Performance Monitoring of a Permeable Reactive Barrier at the Somersworth, NH Landfill Superfund Site

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Abstract: Over a six-month period, the performance of a pilot-scale PRB at the Somersworth, NH Landfill Superfund Site was evaluated. The 21-ft long PRB was installed in November 1999 to test a construction technique that uses a biodegradable polymer slurry to support an open excavation while a granular iron/sand mixture was placed into the subsurface. Criteria used to assess the PRB's performance included (1) hydraulic testing to evaluate potential fluid viscosity effects related to the use of the biopolymer, (2) monitoring of VOCs, groundwater parameters (pH, DO, ORP, specific conductance) and inorganic parameters (including metals, major ions and nutrients), (3) microbial characterization of groundwater, (4) reactivity testing of cored iron material, and (5) advanced surface analysis of cored iron material.

As permeable reactive barriers (PRBs) containing zero-valent iron become more widely used to remediate contaminated groundwaters, there remains uncertainty in the prediction of their long-term performance. While a number of accelerated aging laboratory and pilot-scale tests have not indicated any significant performance issues caused by the build-up of surface precipitates or bio-fouling, there has been relatively little performance data collected in the field at pilot- or full-scale installations (Vogan *et al.* 1998, O'Hannesin and Gillham 1998, Mackenzie *et al.* 1999).

An increasingly popular and potentially cost-effective construction method for PRBs is the biopolymer (BP) slurry technique (Day *et al.* 1999, Focht and Vogan 2001). Installation of an iron-based PRB using BP slurry trenching is similar to constructing a conventional impermeable bentonite slurry wall. As a trench is excavated, BP (*e.g.,* guar gum) is added as liquid shoring to provide stability to the trench walls. Excavation can continue through the BP without the need for dewatering. Granular iron is then placed into the trench through the slurry using a tremie tube.

While the biopolymer trench construction method had been employed at a limited number of sites prior to the start of the constructability test performed at the Somersworth Landfill Site, some uncertainties existed regarding the use of this construction method. Specific objectives of the constructability test at the site, therefore, were to evaluate whether:

1. the iron/sand mixture could be placed as specified without separation of the iron and sand;
2. the guar gum could be broken down and/or flushed from the PRB within a reasonable timeframe;
3. the use and removal of the guar gum would have an adverse effect on the permeability of the sand/iron mixture or aquifer in the vicinity of the PRB;

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4. the use and removal of the guar gum will have an adverse effect on the reactivity of the granular iron; and
5. the use and removal of the guar gum and associated materials will have an adverse effect on the geochemical or microbial conditions in the vicinity of the PRB.

In late autumn of 1999, a 25-ft long trench was excavated using a CAT 330 backhoe with an extended boom and a 24-inch wide bucket. The depth to bedrock was approximately 34 ft. Iron beams (30-inch wide) were placed 21 feet apart at either end of the trench to control the placement of the sand-iron mixture and to demarcate the ends of the test section. Two temporary development wells were placed in the trench to allow for later removal of BP/groundwater from the trench. The trench was then backfilled with a wetted 90/10 iron-sand mixture using a tremie pipe.

Six monitoring wells were installed in and around the test section as shown in Figure 1. In addition to low-flow purge sampling of groundwater within the PRB and up- and downgradient of the PRB, dedicated groundwater quality data-logging probes (YSI-600 XLM) were also deployed. In four 2-inch wells set along a transect through the PRB, in-well probes were used to collect field parameter data of higher density than could be provided by low-flow purge methods. This data would allow for correlation of groundwater field parameters with changes in barrier performance (*e.g.*, biopolymer breakdown and inorganic precipitation).

