Title : Impact of bacterial biofilm on reactive nanoparticles (NanoFer 25S) mobility in laboratory columns filled with sandy material

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The presence of highly toxic and persistent contaminants (e.g. As, chlorinated hydrocarbons etc…) in the environment, especially due to their intrinsic recalcitrance to volatilization, hydrolysis, and biodegradation, is critical for public health and raises industrial and economic issues. Appropriate remediation techniques for these contaminants in groundwater are often technologically impossible, extremely expensive or hardly effective. Nanoparticles (e.g nZVI (Zero-Valent Iron), iron oxides, ferrate) applicable as *in-situ* reduction or oxidation agents for groundwater treatment show an extremely high reactivity, reflected in the effective transformation of many environmentally contaminants into less toxic or benign products. However, high uncertainties remain around the appropriate use of nanotechnological approaches for contaminated land and brownfield management. In this context, the EU-project NANOREM (Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment; EU FP7/2007-2013, GA n°309517) aims at investigating the feasibility (practical and economic) of applying NPs for groundwater remediation under field conditions.

The efficiency of nanoremediation for the restoration of soil and groundwater depends on the reactivity of NPs but also on the ability to deliver NPs in the vicinity of the contaminant source and to ensure sufficient mobility of the NPs. The mobility, fate and reactivity of 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 specific environmental conditions (e.g groundwater and aquifer solids composition).

Bacteria reach concentrations of 1013 cells per g in soils and around 106-107 cells per g in saturated aquifers (Bone and Balkwill, 1988; Wilson et al., 1983). Although bacteria can be found under free, planktonic form, their main organizational form is as bacterial associations in exopolymeric matrices also called biofilms (Denyer et al., 1993). The effects of biofilms on the mobility of reactive NPs are poorly studied. Biofilms have been reported to interact with NPs in saturated porous media, impacting for instance the mobility of carboxylated nAg (Peulen and Wilkinson, 2011). Lerner et al. (2012) show that the presence of biofilm increases the retention of poly(acrylic acid) stabilized nZVI in column experiments containing soda-lime glass sphere.

As a part of the NANOREM project, our laboratory experiments under anaerobic conditions focus on the influence of biofilm on the mobility and reactivity of a NanoFer 25S suspension through glass columns filled with sand. NPs suspension (1g/L) was prepared using NPs 25S (NANOIRON, 200g/L) and synthetic water (moderately hard water). First, biofilm was grown for 2 months from natural ground water in 20cm-long column (2.5 cm in diameter) containing sand under anaerobic conditions. The biofilm growth and organization was observed either by fluorescence microscopy or cryo-SEM. Then, NPs 25S suspension mobility was determined for high velocity conditions (*i.e.* injection conditions: 100m/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 is low, with less than 1% 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, the analysis at the end of the experiment of the sand from the column with the biofilm shows that the variation of Fe content is concomitant with that of TOC strongly suggesting NPs-biofilm interactions. In the future, the influence of biofilm on mobility and reactivity will be tested with optimized NPs (more mobile but still reactive) provided by partners involved in the Nanorem project.