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Influence of particle size on solute transport and dispersion in porous media during evaporation

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Increasing salinity in groundwater and soil poses a threat to the ecosystem functioning, water quality and evaporation, and crop production. Understanding salt transport in the flow of water through soil entails studying solute transport through partially saturated sediments during evaporation, which is a complex process (1-4). We provide experimentally verified insights into the ion transport in porous media during evaporation, as well as particle-size influences on solute transport at the pore- and macro-scales. To do so, we utilized four-dimension (space plus time) synchrotron X-ray for iodine k-edge dual energy imaging to obtain solute concentration profiles in every single pore during saline water evaporation from coarse- and fine-grained sands. Close to the surface of the coarse-grained sand significantly higher salt concentrations were observed, when compared with fine-grained sand with the same porosity and cumulative evaporative mass losses. The physics behind this counter-intuitive result was delineated using the recorded pore-scale data with high spatial and temporal resolutions. Moreover, the measured data enabled us to quantify the variations of the dispersion coefficient during evaporation. We show that the dispersion coefficient varies as a function of liquid saturation as well as the transport properties of porous media, and increases as water saturation decreases.

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