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Experimental Sensitivity Analysis of Oxygen Transfer in the Capillary Fringe

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Abstract:

Oxygen transfer in the capillary fringe (CF) is of primary importance for a wide variety of biogeochemical processes occurring in shallow groundwater systems. In case of a fluctuating groundwater table two distinct mechanisms of oxygen transfer within the capillary zone can be identified: vertical predominantly diffusive mass flux oxygen, and mass transfer between entrapped gas and groundwater. In this study, we perform a systematic experimental sensitivity analysis in order to assess the influence of different parameters on oxygen transfer from entrapped air within the CF to underlying anoxic groundwater. We carry out quasi two-dimension flow-through experiments focusing on the transient phase following imbibition to investigate the influence of the horizontal flow velocity, the average grain diameter of the porous medium, as well as the magnitude and the speed of the water table rise. We present a numerical flow and transport model that quantitatively represents the main mechanisms governing oxygen transfer. . Assuming local equilibrium between the aqueous and the gaseous phase, the partitioning process from entrapped air can be satisfactorily simulated. The different experiments are monitored by measuring vertical oxygen concentration profiles at high spatial resolution with a non-invasive optode technique as well as by determining oxygen fluxes at the outlet of the flow-through chamber. The results show that all parameters investigated have a significant effect and determine different amounts of oxygen transferred to the oxygen-depleted groundwater. Particularly relevant are the magnitude of the water table rise and the grain size of the porous medium.

Keywords: *oxygen transfer, capillary fringe, anoxic groundwater, entrapped air, water table rise, grain size*