Florida A&M University – Florida State University
College of Engineering
Gang Chen, Ph.D.
Department of Civil & Environmental Engineering
2525 Pottsdamer Street, Tallahassee, FL 32310-6046
Tel (850) 410-6303 Fax (850) 410-6142
E-mail: gchen@eng.fsu.edu

Project Title

Usage of Water-Filled Trench in Improving Groundwater Quality

Tag Members

Lee Martin, Peter Grasel, Casey Taylor, Jim Langenbach, Subramanian Ramakrishnan, Michael Watts, and Clayton Clark

Third Progress Report

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John D. Schert
Executive Director
Hinkley Center for Solid and Hazardous Waste Management
4635 NW 53rd Avenue, Suite 205
Gainesville, FL 32606-4367

by

Gang Chen, Amy Chan Hilton, and Kamal Tawfiq
Department of Civil and Environmental Engineering
FAMU-FSU College of Engineering

1. Introduction

The water-filled trench method is a simple and cost effective in situ groundwater remediation technique. The mechanisms of water-filled trenches in cleaning up contaminated groundwater include biological degradation, volatilization, and chemical or biological oxidation and precipitation (1, 2). Water-filled trenches make use of these mechanisms to clean up contaminated groundwater, thereby reducing levels of risk to human health and the environment. In Florida, groundwater is vulnerable to different kinds of contamination, in part because of the shallow depth to groundwater in most Florida regions. At Patrick Air Force Base, soil and groundwater contamination caused by benzene, toluene, ethylbenzene, and xylene (BTEX) has been known to occur near the BX Service Station (Site ST-29). At other locations in Florida, groundwater is also easily to be contaminated by contaminants associated with petroleum hydrocarbon releases, which include BTEX. At Hurlburt Air Force Base, perchloroethylene (PCE) and trichloroethylene (TCE) were the major contaminants released over a long period of time. On the other hand, groundwater in Northwest Florida is easily to be contaminated by heavy metals such as iron.

2. Objectives

This research will explore the possibility of the usage of water-filled trenches in removing the organic and inorganic contaminants from the groundwater. During water-filled trench processes, the contaminants may be removed by one or more mechanisms, with certain mechanisms dominating over the others. Therefore, knowledge of the physicochemical and biological processes that are responsible for groundwater decontamination in water-filled trenches is required in order to promote field applications. Three major contaminants in the groundwater are the focus of this research, i.e., BTEX, TCE and iron. Our objective for this section of the project is to investigate BTEX, TCE and iron removal using a mulch filter.

3. Project Progress

To investigate BTEX, TCE and iron removal using a mulch filter, simulated groundwater with BTEX, TCE and iron was introduced to a column filled with shredded mulch. The mulch used in this research is pine bark. The shredded mulch has large exposed surface areas that can absorb the contaminants. Column experiments were conducted using an acrylic column (5 inch × 25 inch) to investigate BTEX, TCE and iron removal when passing through the medium of mulch. The column was oriented vertically and sealed at the bottom with a custom frit to permit the flow of water and retain the medium. Prior to starting each experiment, approximately 100 pore volumes of de-ionized water was eluted through the column by a peristaltic pump to stabilize the column. BTEX and TCE reducing bacteria were inoculated into the column by introducing 1 L logarithmic state bacterial suspension in minimal salt media (as described before) by the peristaltic pump from the top. The column was then supplied with minimal salt media alone for 12 hrs to stabilize the microbial community. The simulated groundwater was then introduced to the column at a flow rate of 40 ml/min. The elution was collected and quantified for BTEX, TCE and iron, respectively.

4. Experimental Results

Depending on the input concentration, around 44% to 61% of benzene, 49% to 53% of toluene, 46% of TCE, and 30% of xylene was removed from the simulated groundwater (Figure 1). There was a general trend that input concentration had minimal impact on the removal percentage. Based on previous research as reported in the Second Quarterly Report, around 64% to 68% of BTEX was degraded within 8 days. For this research, the duration of the filtration process was around 2 hours, thus it was suspected that BTEX and TCE removal was resulted from adsorption.

