Permeable Reactive Barrier (PRB) Options

For Heavy Metals and Organics Remediation

Stabilization of soil and waste by chemical addition is used to reduce the leachability of metals in unsaturated settings and in groundwater. The point of application is usually the source area where spills have occurred or waste has been disposed. In some settings, however reagent application in these areas is not feasible or appropriate. Such settings include:

- Sites where the releases occurred under industrial facilities or where redevelopment activities have placed structures over sources.
- Sites where many years of waste accumulation have resulted in such large volumes of contaminated soil and waste that stabilization costs are prohibitive.

An alternative approach in these settings is to manage the leached constituents in the groundwater leaving the site such that acceptable concentrations are achieved before a point of compliance or point of exposure is reached. Permeable reactive barriers (PRBs) can be installed that allow the metal-bearing groundwater to pass through a saturated zone where emplaced reagents cause the metals to be removed from the groundwater. PRBs can be installed across the entire width of the affected groundwater if the PRBs can be installed as gates in below-ground impermeable barriers that direct the groundwater to the gates. Two examples of such gates are described in this newsletter.

Zinc Stabilization below a Redevelopment

A former industrial site had been redeveloped into an apartment complex. Surficial soil remediation was completed to meet the new land use, but groundwater remediation was deferred until after the site was redeveloped. Zinc concentrations as high as 30 mg/L below the site flowed toward a nearby creek where the discharging groundwater resulted in surface water zinc concentrations in excess of the Surface Water Quality Criteria of 2 mg/L for protection of aquatic life.

The development covered the likely zinc source areas, making source remediation infeasible. The proposed remedy was therefore to install a PRB on the downgradient side of the site to remove the zinc before the groundwater discharges to the creek.

ReSolution Partners completed a treatability study to identify reagents that would remove the zinc from the groundwater as well as be suitable for injection by direct-push technologies in the limited space available in the apartment complex. An injectable slurry was identified that lowered zinc concentrations in bench trials to ≤ 0.010 mg/L. Additional bench trials were completed in response to regulatory agency concerns regarding the longevity of the PRB. Multiple extraction procedures using site groundwater were combined with site hydrogeologic conditions to show that aqueous zinc concentrations were 0.088 mg/L after an equivalent of more than 400 years of groundwater flow through the PRB. This was considered adequate by the State regulatory agency, and ReSolution Partners completed pilot scale trials to evaluate the physical injection (e.g., reagent distribution, radius of influence).

The pilot test confirmed reagent distribution and *in situ* zinc concentration reductions. The full-scale PRB application included a total of 45,000 gallons of slurry injected at 63 locations over 4 weeks. Within two years the zinc concentrations in the creek met the 2 mg/L remediation goal, and the site achieved regulatory closure.

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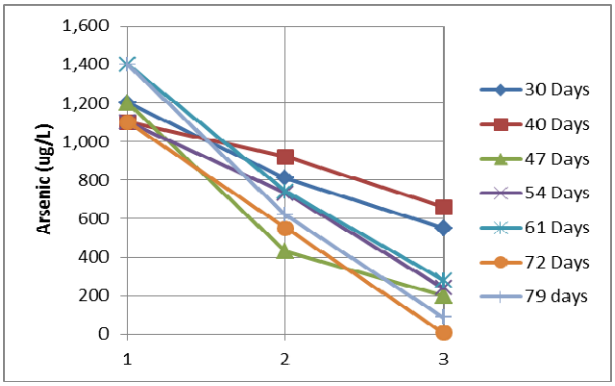
Multiple Metals Stabilization - Former Smelter

Approximately 100,000 cubic yards of slag accumulated over 100 years of operation leaches antimony, arsenic, cadmium, copper, lead, nickel, selenium, and zinc. Groundwater discharging to nearby surface water contained metals concentrations that ranged from 50 to 5,000 µg/L. The site owners planned to redevelop the site. The slag volume was very large and the slag composition was heterogeneous, making direct stabilization of the slag difficult and cost prohibitive.

The site consultant therefore took the approach of placing an impermeable cut-off wall along the sides and the downgradient site boundary. The upgradient side of the slag consisted of low permeability silt and clay, but low flows through the soil and infiltration of precipitation would result in continuing buildup of groundwater behind the wall. A permeable barrier in the wall (i.e., a gate) would allow the groundwater to escape, but the barrier would have to reduce the metals concentrations leaving the site.

ReSolution Partners focused on sulfide mineral precipitation as the best "common denominator" for the mix of metals and metalloids present in the groundwater. There was too little sulfate in the groundwater to support the approach, therefore the treatability study trials used a combination of reducing agents and sulfate (as gypsum) to achieve the needed concentration reductions. Batch testing found that concentration reductions of 84 percent (nickel) to >99 percent (cadmium) could be achieved. Batch testing, however does not address the dynamic processes that would occur within a PRB. Working with the site consultant and owner, it was decided to construct large columns in the field. Several 8-foot long, 8-inch diameter columns were constructed in the field and packed with several reactive media for the gate.

The columns were connected to a site monitoring well equipped with a pump. Flow rates were controlled to approximate the rates estimated for potential full-scale gate applications. Each column was equipped with sampling ports at influent, mid-, and effluent points in the column. The results are illustrated for arsenic in one of the columns.



Influent arsenic concentrations over the 79-day trial ranged from 1,100 to 1,400 µg/L. As the column became anaerobic, the sulfate released from the gypsum that was part of the reactive media, was converted to sulfide, and an iron-arsenic-sulfide mineral was formed removing the arsenic from solution. By the end of the trial the arsenic concentration leaving the column was reduced by approximately 93 percent, to 89 µg/L. Concentrations for the remaining constituents at the end of the trial were less than to approximately equal to the constituent analytical reporting limits. Planning for the full-scale remediation of the site by the site consultant and owner are on-going.

About ReSolution Partners

ReSolution Partners provides technology applications for the stabilization of metals and the destruction of organic compounds. Services include treatability studies, remedial design, and full-scale implementation. Contact us about the potential application of a PRB for your site.

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