Nanoparticles and bacterial biofilm interactions in natural groundwater: Implication for NPs mobility and toxicity for bacteria

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The mobility, fate and reactivity of zero valent iron NPs in groundwater are controlled by the intrinsic properties of the NPs (e.g. composition, size and size distribution, density, shape, nature of the suspension, surface chemistry) as well as by the environmental conditions (e.g groundwater and aquifer solids composition). Though biofilms have been reported to interact with NPs in saturated porous media (Lerner et al., 2012), the effects of biofilms on the mobility of reactive NPs remain poorly studied. As a part of the NANOREM project, our work presented here focuses on interactions between complex biofilms developed from contaminated groundwater under anaerobic conditions and zero valent iron (ZVI) NPs (NanoFer 25S; NANOIRON, 1g/L). Initial toxicity of NPs towards microbial communities was studied through batch experiments monitoring bacterial nitrate reducing activity and biomass (live & dead cell counts). Results showed a significant impact of NPs (loss of denitrification activity) at concentrations higher than 30 mg/L. Then the influence of the presence of microbial communities on the mobility of a NP suspension was investigated using glass columns. Biofilms were grown for 2 months from natural groundwater in 20cm-long column (2.5 cm in diameter) containing sand under anaerobic conditions. NPs suspension mobility was determined for high velocity conditions (i.e. 10m/d) in the absence and the presence of biofilm in the column. Before the NPs injection, SEM and Fluorescence images show a high density of bacteria and EPS in the column. The Fe concentration breakthrough curves indicate that the mobility of NPs through the sand in the absence and the presence of biofilm were similar, with approximately 40 to 50 % of the total injected Fe NPs found in the effluent. Consequently, the influence of the biofilm on the retention of NPs within the sandy material of the column is not obvious. However, at the end of the experiment, the analysis of the sand from the column containing the biofilm shows that the variation of Fe content is concomitant with that of total organic carbon (TOC), strongly suggesting NPs-biofilm interactions.