

Environmental assessment of the arsenic-rich, Rodalquilar gold–(copper–lead–zinc) mining district, SE Spain: data from soils and vegetation

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Abstract The Rodalquilar mineral deposits (SE Spain) were formed in Miocene time in relation to caldera volcanic episodes and dome emplacement phenomena. Two types of ore deposits are recognized: (1) the El Cinto epithermal, Au–As high sulphidation vein and breccia type; and (2) peripheral low sulphidation epithermal Pb–Zn–Cu–(Au) veins. The first metallurgical plants for gold extraction were set up in the 1920s and used amalgamation. Cyanide leaching began in the 1930s and the operations lasted until the mid 1960s. The latter left a huge pile of ~900,000–1,250,000 m³ of abandoned As-rich tailings adjacent to the town of Rodalquilar. A frustrated initiative to reactivate the El Cinto mines took place in the late 1980s and left a heap leaching pile of ~120,000 m³. Adverse mineralogical and structural conditions favoured metal and

metalloid dispersion from the ore bodies into soils and sediments, whereas mining and metallurgical operations considerably aggravated contamination. We present geochemical data for soils, tailings and wild plant species. Compared to world and local baselines, both the tailings and soils of Rodalquilar are highly enriched in As (mean concentrations of 950 and 180 µg g⁻¹, respectively). Regarding plants, only the concentrations of As, Bi and Sb in *Asparagus horridus*, *Launaea arborescens*, *Salsola genistoides*, and *Stipa tenacissima* are above the local baselines. Bioaccumulation factors in these species are generally lower in the tailings, which may be related to an exclusion strategy for metal tolerance. The statistical analysis of geochemical data from soils and plants allows recognition of two well-differentiated clusters of elements (As–Bi–Sb–Se–Sn–Te and Cd–Cu–Hg–Pb–Zn), which ultimately reflect the strong chemical influence of both El Cinto and peripheral deposits mineral assemblages.

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Introduction

The Rodalquilar gold mining district (all mines and metallurgical plants presently decommissioned) is located in the Almería province (SE Spain), within the Cabo de Gata–Níjar Natural Park (Fig. 1). The park encompasses about 457 km² of protected land and sea (Fig. 1) and is located in the most arid part of Europe, where volcanic outcrops characterize a landscape, in which Mediterranean plant communities grow. The region has a high floristic diversity and is considered a priority for conservation in Europe. The climate is semi-arid Mediterranean, with low