Remediation of TCE-contaminated groundwater using nanocatalyst and bacteria

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Nano-bio-technology has the potential to create novel and effective treatment technologies for groundwater remediation. The objective of this study was to develop and evaluate remediation of TCE-contaminated groundwater using both nanocatalyst (biomagnetite) and bacteria (mostly *Clostridium* sp.) in anoxic environments.

Four columns (43 cm long and 7 cm internal diameter) packed with synthetic silica beads with diameter of 1 mm were used in anoxic environments: (1) control column, (2) bacteria inoculated column, (3) nanocatalyst inoculated column, and (4) both nanocatalyst and bacteria inoculated column. TCE contaminated water was injected from the bottom of the column using peristaltic pump at constant flow rate.

In the case of the control column, 50% natural reduction of TCE was observed within 5 days of the column experiments. The column tests confirmed that the application of bacteria, nanocatalyst and both nanocatalyst and bacteria showed 100% TCE dechloination within 4 days of the column experiments. The TCE dechlorination mechanism appeared to be reductive dechlorination, with electrons supplied by the magnetite oxidation and microbial oxidation of organics. These results suggested that application of nanocatalyst and bacteria has potential to create novel and effective treatment technologies for TCE-contaminated groundwater.

Phosphate Sorption on TiO_2

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Dissolved phosphorus has been the subject of interest in natural sciences because of its potential roles in ecosystems and its mobility in near-subsurface environments such as soils and groundwater. Partitioning of the phosphate to minerals such as metal-(hydr)oxides has been known to influence the surface reactivity of minerals and the fate and transport of phosphate species in natural ecosystems. Despite the importance of phosphate interaction with minerals and biological materials like TiO_2 in ecosystems and medicine, the mode of phosphate uptake by TiO_2 is still not clearly understood. Moreover, no direct confirmation of modes of phosphate interaction with TiO_2 has been provided, especially in a molecular level.

Systematic studies, combined batch experiments with NMR spectroscopic methods, have been used to evaluate phosphate sorption on TiO_2. Results show that phosphate sorption on TiO_2 decreases with increasing pH, whereas the phosphate uptake by TiO_2 increases with increasing ionic strength of the solution. In $I \leq 0.1$ M, the sorption sharply increases and reaches a near maximum and then followed by little changes showing Langmuir type behavior, whereas in $I = 0.7$ M non-Langmuirian uptake becomes evident as equilibrium phosphate concentrations increase in solution. $^{31}P\{^{1}H\}$ CP/MAS NMR results show that the local environment of phosphate sorbed at the TiO_2 surface is very similar. Spinning side binds (SSBs) suggest that the phosphate sorbed on TiO_2 forms inner-sphere adsorption surface complexes with Ti atoms at the surface under the conditions of our experiments. Upon ^{31}P-^{1}H distance at 1.98 Å and 1.95 Å for two at $\delta = -2$ and $\delta = -9$ ppm, CP dynamics indicates that protonated phosphate species is dominant at pH 4.5, whereas deprotonated phosphate at the TiO_2 surface becomes evident at pH 9.0.