Effects of Co-solutes on bioaugmented granular iron systems

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Rationale

Previous work has demonstrated the utility of iron and bioaugmented granular iron systems for the remediation of many groundwater contaminants. Although progress has been made towards understanding the mechanisms and effectiveness of the degradation process, factors governing variations in the performance of these systems have thus far received significantly less attention. This work focused on elucidating the effects of bioaugmentation and groundwater co-solutes on granular iron reactivity.

Experimental

Studies were conducted using columns packed with untreated sieved iron that were fed with simulated groundwaters containing various co-solutes and the model contaminant trichloroethylene (TCE). Furthermore, the columns were bioaugmented by inoculating them with the metal reducing bacterial strains *Shewanella alga BRY* and *Geobactger sulfurreducens*. Thereafter, bacterial growth and distribution profiles were monitored. Other chemical parameters such as TCE, Fe^{II}, HCO_3^-, TOC, and H_2 concentrations were obtained from sampling ports located down the length of the columns.

Results and Discussion

Evaluations of individual contaminant and daughter product profiles and pore water velocities suggest that significant differences in column reactivity result from variations in the types and quantities of co-solutes present. In addition, the bioaugmented columns exhibited behavior that varied considerably from that observed in the non-augmented columns. Surface analyses suggest formation of different iron oxide species dictated by the presence of the co-solutes and by bacterial activity. These results extend our understanding of the 'passivation' process that iron barriers undergo.

Geochemical dynamics in Fe(0)-PRB's: H_2 evolution and passivation

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In order to assure the acceptance of Fe(0)-PRB's (permeable reactive barriers) as a remediation strategy for groundwater pollution, data about the long-term performance are needed [1]. The impacts of hydrogen (H_2) evolution and passivation due to the build-up of secondary minerals have received only minor attention up to now [2, 3].

We conducted horizontal column experiments with Fe(0) under varying geochemical conditions for over 2 years. Results indicate that H_2 evolution and reactivity loss due to passivation may cause severe problems regarding the performance of PRB's. While for columns fed with deionized water mean H_2-evolution rates of 0,02-0,2 mmol H_2/d*kg Fe were determined, the presence of 1 g/l HCO_3^- increased H_2-evolution rates to 2,5-3,5 mmol H_2/d*kg Fe. Before the onset of iron passivation maximum rates of up to 14 mmol H_2/d*kg Fe were determined. H_2-evolution did not exhibit a linear relationship in regard to varying feed concentrations of HCO_3^-, complicating predictions of field corrosion rates with natural groundwaters. With increasing experimental duration a loss of reactivity due to the build-up of passivating precipitates was observed This reactivity loss caused a decrease in H_2-evolution as well as in contaminant degradation. The progression of the passivation front could be described with the development of a completely unreactive zone combined with a reactivity loss in the still active sections. Geochemical equilibrium modeling based on experimental data enabled us to calculate the amount and general type of precipitates formed in the column systems. Since gaseous H_2 was collected individually for different sections in the column systems, we were able to describe spatial differences in corrosion rates and precipitate build-up, and their development with progressing experimental duration.

References

[1] EPA (2003), EPA/600/R03/045a, 156 p.
[2] Reardon, E.J. (1995), *Environ. Sci. Technol.,* 2936-2945.
[3] Klausen, J.; P.J. Vikesland; T. Kohn; D.R. Burris; W.P. Ball & A.L. Roberts *Environ. Sci. Technol.*; 1208-1218.