



Investigation of mixing enhancement in porous media under helical flow conditions: 3-D bench-scale experiments

Chiogna, Gabriele; Ye, Yu; Cirpka, Olaf A. ; Grathwohl, Peter ; Rolle, Massimo

Published in:
Geophysical Research Abstracts

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Chiogna, G., Ye, Y., Cirpka, O. A., Grathwohl, P., & Rolle, M. (2017). Investigation of mixing enhancement in porous media under helical flow conditions: 3-D bench-scale experiments. *Geophysical Research Abstracts*, 19, [EGU2017-5619].

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



Investigation of mixing enhancement in porous media under helical flow conditions: 3-D bench-scale experiments

Gabriele Chiogna (1,2), Yu Ye (3), Olaf A. Cirpka (4), Peter Grathwohl (4), and Massimo Rolle (5)

(1) Technical University of Munich, Germany (gabriele.chiogna@tum.de), (2) University of Innsbruck, Austria, (3) Hohai University, Nanjing/China, (4) University of Tuebingen, Germany, (5) Technical University of Denmark,

Lateral mass exchange at the fringe of solute plumes is a fundamental process leading to plume dilution and reactive mixing. Mass transfer between the plume and ambient water can be considerably enhanced by helical flow occurring in three-dimensional heterogeneous anisotropic porous media [1-3]. We performed steady-state conservative tracer experiments in a fully three-dimensional flow-through chamber to investigate the effects of helical flow on plume spiraling and deformation, as well as on its dilution [4]. Helical flow was created by packing the porous medium in angled stripes of materials with different grain sizes to create blocks with macroscopically anisotropic hydraulic conductivity. The hydraulic conductivity of the blocks was varied in different experiments. Solute concentrations and flow rates were measured at high spatial resolution for samples collected at 49 outlet ports. This allowed us to quantify spreading and dilution of the solute plumes at the outlet cross section. Moreover, we collected direct evidence of plume spiraling and visual proof of helical flow by freezing and slicing the porous medium at different cross sections and observing the dye-tracer distribution. Model-based interpretation of the results allowed substantiating the effect of the helical flow field on plume dilution and on mixing-controlled reactive transport. The simulation results were evaluated using metrics of reactive mixing such as the critical dilution index and the length of continuously injected steady-state plumes.

[1] Cirpka O.A., Chiogna G., Rolle M. and A. Bellin (2015). Transverse mixing in three-dimensional non-stationary anisotropic heterogeneous porous media. *Water Resources Research*, 51, DOI: 10.1002/2014WR015331.

[2] Chiogna G., Cirpka O.A., Rolle M. and A. Bellin (2015). Helical flow streamlines in three-dimensional nonstationary anisotropic heterogeneous porous media. *Water Resources Research*, 51, DOI:10.1002/2014WR015330.

[3] Ye Y., Chiogna G., Cirpka O.A., Grathwohl P. and M. Rolle (2015). Experimental evidence of helical flow in porous media. *Phys. Rev. Lett.*, 115, 194502, DOI: 10.1103/PhysRevLett.115.194502.

[4] Ye Y., Chiogna G., Cirpka O.A., Grathwohl P. and M. Rolle (2016). Experimental investigation of transverse mixing in porous media under helical flow conditions. *Physical Review E*, 94(1), [013113]. DOI:10.1103/PhysRevE.94.013113.