



HYDROGEN RELEASE COMPOUND (HRC®)

HRC is a proprietary, environmentally safe, polylactate ester specially formulated for the slow release of hydrogen into groundwater

How it Works

HRC is supplied as a viscous liquid for direct injection into contaminated groundwater and saturated soils. This specially formulated product slowly releases lactic acid upon contact with water (Figure 1). This source of lactic acid is then metabolized by microbes to produce hydrogen which is then used in a natural process known as reductive dechlorination (Figure 2). Reductive dechlorination results in the step-by-step biological degradation of chlorinated contaminants. HRC can be used to degrade a range of chlorinated compounds including: degreasing agents (PCE, TCE, TCA and their breakdown products), carbon tetrachloride, chloroform, methylene chloride, certain pesticides/herbicides, perchlorate, nitrate, nitroaromatic explosives and dyes, chlorofluorocarbons, certain metals and radionuclides.

More on Reductive Dechlorination

As discussed, reductive dechlorination is a term used to describe the mechanism by which chlorinated hydrocarbons are biologically degraded under anaerobic conditions. In this natural process, anaerobic microbes substitute hydrogen (H) for chlorine (Cl) on chlorinated contaminant molecules, thus dechlorinating the compound. Being a natural process, reductive dechlorination usually proceeds at very slow, unsustainable rates. HRC increases the rate of dechlorination up to several orders of magnitude, rapidly taking the contaminant through a step-wise dechlorination process that ultimately results in the production of non-toxic compounds such as ethene and ethane. Under the influence of HRC, this process may continue at an accelerated rate for up to 18 months.

HRC May Favor Reductive Dechlorination Over Competing Methanogenic Activity

Within the subsurface anaerobic microbial consortium, there exist microbes that use hydrogen primarily for the production of methane (methanogens), and also present are microbes that use hydrogen primarily for dechlorination (reductive dechlorinators). Results from university studies suggest that there is competition for hydrogen between the reductive dechlorinators and methanogens. High concentrations of hydrogen favor methanogenic activity, whereas reductive dechlorinators are best supported in conditions of low hydrogen concentrations (2-10 nM). With HRC's long-lasting, time-release feature, a more steady and low hydrogen concentration is possible which can optimize reductive dechlorination over competing methanogenic activity.

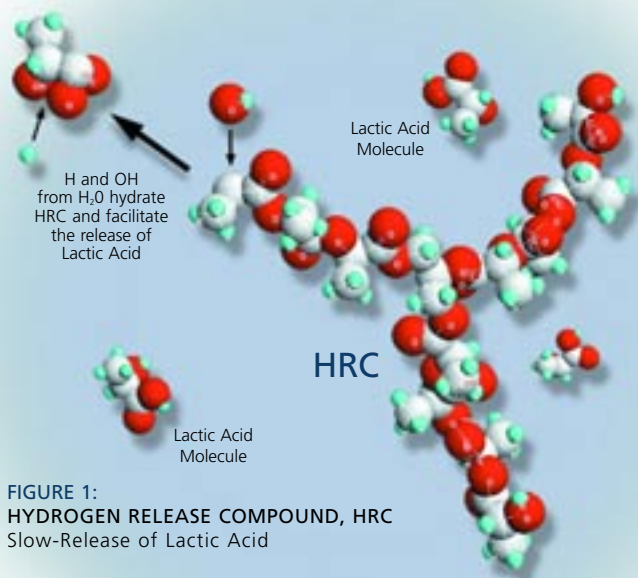
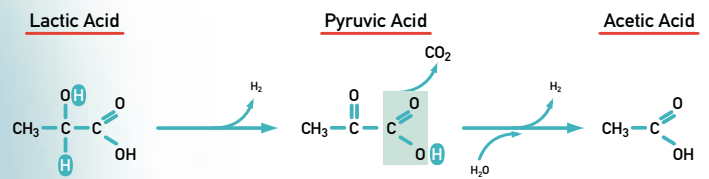


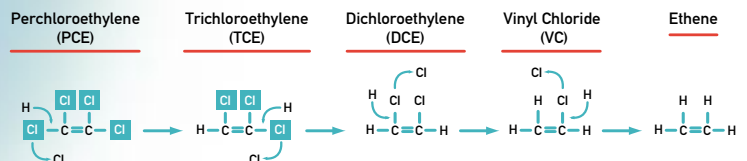
FIGURE 1: HYDROGEN RELEASE COMPOUND, HRC Slow-Release of Lactic Acid

FIGURE 2: BREAKDOWN OF LACTIC ACID AND RELEASE OF HYDROGEN

BREAKDOWN OF LACTIC ACID FROM HRC YIELDS HYDROGEN (H₂)



INCREASED HYDROGEN ENHANCES REDUCTIVE DECHLORINATION





Leaders in Accelerated Natural Attenuation

HRC a Cost-Effective Remediation Strategy

HRC offers an efficient, low-cost and effective method of treating *in-situ*, chlorinated compounds. Application of HRC is accomplished inexpensively using push-point or borehole delivery methods. Once in the subsurface, HRC continues to stimulate the biodegradation of contaminants for an extended period of time (up to 18 months) eliminating the need for multiple, more frequent injections. A combination of low-cost application, an extended release profile, no operations and maintenance, minimal site disturbance and a lack of dependence on external power sources gives HRC a substantial cost advantage over other treatment technologies. HRC is a sensible, economical solution for treating chlorinated contaminants in saturated soils and groundwater.

Plume Wide Remediation*

The example below illustrates four different size groundwater plumes and four remediation scenarios, including use of HRC. This comparison assumes a TCE contaminant concentration of 10 ppm.

Treatment	Smaller Site (50' x 75')		Larger Site (200' x 200')	
	Shallow Aquifer (20' bgs)	Deeper Aquifer (50' bgs)	Shallow Aquifer (20' bgs)	Deeper Aquifer (50' bgs)
HRC Treatment	\$130,000	\$134,000	\$316,000	\$324,000
Pump and Treat	\$595,000	\$633,000	\$778,000	\$876,000
Air Sparging w/SVE	\$334,000	\$358,000	\$639,000	\$760,000
Chemical Oxidation	\$320,000	\$343,000	\$1,495,000	\$1,636,000

* Comparison costs were generated by an independent environmental consulting firm and include costs through project completion, e.g. sampling, monitoring, reporting, etc. All costs are reported in today's dollars. A net present value analysis would make HRC treatment appear considerably more favorable.

Plume Cut-Off / Barrier Remediation*

The example below illustrates four different size groundwater plumes and four typical, cut-off barrier remediation scenarios, including use of HRC. This comparison assumes a TCE contaminant concentration of 10 ppm.

Treatment	Smaller Plume (50' wide)		Larger Plume (200' wide)	
	Shallow Aquifer (20' bgs)	Deeper Aquifer (50' bgs)	Shallow Aquifer (20' bgs)	Deeper Aquifer (50' bgs)
HRC Treatment	\$145,000	\$149,000	\$175,000	\$184,000
Iron Wall Barrier	\$336,000	\$394,000	\$632,000	\$776,000
Pump and Treat	\$578,000	\$615,000	\$685,000	\$757,000
Air Sparging w/SVE	\$350,000	\$356,000	\$641,000	\$675,000

* Comparison costs were generated by an independent environmental consulting firm and include all project costs for operating a plume cut-off for a five year period. All costs are reported in today's dollars. A net present value analysis would make HRC treatment appear considerably more favorable.