ from -0.3‰ of a pyrite sample due to the isotopic fractionation during the oxidative dissolution of Cu. Subsequently, at the paddy field, Cu may have been precipitated as sulfides by sulfate reduction having δ^{65}Cu of 0.4–1.1‰ which was depleted by the isotopic fractionation during sulfide precipitation. Moreover, the soil exhibited δ^{66}Zn between -0.7 and 0.2‰ that was depleted from those (0.1–0.2‰) in the adit seepages, which also suggests the isotopic fractionation during sulfide precipitation. Nevertheless, δ^{66}Zn could not be utilized as a tracer for contaminants because δ^{66}Zn of ore (0.2‰), contaminated water (0.1–0.2‰), and background soil (-0.4–0.0‰) were similar. Similarly, as some samples downstream of the tailings dump also had δ^{34}S similar to those downstream of the adit seepages, δ^{34}S signature may be utilized only as an additional tool. With increasing Pb concentrations, $^{208/206}$Pb values of soil samples downstream of the tailings dump and the contaminated creek approached those of the ore and the creek water, respectively. In the village after the junction downstream of the adit seepages and the tailings dump, soil samples exhibited δ^{65}Cu of 0.1–0.2‰ and $^{208/206}$Pb similar to the ore, which suggests the contamination source is tailings. Therefore, δ^{65}Cu and $^{208/206}$Pb of soil effectively could indicate contamination sources, and δ^{34}S and δ^{66}Zn could support the findings in the mining area.

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