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Experimental study of advective-diffusive gaseous CO_2 transport through porous media

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Leakage of gaseous CO_2 into the shallow subsurface system is one of the main concerns associated with geologic storage resources. A better understanding of CO_2 leakage in the shallow subsurface plays an important role for developing leakage monitoring programs. CO_2 may reach the unsaturated zone by different leak mechanisms such as exsolution from CO_2 supersaturated water and continuous bubbling or gas flow along a leakage path. In the unsaturated zone, the CO_2 is heavier than air and may accumulate below the ground surface and move laterally. We developed a small-scale experiment setup to study the possible gaseous CO_2 transport mechanisms with different controlled conditions. In this study, the experiment setup was applied to measure CO_2 distributions in time and space through homogenous dry sand in which the CO_2 concentrations through the domain were measured by sensitive gas sensors. The preliminary analysis of the result suggests that the transport and distribution of gaseous CO_2 is spatially and temporally sensitive for the selected experimental conditions of gas flow rate and porous media. To better understand the advection and diffusion processes through the unsaturated zone, the experimental results are coupled with the dusty gas model (DGM) of Mason et al. (1967). The dusty gas model's constitutive relationships are integrated into a numerical model for multicomponent gas mixture flow and transport in porous media. The DGM considers interactions between all gaseous species and Knudsen diffusion which is important in fine grained soils. Results from the applied model were consistent with the experimental breakthrough curves obtained in this study.