THE ORACLE

News and Recent Developments from Regenesis - Leaders in Accelerated Natural Attenuation

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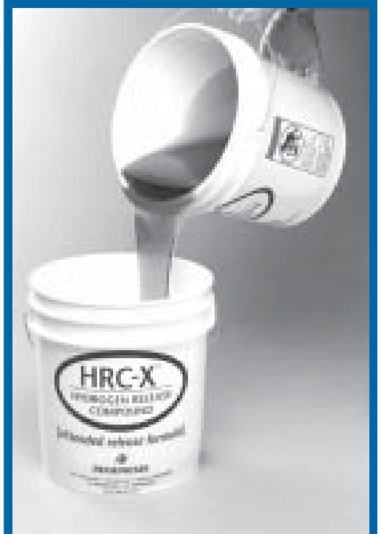

New HRC-X™: Cost-Effective Residual Source Area and DNAPL Treatment

by Scott Wilson, President,
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After several years of development, in both laboratory and field applications, Regenesis has released a unique new product: HRC-X™. The name HRC-X alludes to the product's extended release feature. This allows for in situ treatment over a three-year period of time with only a single application. Field test and actual site cleanup projects have shown the unique features of HRC-X to allow for rapid and cost effective degradation of chlorinated ethene contamination (PCE, TCE, etc), even when these common groundwater contaminants are in extremely high concentrations. In fact, residual Dense Non-Aqueous Phases Liquid can be rapidly degraded when treated with HRC-X. This data has been well documented.

Often when attempting a groundwater cleanup involving chlorinated solvents, high concentrations of the contaminant linger in areas near the source zone. This persistent high-level contamination is generally associated with residual DNAPL, a separate phase contaminant that remains held within the interstices of the soil below the water table. This material is not recoverable as a separate phase contaminant because, instead of being one continuous layer, it leaves blobs or drops behind when a larger contaminant mass moves through the area. Locating residual DNAPL is very difficult because it often remains in the subsurface as "ganglia" or fingers of intermittent contamination. Most groundwater treatment strategies employed to deal with this contamination are very costly to implement for this reason and because the DNAPL itself acts as an ongoing source of dissolved contamination requiring most treatment systems to operate for decades.

HRC-X has been shown to solve these issues. HRC-X is a viscous fluid that is injected directly into the contaminated aquifer and subsequently into the general area of the suspected residual DNAPL. HRC-X can be injected using a low cost push point apparatus or, when required, through borings or wells (such as into bedrock). Once in place it slowly and continuously releases lactic acid, which in turn, biologically degrades to release low concentrations of hydrogen. Indigenous microbes (dehalogenators) then use this hydrogen to stimulate the rapid dechlorination of dissolved contaminants. As a result, a very steep concentration gradient is established, rapidly pulling more and more contaminant from the residual DNAPL phase into the aqueous phase, and finally through the degradation process. HRC-X stimulates and optimizes this process because it slowly and continuously releases a water-soluble hydrogen source (not an insoluble oil) over a long period of time. This continuous release has been shown to be key. Other proucts require multiple injections using rapidly degrading carbon sources. This process cannot cost effectively maintain the steep concentrated gradient required to treat the DNAPL as HRC-X does. Because HRC-X slowly releases water-soluble lactic acid and hydrogen, these components move into the groundwater penetrating and treating the DNAPL without requiring knowledge of its exact location.

When we first began experimenting with DNAPL treatment, we found that a sessile drop of TCE in a flask could be degraded by the continuous hydrogen release of HRC®, our standard release material, within a few days' time. Then Dr. Joe Hughes at the Rice University Center took the concept a step further. He used the Experimental Control Release System, a large aquifer simulation vessel to show unequivocally that the HRC product rapidly degraded DNAPL from within a saturated soil. In fact, 90% of the DNAPL mass was degraded within 6 months time. Although standard HRC showed affectiveness in these experiments for the treatment of DNAPL, we realized that most DNAPL sites would require treatment in excess of 12 to 18 months (standard HRC's release period). In response to that, our research team focused on extending the release period of HRC. The goal was to allow for a single injection of product to continuously treat the residual DNAPL for a period of three years. The product resulted into what is now HRC-X, and was tested on a project site managed by the Oregon Dept of Environmental Quality. The HRC-X was injected into an area of suspected DNAPL with dissolved TCE concentrations in excess of 100,000 ppb. Site data collected by the ODEQ indicate clearly that 26 months after the injection, the mass of groundwater contaminants had been reduced by 40% and the single injection of HRC-X is still working today, continuing to actively restore groundwater.

