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Exploring transport dynamics of “new” and “old” tracers under varying hydrologic conditions in structured soils

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Fine-grained, structured soils are prone to preferential flow along macropores that can enhance vertical migration of surface applied contaminants (“new” solutes) due to water bypassing the soil matrix. This same bypass phenomenon can also inhibit the flushing of in situ salt or other contaminants (“old” solutes), thereby hampering reclamation of previously impacted soils. In all cases, mass exchange between the soil matrix and macropores is a significant control on water and solute movement in the soil profile. The dynamics of these mass exchange processes and the associated transport of both new and old tracers were studied in field- and core-scale experiments on low permeability, macroporous soils. A multi-year investigation of new (DFBA) and old (Cl) tracer transport was completed on two 20 x 20 m test plots within a tile-drained field. Irrigation water was applied to one test plot, while the second plot served as an unirrigated control. Detailed monitoring, including wells, lysimeters, tensiometers, soil cores, tile drains, and electrical resistivity tomography, revealed a comprehensive picture of the hydraulic system response and distribution of chemical tracers over multiple field seasons. A large difference in solute transport within and between seasons was attributed to temporally varying hydrologic (water table and soil moisture) conditions, despite similar total volumes of water application. Time-varying soil hydraulic properties and soil macropore saturation were believed to play a major role, and were explored in more detail with large, intact soil monolith experiments. Two paired-core infiltration experiments were completed using the same volumes of irrigation water, but different irrigation rates and durations. The migration of new (Br, I, and dye) and old (Cl) tracers was monitored throughout the experiments, and the final tracer distribution was characterized by destructive sampling at the conclusion of irrigation. The spatial and temporal distribution of tracers varied as a function of the irrigation rate, revealing distinct macropore-matrix mass exchange behavior for new and old tracers. These observations and ongoing efforts to simulate the transport of old and new tracers suggest tracer-specific, and possibly time varying, mass exchange processes should be considered for highly structured soils that exhibit significant preferential flow.