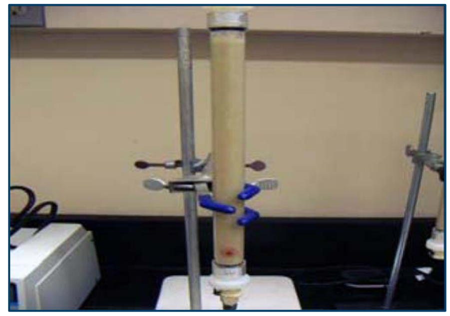
Fate and Transport of Nanomaterials in Porous Media

Background

Nanomaterials are being manufactured and used at rapidly increasing rates, with commercial production and use of engineered nanomaterials anticipated to increase dramatically over the next several years. As nanoparticles are used in commercial applications, they will inevitably be released into the environment as a result of manufacture, transport, application, and disposal practices. Furthermore, a wide range of manufactured nanoparticles have been shown to exhibit properties of increased reactivity and toxicity. Little attention has been focused on understanding the processes that govern the fate and transport of manufactured nanomaterials in the environment.



Objectives

The overall goal of this research is to better understand the fate and transport characteristics of different nanoparticles under varying physical and chemical conditions. Nanosized particles can be sorbed onto native soil and sediment particles because of their highly specific surface area. Nanoparticles can also be subjected to biological and abiotic degradation. Sorption, agglomeration, dispersion, and mobility of nanoparticles are strongly affected by the surface charge of nanoparticles, solution pH and ionic strength, and redox conditions (for redox-sensitive nanomaterials). The extent of transport of a nanoparticle will be dependent on its size, surface chemistry (e.g., charge), and the hydrogeochemical conditions under which it is applied.

Some dispersed nanoparticles can be stabilized in aquatic environments. The stability of the nanoparticle suspensions is sensitive to both the pH and ionic strength of the solution, as well as surface charge characteristics of the media and the particles. While some models have been used to predict the transport of organic colloids, viruses, and bacteria in the subsurface, there has not been the same level of investigation and use of appropriate models to predict the transport of nanomaterials (e.g., carbon onions, iron, titanium dioxide, silver). Results from this fundamental research can help decision makers in assessing and managing risk from nanomaterials.

Approach

A parametric study composed of carefully controlled laboratory column studies is required to address the controlling factors and extent of transport of a number of nanoparticles through different soil and aquifer materials. Nanomaterials to be studied include carbon onions, zero-valent iron, elemental copper, elemental silver, zinc oxide, titanium dioxide, silicon dioxide, and iron oxide, which are currently released to the environment. There is little or no information available on the transport of these materials in ground water systems, how far they may be transported, and what negative effects could occur if transported greater distances than intended.

Accomplishments

Sand column tests on zero-valent copper and carbon onions were initiated and the influence of humic/fulvic acids on transport was studied. More data will be generated and the research findings will be published in EPA reports and peer-reviewed journal articles.

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