Geophysical Research Abstracts
Vol. 15, EGU2013-7115, 2013
EGU General Assembly 2013

Experimental and numerical study of infiltration into arid soils with contrasting physical and textural properties

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Dye infiltration tests were performed in the arid environments of the Ti Tree catchment, Central Australia. This area has a mean annual precipitation of 300 mm and is further known to have infrequent intensive rainfall events linked to short-term flooding. The mechanisms of groundwater recharge in these arid environments are generally unknown. The upper 1-2 m of soil play an important role in water redistribution with preferential flow often contributing to inhomogeneous moisture storage, soil water flow and groundwater recharge. Reducing uncertainty in recharge estimation thus requires a detailed study of water flow especially near the soil surface where heterogeneity may be enhanced by biological activity and geomorphological processes. Each of three infiltration tests involved application of 100 L of a mixed dye solution applied by using a standard 60-cm diameter ring infiltrometer under constant-head ponded conditions. After complete water infiltration several vertical soil sections were prepared in a soil block of approximately 1.5-2 m3. Staining patterns were photographed to provide evidence of preferential flow while numerous disturbed and undisturbed samples were collected and analysed in the laboratory to determine soil physical and hydraulic properties including saturated hydraulic conductivity, water retention curve, initial moisture content prior to dye application and bulk densities.

Staining patterns in the top 30-40 cm were relatively homogeneous with some fingering. However, presence of a textural break (fine over coarse sand) hypothesized to represent a paleo-riverbed significantly affected redistribution of water, possibly acting as a capillary barrier. Measurements of soil physical properties and soil profile digital photos were used to build a 3D heterogeneous soil hydraulic property model in HYDRUS-3D. Model results for the infiltration tests were quantitatively and qualitatively compared to staining patterns obtained during field experiments. Such studies are important for building better vadose zone models capable of modeling large-scale recharge processes.