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Predicting spatial distribution of heavy metals in agricultural soils using electrical resistivity tomography technique 2D-ERT

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Increasing consideration is being placed on the environmental impact of soil contamination with heavy metals (HM), especially in productive agricultural areas. So, a key task is to characterize this contamination qualitatively and quantitatively in order to understand the spatial distribution of HM and decide about the adequate management. Traditional sampling to monitor HM distribution is time, cost-consuming and often unrepresentative. Additionally, sparse and punctual data measurements may not allow understanding the real dynamic of HM in the soil profile, and in many cases the collected data fails in providing the needed information. Recently, in-situ geophysical techniques based on electrical resistivity tomography measurements (ERT) were implemented in agriculture as a “proxy” to determine spatial and temporal distribution of HM. The objective of this study was to provide an accurate information for future efficient measures of soil remediation, by understanding the HM distribution, specifically cadmium (Cd) and arsenic (As), using electrical resistivity measurements combined with soil chemical analyses. A UNI-T UT523A devise was used in a “Wenner Alpha” configuration to perform ERT survey at 2 m depth in nine locations of Tolima department-Colombia. 2D-ERT cross sections “Tomograms” were obtained by the Res2Dinv software which allowed characterizing qualitatively the spatial distribution of Cd and As. Chemical concentration values for both Cd (0.36±0.06 $mg.kg^{-1}$) and As (3.00±0.28 $mg.kg^{-1}$) were introduced in the inverse modelling procedure as a solution to provide an easier and reliable alternative to determine the shape, size, and path of the likely electrical resistivity distribution of the studied HM. Tomograms revealed that Cd distribution was mainly observed in deeper soil profile (0.80 m), while As was observed basically in shallower soil layers (0.45 m). Higher electrical resistivity values (330–48000 Ω m) correspond to Cd distribution and lower electrical resistivity values (138-291 Ω m) are related to As distribution. A high positive Pearson correlation (ρ) between electrical resistivity measurements and soil chemical properties (for Cd and As content) was obtained for the nine locations; ρ values of 0.97 and 0.98 were obtained for Cd and As; respectively. A linear regression was performed between ERT measurements and Cd and As contents; (R^2=0.94, RMSE=0.33) and (R^2=0.97 RMSE=0.18) for Cd and As; respectively. The results underlie the utility of the combined geophysical techniques, based on electrical resistivity measurements, and soil chemical properties to improve the understanding of HM dynamic.

Key words: Geophysical techniques, tomograms, heavy metals, soil chemical properties, spatial

distribution, Pearson correlation.