If you would like additional information on DNAPL treatment with HRC-X, or would like our technical services group to perform an application design for a project site at no charge, please give us a call at (949) 366-8000. We would like to hear from you.

What's Inside...

HRC® Treatment of a PCE Impacted Unconsolidated Aquifer

by Johnathan K. Child, Timothy J. St. Germain and John B. Hankins, Fuss & O'Neill, Inc.

In one of the first projects of its kind in the State of Connecticut, Hydrogen Release Compound (HRC) was used to enhance the natural biodegradation of a plume of groundwater contaminated with tetrachloroethene (PCE). The technique was particularly beneficial due to tight soil conditions and the setting of the site inside the security fence of a State correctional facility. Chlorinated volatile organic compound (VOC) contamination at the study area was identified within an approximate 8,000 square foot area.

The potential effectiveness of HRC was evaluated through a pilot test undertaken at the release area in the summer of 2001. The pilot test included the injection of 420 pounds of HRC by Geoprobe® within an approximate 1,200 square foot area centered on the region of maximum PCE groundwater impacts (approximately 3,000 to 4,000 micrograms per liter). HRC was injected over an approximate 10-foot vertical interval between a depth of 4 and 14 feet. Groundwater monitoring results, obtained during four post-injection quarterly groundwater monitoring events, documented HRC related geochemical effects within the aquifer and a significant decline in PCE groundwater concentrations in the pilot test area. Geochemical effects within the aquifer were monitored through field parameters and a comprehensive suite of laboratory analyses including dissolved gases, metabolic acids, and a variety of inorganic parameters.

Based on results of the successful pilot test demonstration, full-scale HRC treatment was undertaken in the summer of 2002. Full-scale treatment included the injection of 1,200 pounds of HRC by Geoprobe over an approximate 8,000 square foot area. Effects of full-scale treatment are being evaluated through a quarterly groundwater monitoring program to be completed in the summer of 2003. It is anticipated that a program of monitored natural attenuation and/or groundwater compliance monitoring will be implemented in the fall of 2003 to document post-remediation conditions within the aquifer.

Frequently Asked Questions (FAQ's)

Can ORC® & HRC® be Used in the Vadose Zone?

by Anna Willett, Research and Development Manager
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Regenesis recently updated our website's list of Frequently Asked Quesetions (FAQ's). Two FAQ's generated significant discussion among our engineering and R&D staff. These FAQ's addressed the use of ORC and HRC in the vadose or unsaturated zone, a topic relevant to many of our current and potential customers. The FAQ's and answers are listed below. Please keep in mind that ORC and HRC applications in the vadose zone are very site specific and evaluation by our technical staff is recommended before projects are commenced.

Can ORC be used to treat the vadose zone?

Yes, provided that the majority of the contaminant mass is present in a compact and well-defined area that can be flooded with a dilute ORC slurry. The contaminant must not be pooled as a separate phase. ORC application in the vadose zone consists of a series of closely spaced injection points to which a dilute slurry of ORC and water is delivered by traditional direct-push methods or via a modified injection using a pressure sprayer. A dilute ORC and water mixture is used to provide good coverage of the contaminated volume and to provide moisture for oxygen release in the unsaturated vadose zone.

Calculations on the amount of oxygen naturally present in the vadose zone soil void space and the amount of oxygen provided by ORC show that ORC has the potential to increase oxygen amounts to as much as 3 times the amount already present in a semi-aerobic vadose zone. This added oxygen can increase the rate at which indigenous bacteria degrade contaminants, especially if the presence of contaminants and biological activity has created low oxygen conditions.

In the area of the injection, the ORC slurry contacts the soil and delivers tiny ORC particles to the thin films of moisture that coat soil particles. Release of oxygen from the ORC particles supersaturates the moisture in the soil and provides bacteria that reside in the soil moisture with a substrate for biodegradation. Although there is no groundwater flow in the vadose zone to facilitate the distribution of oxygen from ORC throughout the contaminated area, oxygen from ORC can move from the soil moisture to air in interstitial spaces between soil particles. Calculations with Henry's Law show that there is enough oxygen in ORC to increase interstitial space gas from 10% oxygen to 20% oxygen (close to atmospheric levels). Oxygen in the interstitial space can then diffuse through the contaminated area and saturate moisture in soil surrounding the ORC injection point.

