Uncertainty of saturated hydraulic conductivity measurements: comparative assessment of different determination methods

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Abstract

Vadose zone related processes (i.e. water movement, contaminant transport) depend highly on soil hydraulic properties. Saturated hydraulic conductivity (KSAT) is a key parameter for the soil water movement. KSAT have a crucial impact on water movement from the soil surface to ground water. This parameter is required as input for many ecological, environmental and agricultural models, not only to characterize the plant-soil-atmosphere interactions, but also to characterize compacted fractions used for landfill in final cover that are subjected to weathering. Therefore, testing and validation of soil hydraulic properties should be given to the sources of variability of KSAT in particular in time and space. The method used to determine the saturated hydraulic conductivity is considered as a source of variability of this parameter among many others. While various laboratory methods and in-situ measurement techniques have been developed to measure the KSAT, their implementation remains expensive and time consuming. Modelling based techniques such as parameter estimation and pedotransfer functions have gained a large popularity as alternatives to the former traditional KSAT parameter measurements. In this study, together with the assessment of spatial variability of KSAT within an agricultural land and a landfill we compared different methods for the KSAT determination. The comparison was carried out between in-situ and laboratory measurements by fitting equations to the experimental evaporation method as well as assessing the applicability of some pedotransfer functions (PTFs) for the KSAT estimation.

KEY WORDS: saturated hydraulic conductivity, Guelph, evaporation method, pedotransfer, laboratory experiments, landfill, agricultural field

Methods

Within both study sites soil sampling for laboratory experiments and field measurements using Guelph permeameter were performed, only for site B double ring infiltromenter tests (DRI) were performed in order to compare the two in-situ KSAT measuring methods (Guelph and DRI). Soil samples and in-situ measurements on the top-soil of the two study sites were used in order to compare the in-situ and laboratory measurements. The study site A was used to test different fitting equations for the KSAT estimation accuracy using the evaporation method data (Brooks and Corey and Van Genuchten) and to evaluate the relevance of selected pedotransfer functions (PTFs) for KSAT estimation for the selected study area.

Results

Undisturbed soil samples were collected for laboratory measurements of KSAT, and bulk density determination together with disturbed soil samples that were used to measure other soil properties, organic matter content and soil texture, that were used as inputs for PTFs. Replicate soil core samples were excavated at each sampling point were collected from least possible distance (20 cm) in order to avoid the effect of spatial variability and within the same day during which field measurements were taken in order to avoid the temporal variability of soil properties.

• Field methods exhibit the advantages of larger sampled volume with a lower volume that is not exactly known. Guelph permeameter gave lower values of KSAT due to the air entrapment.

• Field measurements usually yield lower values of KSAT due to the air entrapment during the measurements and the soil can’t reach full saturation.

Conclusions

The experiments were carried out at two different study sites (agricultural field and landfill), yet they allowed to derive the same conclusions. The saturated hydraulic conductivity is subjected to spatial variation. The method used to determine the saturated hydraulic conductivity is considered as a source of variability of this parameter among many other factors of variability (i.e. land use, agronomic practices, roots, pedo-fauna, soil layering and others). This parameter for hydrological simulations should be defined with high accuracy since it highly impacts the water movement. The uncertainty in the prediction of the saturated hydraulic conductivity depends on the method used to define this parameter, Field and laboratory measurements that are usually considered as the most accurate determination methods may also exhibit a certain level of error, depending on the study site conditions, sample collection and disturbance, and instrument installation. Further studies are required to confirm results of this research. The variability of the saturated hydraulic conductivity due to the measuring technique in interaction with other sources of variability should be studied.