Generation of Enriched, Anaerobic "Chase Water" to Repair Aquifer Biogeochemistry: The Best Solution is EHC® ISCR™ Technology

Understanding of the Problem

"DCE Stall" is a problem frequently encountered when simple, "carbon-only" substrates such as hydrogen releasing compounds, [emulsified] oils, lactates or sugars are used to stimulate *in situ* reductive dehalogenation of chlorinated solvents (*i.e.,* non-EHC® ISCR applications). In response to the excessive accumulation of these problematic intermediates (*e.g.*, 1,2-DCE and Vinyl Chloride), inoculation of groundwater with *Dehalococcoides* sp., or other dehalogenators, is sometimes required.

With increasing frequency, however, it is reported to us that various microbial inoculants do not survive well in aquifers that have been previously treated with substrates other than EHC®. Hence a viable population of dehalogenators is not established and the accumulated metabolites persist and potentially migrate off site. The" failure" of the inoculum is usually caused by unsuitable environmental conditions such as:

- unacceptably low pH; unacceptably high Eh
- low availability of required nutrients;
- microbial toxicity due to surfactants/emulsifying agents present in the remedial amendments; and /or
- microbial inhibition due to induced mobilization of toxic heavy metals, such as arsenic.

These conditions are the direct result of using non-buffered, simple carbon-only remedial amendments. Thus, re-establishment of environmental conditions more conducive to the growth and proliferation of the inoculant is often needed to yield effective remediation of the impacted aquifers.

EHC Mode of Action

The organic carbon in EHC is produced by milling of food grains and, as a result, provides an excellent balance of soluble carbon, relatively insoluble carbon, major nutrients (N, P, K, S), minor nutrients (Ca, Mg, Fe), and micronutrients (Co, Mn, Mo, B). Thus, water to which EHC is added will be rapidly enriched in a broad range of essential nutrients thereby addressing the nutritional requirements of fastidious dehalogenating bacteria. This supports the survival of the bacteria since many species are known to have complex nutritional requirements that cannot be satisfied by the use of simple hydrogen releasing compounds for nutrient-limited groundwater present in many aquifers. A select fraction of the organic component of EHC will be rapidly consumed (fermented) yielding various volatile fatty acids (VFAs) that are source of hydrogen for resident microbes.

EHC does not contain chemical surfactants or emulsifying agents.

Finally, the problem of heavy metal toxicity can be eliminated by precipitation of metals as iron sulfides. As the iron in EHC corrodes it releases ferrous iron (Fe^{+2}). Simultaneously, sulfate present in the water is both chemically and microbiologically reduced to sulfide. Many heavy metal species - including As, Ni, Pb, Zn, Cu and Cd - are readily precipitated from groundwater by precipitation as metal-sulfides or mixed iron-metal- sulfides. This precipitation process results in removal of much of the heavy metal toxicity and thereby enhances survival of the inoculated dehalogenators.

