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Transport in heterogeneously reactive media

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Plume deformation and mixing determines the effective reaction in porous media
chracterised by internal heterogeneous reaction. Via pore-scale simulations, we show the dynamic of a passive scalar injected in a packed bed consisting of a mixture of chemically inert and reactive spherical particles (adorbers), to mimic, e.g., the contaminat uptake by a fraction of grains in the soil matrix [1].
The scalar plume deformation is a consequence of the different mechanisms of transport characterising the transport of molecules in the proximal and remote pores relative to the adsorbers, diffusion and advection, respectively. The scaling laws governing stretching and broadening of isoscalars are quantified and discussed in relation to medium characteristics, such as the mean adsorbers' interparticle distance.
We show that a transition from diffusion- to advection- dominated macroscopic adsorption is determined by the amount of adsorbers within the medium, with diffusion and advection dominating at high and low fractions, respectively.
At high fractions the temporal evolution of the macroscopic adsorption scale as $\propto \sqrt{t}$. while at law fractions it follows $\propto t$. The transition shows that more rapid adsorption is taking places in areas of soils where the fraction of adsorbers is lower, leading also to a faster saturation of contaminant uptake capacity.

Participation

In-Person

References

[1] Maggiolo, Dario, Oskar Modin, and Angela Sasic Kalagasidis. "Transition from diffusion to advection controlled contaminant adsorption in saturated chemically heterogeneous porous subsurfaces." Physical Review Fluids 8.2 (2023): 024502.

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Primary author: Dr MAGGIOLO, Dario (Chalmers University of Technology)

Co-authors: Dr MODIN, Oskar (Chalmers University of Technology); Prof. SASIC KALAGASIDIS, Angela (Chalmers University of Technology)

Presenter: Dr MAGGIOLO, Dario (Chalmers University of Technology)

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