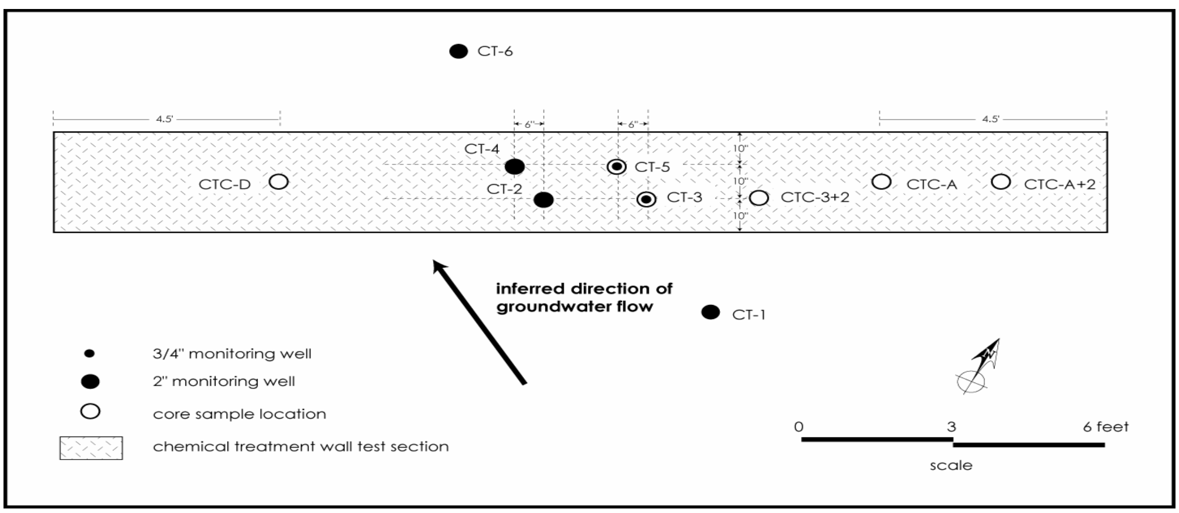

Figure 1. Locations of core samples and monitoring wells in a 25-ft. long pilot PRB at the Somersworth, NH Landfill Superfund Site

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Field measurements of groundwater temperature, pH, specific conductance, dissolved oxygen, oxidation-reduction potential, and relative viscosity were made over three sampling events using conventional low-flow purge methods and were compared with the near real-time data collected by the YSI in-well groundwater probes. Representative pH and ORP profiles are displayed in Figure 2, indicating the high pH and low ORP values commonly measured in zero-valent iron/water environments (wells CT-2 and CT-4).

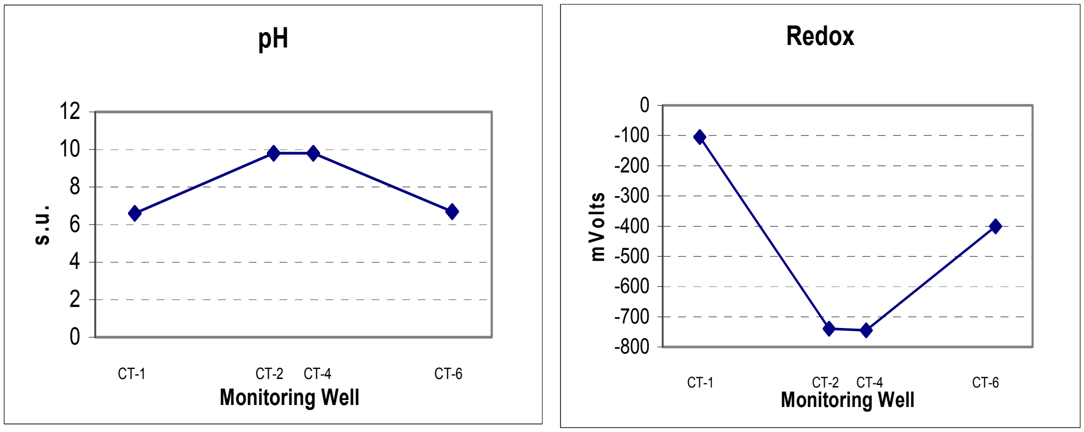

Figure 2. Representative pH and oxidation-reduction potential measurements obtained using devoted, in-well groundwater parameter probes (YSI) in wells along a transect through the pilot PRB.

Six weeks after the PRB installation, core samples of the iron-sand mixture in the test section were collected at seven locations using either a split-spoon or direct-push (Geoprobe) sampling technique. Nine samples were analyzed using magnetic separation and indicated a relatively homogeneous composition (72-85%). Bench-scale reactivity testing of cored iron-sand media indicated degradation rates for chlorinated ethenes consistent with those determined in earlier studies.

A number of samples were also subjected to x-ray photoelectron spectroscopy (XPS) with depth profiling and scanning electron microscopy (SEM). While traces of guar gum residue on the iron surfaces could be detected by XPS, the grain boundaries measured for cored iron were virtually identical to those of virgin iron as seen by SEM.

In addition, estimated hydraulic conductivity values calculated from slug tests, along with measurements of the viscosity of the fluid from the wells in the test section, demonstrated that the amount of residual guar gum in the test section was not significant to have any measurable effect on the hydraulics of the test section.

References

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