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Bismuth speciation and secondary recovery of weathered mine tailings

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The increasing demand for bismuth (Bi) in emerging scientific and technological applications has heightened the need to identify and secure new sources of Bi. Secondary recovery from mining waste streams presents a promising opportunity to supplement global supply. However, the reprocessing of these waste streams is hindered by limited knowledge of Bi speciation in tailings materials. This challenge is compounded by the complex geochemistry of Bi, which exhibits high mineral diversity and fractionates into a wide range of minerals, including auriferous, sulfidic, telluridic, and oxide species (Deady, 2022). The current lack of understanding regarding Bi weathering patterns in tailings constrains predictions of its mobility and recovery potential.

This study aims to investigate (1) Bi speciation in weathered tailings and (2) the recovery of Bi in relation to its chemical forms in tailings. Bismuth L_{III}-edge X-ray absorption near edge spectroscopy (XANES) was used to examine Bi speciation, complemented by sequential extraction procedures, sulfur K-edge XANES, X-ray diffraction, and electron microscopy. The bismuth content in the tailings averaged 317 mg/kg (209–552 mg/kg), with lower concentrations of tellurium (8.8–22 mg/kg) and gold (0.23–2.6 mg/kg). Sequential extraction revealed that the majority of Bi resides in the reducible fraction (55–74%), followed by the 'adsorbed' fraction (11–17%) and the 'oxidisable' fraction (9–10%), with an average of 12% in the ‘residual’ fraction. Sulfur K-edge XANES confirmed the absence of sulfides or metal sulfides. These findings were consistent with Bi L_{III}-edge XANES, which indicated no Bi sulfides, tellurides, or elemental Bi, in contrast to the initial ore material. Instead, linear combination fitting identified bismuth oxide as the dominant species in the tailings, with minor amounts of Bi carboxylate and carbonate species. HCl extraction demonstrated significant recovery potential, with up to 75% of recoverable Bi extracted within one hour at ambient temperature. These results provide new insights into Bi geochemistry in tailings and highlight the potential for secondary recovery as a sustainable source of Bi.

References

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