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Quantification of small-scale physicochemical properties of intact macropore surfaces in Bt-horizons of Luvisols

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During preferential flow in structured soils, the interaction of percolating water and reactive solutes with the soil matrix is mostly restricted to surfaces of preferential flow paths which affect mass exchange processes by the physical and chemical properties. These properties can strongly differ from bulk soil properties with respect to texture, organic matter (OM), pore geometry, density, and porosity. The aim of our work was to identify and to quantify effective macropore properties which concurrently are appropriate to represent physical mechanisms for entire soil horizons with respect to preferential flow.

We studied physical and chemical properties of intact surfaces of soil aggregates, biopores (root channels, worm burrows), and coated cracks from Luvisol Bt-horizons. The spatial distribution of the OM composition and related physical properties such as wettability, the organic carbon content, and the cation exchange capacity of these macropores as characterized by DRIFT spectroscopy and complementary techniques were found spatially distributed at the mm-scale. Differences could be observed for loess and glacial till as parent materials, land use, and macropore types, in particular for cracks and biopores. The geometrical properties (pore volume, diameter, surfaces area, connectivity, and tortuosity) of all potentially available macropores, in particular the differences between cracks and biopores, were quantified in large soil columns using X-ray computed tomography (μCT). Dye tracer experiments at the cm-to-m-scale showed substrate-specific and macropore-specific differences between the active preferential flow paths.

In a summarizing step we aim to combine the chemical and physical surface properties with the geometrical properties of the macropores in order to estimate the effects of the surface properties on preferential flow in Bt-horizons. The specific surface areas and chemical compositions may help explain differences in the staining patterns observed for the Bt-horizons from loess and till Luvisols.