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A promising new device to assess key soil hydraulic properties

Abdallah Alaoui and Gudrun Schwilch
Centre for Development and Environment (CDE), University of Bern, Bern, Switzerland (abdallah.alaoui@cde.unibe.ch)

Hydraulic functions measured at the core or plot scale are notoriously variable in natural soils, with properties such as infiltration rate ranging across several orders of magnitude within a typical field. Because the information required to create a continuous map of these properties' variability is unobtainable, plot- and field-scale models of flow processes generally use average or "effective" soil hydraulic properties to represent the processes. This makes it difficult to scale up knowledge from the local to the catchment scale, as soil heterogeneity increases with scale. Overcoming this difficulty requires an instrument that enables rapid and easy assessment of the relevant soil properties and their changes under varying land uses and climatic conditions. For this reason, we devised a new infiltrometer that makes it possible to rapidly and reliably assess soil infiltration capacity in the field. Based on laboratory and field data, we then developed a software (Soil Quality Analyzer) to determine key hydraulic properties such as saturated hydraulic conductivity, saturated water content, total porosity, and the van Genuchten parameters. Our device consists of a Plexiglas tube about 4 cm in diameter mounted on a semisoft, porous tube of the same diameter which easily adapts to surrounding soil, and ending in a conic steel point that facilitates insertion into the soil at different depths. We first calibrated our infiltrometer based on reconstructed soil columns of different textures with no coarse structures (i.e. organic material, macropores). A second series of infiltration experiments was carried out in situ in undisturbed soils under forest and grassland that had the same textures as those in the laboratory experiments. Finally, we analyzed all samples in the laboratory to determine the key hydraulic parameters. Linear relationships between the infiltrated water volume and the corresponding time intervals of infiltration were determined for each sample. Concerning the paired variables of texture and infiltrated water volume, we found the best correlations to be exponential ones between clay and infiltrated water volume in all cases. Looking at a fixed time interval of 20 minutes, we assumed that the difference in the value of a given hydraulic parameter between samples of disturbed and undisturbed soil of the same texture is due to the additional coarse structures introduced by land use and land cover. This enabled us to determine a factor expressing the impact of structure for each parameter and each type of texture. Overall, the calibrated and validated data from our laboratory and field experiments showed that a simple 20-minute in situ infiltration measurement is sufficient to estimate the key hydraulic parameters. This opens up a new avenue for tackling soil heterogeneity, which is widely acknowledged as the greatest challenge in soil hydrology today. Further investigations are needed to extend our findings to other land uses and land covers.