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The field-scale break through curve of the deep vadose zone retrieved by time-lapse cross-borehole radar data

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In this study, time-lapse cross-borehole ground-penetrating radar (GPR) data were collected in an artificial groundwater recharge pit test and salt tracer test to monitor an infiltration process and its solute dynamics through the vadose zone. The field test was conducted in Makinohara upland area in Shizuoka prefecture, Japan. We measured electromagnetic wave velocity and its attenuation with the geometry that transmitter and receiver antennas set at the same depth, and estimated changes in the water content profile based on the petro-physical relationships between dielectric constants and water contents. The velocity of wetting front and the increment of soil water were then estimated. When the water profile in observed zone became in steady state, we change the infiltration water to the water with salt as tracer. We monitored not only the velocity but also the attenuation of the electromagnetic wave. From the relationship between attenuation and electrical conductivity of soil, we estimated the breakthrough curve through the deep vadose zone at each depth from the bottom of infiltration pit to the 5.5m depth.
From the shape of the breakthrough curve, we suppose that the injected tracer percolated down through vadose zone relatively quickly, while the existing soil water with low mobility in the finer part of soil was contaminated gradually by the dispersion effect of tracer. The time-lapse cross-borehole radar is applicable for the estimation for solute dynamics in vadose zone.

Keywords: Hydrogeophysics, Solute dynamics, Vadose zone, Cross-borehole Radar