Effects of pH and grain size of porous media on the transport of titanium dioxide nanoparticles in water-saturated sand columns

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Nanoparticles, mineral colloids, and natural organic matter (e.g., humic substances) have important environmental functions in soil and groundwater. These small particles may occur naturally or can be produced unintentionally or intentionally engineered. Nanoparticles have an important role in pollutant chemistry. Nanoparticles potentially pose risks to aquatic ecosystems as well as human health. Titanium dioxide nanoparticles are toxic to human cells and aquatic organisms. In order to understand the fate and distribution of nanoparticles after they are released to the environment, it is important to understand the factors that influence nanoparticle transport and mobilization in the vadose zone and groundwater.

This research examined how grain size of the transport media influences the transport of titanium dioxide nanoparticles using bench-top column experiments. Pure quartz sand with size ranges of 0.250 to 0.355 mm (fine sand) and 0.600 to 0.710 mm (coarse sand) was used to pack the columns. Titanium dioxide particle suspensions prepared at a concentration of 20 mg/L with or without Xanthan gum (a surfactant) were injected into the columns at pH 5 and pH 9, and the effluents from the columns were collected with a fraction collector. A spectrophotometer was used to measure the absorbance of the influent as well as the effluent samples in order to quantify particle concentration. The results of our column experiments showed that there is no significant change in the effluent when Xanthan gum was used, on the other hand without using the Xanthan gum the normalized effluent concentration (C/C_0) of titanium dioxide particles in the coarse sand columns at pH 5 was close to 0 whereas at pH 9 it was near 90%. At pH 9 without using the Xanthan gum, the normalized effluent concentration (C/C_0) for the fine sand column gradually increased and reached its maximum at 4.5 pore volume (V/V_p) whereas for the coarse sand column the normalized effluent concentration (C/C_0) sharply increased and reached its maximum at 2.5 pore volume (V/V_p). Our results indicate the importance of pH and grain size on nanoparticles transport.

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