The Aznalcóllar Mine-Tailing Spill: Trace Elements in Remediated Soils.

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1. Introduction

The Aznalcóllar mine-tailing spill (25th April 1998) affected about 2700 ha of agricultural land. Approximately 6 million cubic meters of slurry inundated both riverbanks of the Agrio and Guadiamar rivers. Slurry was composed of acidic water loaded with heavy metals and other toxic elements, and sludge consisting of finely divided metal sulphides: pyrite with arsenopyrite (75-80%) and sphalerite and galena (5%). A strip 40 km long and 300 m wide along both rivers was covered by a layer (0-30 cm thick) of black sludge.
Severe heavy metal pollution was observed in the superficial layer (0-20 cm) of most of the sludge-affected soils. Generally, in soils with more than 20% of clay, concentration of heavy metals below the 20-cm depth decreased to values close to the background level of the Guadiamar valley soils. In coarser soils, heavy metal pollution penetrated below this depth, being noticeable down to at least 50-80 cm (Cabrera et al.,1999). Remediation works started soon after the accident and consisted in: 1) removal of the sludge from the surface soils together with a layer of soil of 5 to 20 cm; 2) deep ploughing (20 cm) to mix soil within the ploughed depth; 3) application of amendments (e.g. lime, Fe-rich soil, compost, manure).
To know the effectiveness of the remediations works, total and available trace elements were determined in soils of two affected areas of the Guadiamar river valley.

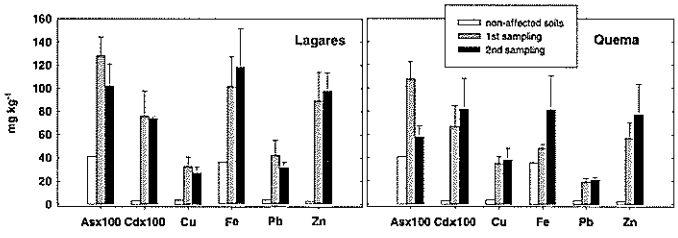
2. Materials and Methods

Two areas were selected for the experimentation: Lagares (W 06°13" N 37°21"; calcareous clay loam Typic Xerofluvent within an association Typic-Aquic soil) and Quema (W 06°15" N 37°14"; calcareous loam Thapto Fluventic Haploxeralf soil). Spatial variability of some physical and chemical properties was studied in two 10-ha plots. Samples (0-10, 10-20 and 20-30 cm) were taken at the nodes of a 50 x 50 m grid, either after the liming the soils and after the application of organic matter amendment. Total trace elements and S in soil samples (< 60µm) were determined after digestion with aqua regia in a microwave oven. Available trace element was determined in the EDTA extract. Dissolved trace elements and S in solution were determined by ICP-OES.

3. Results and Discussion

After the removal of the sludge deposited on the surface and the application of 20 t ha^{-1} of lime total concentrations of trace elements in the soils (0-30 cm) decrease with depth and show a big spatial variability. Mean values of total trace elements were much higher than the background values of the non-contaminated soils of the Guadiamar river valley (Cabrera et al., 1999); one exception were the mean the values of As in Quema below 10 cm of depth. In the surface layer (0-10 cm) many individual values in both areas, the mean values of total As, Cd, Cu Pb and Zn in Lagares and of Zn in Quema exceed the limit values for agricultural non-contaminated soils (Consejería de Medio Ambiente de la Junta de Andalucía, 1999). In many cases, especially in Lagares, trace element concentrations were even greater than those of the affected soils before the sludge withdrawal (Cabrera et al. 1999). These anomalies are due to the sludge left behind and buried in the soil by the machinery used in the remediation works. This is corroborated by the total S concentrations that decrease with soil depth and are higher than the typical values of non-affected soil of the studied zone. Total S values are correlated with total trace elements values, indicating that S and trace elements have the same origin, that is the residual sludge left behind during the remediation works.
Trace elements extracted with EDTA were determined after liming and after the application of 20 t ha^{-1} of compost or manure (Figure 1). Mean values of extractable trace element were generally higher in Lagares than in Quema, and in both areas they were much higher than the values for the non-affected soils of the Guadiamar valley. No significant differences were found between trace element available values before and after the manuring, except Fe in Quemas that increased significantly after the organic amendment.

Figure 1. *EDTA-extractable trace elements.*



4. Conclusions

After the withdrawal of the sludge from the surface of the soils, the concentrations of total and available trace element indicate soil contamination. Sludge left behind randomly on the surface of the soils and buried during the removal and amendment labours, contributed to the increase of the contamination.

References

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