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Macropore system characteristics controls on non-reactive solute transport at different flow rates

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Preferential flow and transport in macroporous soils are important pathways for the leaching of agrochemicals through soils. Preferential solute transport in soil is to a large extent determined by the macropore system characteristics and the water flow conditions. The importance of different characteristics of the macropore system is likely to vary with the flow conditions. The objective of this study was to determine which properties of the macropore system that control the shape of non-reactive tracer solute breakthrough curves at different steady-state flow rates. We sampled five undisturbed columns (20 cm high, 20 cm diameter) from the soil surface of four soils with clay contents between 21 and 50 %. Solute transport experiments were carried out under unsaturated conditions at 2, 4, 6, 8 and 12 mm h-1 flow rates. For each flow rate a pulse of potassium bromide solution was applied at the soil surface and the electrical conductivity was measured with high temporal resolution in the column effluent. We used the 5 % arrival time and the holdback factor to estimate the degree of preferential transport from the resulting breakthrough curves. Unsaturated hydraulic conductivities were measured at the soil surface of the columns using a tension disc infiltrometer. The macropore system was imaged by industrial X-ray computed tomography at a resolution of 125 μm in all directions. Measures of the macropore system characteristics including measures of pore continuity were calculated from these images using the ImageJ software. Results show that the degree of preferential transport is generally increasing with flow rate when larger pores become active in the transport. The degree of preferential flow was correlated to measures of macropore topology. This study show that conclusions drawn from experiments carried out at one flow rate should generally not be extrapolated to other flow rates.