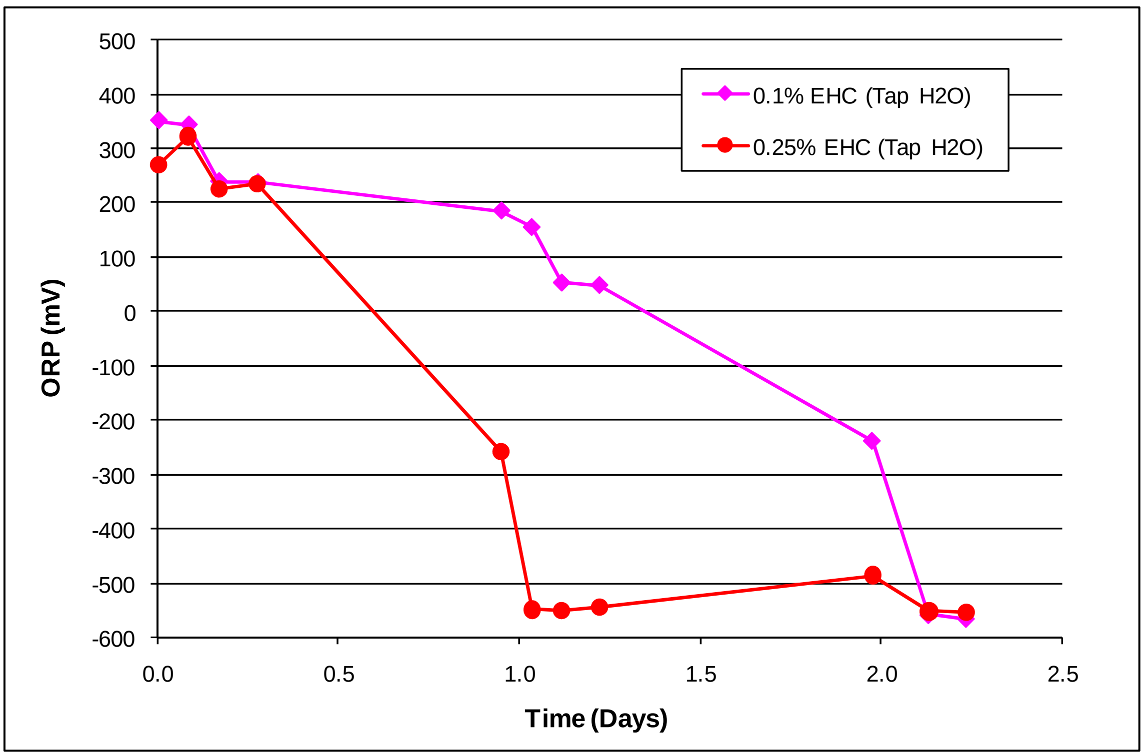
EHC to Generate Enriched, Anaerobic Chase Water

In order to simultaneously address the potential causes of poor inoculum survival the aquifer can be enriched with anaerobic chase water that was generated using EHC®. EHC uniquely combines food-grade, controlled release carbon plus fine-grained, reduced metal (such as zero-valent iron; ZVI) to induce complete mineralization of multiple contaminants. When added to water several important reactions occur.

First, the ZVI in EHC provides a powerful mechanism to rapidly drop the Eh of water into the range most conducive to the survival of dehalogenators, such as *Dehalococcoides* sp. When in contact with water, ZVI corrodes (is oxidized) and during the process consumes dissolved oxygen, sulfate and nitrate. As a result the Eh of water placed in contact with EHC is generally reduced by between -300 and -500 mV over a period of hours. For example water that starts with an Eh of +100 mV would generally be reduced to a level of -300 to -400 mV. The process of ZVI corrosion is alkaline, therefore acids are balanced by alkalinity and the pH of the EHC generated chase water will drop a little and may need to be buffered.

Figure 1 shows the effect of 0.1% and 0.25% EHC on the ORP of tap water in a laboratory test. The test was performed in a closed bottle with headspace which was gently stirred after amendment. The ORP was lowered from +300 mV to less than -500 mV within 24 hrs using 0.25% EHC to mass of water, and from +350 mV to less than -500 mV in 48 hrs using 0.1% EHC to mass of water.

Figure 1: Anaerobic chase water – ORP trend with time in tap water.



The bottle was then decanted and refilled three times. The higher application rate of EHC provided consistent ORP buffering to below -350 mV in all four cycles, while the effect of 0.1% rate diminished after the 1st cycle. This data is not shown on the graph.

