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Measurement of hydraulic properties of soils and rocks using an unconventional triaxial system coupled to the multistep outflow method.

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The understanding of water flow and solute transport processes through the vadose zone is a cornerstone in the preservation of groundwater resources. For many years, various laboratory techniques and equipments have been designed to estimate soil hydraulic properties. We present an unconventional triaxial system adapted to 70 mm-diameter samples that is coupled to the multistep outflow method (MSOF) to measure the hydraulic properties of soils and rocks under both saturated and unsaturated conditions by means of a gas pressure-volume controller creating a three-phase unsaturated porous media. The purpose of this experiment is its versatility that allows the estimation of the hydraulic properties of all vadose zone samples using a unique assembly that runs the same specimen. This technique shows the benefits of using a triaxial cell, which allows reproducing overburden field conditions. The whole operating mode in saturated and unsaturated conditions may be successively carried out, thus avoiding sample being disturbed due to switching of the method or recoring that could impact the reproducibility of measurements. Among the advantages of the device is the high accuracy of the outflow measurement since the pressure-volume controller has a 1 mm3 resolution. Void ratio is also measured throughout the experiment in order to evaluate the volume change of the samples as a consequence of each pressure step. As a testing material a large range of samples with different textures and hardness were used such as repacked silty loam, undisturbed silty clay loam soil with plastic behavior, loamy sand sediment, as well as highly cemented limestone. After several tests, the effectiveness of the system has been evaluated according to the nature of the samples. Results show that the shape of the water retention curve and unsaturated hydraulic conductivity curves are in agreement with the information found in the literature according to the nature of the material. However, it seems that the effect of overburden decreases hydraulic properties when compared with other laboratory experiments. Void ratio measurements showed that porosity values decreased slightly in the order of 3-5% at the end of the whole experiment.

Keywords: hydraulic properties, multistep outflow, triaxial system, unsaturated flow, vadose zone.