There is another caveat with the use of ORC in the vadose zone. There must be enough moisture to support biological activity. Typically, bacteria are located in thin films of water and contaminant that coat soil, and these thin films must have enough area to provide good contact between bacteria, oxygen, and contaminant. However, most vadose zone sites, with the exception of extremely coarse, sandy soils, should meet the microbial soil moisture requirement.

For good examples of vadose zone treatment with ORC, please see case histories (located in the Library section of (www.regenesis.com) on diesel and gasoline remediation in Tracy, CA and ORC use at a former PG&E gas dehydrator site in the San Joaquin Valley, CA.

Can HRC be used in the vadose zone?

We typically do not recommend using conventional HRC in the vadose zone. For certain sites with compact, well-defined contaminant mass, we may recommend (after a thorough technical evaluation) the use of HRC Primer. HRC Primer is a low viscosity, free flowing version of HRC. A key difficulty with using conventional HRC (a thick, viscous, honey-like material that slowly releases lactate upon contact with water) in the vadose zone is obtaining sufficient HRC coverage to create anaerobic conditions in the typically aerobic and unsaturated vadose zone. In contrast, HRC Primer rapidly releases lactate, can be used to flush the contaminated area, and can quickly create an anaerobic treatment zone. For HRC primer treatment in the vadose zone, closely spaced injection points must be used and additional irrigation may be necessary. For vadose zone sites with large, highly contaminated plumes in shallow areas that are easily oxygenated, the amount of HRC Primer necessary for treatment, and thus, the cost may be prohibitive.

Application of HRC-X™

by Michael R. Sieczkowski, CHMM, Plains District Manager
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From time to time a question arises regarding the application of HRC as a result of the thick viscosity of the material. The original development of HRC was closely related to viscosity as the time-release properties of HRC are related to the “thickness” of the material. This is one of the fundamental benefits of HRC; it slowly releases lactic acid over a long period of time, usually in excess of one year. Other carbon sources cannot do this.

HRC-X, a thicker material, was developed for cases where a longer release rate was preferred such as where residual DNAPL is present or a long term barrier application is required. HRC-X was designed to promote reducing conditions for a period of about 3 years. Physically, HRC-X is more viscous than standard HRC, generally in the range of 200,000 centipoise. Although HRC of similar viscosities has been successfully applied under trial conditions in the past, a program was recently developed by Regenesis to ensure that HRC-X can be applied using heating and pumping procedures currently in general use within the industry. In January, 2003, Regenesis and PSA Environmental of Lee’s Summit, Missouri conducted a field demonstration consisting of heating and pumping 600,000 centipoise HRC-X under simulated field conditions.

Although other application systems are in use throughout the country, PSA has routinely applied standard HRC using Geoprobe® pumps and direct push equipment. Heating procedures and application equipment used by PSA have been demonstrated on a number of sites in the Midwest. These same procedures and equipment were used to simulate field conditions for this demonstration. For the test, two buckets of HRC-X (600,000 centipoise material), were stored at approximately 48°F for several days prior to the field work. The product was then heated in a water bath to about 115°F. Hot water of about 170°F was supplied for the bath using a steam cleaner. Once HRC-X reached a temperature of about 115°F, it became significantly less viscous and readily pumpable.

The warm HRC-X was then placed in the hopper of a Geoprobe GS-2000 pump and pumped through three sections of standard 1.25 inch OD, 0.625 inch ID, probe rod. The entire pump and rod assembly were exposed to an ambient temperature of about 35°F for the duration of the test. Under these conditions, the HRC-X was pumped at a rate of about 3 gallons per minute. In order to simulate back pressure seen during application in heavy clay soils, a solid drive point was loosely threaded onto the end of the last probe rod. Back pressure was then built up to the point where HRC-X was being forced through the rod joints and the pump began to noticeably labor.

The general conclusion of the test was that HRC-X can be pumped using standard equipment when the material is heated to a temperature above about 110°F. The standard procedures to heat HRC (a hot water bath) are capable of bringing the HRC-X to a pumpable temperature in about an hour and a half at ambient temperatures near freezing. It was clear by the observations of the PSA’s field applicators that HRC-X can be readily applied with minimal loss of efficiency. Although this test was conducted on high viscosity HRC-X (600,000 centipoise), the results of this demonstration indicate that the application of standard HRC-X (200,000 centipoise) will be similar to standard HRC.

