

The mobility of critical raw materials from mining waste to acid river and its removal by jarosite, schwertmannite and goethite

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Critical Raw Materials (CRM) were analysed along the Tinto River basin (SW, Spain), which is affected by acid mine drainages (AMD) originating from several leachate inputs from waste-rock piles and mine adits. While the Tinto River and AMD showed acid pH values (0.73–2.46), AMD presented higher electric conductivities compared to the Tinto River (20.17–56.14 mS/cm and 9.34–1.58 mS/cm, respectively). Total rare earth elements and yttrium (Σ REY) measured concentrations were up to 2600 μ g/L in the Tinto River and 17056 μ g/L in AMD. Moreover, the Tinto River showed high concentrations of other dissolved CRM as Mg, Al, Mn, Co, Sr, P, Ni, Sb, and As.

Iron precipitates, collected from the riverbed, were identified mainly as jarosite, schwertmannite and goethite by XRD and SEM-EDS. The formation of the different minerals depends on water parameters, with pH and electrical potential being key factors. These minerals are metastable, i.e. they can evolve from schwertmannite to goethite, and present the capacity to adsorb elements. Measurements revealed high concentrations of CRM, as Mg (up to wt. 3%), Mn, As, Ba, Cu, P, Sb (up to 4220, 6131, 2399, 3400, 2004, 1860 and 319 μ g/g, respectively), as well as low concentrations of REY (Y, Ce, La, and Nd). Although iron precipitates generally exhibit a low affinity for the adsorption of REY, at low pH their adsorption capacity improves through sulfated anionic complexes (e.g., $\text{REY}(\text{SO}_4)_2^-$).

Knowing the mobility of CRM from mining waste to acid waters and its mineral precipitates is essential for assessing their potential as sources of strategic and critical elements. Moreover, evaluating the feasibility of recovering these materials can contribute to the advancement of a circular economy.

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