



## **Spatial variability in depth and landscape of heavy metal contents of volcanic soils of the National Cajas Park in the Azuay Andes (Ecuador)**

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Although the soils in the Azuay Andes are thought to be generally non-contaminated, it is necessary to preserve them from anthropogenic pollution. This area supplies drinking water to Cuenca, the third city of Ecuador. At present, very little information is available on baseline metal concentrations in Latin American soils. Therefore, it is important to establish the baseline of elements in soils as reference values for evaluating potential changes in their concentrations and to be able to define their origins. The objectives of this study are: (1) to show morphological, physical and chemical characteristics of Andisols in the Azuay Andes (Ecuador); (2) to determine the concentrations of six heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) and (3) to evaluate the relationship between metal concentration and soil properties.

The study area is located in National Cajas Park in the Paramo area of the Andes at Azuay Province (Ecuador). The geological origin of the National Cajas Park dates back to the Quaternary age. This area is a U-shaped glaciated valley formed over a pre-existing volcanic basement which consists of rhyolite and andesite volcanic tuff. The moraines are covered by discontinuous patches of volcanic ash. The climate is characterized by rather high rainfall, between 1200 to 2000 mm per year, regularly distributed and generally of a low intensity with a yearly average constant temperature (7°C) with high diurnal amplitudes. The paramo is a high altitude neotropical grassland ecosystem, located between the continuous forest border (~3500 m) and the eternal snow line (~5000 m). Seven representative volcanic soil pedons of a toposequence were studied and sampled. All horizons were analysed for physical and chemical properties by standard and specific methods for volcanic soils. Total metal concentrations in soil horizons were determined by ICP-MS spectrometer. The background values were calculated using the  $4\sigma$ -outlier test. This requires the elimination of potential outliers from the data set and the calculation of the mean and the standard deviation for the remaining sub-collective.

Andisols are dominated by amorphous aluminium silicates and Al-organic complexes. The soils of a volcanic area usually have an Ah-Bh-Bhs/ Bw-C horizon sequence. The Ah horizon is dark-coloured and very high in organic carbon. The pH NaF usually rises to 10.5 below 20 cm. Correlation metal concentration with pH NaF may reflect the impact of volcanic pedogenetic pathways of soils on the original trace elements distribution (Cr and Pb). Close relationships between organic matter have a marked affinity to trace elements (Cd and Cu) forming organomineral complexes. Ni and Zn present a close relationship with soil grain distribution. This may reflect the impact of wind or water on the original parent material distribution. The great dispersion of heavy metals between horizons could be horizon discontinuities. The elements Zr, Ti and Y, have been widely used as indices of immobile minerals. These studies must be performed to definitively confirm the complex profiles. Cadmium, Cu, Ni and Zn showed highly significant differences between Andisols. The complex association of the soils in the landscape was attributed to the difference in their parent material compositions. Occasional or continuous addition of volcanic deposits to soil becomes the soil forming process, and is decisive in the distribution of heavy metals. Although, the Azuay soils have shown a spatial variability of heavy metal concentrations in depth and landscape, the data sets were predominantly influenced by natural element distribution. In general, the upper limits of heavy metal background are (in mg•kg<sup>-1</sup>): Cd (1), Cr (44), Cu (54), Ni (10), Pb (69) and Zn (149). Only one point with slight enrichment Cd anomalies were observed: A4 (35-69 cm): 1.72 mg•kg<sup>-1</sup>. The concentrations of heavy metals found in the Cajas National Park are normal and do not show any sign of contamination.

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