EnviroMetal Technologies Inc.

Permeable Reactive Barrier Update

solutions for groundwater remediation

May 2005

Effect of Worldwide Iron Markets on PRB Application Costs

The price of granular iron for use in ETI's PRB applications was maintained at a level of about US$350 to $375/ton for several years. However, worldwide demand for all types of iron and steel products, driven in large part by the Chinese economy, has led to significant price fluctuations in the last 2 years. Prices for the feedstock used by our main suppliers increased by over 200%, leading to quotations for iron costs in the neighborhood of US$1000/ton by the fall of 2004. Fortunately, these prices have decreased, to around US$700-$750/ton at this time. While this iron cost has a direct impact on the cost of application, PRB technology still maintains its cost competitiveness relative to other alternatives due to its no operating and low maintenance costs. Indeed, the first commercial application in 1994 used an iron source which cost about US$700/ton at the time, and payback on this project relative to a pump and treat option was achieved in about three years.

Inside This Issue:

ETI is hopeful that iron prices will continue to fall, but we are also enthusiastic about a newly identified third iron source material, developed from primary ore processing, which costs about US$550/ton. This material has been used in two small field applications and is undergoing extensive testing at the University of Waterloo. We are also involved in testing programs to examine the feasibility of using processed foundry sand and other reclaimed iron materials, which may be useful in certain applications.

Advances in Organic Compounds Treated by Granular Iron

Recent laboratory studies conducted by DuPont have shown that chlorinated fluorocarbons (CFCs) are readily degraded in the presence of granular iron, in particular trichlororfluoromethane (CFC 11) and 1,1,2-trichloro-1,2,2-trifluoroethane (CFC 113). These studies indicate that 30% molar of CFC 11 degraded rapidly to acetate and formate, 65% converted to dichlorofluoromethane (HCFC 21) and less than 10% of HCFC 21 was converted to chlorofluoromethane (HCFC 31). A room temperature half-life of CFC 11 was about 0.9 hrs in contact with a commercial granular iron source (Vidumsky et al., 2004). CFC 113 had a room temperature half-life of about 3.6 hrs in contact with a commercial granular iron source. About 70 to 90% of CFC 113 was converted to 1-chloro-1,2,2-trifluoroethene (CFC 1113) and then completely degraded to non-chlorinated end products. The remaining 10 to 30% was converted to 1,2-dichloro-1,1,2-trifluoroethane (HCFC 123a) (Vidumsky et al., 2004).

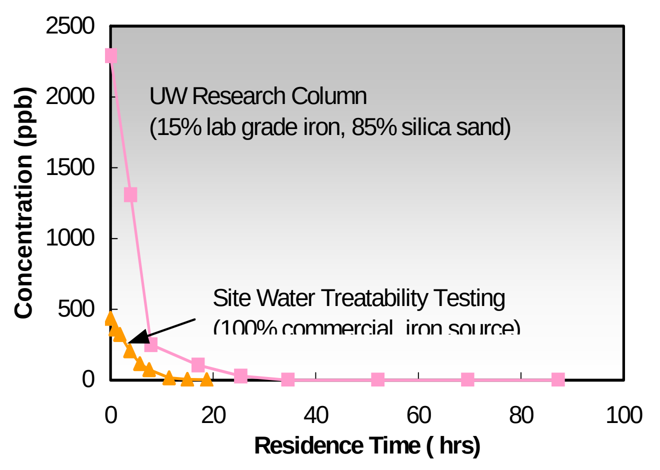
First PRB in Italy (details on page 3)

The compound 1,2,3-trichloropropane (123TCP) has not been exhaustively tested, however research column tests undertaken by the University of

(Continued on page 2)

(Continued from page 1)

Waterloo show a 123TCP room temperature half-life of 3.5 hrs in a mixture of 15% by weight laboratory grade iron and 85% by weight silica sand (see Figure below). A site water from California exhibited a room temperature half-life of 2.4 hrs in a 100% commercial iron (see Figure below).



123TCP Degradation in Iron Column Tests

Brominated compounds such as polybrominated biphenyl ethers (PBDEs) are used widely in flame retardants in various industrial products. PBDEs have been found in various species of wildlife along with soils and are becoming more increasingly recognized for their persistence in the environment. The recent study completed by Keum and Li (2005) show rapid debromination of highly brominated congeners suggesting that granular iron can be used for remediation of various PBDEs.

References:

Keum, Y-S. and Li, Q.X, 2005. Reductive Debromination of Polybrominated Diphenyl Ethers by Zerovalent Iron. Environ. Sci. Technol., Vol 39, No. 7, pp. 2280-2286.

