INTEGRATED ASSESSMENT OF LEAD IN SOIL FROM A BATTERY-DISPOSAL SITE BEFORE REMEDIATION

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Introduction

Lead ranks second among the most hazardous metals in the Priority List of the US Environmental Protection Agency (ATSDR, 2011). Battery recycling facilities are significant sources of Pb contaminating soils and posing serious risks to human health and the environment (de Araújo and do Nascimento, 2010). Soil remediation by conventional physicochemical technologies is often expensive and not eco-sustainable, while phytoremediation is a cost-effective and eco-friendly technique, particularly proper for reducing risks of large-scale contaminated sites. However, before implementing a phytoremediation plant, it is crucial to characterize the soil of the contaminated site by an integrated approach, assessing, beside the spatial variability of the contamination, the bioavailability, bioaccessibility, and the geochemical forms of the contaminants in the soil.

Methods

The study was carried out in a 33,000 m^2 site inside an automobile-battery recycling facility in S Italy. In order to assess the spatial variability of soil contamination in the site, preliminary geophysical surveys were carried out along with field punctual measurements of element contents in soil by an Handheld X-ray fluorescence analyzer. Contextually, two soil layers (0-10 and 10-40 cm) were collected from 120 georeferenced points according to a sampling grid of 20 x 20 m.

The total content of Pb and other potentially toxic elements (e.g. As, Cd, Cu, Sb) in 2-mm sieved soil samples was determined by *aqua regia* digestion and ICP-MS. In ten selected soil samples, readily and potentially bioavailable fractions of toxic elements were determined by the selective extracting procedures 1M NH_4NO_3 (DIN 19730, 1997) and 0.05M EDTA (Rauret *et al.*, 2001). The BCR sequential extractions were also performed on the selected samples, to assess the partitioning of the elements among the soil components. Standard reference materials ERMCC141, BCR700 and BCR701 were used to check the quality of soil analyses, with element recoveries around ±10% of the certified values.

Results

Proximal sensing survey showed a complex soil spatial variability, as observed by the experimental variogram. The combination of geophysical covariates and XRF field analysis enabled to efficiently differentiate different areas with varying degree of potential contamination. Such geospatial differentiation has been the basis for all other research activities and soil sampling which was limited to the soil surface layer (0-40 cm). Briefly, the soil was sandy loam, moderately alkaline (pH≈8.0), with medium-low organic matter content. A widespread soil compaction interested the all site. *Aqua regia* extraction highlighted a wide and important contamination by Pb, associated with Cd, Sb, As, and in scattered areas with Cu. Generally, the level of contamination in the 0-10 cm layer was higher than in 10-40 cm layer. Lead contamination was particularly severe, with a medium content of 15.5 and 9.9 g kg^{-1} in surface and subsurface soil, 15-times higher than the Italian screening value of 1 g kg^{-1} fixed for industrial sites. A similar behavior was observed for Sb and Cd occurring in the surface layer with medium contents of 184 and 58 mg kg^{-1} respectively (screening values of 30 (Sb) and 15 (Cd) mg kg^{-1}). Arsenic contamination was always less severe. The presence of As, Cd and Sb it is conceivable in a Pb-battery-disposal site, since these elements are usually added to battery to enhance their performance (Sloop *et al.*, 2009). Despite the high level of pollution as assessed by total metal contents, the amounts extracted by NH_4NO_3 (i.e. the readily soluble and easily bioavailable fraction) were less than 1 - 1.3% of the total Pb and Cd contents. More important were the EDTA extractable metal contents (i.e. the potentially bioavailable fraction, partially bound to soil humic compounds), on average 34 and 43% of the total Pb and Cd soil contents. The first step of the SEP supported the relatively low solubility of Pb in soil, which was mostly associated to reducible (i.e. Fe- and Mn-oxides) and oxidable phases (i.e. soil humic compounds). In contrast, the soluble fraction of Cd was more important (52% of the total). Physical fractionations and tests with extractants simulating the human gastro-intestinal activity, are being carried out to assess the metal load in the finest soil fractions (PM2.5 and PM10) and the related bioaccessibility of Pb and Cd.

Conclusion

Before implementing a remediation activity, an integrated characterization of the soil of a battery recycling site was carried out to assess the spatial variability of the contamination, the bioavailability, bioaccessibility, and geochemical forms of the contaminant(s) in the soil. Soil sampling interested the soil surface layer (0-40 cm) where, according to geophysical preliminary survey, pollution was mostly confined. On the basis of the low mobility and bioavailability of pollutants, a poplar and permanent grass plantation assisted by compost amendment was realized on the site. This would reduce the risk of polluted soil erosion and potential particle inhalation and ingestion by humans working or living around the site.

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