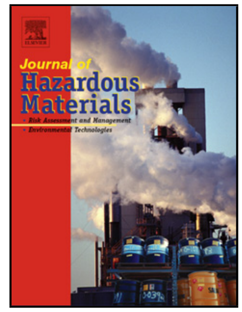

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Column study for the evaluation of the transport properties of polyphenol-coated nano iron

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ABSTRACT

Injection of a nano zero valent iron (nZVI) suspension in the subsurface is a remedial option for obtaining the in-situ reduction and immobilization of hexavalent chromium in contaminated aquifers. Prerequisite for the successful implementation of this technology is that the nanoparticles form a stable colloidal suspension with good transport properties when delivered in the subsurface. In this study we produced stable suspensions of polyphenol-coated nZVI (GT-nZVI) and we evaluated their transport behavior through representative porous media. Two types of porous materials were tested: (a) silica sand as a typical inert medium and (b) a mixture of calcareous soil and sand. The transport of GT-nZVI through the sand column was effectively described using a classic 1-D convection-dispersion flow equation (CDE) in combination with the colloid filtration theory (CFT). The calculations indicate that nZVI travel distance will be limited in the range 2.5-25 cm for low Darcy velocities (0.1 to 1 m/d) and in the order of 2.5 m at higher velocities (10 m/d). The mobility of GT-nZVI suspension in the soil-sand column is lower and is directly related to the progress of the neutralization reactions between the acidic GT-nZVI suspension and soil calcite.

1. INTODUCTION

In situ reduction of hexavalent chromium through the injection of appropriate reducing reagents in the contaminated aquifer is considered an attractive treatment option and many research efforts have been devoted to develop this category of technologies. A wide variety of materials have been tested as possible reductants appropriate for in situ injection, including $Na_2S_2O_4$ [1] CaS_x [2], $FeSO_4 \cdot 7H_2O$ [3-5] etc., which can be delivered in the subsurface as aqueous solutions. Another alternative reductant that has attracted recently the interest of many researchers is nano zero valent iron (nZVI), which is not soluble but can be injected in the subsurface in the form of a colloidal suspension. Elemental iron, in the scale of millimeter and micrometer particles, has been used as filler in many permeable reactive barriers since 1990 and was proved to be very efficient for the remediation of Cr(VI) waters [6,7]. An important technological progress, which emerged in the early 2000s, was the production of nanoscale ZVI. Due to their large reactive surface area, the nZVI particles can be 10-1000 times more reactive, compared to the granular or micro-scale ZVI particles. On the other hand, due to their small size, nanoparticles can be injected in the aquifer as colloidal suspension in water and are expected to penetrate easily in the porous material in order to reach the hotspots of contaminants [8].

However, contrary to the initial expectations, many studies indicated that nZVI particles presented limited subsurface mobility, due to rapid agglomeration under the action of attractive interparticle forces [9]. Many column and field studies showed that the transport of bare nanoparticles in porous media is limited to few centimeters around the point of their injection. Nano ZVI particles tend to precipitate to soil surfaces resulting in clogging and thus in a less efficient treatment of the contaminated groundwater. In order to enhance the mobility and inhibit aggregation and oxidation