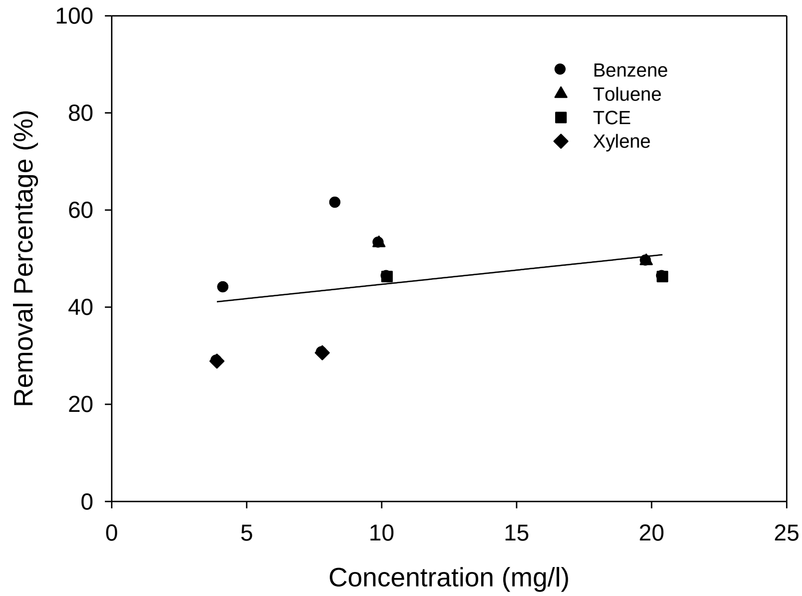

Figure 1. BTEX and TCE Percentage Removal against Input Concentration

Similar observations were made for ferrous iron removal (Figure 2). Around 76% of ferrous iron was removed when the simulated groundwater passed through the mulch filter. Again, the removal seemed not to be a function of input concentration. There was a slight difference between BTEX removal and iron removal, i.e., BTEX removal increased slightly with the increase of input concentration. Since the majority removal of BTEX was through adsorption, only a small portion of BTEX was removed by biodegradation. The slight increase of BTEX removal with the increase of input concentration was believed to be contributed by enhanced biodegradation in response to higher organic concentrations.

The removal of BTEX, TCE and iron can be quantified in terms of removal coefficient, K_c:

$$\frac{K_c L}{v} = -\mathrm{Ln}(1 - \mathrm{fr}) \qquad (1)$$

where K_c is the removal coefficient (min^{-1}); L is the length of the column (cm); v is the velocity (cm/min); and fr is the percentage removal (-).

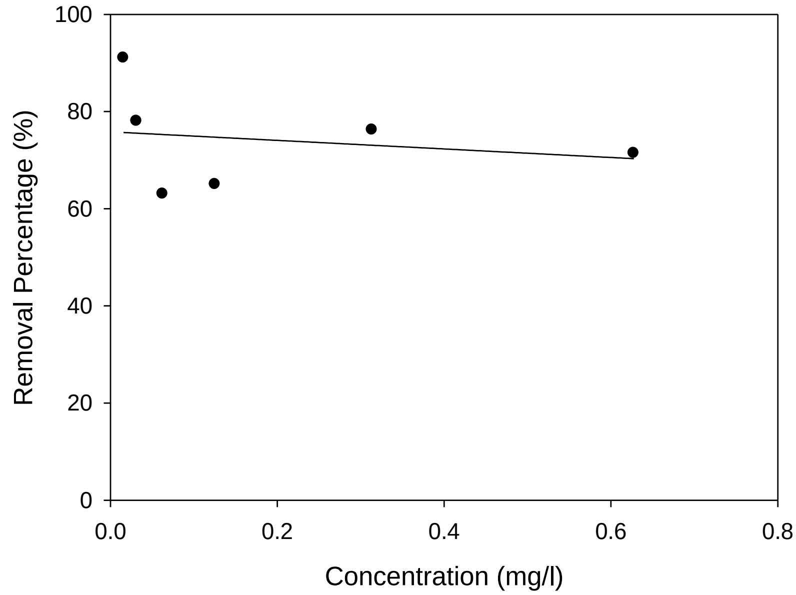

Figure 2. Iron Percentage Removal against Input Concentration

By plotting BTEX, TCE and iron removal coefficient against input concentration, similar trend was observed as reported in terms of percentage removal (Figure 3 and Figure 4). However, the quantification of the removal coefficient can be combined with the biodegradation parameters of these compounds to identify the dominating removal mechanisms. The removal coefficient was in the range of 0.003 min^{-1} to 0.008 min^{-1} for BTEX and 0.01 min^{-1} to 0.02 min^{-1} for iron.

