



Evaluation of the risk caused by soil ingestion in a highly contaminated old mine site

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The Sierra Minera is situated at the southeast of Spain, close to La Unión town and the marine lagoon known as Mar Menor. The mining resources of the area have been exploited for centuries but the activity ceased several decades ago and, at present, there is a large number of abandoned mine sites including old ponds containing fine mining materials. As a consequence of aerial and watercourses transports there is a dispersion to the surroundings of materials containing heavy metals. The transport caused by watercourses is particularly relevant due to the climate of the zone which is characterized by scant, occasional but torrential rainfalls that result in temporary gullies that run into the Mar Menor and mobilize soluble and particulate matters from the soils (mainly Calcic and Petrocalcic Xerosols and Calcaric Fluvisols, along with Luvic Xerosols and Calcic Luvisols and Arenosols near the coast line).

In this work, the mobility of both solid particles and soluble heavy metals compounds from the emission sources and the argilic horizons is studied, and a conceptual contamination model is discussed. Selective extractants (sodium dithionite plus sodium citrate (M-J), ammonium oxalate and nitric acid) were used, the levels of heavy metals being determined in each fraction and in the raw soils by means of atomic absorption spectrometry. X-ray diffraction (XRD) and scanning electron microscopy coupled to energy-dispersive spectrometry (SEM-EDS) were applied to the characterization of both raw samples and the residues remaining after each extraction, thus providing additional information about the sediment phases carrying the metals studied. On the other hand, studies on the bioavailability of the metals assessed by means of in-vitro digestion experiments were carried out.

Two possible scenarios are contemplated in the conceptual contamination model. The first scenario (S1) is represented by samples of beach materials. Some of these soils (Arenosols) are dedicated to residential use in a zone not influenced by the mining activity. It also covers other zones that receive contaminated run off from the hills and/or an old pond near the beach. Scenario 2 (S2) is represented by samples coming from sites near the temporary watercourses or devoted to agricultural use, samples all of which are influenced by the past mining activities. The results confirm that the processes governing the heavy metals transfer are strongly influenced by the semi-aridic climate, the presence of a high proportion of carbonates and the occasional but torrential rainfalls which, favoured by the Bt horizon impermeability, led to the transport of heavy metals from the upper zone of the hill to the surrounding agricultural soils. The gullies play an important role for the mobilization/ immobilization processes, their high carbonate contents providing a first barrier for metals mobility.