Determination of attachment efficiency (α) for AuNPs in soils by saturated column experiments

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The attachment efficiency (α) has been suggested as the most appropriate fate descriptor for nanoparticle (NP) transport in soils and column experiments as the most accurate method to obtain α [1].

In this work, the α values for nominally 20 and 80 nm citrate coated gold NPs (AuNPs) were determined from saturated packed column experiments in different soils sampled in the UK, using artificial rainwater as the eluent. 10 mM $NaNO_3$ was used as a concervative tracer to estimate the effective porosity and dispersivity. α was either calculated from breakthrough curves of Au or from the irreversible attachment rate modelled using Hydrus 1D based on the breakthrough curve and/or the depth profile. The impact of different parameters, such as added NP concentration, flow rate and NP size, on accuracy and reproducability of α values was investigated. In addition, the amount and distribution of air and AuNPs in the columns was imaged using X-ray tomography.

Preliminary results shows that the α is higher for 80 nm AuNPs than 20 nm AuNPs. As a result, the 80 nm AuNPs will be accumulated to higher extent in the soils than the 20 nm AuNPs, while the 20 nm AuNPs will be travelled further with the rainwater. In addition, the AuNP breakthrough curves appeared dependent on the flow rate and total AuNP concentration. For instance, the 20 nm AuNPs were partly transported with preferential flow paths at higher flow rates, a phenomenon that was not observed at lower flow rates. From the X-ray tomography, it was found that the 80 nm AuNPs were transported and accumulated at the air/water-interfaces present in the packed soil columns.

Hence, realistic flow rates and low NP concentrations need to be used in the column experiments to maximize reproducability of calculated α values. Moreover, inclusion of air in the systems appears to induce artefacts that complicates determination of α for specific NP-soil combinations.

[1] S. Treumann et al., *Journal of Contaminant Hydrology* 164 (2014), 219–229