Announcements

Meet Regenesis at the In Situ and On Site Bioremediation Conference (June 2-5, 2003)

Over 50 papers and poster presentations documenting the use of ORC and HRC will be presented at the upcoming In Situ and On Site Bioremediation Conference in Orlando, Florida. This conference, sponsored by Battelle, represents the latest and greatest research in bioremediation and its supporting technologies. It is designed to bring together engineers, scientists, academics and other environmental professionals to share and advance current research and results. As a dedicated recurring sponsor of this event, Regenesis finds it to be of significant importance to the scientific and environmental community. For more information visit www.battelle.org.

New York/New Jersey Metro

Working out of New York City, **Erik White** now manages the technical sales and business development for the New York/New Jersey metro areas. Erik, a Professional Engineer, brings to Regenesis over 12 years of environmental experience with a solid technical background. Erik can be reached at (212) 308-0678 or at erik@regenesis.com.

Federal Programs

Doug Shattuck, our previous Mid-Atlantic district sales manager, has recently been appointed to focus on the management of remediation activities involving the Department of Defense (DOD) and the Department of Energy (DOE). Doug can be reached at (732) 761-0630 or at doug@regenesis.com.

U.K.

In response to increased demand for Regenesis products in the United Kingdom (U.K.) and European Union (E.U.), Regenesis welcomes the addition of a dedicated European technical sales and support manager. **Dr. Jeremy Birnstingl**, working out of Wimbledon, is now responsible for technical sales and support of Regenesis groundwater remediation products. His efforts will be focused on growing product sales and increasing the level of technical support available to the network of existing representatives already in place in the U.K. and E.U. Dr. Birnstingl brings to the table a wealth of environmental experience and knowledge. Jeremy can be reached at +44(0)20 8785 6324 or at jeremy@regenesis.com.

Can a Vendor Contribute to the Science of Bioremediation?

by Stephen S. Koenigsberg, Ph.D., Vice President, R&D
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Over the years we have been perplexed that our observations on bioremediation go unheeded in certain circles despite the fact we have been in the center of about 8000 sites treated with ORC® and HRC®. My thesis is that a vendor can make a significant contribution to the science and, with the assistance of academic and commercial centers of excellence, make a major impact in formulating new paradigms for groundwater remediation. Given the sheer volume of sites treated we become both the deliberate and accidental observer of new causal relationships. Important practical truths or "lessons learned" readily emerge from our large-scale vendor-driven dynamic.

I must stress that I am not departing from the central dogma of the conventional scientific method - but rather indicating that auxiliary processes buttress the development of first principles that eventually merit wide acceptance. Clearly, nothing replaces intensive quantitative field demonstrations that are vetted in peer-reviewed journals. However, by having a large volume of cases with lower resolution the truth can emerge which is particularly important in aquifers given their macroscopic and multivariable nature. So, what are some of the lessons learned? Here are examples which validate the wisdom of Yogi Berra who said "You can observe a lot just by watching."

Accelerated Natural Attenuation is Often the Right Tool for the Job

Over 7500 applications of ORC and 450 applications of HRC have established it as an effective solution to many groundwater problems where accelerated biological reduction is the most sensible solution.

Chasing Mass Balance in an Aquifer is a Holy Grail

Achieving a mass balance is definitely a noble concept but relegated to the laboratory where, even there, it is rarely if ever achieved. Common sense dictates that a complex and somewhat inaccessible aquifer does not lend itself well to notions of closing a loop. This has serious implications for those who expect all daughter products be present in textbook harmony as a metric of success in site clean-up.

DCE Can Hang Around - But Something Can Be Done About It

My last article in this column gave chapter and verse on this. Overall, we believe that DCE's truly problematic inability to degrade further at some sites will not persist given "enough time and enough electrons."

High Levels of Sulfate are Not the End of the World

As a result of having HRC out in the world en masse, sites would show up dechlorinating quite nicely (thank you) with hundreds and thousands of ppm of sulfate. How is this possible? Several researchers have pointed to toxic sulfide reduction products as one of the problems. Sulfide can be neutralized with iron and further drive abiotic dechlorination, so we developed a slow-release iron compound that will assist HRC under high sulfate conditions.

Bioremediation Can Facilitate Dissolution and Desorbtion of Sources

On this subject we stand on the shoulders of others who have articulated the principles of source removal by microbial processes. Our co-sponsored Rice University macrocosm studies and commercial field data sets lend support to this. We have now formulated a new extended release product called HRC-X™ that is designed to facilitate long term removal of residual sources.

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