

## Impact of scale-dependent coupled processes on the bioremediation of contaminant metals in heterogeneous subsurface environments

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The objective of this presentation is to provide an overview of metal bioreductive processes and its use as a remedial tool in heterogeneous subsurface environments that are impacted by scale-dependent coupled processes. The presentation is motivated by the fact that various government agencies and industries are faced with the daunting task of remediating thousands of sites throughout the world that contain groundwater contaminated with unacceptable levels of toxic metals, organics, and radionuclides. Many remediation techniques have offered promise as cleanup options for contaminated sites with bioremediation being attractive based on cost and effectiveness. Bioremediation techniques can create anaerobic subsurface conditions designed to stimulate microorganisms that degrade organic contaminants and reduce toxic metals to sparingly soluble forms, immobilizing them *in situ*. In this presentation we focus on field scale case studies that use subsurface biostimulation as a technique for remediating contaminant metals such as Cr (VI), U (VI), Hg, Se, and As. I show examples of engineered bioremediation successes and the limitations and obstacles encountered due to coupled hydrological, geochemical, and microbial processes that exist in subsurface heterogeneous media. Potential limitations such as preferential flow, matrix diffusion, nanoparticle formation, reoxidation, and media structural collapse are often the difference between bioremediation successes and failures. Understanding these processes at relevant spatial and temporal scales is shown to be essential to designing an efficient and effective monitoring program following the implementation of *in situ* bioremediation.

## Effects of surfactant coating on the fate of engineered oxide nanoparticles in simulated wastewater treatment

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Engineered oxide nanoparticles (e.g. silica, titania, ceria) constitute a major component of global nanomaterial production, with a vast range of commercial applications, including personal care products, cosmetics, pharmaceuticals, foods and household cleaners. For a large proportion of these nanoparticles, their major route of release into the natural environment is via sewage and industrial wastewater. Wastewater treatment plants therefore act as 'gateways' controlling nanoparticle release to aquatic or terrestrial environments: either via treated effluent discharged to surface waters or, via sewage sludge disposal to land.

Using a novel application of small-angle neutron scattering (SANS), we examined the fate of silica nanoparticles in laboratory primary wastewater treatment microcosms [1]. In many commercial formulations, surfactant and/or polymer may be designed to adsorb on the nanoparticles to alter their surface physical chemistry. In our experiments, we therefore examined the effects of a commonly-used non-ionic surfactant coating on the behaviour of the nanoparticles.

Our results show a dramatic difference in the colloidal behaviour and fate of silica nanoparticles in wastewater, as a direct result of the thin surfactant coating. Our results suggest that by manipulating the surface functionality of engineered oxide nanoparticles, it may in future be possible to optimise or direct their fate along particular environmental pathways.

[1] Jarvie *et al.* (2009) *Environ. Sci. Technol.* **43**, 8622–8628.