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Dilution and reactive mixing in three-dimensional helical flows in porous media

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Dilution under steady-state flow and transport conditions in porous media occurs primarily by lateral mass exchange at the fringe of solute plumes. This process controls the fate and transport of scalars in groundwater and in chemical reactors and it is fundamental for the understanding of many reactive processes. Three-dimensional flow fields can be characterized by a complex topological structure, which may greatly influence dilution and dilution enhancement of dissolved plumes, which is quantified by the exponential of the Shannon entropy [1]. In previous works, we identified the necessary conditions to obtain helical flow fields in non-stationary anisotropic heterogeneous porous media [2, 3]. To prove our theoretical findings, we perform steady-state bench-scale experiments with a conservative tracer and we provide a model-based investigation of the results [4]. The relevance of transverse mixing enhancement for the case of reactive solute transport is computed numerically using, as metrics of mixing, the length of a reactive plume undergoing an instantaneous complete bimolecular reaction and its critical dilution index.

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