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Tuned Nanoparticle Deposition In Porous Media To Improve Efficiency of Nanoremediation

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Nanoremediation is an innovative environmental nanotechnology aimed at reclaiming contaminated aquifers. It consists in the subsurface injection of a reactive colloidal suspension for the in-situ treatment of pollutants. The greatest challenges faced by engineers to advance nanoremediation are the effective delivery and the appropriate dosing of the nanoparticles into the subsoil. These are necessary for the correct emplacement of the in situ reactive zone and to minimize the overall cost of the reclamation and the potential secondary risks associated to the uncontrolled migration of the injected particles.
In this study, a model assisted strategy, called NanoTune, is developed to control the distribution of colloids in porous media. The proposed approach consists in the sequential injection of a stable suspension of reactive nanoparticles and of a destabilizing agent with the aim of creating a reactive zone within a targeted portion of the contaminated aquifer. The controlled and irreversible deposition of the particles is achieved by inducing the mixing of the two fluids in the desired portion of the aquifer.
This approach is here exemplified by the delivery of humic acid-stabilized iron oxide nanoparticles (FeOx), a typical reagent for in situ immobilization of heavy metals. Divalent cations, which are known to cause rapid aggregation of the suspension because of their strong interaction with the humic acid coating, are used as destabilizing agents. The injection strategy is here applied in 1D columns to create a reactive zone for heavy metal removal in the central region of the sandy bed. The software MNMs was used to assess the correct sequence and duration of the injection of the different solutions in the 1D medium. Moreover, the numerical code MNM3D (MNM3D - Micro and Nanoparticle transport Model in 3D geometries) was developed by the authors of this work to support the case-specific design of the injection strategy during field scale applications.
The NanoTune approach represents an advancement in the control of the fate of nanomaterials in the environment, and could enhance nanoremediation making it an effective alternative to more conventional techniques.
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References

Bianco C., Patiño Higuita J. E., Tosco T., Tiraferri A., and Sethi R. (2017), Controlled Deposition of Particles in Porous Media for Effective Aquifer Nanoremediation. Scientific Reports 7, art. n. 12992 (2017), doi:10.1038/s41598-017-13423-y

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