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Stormwater green infrastructures retain high concentrations of TiO2 engineered (nano)-particles

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ABSTRACT

Stormwater conveys natural and engineered (nano)-particles, like any other pollutants, from urban areas to water resources. Thus, the use of stormwater green infrastructures (SGI), which infiltrate and treat stormwater, can potentially limit the spread of engineered (nano)-particles in the environment. However, the concentration of engineered (nano)-particles in soil or biofilter media used in SGI has not been measured due to difficulties in distinguishing natural vs. engineered (nano)-particles. This study reports, for the first time, the concentration and size distribution of TiO2 engineered (nano)-particles in soils collected from SGI. The concentrations of TiO2 engineered (nano)-particles were determined by mass balance calculations based on shifts in elemental concentration ratios, i.e., Ti to Nb, Ti to Ta, and Ti to Al in SGI soils relative to natural background elemental ratios. The concentrations of TiO2 engineered (nano)-particles in SGI soils varied between 550±13 and 1800±200 mg kg−1. A small fraction of TiO2 engineered (nano)-particles could be extracted by ultrapure water (UPW) and Na4P2O7; however, the concentration of TiO2 engineered (nano)-particles was higher in the Na4P2O7-extracted suspensions than in UPW-extracted suspensions. The concentration of TiO2 in the nanosize range increased with the increase in extractant (Na4P2O7) volume to soil mass ratio due to the increased disaggregation of soil heteroaggregates. The size distribution of TiO2 engineered (nano)-particles in the<450 nm Na4P2O7-extracted suspension from one of the SGI soils was determined by asymmetrical flow-field flow fractionation coupled to inductively coupled plasma-mass spectrometer, and was found to vary in the range of 25 −200 nm with a modal size of 50 nm. These results demonstrated that the increase in the Ti to natural tracers (e.g., Nb, Ta, and Al) elemental ratios in the SGI soil relative to bulk soil can be used to estimate the concentration of TiO2 engineered (nano)-particles in SGI.