Vidumsky, J.E., Thomson, M.M., Mack, E.E. and Payne, J.A., 2004. Treatability of CFC 11 and CFC 113 with Zerovalent Iron. Proceedings of the Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 24-27.

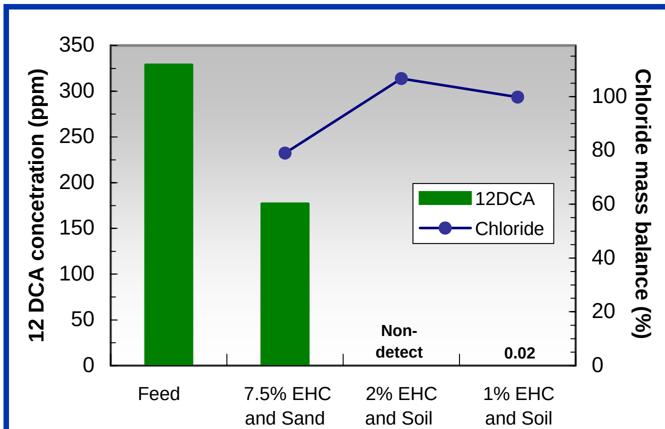
Treatment of 12DCA /EDC in Groundwater and Soil Using EHC™

One of a few chlorinated aliphatic hydrocarbons not degraded by granular iron is 12DCA or EDC (1,2-dichloroethane). However, recent treatability testing has shown that this compound can be effectively treated *in-situ* using EHC™ material, marketed by ETI's parent company Adventus Remediation Technologies [www.adventusremediation.com].

EHC™ is a patented combination of controlled-release solid carbon and zero-valent iron for stimulating reductive dechlorination of persistent organic solvents in groundwater and source zones. The EHC material has been tested recently for a site groundwater contaminated with 12DCA concentrations of more than 300 mg/L. Two types of EHC™ application were tested using flow-through columns, followed by site soil microcosms:

- EHC mixed with sand at a ratio of 7.5 to 30% (simulating an application as a permeable reactive barrier); and
- EHC dispersed in native soil at a ratio of 1 to 2% (simulating direct EHC addition into the aquifer material).

Removal rates of 12DCA of 50% in the EHC PRB column and >99% in EHC soil dispersion columns were observed after 98 days of operation, without generation of chloroethane. Chloride mass balance of 80% and 100% was obtained in the PRB and soil dispersion columns, respectively, confirming compete degradation with no formation of chlorinated breakdown products.



12DCA Degradation in EHC™ columns

First PRB in Italy

Construction of the first granular iron PRB was completed at a site near Turin, Italy in November 2004. Biopolymer slurry was used as trench support for the 120 m (395 ft) long, 13 m deep (43 ft) and 0.6 m (2 ft) trench width. Prior to trench excavation, a 1 m (3 ft) concrete guide wall was installed to guide the clam bucket excavator (see Photo on page 1). The PRB was installed in 7 m (23 ft) sections separated by a 0.6 m (2 ft) diameter metal end stop. The PRB consisted of a granular iron and sand mix containing 83% (by volume) granular iron. The installation of the PRB was completed in less than eight days. A total of about 1,700 metric tons (about 1,870 US tons) were used for the installation of the PRB.

Iron Placement through a Tremie Pipe

Congratulations to the following Project Participants:

I.M.E.S. (ETI's Licensee in Italy)
Studio Tecnico Associato Bortolami e Di Molfetta (Managing Consultant)
Trevi S. p. A. and Rodio S. p. A. (Installation Contractors)
Geo-Solutions, Inc. (Contractor Support)
Gotthart Maier Metallpulver GmbH (Iron Supplier)

I.M.E.S.
www.imes-gmbh.net

Industrial Research Chair in Groundwater Remediation

Dr. R. W. Gillham's NSERC/DuPont/EnviroMetal Industrial Research Chair is entering the fourth year of a five year agreement. In addition to the Chairholder, the staff currently includes two Research Professors, two technicians and ten graduate students. As in the past three years, the research program is focused in two areas; long-term performance of PRBs, and means to broaden the scope of application, particularly with respect to treatable contaminants. Examples of current projects include degradation (kinetics and products) of CFCs and PETN, sequential treatment of DNT, effect of competing oxidants on performance, and the passivation and reactivation of bimetallic catalysts.

