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Insights from a spatially and temporally resolved nanoparticle fate model

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We introduce a spatially and temporally resolved mass balance model for sulfidized Ag NP and ZnO NP loadings to the James River Basin in Virginia. The model includes oxygen-, sulfide-, and temperature-dependent NP and byproduct (ion) transformations, oxic and anoxic sediment layers, and flow-dependent sediment transport. Although it has been generally ignored in NP fate models, surface runoff of land-applied biosolids accounts for roughly a quarter of NP stream loads in our model. Due to daily flow dynamics, NPs were also more mobile than anticipated in the stream, with only ~5-10% of the cumulative stream load remaining in the basin at the end of the simulation. Therefore, metals from NPs will accumulate downstream in estuarine or marine ecosystems. Spatially variable discharges and stream flows, control predicted environmental concentrations (PECs) in this model. Previous steady state models or those applying time-constant parameters and processes suggest peak PECs occur during low flows. We also observe peaks during high flows due to surface runoff. Unlike sulfidized Ag
NPs, ZnO NPs rapidly dissolve. PECs never exceed USEPA water or sediment guidelines for Ag and Zn, suggesting low risk in this system at estimated current loading levels.

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