Title: Using Waste Foundry Sands as Reactive Media in Permeable Reactive Barriers

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Background/Need: Permeable reactive barriers (PRBs) are a relatively new groundwater treatment technology where contaminants are converted into innocuous by-products in situ. A drawback of PRBs is their high initial capital cost. One method to reduce the total cost of PRBs is to reduce the cost of the reactive medium.

This study was conducted to assess the feasibility of using waste foundry sand as a low-cost reactive medium. Foundry sands are mixture of sand, clay binder, coal dust, and fine residual iron particles. The coal dust provides organic carbon as a sorbent and the iron particles act as a reducing agent.

Objectives: The primary objective of this study was to evaluate the potential use of waste foundry sand as an inexpensive medium for PRBs. A secondary objective was to provide designers with practical information and guidelines for using foundry sands as a reactive medium for PRBs. The third objective was to evaluate leaching of other contaminants from foundry sands that might adversely affect groundwater quality.

Methods: Laboratory experiments and analytical modeling were conducted to meet the objectives of the project. Batch and column tests were conducted to evaluate reactivity, sorptive capacity, and leaching behavior for twelve foundry sands. Four groundwater contaminants were used: trichloroethylene (TCE), the herbicides alachlor and metolachlor, and zinc. Parameters obtained from these tests were then used to size PRBs for typical field conditions.

Results and Discussion: The batch and column tests showed that sorption of TCE, alachlor, and metolachlor on foundry sands is appreciable, and can be described with a partition coefficient from a linear isotherm model. Foundry sands are also a good sorbent for zinc, particularly at higher solution pH. Rate constants for reduction of chlorinated compounds were found to be comparable to those for conventional iron media used for PRBs. The rate constant for zinc was found to vary within a small range (typically 0.05 – 0.20 1/hr).

Partition coefficients and rate constants obtained from the batch and column tests were compared to determine if parameters obtained from batch tests can be used for design. For TCE, partition coefficients and rate constants obtained using both methods are similar. For the herbicides, the partition coefficients and rate constants obtained from the batch tests tended to be higher than those from the column tests. The comparison made for zinc indicated that the batch and column tests yield similar partition coefficients and rate constants provided that the solution

pH is the same. Empirical equations were developed using multivariate regression to predict partition coefficients and rate constants as a function of properties of the foundry sand such as iron content, total organic carbon content, and clay content.

Leaching characteristics of the foundry sands were evaluated using batch water leach tests, column leach tests, and total elemental analyses. The water leach tests and total elemental analyses were conducted to categorize the foundry sands in accordance with Section NR 538 of the Wisconsin Administration Code. All of the foundry sands are Category 2 materials as defined in NR 538. Tests on an iron medium used for PRBs, typical aquifer sand, and a typical fill material also showed that these common construction materials are Category 2 materials. Thus, using foundry sand as a PRB medium should pose no greater risk than that imposed by conventional PRBs.

Effluent from the column tests was analyzed for concentrations of Fe, Cr, and Pb. Cr and Pb in the effluent were always below the maximum contaminant level (MCL). Several pore volumes of flow were often required to meet the MCL for Fe. A method was developed to predict the pore volumes required to meet the MCL for Fe.

Conclusions: For typical conditions, sizing calculations show that foundry-sand PRBs containing at least 1% iron are viable for remediating groundwater contaminated with solvents, herbicides, and metals to concentrations below the MCL. Preliminary design calculations can be made with the empirical equations for the partition coefficient and rate constant using index properties of the foundry sands as input. These calculations can then be confirmed using partition coefficients and rate constants obtained from batch and/or column tests.

Publications: None available at time of report.

Key Words: Trichloroethylene (TCE), alachlor, metolachlor, zinc, permeable reactive barriers, iron metal, organic carbon, sorption, groundwater remediation, reductive dehalogenation, foundry sands, beneficial reuse.

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Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.