A particularly important project concerns the long-term prediction of performance. While confidence in performance over long periods of time has increased with the period of record for commercial installations, it continues to be the case that there are limited quantitative means for predicting how long a PRB is likely to perform satisfactorily under a particular set of hydrogeochemical conditions, or for adjusting the design to meet a particular performance expectation. Quantitative predictions based on fundamental principles could increase the level of confidence in the technology and could also provide for more efficient designs. A current Ph.D. student, Sung-Wook Jeen, has conducted long-term column tests that demonstrated a gradual decline in reactivity of the iron material, and developed a reactive transport model that was remarkably successful in simulating the concentration trends observed in the columns. These experiments simulated several years of flow through a typical PRB. The key element in the model, not present in other models, was a means to decrease the reactivity of the iron over time according to the amount of inorganic precipitates that had accumulated. Though further testing is required, we are optimistic that the model will be highly effective for predicting performance and for the design of more cost-effective PRBs.

EnviroMetal Technologies Inc.'s Open Letter to the Remediation Industry

WATERLOO, Ontario (March 31, 2005) Lately, there has been considerable confusion and speculation in the industry concerning EnviroMetal Technologies Inc.'s (ETI's) intellectual property rights as they relate to iron-based technologies for treatment of halogenated organic compounds in groundwater. We wrote this letter to make our position as clear and open as possible.

ETI is now a member of the Adventus Group of Companies. ETI's core technology is that embodied in U.S. Patent No. 5,266,213 (issued 30 November 1993), owned by the University of Waterloo, and licensed exclusively to ETI. To facilitate access to this valuable technology, ETI has made this patent available to the industry through a licensing program. Simply put, ETI's technology consists of providing a permeable body of metal that is absent of substantially all traces of atmospheric oxygen in the path of groundwater containing halogenated contaminants (Claim 1 of the patent). This body of metal can comprise, among other configurations, a trench (Claim 3), a trench in conjunction with pumping well (Claim 4), a tank unit (Claim 5), or metal placed by in the ground by injection methods (Claim 6). These "bodies of metal" have been described as iron permeable reactive barriers (PRBs), iron reactive walls, iron treatment zones, or permeable reactive zones among other terminologies. Therefore, any process that cleans halogenated organic contaminants from groundwater in an aquifer that employs a "body of metal" (any metal, shape and size) through which the aquifer's water passes, may well infringe U.S. Patent No. 5,266,213.

ETI's patent rights are not tied into a specific configuration of the "body of metal" or the method used to emplace the body of metal. Indeed, we work with many installation firms and their own proprietary or patented emplacement/injection methods to install our technology, and these firms understand and respect our patent rights. There are, however, other contractors who do not respect ETI's patent rights, and are therefore subject to legal action for patent infringement. End users and their consultants who employ these contractors should be aware of their exposure to potential litigation through the use of these contractors.

A second area of confusion involves the use of iron in combination with other materials (liquid, solid, or gaseous) as a remedial technology. Some of these combinations have been patented themselves. A major source of this confusion appears to be the incorrect assumption that if the U.S. Patent Office issues a patent on an integrated process, the Patent Office has approved the integrated process as not infringing the original patent. In fact, most patents issued are improvement patents pursuant to which the commercial exploitation infringes a pre-existing patent. When the two patents are not co-owned, royalties must be paid to the original patent holder when someone operates under an independent improvement patent (assuming as in this case the patent owner is willing to grant such licenses). In other words, schemes involving, for example, iron plus liquid organic carbon sources (e.g., lactate or molasses), iron plus bacterial inocula, iron plus solid carbon, or iron plus other amendments, still must obtain a license from ETI for the use of ETI's base technology. We note that several combinations of iron and carbon sources are the subject of patents owned by ETI's affiliate, Adventus Remediation Technologies Inc. (ART).

Lastly, ETI is often asked its opinion on nano-scale iron-based materials. Much of the confusion here stems from what is suggested in the U.S. patent literature (e.g., nanometer-sized, often bimetallic particles that continue to move advectively with groundwater after injection) versus what may actually be occurring in the field (i.e., the injection of fine-grained metallic iron forming an immobile body of metal around the injection point). While ETI's patent rights may not apply to the former concept, we believe ETI's rights certainly apply to the latter applications.

ETI and ART are committed to enforcing their patent rights. It is unfair to the licensees who respect patent law, and thus obtain a license, to be at a cost disadvantage to those who misappropriate our patented technology. Our business model is not dissimilar from others in our industry where by ART and ETI support a design team and subsequently provide patented technologies.

ART and ETI remain willing to grant reasonable licenses under our U.S. patents to both end users and installation contractors.