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Small-scale maps of organic matter properties of intact preferential flow path surfaces using DRIFT spectroscopy

Martin Leue, Horst H. Gerke, and Ruth H. Ellerbrock

Leibniz-Centre for Agricultural Landscape Research (ZALF), Institute of Soil Landscape Research, Müncheberg, Germany (Martin.Leue@zalf.de)

The interaction of percolating water and reactive solutes with the soil matrix is mostly restricted to surfaces of preferential flow paths in structured soils. Surfaces of flow paths are often formed by cracks, decayed root channels or worm burrows that may have clay-organic coatings (i.e. cutanes) in which the outermost layer is formed by organic matter (OM). The composition of OM finally controls wettability, and sorption and transfer properties. However, the local distribution of OM-properties along such surfaces is largely unknown to date since the coatings are relatively thin and vulnerable. The Fourier transformed infrared spectroscopy in diffuse reflectance mode (DRIFT) was applied to determine 1 mm x 1 mm maps of OM functional group ratios (i.e. CH/CO-ratios, OH bands) of intact structural surfaces from Luvisol soil samples. However, DRIFT signals are affected by the microtopography of intact surfaces. Both the illumination and reflectance are affected by the measurement point position (e.g., height, slope, aspect) on the sample surface and by the geometric arrangement of light source, sample, and detector. The objective of this paper was to analyze and develop a correction method for the effects of the surface topography on the signal by using gypsum block with defined shapes as an experimental model system. One part of gypsum block surface was coated with humic acid (HA). For both, the coated and the uncoated sides of the gypsum block, DRIFT mapping illustrated the wave length- and material-specific relief effect on the reflectance signal's intensity. To compensate such relief effects, (i) a reflectance-to-height regression was developed using a digital terrain model (DTM) that corrected measured reflectance signal intensity, (ii) a signal intensity calibration was related to each specific wave number's reflectance, and (iii) the corrections were used for spectral ratios calculations. The methods were tested using data from an intact soil sample surface and found applicable for analyzing intact structural surfaces. The interpretation of DRIFT measured OM composition maps of preferential flow path surfaces was improved. The local distributions of the OM properties at structural surfaces indicate yet unknown implications for preferential flow and transport especially for reactive solutes.