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Fifteen-year assessment of a permeable reactive barrier for treatment of chromate and trichloroethylene in groundwater

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HIGHLIGHTS

- We examine the fifteen-year performance record of a permeable reactive barrier.
- The longest available performance record of a PRB for groundwater treatment.
- Chromate concentrations have been reduced to below regulatory thresholds.
- Trichloroethylene treatment has also been effective.
- Groundwater in the PRB remains moderately alkaline and moderately reducing.

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ABSTRACT

The fifteen-year performance of a granular iron, permeable reactive barrier (PRB; Elizabeth City, North Carolina) is reviewed with respect to contaminant treatment (hexavalent chromium and trichloroethylene) and hydraulic performance. Due to in-situ treatment of the chromium source zone, reactive and hydraulic longevity of the PRB has outlived the mobile chromate plume. Chromium concentrations exceeding 3 μg/L have not been detected in regions located hydraulically down-gradient of the PRB. Trichloroethylene treatment has also been effective, although non-constant influent concentrations of trichloroethylene have at times resulted in incomplete dechlorination. Daughter products: *cis*-1,2-dichloroethylene, vinyl chloride, ethene, and ethane have been observed within and down-gradient of the PRB at levels <10% of the influent trichloroethylene. Analysis of potentiometric surfaces up-gradient and across the PRB suggests that the PRB may currently represent a zone of reduced hydraulic conductivity; however, measurements of the in-situ hydraulic conductivity provide values in excess of 200 m/d in some intervals and indicate no discernible loss of bulk hydraulic conductivity within the PRB. The results presented here are particularly significant because they provide the longest available record of performance of a PRB. The longevity of the Elizabeth City PRB is principally the result of favorable groundwater geochemistry and hydrologic properties of the site.

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1. Introduction

Interest in site-specific evaluations of the permeable reactive barrier (PRB) technology continues to be high, particularly assessments relating to media longevity and hydraulic performance. Compared to the large number of full-scale PRB applications around the world constructed to remediate groundwater contamination, few long-term data are available in the literature that provide detail on the reactive and hydraulic performance of PRBs (e.g., Warner et al., 2005; Phillips et al., 2010). Higgins and Olson (2009) conducted life-cycle comparisons of PRBs versus pump-and-treat systems for groundwater remediation. Based on their analysis, environmental impacts from PRBs are driven mainly by material production requirements and by energy usage during construction, while for pump-and-treat systems, environmental impacts are driven by energy demands of operation. Higgins and Olson (2009) conclude that the minimum longevity needed of granular iron PRBs to out-compete pump-and-treat systems is 10 years. Consequently, key input factors for life-cycle analysis and cost/performance assessment are predictive tools that reasonably estimate long-term PRB performance using site-specific parameters such as groundwater chemistry and hydrologic setting. Ideally predictive tools are grounded in field-based observations (Henderson and Demond, 2007) and are able to link model results together

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