Transformations that affect fate, form and bioavailability of inorganic nanoparticles in aquatic sediments

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Environmental context. Engineered nanomaterials are increasingly being used and their release to the aquatic environment poses potential risk. We review the research on transformations of engineered nanomaterial in the aquatic sediment environments, and consider the implications of their release. The key factors defining the fate of engineered nanomaterials in aqueous and sediment systems are identified.

Abstract. Inorganic nanoparticles are at risk of release into the aquatic environment owing to their function, use and methods of disposal. Aquatic sediments are predicted to be a large potential sink for such engineered nanomaterial (ENM) emissions. On entering water bodies, ENMs undergo a range of transformations dependent on the physicochemical nature of the immediate environment, as they pass from the surface waters to sediments and into sediment-dwelling organisms. This review assesses the current state of research on transformations of metal-based ENMs in the aquatic environment, and considers the implications of these transformations for the fate and persistence of ENMs and their bioavailability to organisms within the benthos. We identify the following factors of key importance in the fate pathways of ENMs in aqueous systems: (1) extracellular polymeric substances, prevalent in many aquatic systems, create the potential for temporal fluxes of ENMs to the benthos, currently unaccounted for in predictive models. (2) Weak secondary deposition onto sediment grains may dominate sediment–ENM interactions for larger aggregates >500 nm, potentially granting dynamic long-term mobility of ENMs within sediments. (3) Sulfurisation, aggregation and reduction in the presence of humic acid is likely to limit the presence of dissolved ions from soluble ENMs within sediments. (4) Key benthic species are identified based on their ecosystem functionality and potential for ENM exposure. On the basis of these findings, we recommend future research areas which will support prospective risk assessment by enhancing our knowledge of the transformations ENMs undergo and the likely effects these will have.

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