Natural Attenuation of Titanium Dioxide (TiO2) Nanoparticles Photo-Catalysis – Phase II, Marine Systems

Ellison, Rayna

Most Titanium dioxide nanoparticles (TiO2-NP) are removed from wastewater at wastewater treatment plants (WWTPs), but some leave the WWTP in the effluent and enter downstream aquatic systems including lakes, rivers, ponds, and oceans. TiO2-NPs can be photo-activated by UV-light producing strong reactive oxygen species including hydroxyl radicals (·OH), and may be solar-activated once dispersed into the environment. TiO2-NPs have been directly implicated in ecotoxicological impacts on marine and aquatic organisms, or from the photo-catalytic mechanisms. The main objective of this study was to assess the extent of TiO2-NP photo-oxidation in seawater relative to fresh water systems. Methylene blue (MB) is an indicator compound used to assess the extent of photo-oxidation. The minimum and maximum MB loss was 51.9% and 1% in freshwater and artificial seawater, respectively. Seawater constituents were tested individually and combined in UV-activated TiO2-NP-amended reactors. Chloride, bromide, and bicarbonate played the greatest role in ·OH scavenging due to their very high concentrations in sea water, and/or to their high reaction rate constants. Repeated cycles of MB re-amendment and TiO2-NP photo-activation indicated TiO2-NP inactivation. But this result could not be differentiated from ·OH scavenging due to accumulation of MB fragment residuals measured as total organic carbon. However, long term TiO2-NP photo-activation and mineralization of natural organic matter resulted in progressively greater TOC mineralization with time indicating TiO2-NP inactivation did not occur. Overall results indicate photo-oxidative impacts of TiO2-NP in freshwater systems is much greater than in seawater.

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