

Assessing behaviors of heavy metals and tracing contamination sources in groundwater of mining area using Cu and Zn isotopes

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It is necessary to establish an environmental forensics technique using metal isotopes to determine sources and pathways of contamination and to assess the contribution of sources in groundwater. The groundwater contamination in the studied mine may have been caused by contaminated soil and/or a contamination plume from a goaf. A multilevel sampler was installed to assess ion concentrations and isotopic ratios of Zn, and Cu. Zn concentration was highest at the shallowest depth of 1.2 mbgl (meter below ground level) and gradually decreased with depth, indicating leaching from the contaminated soil. On the contrary, sulfate concentrations were high throughout the depth. At the shallow groundwater of 1.2–5.2 mbgl, $\delta^{66}\text{Zn}$ ranged between 0.355‰ and 0.488‰, which were 0.345–1.144‰ higher than -0.656–0.010‰ in the contaminated soil. The dissolved sulfide concentrations of the depth ranged between 0.02 and 0.09 mg L⁻¹ which were higher than 0.00–0.02 mg L⁻¹ at 6.2–17.2 mbgl, indicating relatively vigorous sulfate reduction. Accordingly, $\delta^{66}\text{Zn}$ in groundwater may have been enriched during precipitation of Zn sulfides. $\delta^{66}\text{Zn}$ at 6.2–19.2 mbgl substantially decreased to between -0.095‰ and 0.151‰, and $\delta^{65}\text{Cu}$ at 9.2–19.2 mbgl substantially increased to 1.064–2.275‰ from 0.319–1.146‰ at 1.7–7.2 mbgl. These results suggest that those depths were mainly affected by the contamination plume from goaf with $\delta^{66}\text{Zn}$ of 0.106–0.179‰ and $\delta^{65}\text{Cu}$ of 2.7–3.1‰. The further depletion of $\delta^{66}\text{Zn}$ in the samples may have resulted from the adsorption of Zn and Cu during the transportation of contaminated plume. Sources of groundwater contamination were effectively differentiated utilizing Zn and Cu isotopes: leaching from the contaminated soil at the shallow groundwater and the contamination plume from the goaf at the deep groundwater.

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