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Soil pipe effect on rainfall-runoff process

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Introduction

At hillslope, soil pipes are often formed by activity of soil fauna and plant roots as well as internal erosion. Many researches indicated that soil pipes parallel to the slope bed greatly influenced hillslope hydrological phenomena. In order to understand hillslope soil water dynamics, it is important to understand and model role of the soil pipes. For this reason, quantitative discussion of the effect of soil pipes on rainfall-runoff process is needed. Several model experiments and numerical analyses using soil box with artificial soil pipes indicated that soil pipes changed groundwater table profile. However, since most previous researches handled the steady-state condition, understanding of soil pipe effect on transient water dynamics during a rainfall event is still limited.

Our research objective is to clarify the effect of soil pipes on unsteady soil water dynamics under rainfall.

Experiment and numerical analysis

We packed toyoura sand homogeneously to form a soil box of 60 cm long, 30 cm high and 4 cm thick, with an outlet at the downstream end. As the artificial soil pipe, perforated acrylic pipes with the inside diameter of 7 mm were buried. The artificial soil pipes had many drain holes of 3 mm in diameter at the lateral side to pass soil water between soil matrix and pipe. The pipes were covered by nylon mesh to prevent inflow of sand particles. Soil pipes were buried at 2.5 cm above the impermeable bed. Soil pipes are commonly considered to be discontinuous in the soil, so we set three soil-pipe conditions, i.e. no pipe, continuous pipe and discontinuous pipes. Rainfall simulator was set above the soil surface to add the rainwater to the soil. At first, constant rainfall was added to attain steady state percolation through the soil. Then, rainfall intensity had risen for a while, and then returned to be the same intensity at the beginning of the rainfall. This procedure gave a pulse-like change in rainfall intensity. During the experiment, we measured rainfall intensity and discharge from an outlet by the tipping bucket. Also, soil water pressure at twelve observation points was monitored using tensiometers.

In the numerical analysis, we tried to reproduce the experiment using HYDRUS-2D software. Soil pipe was modeled as virtual soil matrix with high hydraulic conductivity and low air-entry value. Soil hydraulic function was described by the van Genuchten-Mualem model. Applied rainfall was expressed by the flux boundary and downstream outlet was assigned as seepage face boundary.

Keywords: soil pipes, rainfall-runoff process