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Transport of colloids in unsaturated porous media: Explaining large scale behavior based on pore scale mechanisms

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We conducted column scale experiments to study the transport of colloids (latex particles and Bacteriophage MS2) under water unsaturated conditions. The objective was to draw connections between observations at the pore scale and the results obtained from column scale experiments. The same system had been previously operated under saturated conditions to determine colloid collision efficiency. Breakthrough of colloids was first evaluated under unsaturated but steady water content conditions, with constant trickling flow. After monitoring the steady breakthrough of the colloids, the column was flushed with water at higher flow rate to increase the water content up to a saturated condition. Colloid breakthrough was monitored during the entire experiment, as water content increased. Colloid removal increases significantly with decreasing initial water saturation, reflecting retention at the air-water interface and straining in thin-water films. Colloid breakthrough occurs earlier than a conservative tracer even under unsaturated conditions, although the colloid concentrations are much lower than the tracer. After flushing at similar flowrates, there is increased colloid retention under unsaturated conditions even as the system approaches water saturation, indicating that additional removal is occurring, possibly due to the formation of colloidal clusters. These results can be explained to a great extent by pore scale observations of retention and remobilization mechanisms.