Multimethod characterisation of nanoparticles in the environment

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A range of techniques for the characterisation of nanoparticles will be presented, and their feasibility in studies of nanoparticle toxicity and environmental behaviour will be discussed. Techniques are often complimentary in the information they provide, and a multimethad approach is therefore recommended for nanoparticle characterisation. Results will be presented from the following studies, carried out at the Facility for Environmental Nanoparticle Analysis and Characterisation (FENAC) at the University of Birmingham:

1. Iron-rich and organic nanoparticles in anoxic groundwater, characterised under oxygen-free conditions by atomic force microscopy (AFM), transmission electron microscopy (TEM), scanning electron microscopy with energy-dispersive X-ray diffraction (SEM-EDX) and field-flow fractionation (FFF).
2. Biogenic hydroxyapatite – relation between metal uptake and particle size/surface area, determined by X-ray diffraction (XRD), BET-surface area measurements, SEM, DLS and zeta-potential measurements.
3. ZnO nanoparticle dissolution and toxicity to marine invertebrates - dependency on particle size and morphology, characterised by TEM, AFM, dynamic light scattering (DLS), zeta-potential measurements and nano-tracking analysis (NTA).
4. Nanoparticle impact on bioremediation of hydrocarbons in aquatic ecosystems - relation to particle size and chemistry, determined by DLS, FFF, TEM and XRD.

Pore scale heterogeneity of porous media influencing the spatial and temporal distribution of microbial metabolic activity

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Microbial activity plays a crucial role in the cycling of carbon, nutrient elements and contaminants in the environment. This includes porous environments like soils or aquifers. These bacterial habitatats are often characterized by a high temporal variability of substrate supply, and by a high spatial heterogeneity of the porous matrix at the pore scale. As a consequence, microbial growth conditions and the resulting microbial redox activity in natural porous media environments may differ from typical laboratory setups used to study microbial behaviour. Pore scale heterogeneities and the resulting transport regime can lead to highly complex distribution patterns of substrates and the corresponding microbial growth conditions including the frequent occurrence of stress periods for the microbial population. Microorganisms can respond to such stress periods by switching from an active into an inactive or dormant state, and the corresponding microbial abundance and substrate degradation dynamics may exhibit rather complex temporal and spatial patterns.

This study considers an extended modelling concept for the growth and degradation activity of microbial species able to switch between two different physiological states. This concept is implemented into a pore network model which allows simulating the changes of microbial growth conditions in heterogeneous porous media. The model is used to study the impact of pore scale heterogeneities on the distribution and activity of microorganisms in such media and to determine the biodegradation capacity of the microbial population.