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Evaluating effective reaction rates of kinetically driven solutes in large-scale, anisotropic media: human health risk implications

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Abstract The role of high and low hydraulic conductivity regions in heterogeneous, stratified flow fields and the subsequent effect of rate dependent geochemical reactions are investigated. Human health risk (cancer) is used as an endpoint for comparison via a two-stage nested Monte Carlo scheme, explicitly considering joint uncertainty and variability. Parameter interplay is investigated using stochastic ensembles. This study identifies the effect of geo-hydrologic conditions on solute equilibrium and the effect of preferential flow pathways and mixing at the field and local scales for varying degrees of stratification. Results show effective reaction rates of kinetic ensembles are dissimilar from equilibrium ensembles with local dispersion, resulting in an additive tailing effect of the solute plume, a retarded peak time, and an increased risk. Uncertainty in risk is also controlled by these factors. We demonstrate that a higher associated uncertainty of risk in stratified domains is linked to higher aquifer connectivity and less macrodispersion.

Key words cancer risk; kinetic sorption; local dispersion; stochastic Monte Carlo; CO_2 leakage; arsenic