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Modelling earthworm induced preferential flow in a Paddy rice soil

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Dye tracer studies revealed that earthworm burrows in the compacted plow pan of Chinese paddy rice fields induced preferential flow. In initially dry fields, a horizontal crack system at the interface of the topsoil to the plow pan facilitated redistribution of dye tracer. Cylindrical vertical root channels were found in the compacted horizons by computed tomography. It was unclear whether and how earthworm burrows induce preferential flow in a layered paddy soil.

Burrows were detected by removal of the topsoil and infiltration rates were measured by constant head infiltration studies. A grid of 12 tensiometers was horizontally installed at 4 depths at each of two burrows with comparably high infiltration rates. Pressure heads were measured during falling head double-ring infiltration of 10 cm and 2.1 cm of dye tracer Brilliant Blue. Horizontal profiles were created at the depth of the tensiometers and staining pattern were photographed. Pressure heads were additionally measured by 6 horizontally installed tensiometers at an undisturbed plot. Hydraulic properties were first estimated from data for drying without effects of burrows by inverse modelling during evaporation using Hydrus 1D. Infiltration into one of the burrows was modelled by Hydrus 2D considering the burrow as a domain of highly conductive soil.

1D modelling of data for drying needed the inclusion of a capillary barrier at the interface of the topsoil to the pan representing the interfacial crack system. The 2D model described the measured data with a mostly bypassed zone at the 30 cm depth and comparably strong horizontal proceeding of pressure heads and spreading of dye at the 40 cm depth. However, early and steady state-like final pressure heads at the 30 cm depth were overrated when assuming that hydraulic matrix properties were equal

to the properties modelled for vertical upward flow. The model described the progression only when assuming both, a reduced matrix near-saturated conductivity curve for infiltration and a layer of significantly reduced hydraulic conductivity along the burrow. Lower conductivities during mostly horizontal infiltration through the burrow walls are explained by the anisotropic root channels and burrow coatings. The results showed that soil structure related factors such as burrow geometry, burrow walls, anisotropy of soil matrix properties all influenced preferential flow in Paddy soil.