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Novel method for the simultaneous quantification of soil hydraulic functions in the laboratory under consideration of shrinkage

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Knowledge about the soil hydraulic properties – water retention curve and unsaturated hydraulic conductivity – is required for soil water modelling and various soil hydrological studies. In general, soils and their pore size system are assumed to be rigid during the loss of water on drying. This is different from reality for many soils, especially for soils with high contents of clay or organic matter which are shrinking dependent on the pore pressure. As a result, the porosity, the pore size distribution and the bulk density of these soils are changing. Measurements of soil hydraulic functions with the classical methods are time consuming, the equipment is costly and the measuring results are affected by uncertainties. Methods enabling the quantification of soil hydraulic functions under consideration of shrinkage are missing. A method frequently used for the simultaneous determination of both the hydraulic functions of unsaturated soil samples is the evaporation method. Due to the limited range of common tensiometers, all methodological variations of the evaporation method in the past suffered from the limitation that the hydraulic functions could only be determined to a maximum tension of 50 kPa. The extended evaporation method (EEM) overcomes this restriction. Using new boyling delay tensiometers and applying the air-entry pressure of the tensiometer's porous ceramic cup as final tension value allows the quantification of the soil hydraulic functions in a range to close to the wilting point. Based on EEM a practicable method was developed which additionally allows the consideration of shrinkage. The experimental setup followed the system HYPROP which is a commercial device with vertically aligned tensiometers that is optimized to perform evaporation measurements. Preliminary investigations were conducted to study the geometrical change of 24 samples different in texture and origin. The samples were enwrapped with a rubber membrane impermeable for water and air. The sample height and the sample circumference were detected during drying. The results confirmed (i) isotropic shrinkage and (ii) a quite linear decrease of the sample circumference from the bottom to the top of the sample. As a conclusion, for quantifying the volume change of the sample during evaporation it should be sufficient to measure the changing circumference in the middle position of the cylindrical sample. Together with the recorded tensions and the sample mass, the soil hydraulic functions could be quantified in the range between saturation and close to the permanent wilting point in consideration of shrinkage. Common soil hydraulic data models could be fitted to the soil hydraulic and shrinkage data.