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Nano-scale Hydrous Ferric Oxide (HFO) Incorporated Diatomite for Permeable Reactive Barrier (PRB) Application to Remediate Organic- and Inorganic Arsenic Contaminated Groundwater

Min Jang[1*] · Soo Hong Min[1] · Jae Kwang Park[1] · Eric J. Tlachac[2] · Christopher A. Robb[2] · Sang Il Choi[3]

[1]*Department of Civil and Environmental Engineering, University of Wisconsin-Madison*
[2]*Natural Resource Technology, Incorporated, 23713 W. Paul Road, Suite D, Pewaukee, Wisconsin 53072*
[3]*Department of Environmental Engineering, Kwangwoon University*
e-mail: jang@cae.wisc.edu

ABSTRACT

One of the two largest arsenic contaminated sites in the world exists in the Lower Menominee River, Wisconsin. In order to remediate groundwater contaminated with extremely high level of arsenic [0.6~2,038 mg/L] in this area, there is an urgent demand for a highly effective, reliable, and economical technique. Permeable Reactive Barrier (PRB) technology may be a practical and economical alternative to conventional groundwater remediation systems for treating arsenic contaminated groundwater. In this study, hydrous ferric oxide (HFO) incorporated porous natural-occurring aluminum silicates, diatomite, were prepared to compare arsenic removal efficiencies with zero valent iron (ZVI)/sand system that have been successfully applied for PRB application. The synthesis methods of HFO incorporated porous diatomite studied herein are efficient for arsenic removal process, environmentally acceptable, cost-effective, and simple for synthesis process. Through several batch tests, the HFO (40%) impregnated diatomite showed faster initial sorption rates and higher removal capacities than granular activated carbon or ZVI in both groundwater samples that have different arsenic species and concentrations. In addition, large-scale column studies simulated to PRB application showed that HFO (40%) diatomite (200 g) preloaded with GAC (40 g) showed much higher removal performances than ZVI/sand (1,800 g, 50% w/w) (Figure 1). Since less mass is needed and longer treatability time can be obtained, HFO impregnated diatomite

is a promising adsorptive media for PRBs application in high level of inorganic- and organic arsenic contaminted groundwater.

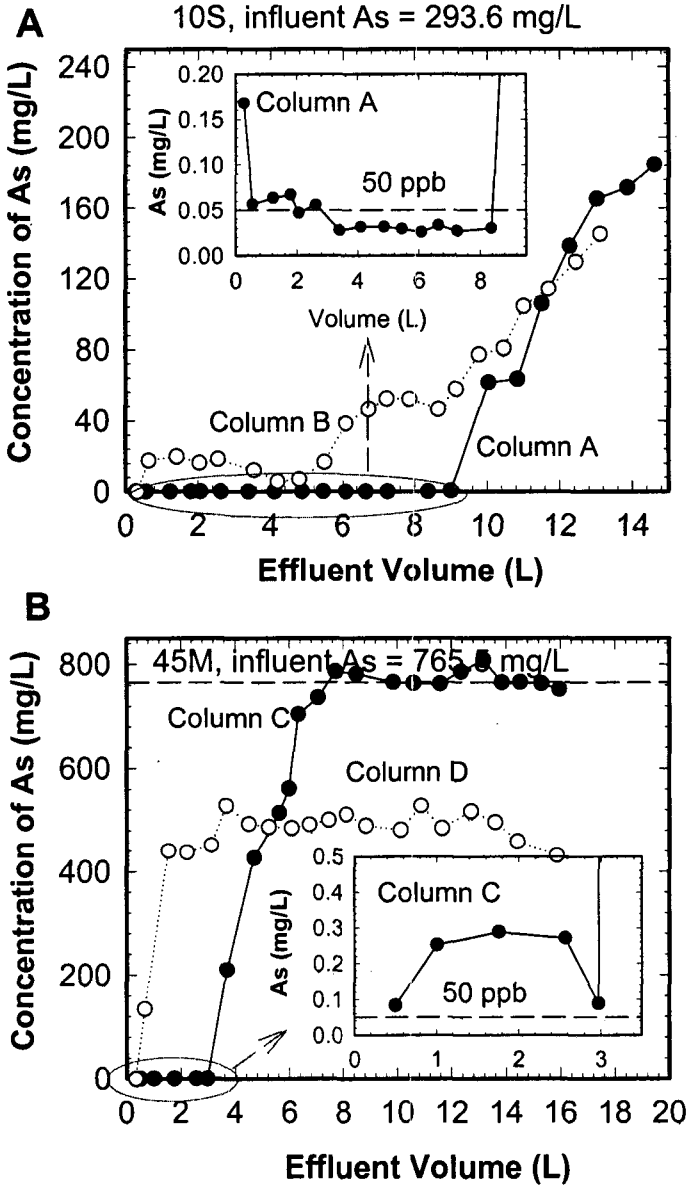

Figure 1. Large-scale column tests for groundwater sample 10S (A) and 45 M (B) [column A and C: 40 g GAC/ 200 g of HFO (40%)-diatomite, column B and D: 1800 g of ZVI/sand (50/50)], flowrate: 0.16~0.19 L/day, empty bed contact time: about 5 days.

Key words: groundwater, arsenic, remediation, hydrous ferric oxide, diatomite, zero valent iron

2. Throughout the experiment, the organic loading rate was fluctuated; high during summer, low duing fall (COD_{Mn}=57-123 mg/L) and high during winter (COD_{Mn}=280-488 mg/L). The organic loading was highest during spring (COD_{Mn}=1120-1360 mg/L). 1500 mg/L of Ecofloc was added for coagulation and the hydraulic retention time was maintained at 15 to 30 min. COD removal rate duing summer and winter(58-92%) was higher than that during fall and spring (42-81%). The removal rate was shown to be similar in the removal of suspended solid, nitrogen, phosphorous, and color.

3. The removal rates of SS and T-P were 87-98.3% and 90.5-99.6%, respectively. It was higher during dry season than during rainy season. The removal rate decreased with a decreasing HRT. However, even though volumetric loading rate increased, the removal rate of SS, color, and T-P were 96.4-99.6%, 76.2-88.3% and 76.5-97.8%.

4. The influent turbidity was varied from 340 to 3152 NTU. The removal rate was 99.3-99.5% by reaction mechanism with atomized slag and contaminant. The removal rate of recalcitrant natural organic matter was from 49.3% to 93.2%.

5. With the PRB made of atomized slag, the removal rate of organic matters was improved by 6-7%. The removal rates of color, SS and T-P were improved by 2-4%. The removal rate of TKN was enhanced by 8-11% and Zn by 40.6%. The removal rate of Cu and ABS were 100% and 97.3%, respectively.

6. The effluent from the PRB process was the following; 7.5mg/L COD, 9 mg/L BOD, 1 mg/L SS, 14 mg/L T-N, 0.05 mg/L T-P, 3 CU color, 1.2 NTU turbidity and no E. coli. This satisfies the groundwater standard for groundwater for living.

CONCLUSION

As a conclusion, the PRB system with atomized slag is ecomic because they are made of slag wasted from steal making industry. The system consisting atomized slag has shown to be effective in removing organics, SS, color, phosphorous, nitrogen. It is also proved that the system can effectively remove E. coli, heavy metal and turbidity. This technology can be suggested for remediation of contaminated ground in contaminated site and waste landfill.