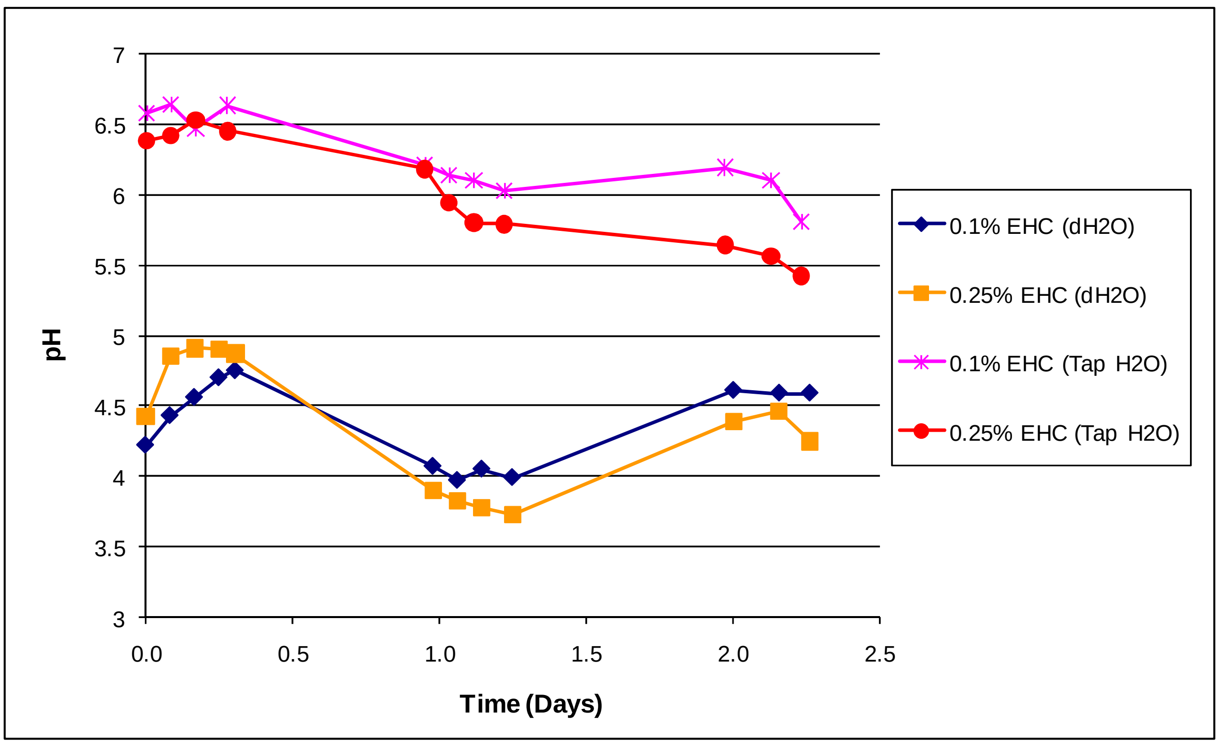
Depending on the quantity of anaerobic chase water required, the frequency, and the equipment set up for reusing EHC, the desired application rate of EHC can be selected.

Potential Need to Buffer Anaerobic Chase Water

Depending on the pH and buffering capacity of the site water, a change in pH may be observed. **Figure 2** shows the effect of 0.1% and 0.25% EHC on the pH of tap water and deionized water in a laboratory test. The test was performed in a closed bottle with headspace which was gently stirred after amendment. The pH in tap water was lowered from around 6.5 to 5.8 with 0.1% and from 6.5 to 5.45 with 0.25% EHC in 48 hrs.

If desired, the pH can be quickly raised to neutral by adding sodium bicarbonate. We recommend that the user prepare a small test mixture of EHC mixed in site tap water to get a better understanding of the pH and ORP trends, the need for buffering and the time required to prepare a batch of anaerobic chase water before the injections.

Figure 2: Effect of water source on pH of anaerobic chase water.



Conclusions

In summary, EHC can be used to generate anaerobic chase water to restore environmental conditions that have been misaligned due to the addition of emulsified oils and other sources of carbon-only remedial amendments. The EHC Chase Water is:

- Rapidly generated on site using conventional equipment and machinery
- Not temperature sensitive

- pH neutral; extremely low Eh
- Enriched in dissolved nutrients and VFAs known to be important and useful to select microflora

General Application Guidelines

- Add the desired amount of EHC (8.5 lb for 0.1% or 20 lb for 0.25% application rate) to 1,000 USG water in a closed but **VENTED** container
- Gentle mixing (no aeration) for 12-24 hrs; let settle for 4 hrs
- Eh drop to <-400 mV in most water sources
- Decant enriched Chase Water (NOTE: depending on the configuration of the injection network a filter bag [100 micron or smaller] maybe be required to remove suspended solids).
- Keep 50 gallons of water to make the next batch of anaerobic chase water.

Ordering Information:

EHC costs $2.50/lb.

Contact us at:

Adventus Americas Inc.

2871 W. Forest Rd - Suite 2, Freeport, IL USA 61032

phone (+01) 815 235-3503; fax (+01) 815 235-3506;

Adventus Europe GmbH

Franz-Plattner 28F, 6170 Zirl, Tirol, Austria

EU office (+43) 5238.53262 / EU fax (+43) 512.219.100333 / Mobile (+43) 664.180.3060

www.AdventusGroup.com | www.Adventus.eu | www.ETI.ca