Transport of Fe/Ni Bi-metallic Fine Particles through a Clayey Soil

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Abstract: Transport of Fe/Ni fine particles through a clayey soil column was investigated. By sampling the soil, the distribution of 100 g/L bimetallic particles (Fe/Ni) in the soil column was determined. The effluent ORP and pH were measured with the Fe/Ni concentration.

1 Introduction

The transport and deposition of colloidal particles during flow through porous media have been studied extensively using well characterized model systems [Bettina S. et al., 2004]. Early research was driven by the need to understand the performance of deep bed filters used in chemical engineering and wastewater treatment [Liuzong Z. et al., 2001]. Filtration theories have been developed from theoretical considerations and experimental results for the transport of monodisperse microspheres through columns packed with spherical grains. More recently, the focus of interest has shifted to the transport of mobile colloids in natural subsurface porous media. The injection of reactive slurries or suspended solids, to treat contaminants at greater depth are being investigated. Recently, reactive slurries of nanoscale colloidal Fe-Ni particles were fed into an injection well to study the transport and reactivity of the particles in an aquifer [Yao et al., 1971]. Hence there is a need to further investigate the transport of Fe/Ni bimetallic particle.

2 Objective

The overall objective of this study was to determine the bimetallic particle distribution and effluent quality when Fe/Ni colloidal solution is transported through a clayey soil.

3 Materials and methods

In this study, Fe/Ni bimetallic particles produced by the solution method were used (Fig 1). Soil was packed in 5.1 cm diameter column to a height of 6 cm and the breakthrough curve for bimetallic particles was determined from the effluents from the column study. The permeability of the soil was 10^{-4}cm/s. The bimetallic particles were produced by mixing 6.15 g of $FeSO_4.7H_20$ and 1.5 g of $NiCl_2.6H_2O$ in 50 ml water and stirring in 200 ml bottles for 30 minutes and finally adding 1.3g $NaBH_4$ into the solution for preparation of Fe-Ni bimetallic particles. The entire system was kept under nitrogen atmosphere in order to prevent the oxidation of Fe-Ni bimetallic particles.

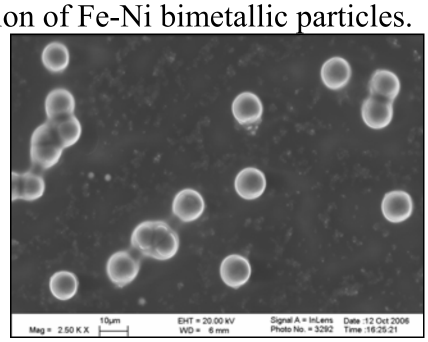

Fig 1: SEM image of Fe/Ni bimetallic particles

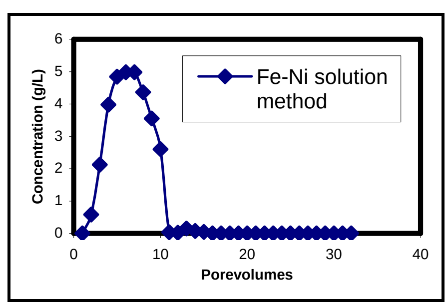

Fig 2: Breakthrough curve of Fe/Ni bimetallic particles

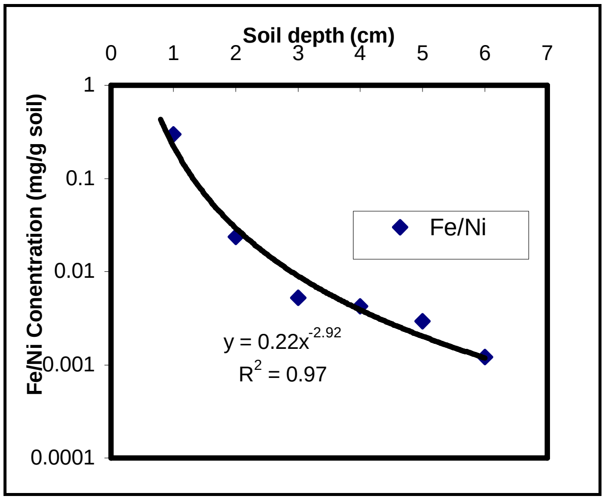

Fig 3: Variation of Fe/Ni concentration along the Soil Column

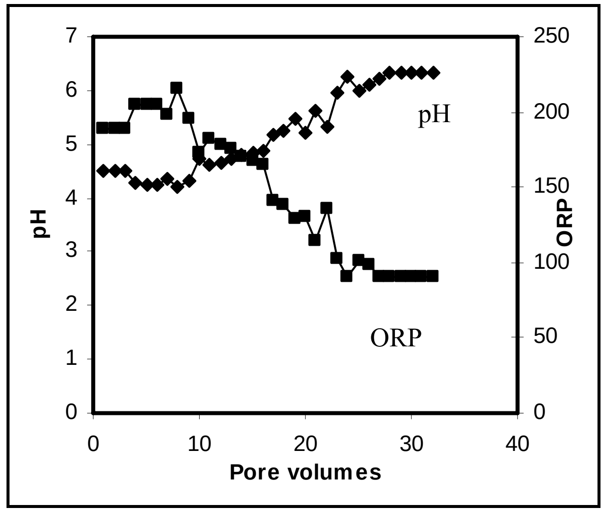

Fig 4: pH, ORP variation in the effluent

4 Discussion

The SEM micrograph of the Fe/Ni particles are shown in Fig (1).Particles were < 10 µm and were spherical in shape (Fig 1) . The breakthrough curve for a pulse input of 100g/L of Fe/Ni is shown in Fig 2. The bell shaped curve is typical response observed for pulse input colloidal solution. The logarithmic concentration varied non linearly with depth (Fig 3). Most of the bimetallic particles were filtered in the top of the column. The effluent pH increased from 4.5 to 6.33 and the ORP decreased from 189 to 90.3 mV (Fig 4) indicating less Fe/Ni particles in the solution.

5. Conclusions

Transport of 100 g/L of Fe/Ni particles in the size range of 10 µm were filtered out of the solution within the top 33% of the soil column. The pH and ORP of the effluent changed from 4.5 and 189 mV to 6.33 and 90.3mVrespectively.

6 Acknowledgement

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7 References

1) Bettina S., Bianca W.H., Jennifer L.B. and Thomas E.M "Delivery vehicles for zerovalent metal nanoparticles in soil and groundwater" *Chem.Mater (2004)*, Vol 16, pp 2187-2193

2) Liuzong Z. and Selim H.M "Solute transport in layered soils: Nonlinear and kinetic reactivity" *Journal of Soil Sci.Soc.Am* (2001)", Vol 65, pp 1056-1064

3) Yao K. et al," Water and waste water filtration: concepts and applications" *Journal of Environ. Sci. and Technol. (1971)*", Vol 5, pp 1105-1112.