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Enhanced pH-dependent transport in porous media

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When a solvent carries cations through a soil with fixed capacity for adsorption or ion exchange, the evolution of concentration fronts, which propagate through the soil at characteristic fractions of the solvent flow speed, is well described by classical theory. When the soil contains hydrophilic minerals such as iron oxyhydroxide, quartz, and clays which readily adsorb and desorb protons, and when the pH of solvent differs from the pH of the soil, non-classical concentration fronts can arise, in addition to the classical. We will present experimental results and theoretical solution compared with numerical simulations.

A manifestation of classical pH-dependent transport occurs when low pH solvent (e.g., brine saturated with CO2) enters a soil containing adsorbed cations. The acidified brine favors the formation of a desorbing front moving slower than the flow speed, but characterized by a peak whose maximum concentration, controlled by the brine pH, can be much larger than the initial value presenting a health hazard.

The manifestation of non-classical behavior is the anomalously rapid solute transport that occurs when a solvent at high pH enters a low pH hydrophilic mineral-bearing soil. In addition to a classical retarded front, a non-classical pulse forms which travels at the flow speed much faster than expected. It is due to the combination of hydrodynamic dispersion and pH-depended adsorption. Dispersion creates a low pH mixing zone within the initial front where cation adsorption is negligible; it detaches from the retarded front and travels un-retarded ahead of it.

References

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