NanoFASE Deliverable D7.2

Soil property – NM fate relationships

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Research Report Summary

Soils are sinks for engineered nanomaterials (ENMs), but there are no agreed fate descriptors for ENMs in soils nor agreed protocols to determine them. Moreover, it is not completely known how soil properties (pH, organic matter, clay content etc.) affect the transport and bioavailability of ENMs in soils. The current deliverable provides experimental evidence aiming at addressing these knowledge gaps suggesting the attachment efficiency (α) as an appropriate fate descriptor. Using 20 nm and 80 nm citrate coated Au ENMs, two different protocols to determine α, saturated column and kinetic batch tests, were optimized using 5 natural soils representative of the range of different soil properties found in the EU. Interpretation of the results was aided by Monte Carlo modelling. The effects of non-saturation, relevant for soil in the field, were then tested and it was investigated whether α is also useful in predicting bioavailability of Ag_2S ENMs to two invertebrates or wheat plants.

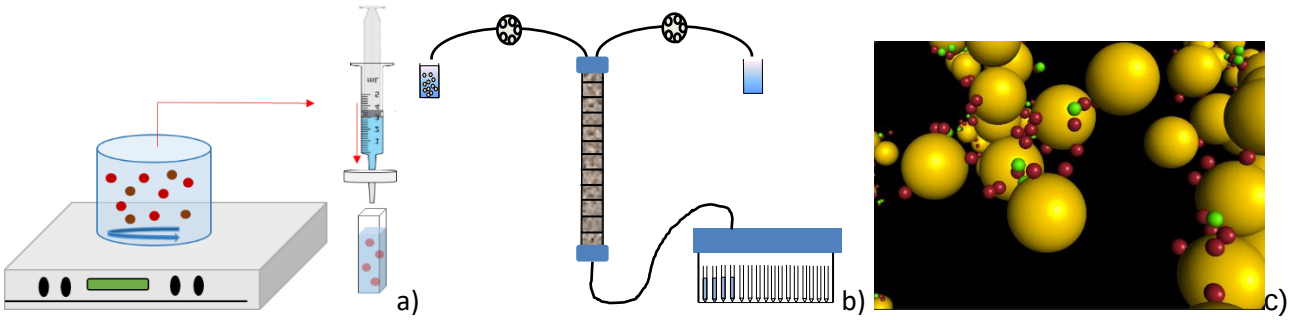

Figure. Schematic of a) batch tests and b) saturated column tests for α determination in soils and c) part of the Monte Carolo modelling shoing the occurrence of heteroaggregates in soils.

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Batch test optimization is not yet complete, because the initially planned UV detection provided an inadequately small experimental window of workable ENM concentration/soil concentration ratios that could be used to obtain α values. The first results with single particle Inductively Coupled Plasma Mass spectrometry (spICP-MS) as a detector show better possibilities. As in the column tests, a low α value was found for the soil (Lufa 2.2) and Au ENMs tested.

The column test protocol was optimized to maximize ENM recovery and reduce the occurrence of involuntary non-saturation. Both effects had a significant effect on the α values determined. Moreover, using a low (i.e. lower than ca. 10 mg L^{-1} for the feed solution) ENM concentrations is recommended as otherwise α values are overestimated. Trends of α values in different soils could be explained based on known colloidal chemistry theories, suggesting that the optimized column tests are accurate protocols for α value determination. When extracting α values from saturated column tests, the value depends highly on the model assumptions used. It was also found that of the available models to calculate α from experimental data, models assuming both irreversible attachment and straining provided the most realistic values. Monte Carlo modelling, however, showed that hetero- or homoaggregation could explain the occurrence of non-hyperexponential depth profiles from column experiments. Moreover, non-saturated column tests showed that decreasing water content increased ENM retention significantly. When modelling ENM transport in the field, the water content is rarely known exactly. Any efforts in maximizing accuracy of α value determination, would thus only result in accurate field soil predictions, if these field soils are saturated.

Finally, while α value appear good fate descriptors for transport, it was found that they could not predict bioavailability. Bio-uptake kinetics were determined for two invertebrates (*Folsomia candida* and *Enchytraeus Crypticus*) and one plant (*Triticum Aestivum*), each having different feeding strategies, in different soils, but the trend in these kinetics could not be related to differences in α values amongst the soils. Prediction of ENM concentrations in a portion of soil as a function of time in the soil can be made using α values, but when combining exposure and hazard, it appears that total ENM concentrations would still have to be used, because the bioavailable ENM concentration cannot be calculated using α values.

[Where possible add illustrative image with legend]

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