



Rationale for the Use of Iron/Sand Mixtures in PRB Installations

Under highly reducing conditions and in the presence of metallic iron surfaces, certain dissolved chlorinated organic compounds in groundwater will degrade to non-toxic compounds such as ethene, ethane and chloride (Gillham and O'Hannesin, 1994; Gillham, 1996). Degradation occurs via abiotic reductive dehalogenation, with the metal serving to lower the solution redox potential (Eh) and as the electron source in the reaction. Using granular iron as the reactive metal, degradation rates are commonly several orders of magnitude higher than those measured under natural conditions. This means that iron zones, only inches in thickness, can be placed below ground to treat chlorinated solvent plumes.

As the process is surface area dependent (Johnson et al., 1996), a given mass of granular iron will treat the same mass flux of contaminants regardless of whether or not the iron is mixed with sand. Unpublished work completed by the University of Waterloo with iron-sand mixtures ranging from 5% to 100% iron by weight confirms this. As an example Focht (1994), evaluated the applicability of metallic iron for above-ground remediation of 1,2,3-trichloropropane (123TCP). The study involved comparison of 123TCP degradation in columns containing iron-sand mixtures with 20%, 50% and 100% iron by weight. The apparent half lives determined for the 20%, 50% and 100% iron columns were 17.6, 6.6 and 3.0 hr, respectively, and the iron surface area to solution volume ratio was calculated to be 1.16, 3.70 and 8.00 m²/mL, respectively. In other words, the half-lives decreased with increasing iron percentage, as expected. However, when the half-lives are normalized to 1.0 m²/mL, the normalized half-lives become 20.4, 24.4 and 24.0 hours for the 20%, 50% and 100% iron columns, respectively (i.e. very close to one another). Similar results were obtained for degradation of TCE in recent multiple iron-sand column study conducted by ETI (O'Hannesin et al., 2004). The TCE half lives normalized to 1.0 m²/mL in 25%, 50%, 75% and 100% iron-sand columns by weight were 3.2, 3.0, 2.8 and 3.2 hrs, respectively. Therefore, regardless of the ratio of iron to sand, the same surface area of iron produced the same degradation rates.

There have been numerous permeable reactive barriers (PRBs) containing iron-sand mixtures installed. Most of these PRBs were designed based on 100% iron treatability testing data. The thickness (and volume) of iron needed was based on the data obtained from 100% iron column data. The PRBs were constructed using native sand that was mixed with the required amount of granular iron to increase the volume of backfill material to fill the minimum excavation achievable by the construction width. To date, all of these sites exhibit the reactivity predicted by the design. Samples retrieved from backfilled material showed no

evidence of segregation of the granular iron and sand into distinct layers. However, designs involving the placement of iron-sand mixtures at greater depths, especially involving biopolymer slurry techniques, may want to consider means of minimizing potential segregation of the two materials.

Maintaining the hydraulic characteristics of these iron-sand mixtures is also important. In the field, ETI recommends using a local native sand of similar grain size as the iron, which when mixed with the iron should give similar porosity and hydraulic conductivity as the 100% iron material. ETI's Technical Note 3.08 describes magnetic separation tests which can be used as a QA/QC procedure on emplaced materials.

References

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