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Assessment of PTE fate in contaminated soils: pedology based approach from the field to the microscopy scale

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In the framework of both characterization plan and sustainable land reclamation, required by the European regulation for contaminated sites, it is fundamental to detail and understand soil processes involved in the dynamics of environmental contamination. Areas affected by potentially toxic elements (PTE) frequently show wide variability of contaminant distribution both in space and in depth. Targeted sampling is meant to reduce the risk of incorrect hazard evaluation, as well as decrease time and cost of this tricky procedure. Therefore, a pedology based multi-scale approach has been tuned and applied to an industrial area inside an automobile-battery recycling plant (operative since 1970) in South of Italy. Field scale investigation, after data fusion of geophysical (EMI), spectrometric (Gamma ray dose rate and XRF elemental content) and penetrometric (cone index data by ultrasonic penetrometer) parameters, enabled to identify 4 main key zones characterized by different intensity of the measured variables. At pedon scale, 6 soil profiles were dug until 2 m of depth in the identified zones and showed presence of massive/no structured soils (thickness ranging from 25 to 85 cm) in which the total Pb content ranged from 1700 and 12000 mg/kg (field measurements by portable XRF). At optical microscopy scale, many discrete particles (larger than 2 mm of diameter), having angular - subangular shape and different color, were identified and preliminary examined by portable XRF spectrometer for a semi-quantitative analysis, in collimator mode, to detect the most PTE enriched fragments; the results showed the presence of several medium (from 0.5 x 1 mm wide), greyish-black particles enriched of S and/or Cl, of some other bigger (1 x 4 mm), very dense (i.e., not porous), anisotropic (black) fragments characterized by higher content of S, Pb, Cl, As and Sn, as a whole incorporated in a mineral matrix lesser enriched of S (11 g/kg), Cl (0.8 g/kg), Pb (0.6 g/kg), As (0.2 g/kg). Detailed analysis at submicroscopic scale with SEM, equipped with EDXRA for quantitative analyses, enabled to discriminate the biggest particles in sub-particles mainly composed of Pb (87-89%) and others combining Pb (72-75%) with Cd (11%) and Sn (11-12%). At molecular scale, the mobility and bioavailability of the most abundant PTE were assessed by standardized single-step (ultrapure water, 1M NH₄NO₃ and 0.05M EDTA) and sequential (EU-BCR and Wenzel) analytical procedures. Although the extent of Cd contamination was much lower than that of Pb, Cd was more mobile and bioavailable than Pb, mainly due to its different geochemical properties. As well, the

bioavailability of Sb in the soil was greater than that of As (anionic contaminants).