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Human bioaccessibility of potentially toxic elements in two Italian polluted soils

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Soil pollution by potentially toxic elements (PTEs) poses serious risks to soil biota, plants and human health. Knowledge of element chemical properties, bioavailability to plants and bioaccessibility to humans constitutes a valid support to assess the factual risk of the PTE-polluted soils, prior to select and apply an efficient remediation strategy.

Our study was carried out in two sites of south Italy: A) three hectares of industrial soil inside an automobile-battery recycling plant in operation since 1970; B) six hectares of farmland currently confiscated by the Judiciary due to past illegal burial of industrial wastes. In these areas, an intense preliminary phase of soil geophysical and geochemical characterisation highlighted a diffuse PTE pollution. Consequently, and with the aim to assist phytoremediation plants consisting of poplars and permanent grass cover, soil samples were collected in the first metre of depth from georeferenced points according to a sampling grid of 20x20 m. The total element contents in 2mm-sieved soil samples were determined by aqua regia digestion and ICP-MS, beside a soil physico-chemical characterisation. In selected soil samples, a physical separation in accordance to Stokes's law (Ajmone et al., 2008) was performed to assess the metal distribution among five soil particle-size fractions (2000-50, 50-20, 20-10, 10-2 and <2 μm). These soil sub-samples were then used to study the lung and oral bioaccessibility of PTEs in the sites A and B. Extractants simulating the human fluids present in the upper respiratory tract (Boisa et al., 2014) and lower respiratory tract (Stopford et al., 2003) were employed to study the lung bioaccessibility of PTEs, while the SBET extraction (Ruby et al., 1999), simulating the human gastric activity, and the most complete Unified BARGE Method (UBM, 2010), taking into account all the human gastro-intestinal fluids, were carried out to assess the oral bioaccessibility of PTEs.

Soil of site A is sandy loam, alkaline (pH≈8.0), with a medium-low organic matter content. A very high and diffuse pollution by Pb (85-80152 ppm), Sb (0.7-1475 ppm), Cd (0.3-235 ppm) and As (9-312 ppm), with a scattered and less severe pollution by Cu, were found in the site. The physical separation revealed that Pb and Sb were mainly associated with the coarsest soil particles, while Cd and As were more concentrated in the finer particles (<10 μm), i.e. the most dangerous for human health. All the extractions revealed an higher lung and oral bioaccessibility of Cd vs Pb, likewise of Sb vs As. Overall PTE-availability was higher in the lower than upper respiratory tracts, as well as it was greater in the gastric than in the intestinal digestive tracts.

Soil of site B is sandy loam, moderately alkaline (pH≈7.6), with a medium-high organic matter content. A diffuse high and inhomogeneous pollution by Cr (8-4487 ppm) and Zn (42-1846 ppm), with a point-source and less severe pollution by Cu, Pb, Cd and As, were measured in the site. Physical separation and soil-fraction extractions to assess lung and oral bioaccessibility of PTEs are on-going and will be completed within January 2019.