WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: A Test of Permeable Zero-Valent Iron Barriers for In-Situ Containment and Remediation of Pesticide Contamination in Unsaturated Soils

Focus Categories: TS, ST, WQL

Keywords: Pesticides, Soil Chemistry, Hazardous Waste, Contaminant Transport

Duration: April 1st, 1999 through March 31st, 2000

Federal funds requested: $12,550

Non-federal funds pledged: $32,778

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Congressional district: North central region

Statement of critical regional of State water problems

A critical need in Nebraska, the Midwest and nationwide is the development of cost-effective and environmentally benign technologies for remediating pesticide-contaminated soils. Each year, leaking tanks, pesticide spills, and inadvertent discharges of agrochemicals lead to a growing number of pesticide-contaminated sites in Nebraska. These point sources of contamination are usually responsible for the highest pesticide concentrations found in ground and surface water throughout the state. It has been estimated that groundwater contamination from 32 different pesticides in 12 different U.S. states can be attributed to point sources (Goodrich et al., 1991). For example, a midwest study in Wisconsin found that in 240 wells monitored for metolachlor, all water samples with a concentration greater than 1 ug L-1 could be related to a known or suspected point source.

Identifying and remediating point-sources of pesticide contamination is a major undertaking. The Nebraska Departments of Agriculture and Environmental Quality continue to identify several pesticide-contaminated sites and are in need of alternative means of remediating pesticide spill sites. Presently in Nebraska, pesticide spills to land are often handled in one of two ways. The contaminated soil is excavated and shipped to a certified landfill or the contaminated soil is diluted with clean soil and reapplied to farmland at labeled rates. Neither approach treats the soil on-site and both are costly and often labor-intensive. This proposal offers the development of an alternative approach employing permeable zero-valent iron (Fe0) barriers to remediate point-sources of pesticide contamination in soil.

Statement of results or benefits:

In recent years, our research group has made great strides in developing alternative technologies for on-site remediation of contaminated soil (Hundal et al., 1997; Li et al., 1997a; 1997b, 1997c, 1998; Singh et al., 1998b; 1998c). Our approach employs environmentally benign catalysts to rapidly transform high concentrations of organic contaminants to less toxic and more biodegradable products, thus enhancing the natural detoxifying processes occurring in soil. Chlorinated and nitrogenated pesticides are particularly resistant to degradation in the soil-water-plant environment. Research conducted in our laboratories indicates the tremendous potential of using zero-valent iron (Fe0) to promote pesticide degradation through reductive dechlorination and nitro group reduction to amino derivatives. We will build upon these results by conducting miscible displacement experiments with our soil column transport (Comfort et al., 1995). The outcome of this work will be to determine if permeable zero-valent iron barriers can be used to contain and remediate point sources of pesticide contamination in unsaturated soils.

The high cost of some soil remedial treatments have kept some fertilizer dealers and end-users from revealing spills that may be point-sources of ground and surface water contamination. Landfill and incineration costs for pesticide contaminated soil can range from $200 to 400 per cubic yard of soil. By developing a straightforward and low-cost approach to handling point-sources of pesticide contamination, considerable cost savings will be achieved. Treatment with zero-valent iron (Fe0) could be as low as $50 per yard. Moreover, we believe the Fe0-barrier approach is low-tech and should be easily adaptable on contaminated sites. These characteristics will make agricultural chemical and fertilizer dealers more inclined to disclose point-sources of contamination and make use of the Fe0-barrier technology.

Nature, scope, and objectives of the research

Nature and Scope

This research will determine the appropriateness of an Fe0-barrier for in situ treatment of pesticide-contaminated soil. Given the success iron walls have had in remediating contaminant plumes in groundwater (Wilson, 1995), this same concept may be applicable to treating contaminant solutes as they move downward in unsaturated soils. In practice, contaminated soils, such as those present at small pesticide-contaminated sites, would be removed and a layer of Fe0 or a sand-Fe0 mixture added to the bottom of the excavation pit. The contaminated soil, or partially treated contaminated soil, would be replaced and natural leaching and attenuation allowed to occur. Theoretically, as the contaminant desorbs from the soil matrix and migrates through the Fe0 layer, it would be transformed and possibly mineralized through subsequent biodegradation. This proposed treatment scheme will be experimentally tested using a soil column transport system (Comfort et al., 1995).

Objectives

1. Determine the destructive capacity of permeable Fe0-barriers to contain and remediate pesticide-containing leachate (atrazine, alachlor and metolachlor) during unsaturated transport.

2. Quantify extent of pesticide degradation in the Fe0-barrier system.

3. Determine if terminal degradates produced via transport through the Fe0-barriers are biodegradable.