

The mobility of cadmium and uranium in undisturbed agricultural soils is affected by colloidal transport: a comparison among different soil solution extraction methods

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Accurate measurements of mobile cadmium (Cd) and uranium (U) in soils are necessary to calculate relevant limits for these trace elements in mineral P-fertilizers. However, the actual concentrations of these elements in the mobile water vary widely with different soil solution extraction methods. In this study, column leaching experiments with porous (1 μm) suction plates were performed with unsaturated and undisturbed soil columns from three Swiss agricultural soils. Percolates were collected for 36 days (0.6 pore volumes; $\sim 1.6 \text{ mm day}^{-1}$) to approximate standard in-situ methods such as rhizon samplers and porous suction cups. New in our approach is that an aqua regia digestion of the porous plates was included to account for the colloids retained in the plate. Of the total mobile mass (sum percolate and plate), $18 \pm 5\%$ (Cd) and $89 \pm 4\%$ (U) was retained in the porous plates of the columns from location 1 (sandy; pH 5.1); $54 \pm 24\%$ (Cd) and $87 \pm 3\%$ (U) for location 2 (clay; pH 5.8); $53 \pm 26\%$ (Cd) and $8 \pm 3\%$ (U) for location 3 (calcareous silt; pH 7.3). This indicates that standard in-situ methods can substantially underestimate mobile U and Cd. Additionally, a CaCl_2 extraction and pore water extraction through centrifugation was performed on each column at the start (field fresh soil) and end of the experiment. The CaCl_2 extraction consistently underestimated mobile U, probably due to colloid coagulation, while mobile Cd was overestimated due to the formation of highly soluble Cd-Cl complexes. Results from the pore water extraction were generally more consistent with the total mobile mass measured in the leaching experiment. Current empirical models to predict mobile Cd are based on data from stored, dried and rewetted soil. Strikingly, the mobile Cd predicted by those soil chemical models largely overestimated the observed mobile Cd in all columns.