Investigating the influence of soil organic matter and Fe/Al-oxyhydroxides on nanoscale titanium dioxide ($nTiO_2$) transport in natural sediment

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Engineered nanoparticles (ENPs) are increasingly being used in medical, industry, wastewater, and remediation applications, and consequently are being released into the environment in unprecedented and unknown quantities. Many ENPs are toxic to plants, animals, and ecosystems, and have a tendency to facilitate the transport of environmental pollutants. Knowledge of ENP migration in subsurface environments is essential for evaluating environmental impacts. Most laboratory ENP transport studies use quartz sand as the porous media, however, natural sediments are far more complex with heterogeneous compositions that may influence nanoparticle transport.

The objective of this research was to investigate the effects of natural organic matter (NOM) and Fe/Al oxyhydroxides in a natural sediment on ENP transport. A natural sediment was treated to deplete either soil organic matter (SOM), Fe/Al-oxyhydroxides, or both; and used as transport medium to study nanoscale titanium dioxide ($nTiO_2$, a widely used ENP) transport. Results indicated $nTiO_2$ transport was strongly influenced by pH and sediment composition. When influent pH = 5, $nTiO_2$ transport was low, as positively-charged $nTiO_2$ was attracted to negatively-charged minerals and SOM. $nTiO_2$ transport was slightly enhanced in sediments containing SOM due to the leaching of dissolved SOM which adsorbed onto $nTiO_2$ surface, stabilizing it in pore water. When influent pH = 9, $nTiO_2$ transport was high since negatively-charged medium repelled negatively-charged $nTiO_2$. However, in sediments with SOM or amorphous Fe/Al-oxyhydroxides depleted, transport was low due to pH buffering by the sediments causing attraction between $nTiO_2$ and crystalline Fe-oxyhydroxides. Our results demonstrate the important influence of SOM and Fe/Al-oxyhydroxides on ENP transport in natural sediment and their dependence on pH and electrostatic forces.

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