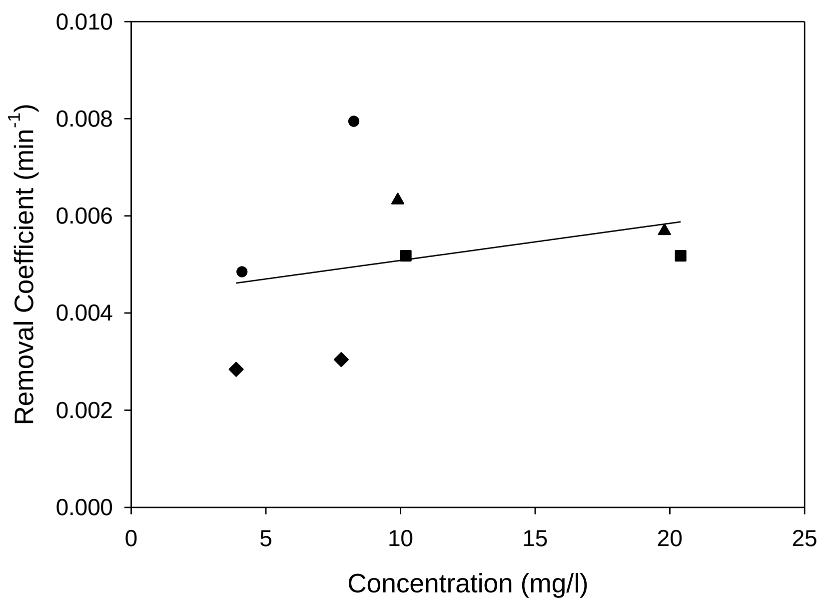

Figure 3. BTEX and TCE Removal Coefficient against Input Concentration

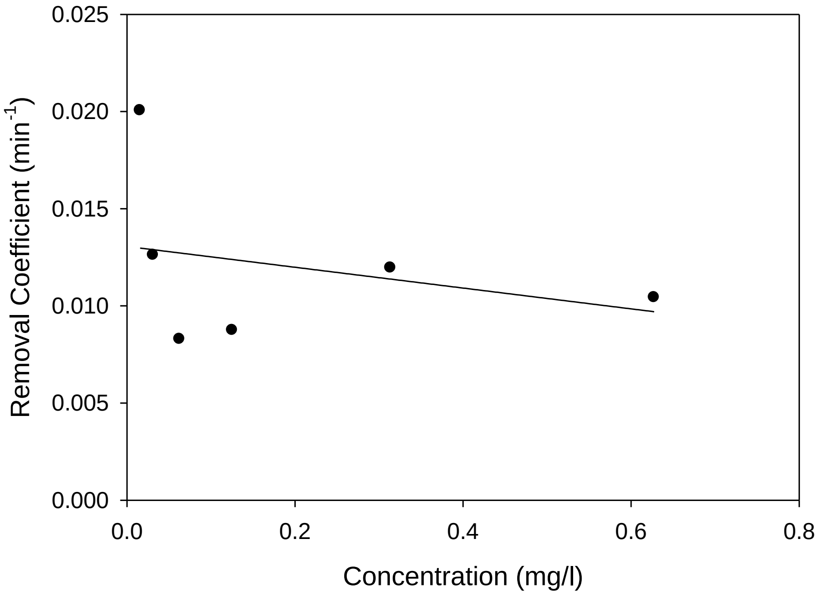

Figure 2. Iron Removal Coefficient against Input Concentration

4. Future work

We will continue to study the anaerobic degradation of TCE. We will also try to quantify the extent of BTEX, TCE and iron removal by means of microbial degradation and adsorption.

5. Miscellaneous

We have updated our website (www.eng.fsu.edu/~gchen) to include this project to facilitate the dissemination of our research discovery. Our prior research regarding iron reduction and release to the groundwater has been accepted and will soon appear in the International Journal of Environment and Waste Management. Our current research on iron sorption on *Shewanella putrefaciens* is almost ready to be submitted to a technical journal. We will have our second TAG meeting at the end of July.

6. References

1. Field JP, Farrell-Poe KL, Walworth JL. 2007. Comparative treatment effectiveness of conventional trench and seepage pit systems. Water Environment Research 79: 310-9.
2. Pankow JF, Johnson RL, Cherry JA. 1993. Air Sparging in Gate Wells in Cutoff Walls and Trenches for Control of Plumes of Volatile Organic-Compounds (Vocs). Ground Water 31: 654-63.

7. Publications

1. Subramaniam, P., Martin, L., Grasel, P. and Chen,G. (2009) Iron Reduction and Sorption on *Shewanella putrefaciens* nearby Landfills in Northwest Florida, to be submitted.
2. Williams, M., Subramaniam, P.K., Tawfiq, K. and Chen, G. (2009) Soil and Microbial Characterization and Microbial Mediated Iron Release nearby Landfills in Northwest Florida, U.S., Int. J. Environment and Waste Management, Vol. X, No. Y., pp.000 000.