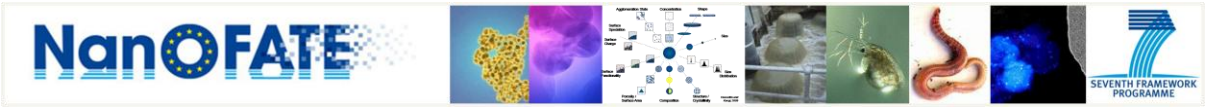

NanoFATE Deliverable 4.1

Factors affecting ENP bioavailability

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Literature and data review - Summary

Which factors determine the bioavailability of engineered nanoparticles (ENPs) to organisms living in soil and water? This NanoFATE deliverable surveys the literature on the fate and effects of ENPs in these environmental compartments. On this basis factors are identified that have the greatest effect on ENP bioavailability. Since the work in NanoFATE focuses on metal-based ENPs, this review is restricted to these ENPs and does not include data on other types of ENP like e.g. carbon nanotubes.

In addition to other published literature, NanoFATE partners jointly reviewed published data regarding the fate and effects of metal-based ENPs in soil and water. On this basis it may be concluded that several physical, chemical and biological factors affect ENP bioavailability in the environment.

The study produced the following main conclusions and recommendations:

- Metal and metal oxide nanoparticle behaviour and fate in the natural environment will be controlled largely by particle stability in the aqueous phase; the same factors seem to be important for bioavailability and toxicity of ENPs.
- The tendency of particles to remain stable in the aqueous phase at environmentally relevant timescales will be determined by those surface properties that confer stability, namely high surface charge/zeta potential and/or steric stabilisation.
- The properties of the nanoparticle surface (including any adsorbed layer) and of the medium that control stability are reasonably well understood in laboratory systems but translation to the natural environment is likely to be challenging due to the complex and heterogeneous nature of soils and waters. More studies of the behaviour of nanoparticles in natural samples are needed to provide baseline data for interpretation.
- Transformations of nanoparticles prior to and following entry to the environment, such as dissolution under natural conditions and portioning to suspended sediments, may be important in controlling behaviour and fate and require further research.
- Nanoparticle properties are important in controlling exposure to organisms, and thus toxicity testing procedures need to be carefully considered in the context of medium effects on particle presentation to the test organism. Parallel physicochemical/toxicity studies are needed to gain more systematic understanding of how properties influence nanoparticle bioavailability and toxicity.
- Understanding of the fate of ENPs in soil, sediment and water (both fresh and marine surface waters) is essential to understanding exposure of organisms living in these environments. Long-term effects will depend on the fate of ENPs, but also on the dissolution rate and the possible interaction of the released free metal ions with the matrix. Efforts focusing on linking development of ENP fate in time (ageing) and toxicity should be encouraged. As indicated above, focus should be on factors that may affect the interaction of ENP fate and effects.
- Effects of reactive oxygen species (ROS) generation by ENPs should also be taken into account. ROS generation may take place outside organisms and already exert effects without ENPs being taken up by organisms. This may cause considerable deviations from the classical

(eco)toxicological assumption that toxicity may be related to the body burden or concentration at the target site.

This deliverable will be published as a refereed journal paper.