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How do Fe-oxyhydroxide, illite clay, and peat moss influence titanium dioxide (TiO_2) particle transport in water-saturated quartz sand columns?

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The complex mineral and chemical composition of natural soil and sediment is expected to significantly influence fine particle migration in subsurface environments. To better understand particle transport under natural conditions, laboratory experiments were conducted to investigate the effect of common mineral and organic components in porous media on particle transport. Water-saturated columns packed using quartz sand with small amount of Fe-oxyhydroxide, or illite clay, or peat moss were used as porous media to investigate the transport of fine titanium dioxide (TiO2) particle, a widely used engineered nanomaterial. TiO2 particle suspensions were injected into the columns and effluents from the columns were collected for measuring TiO2 concentration to obtain breakthrough curves. Results showed that the influence of mineral and organic composition of the porous media on transport was pH dependent. For influent pH = 5, TiO2 transport did not seem to be affected by illite clay, while both Fe-oxyhydroxide and peat moss increased TiO2 transport. The enhanced transport was attributed to increased repulsive electrostatic forces between Fe-oxyhydroxide and TiO2 or increased dissolved organic carbon (DOC) concentration in columns packed with peat moss. For influent pH = 9, TiO_2 transport was not influenced by Fe-oxyhydroxide, whereas illite clay and peat moss inhibited TiO_2 transport, presumably due to increased physical straining and entrapment. Results from this study demonstrated that mineral and chemical composition of porous media played an important role in controlling particle transport and the influence on transport was pH dependent. This study also indicated that mineral and chemical composition of porous media affected particle transport via mechanisms including physical straining and entrapment, electrostatic forces between TiO2 and collector, and DOC adsorption to particle and collector surface.