



EHC is the **ORIGINAL**, patented combination of controlled-release, complex carbon plus zero valent iron (ZVI) that uniquely exhibits the recognized benefits of *in situ* chemical reduction (ISCR™). Hence, EHC integrates chemical and microbiological degradation processes and is routinely viewed as a technically superior product over other conventional enhanced bioremediation technologies. When specifically compared to emulsified oils and carbon sources, EHC offers the following qualitative and implementation advantages:

- 1. EHC Does Not Enhance Physical Sorption as a “Removal” Mechanism.** EHC is a hydrophilic (water loving) substrate. As such, it will not sequester contaminants. Conversely, oils are inherently lipophilic and hydrophobic; hence, emulsified oils will predictably adsorb other hydrophobic compounds, including all chlorinated solvents and other hydrocarbons. Once sorbed, these contaminants can migrate downgradient within globules of emulsified oil. This can be further exacerbated via the injection of large volumes of water commonly applied post-addition of oils (typically, 10,000 gallons of oils are chased with over 150,000 gallons of water in attempt to further distribute/dilute the substrate within the subsurface). The presence of surfactants in the oil emulsions may further complicate this contaminant dispersion / uncontrolled migration.
- 2. Predictable Performance = Accelerated Site Closure.** EHC uniquely integrates chemical and microbiological degradation processes which allow treatment to proceed at a predictable rate **without relying on physical sorption / sequestration as a major “removal” mechanism, ala oil.**
- 3. Direct Mineralization without Production of Catabolites.** Via ISCR reactions unique to EHC, only EHC provides rapid and complete dechlorination of targeted compounds (see “Thermodynamics of Low Eh Reactions” for further scientific validation at: <http://www.adventusgroup.com/library/articles.shtml>). Emulsified oils rely on the presence of specialty microorganisms, and degradation reactions proceed along conventional sequential reductive dehalogenation pathways. As such, potentially problematic intermediates such as DCE and VC from PCE or TCE, and DCM from CT or CF, will often accumulate. Emulsified oils may also reduce the bioavailability of contaminants as they partition into the oil matrix. EHC does not sequester contaminants as oils do, but instead reduces them to harmless end products.
- 4. Minimized Contaminant Displacement / Mobilization.** Relatively speaking, emulsified oils are mobile (as micro globules) when compared to EHC (solid). EHC solids are injected as slurry (30 to 40% by weight / solids). The amount of water used during the injection process is therefore much less, which results in a relatively low displacement of the pore volume. Consequently, EHC injection causes minimal plume displacement. **No Mobilization of Contaminants.** Optimal volume of EHC slurry is injected **without the need for extensive water flushing**, which avoids potential displacement and mobilization issues.
- 5. Contact.** EHC does not require direct contact to act upon targeted constituents. Oils must be consumed by catabolically relevant microbes. Injection of a hydrophobic layer of emulsified oil will alter groundwater flow and the contaminants may be diverted (oil tends to repel water) around the emulsified oil barrier. EHC does not repel water nor does it alter the overall aquifer permeability.
- 6. Ease of Construction.** EHC is available in solid and aqueous (EHC-A) formulations and is manufactured according to site-specific needs and conditions. Oils are viscous liquids delivered as concentrated emulsions and require extensive dilution (typically concentrations between 3 to 12% are recommended to yield a viscosity of between 1.3 to 2.1 times that of water) and water flooding to facilitate *in situ* distribution. This can all translate into significantly increased project costs due to the need for extended field time.
- 7. Environmental Longevity.** EHC-A will last 6 to 12 months in the subsurface environment; solid EHC formulations will last at least **5 years**. Little information is available on how long the emulsified oil stays emulsified. Initially, it stays emulsified and due to a large surface area releases dissolved organic carbon efficiently. Over time, interfacial forces will coagulate the emulsion which will grow into larger oil globules and ultimately into an oil layer, making it less effective over time. If the globules have sorbed enough contaminants, then the emulsified oil/contaminant mass may represent a NAPL. This will not happen with EHC.



8. **Ideal Support for Microbial Growth / Inoculants.** Several independent tests have shown that the addition of microbial inoculants to certain environments can help ensure complete dechlorination of TCE and its degradation products. Due to its inherent buffering capacity and complex inorganic nutrient base (plant based carbon sources), EHC is able to provide and sustain ideal conditions for the survival, growth and proliferation of microbes. Plant-based inoculum carriers have been widely used commercially for over 50 years; conversely, oils and surfactants (soaps) even in low concentrations are often used as sterilizing agents to kill microorganisms.
9. **Superior Technology for Permeable Reactive Barriers (PRBs).** Ideally, an amendment which is not mobile (*i.e.*, solid EHC) is required for a PRB application.
10. **Adaptable Formulations for Heavy Metals.** In environments that are co-impacted with various inorganic contaminants (*e.g.*, As, [Hg], Ni, Pb, Zn) the presence of ZVI and other amendments unique to EHC-M[®] formulations will yield rapid, irreversible, long-term immobilization of heavy metals - while simultaneously mineralizing the organic compounds. This is not an option with emulsified oils since they do not provide ZVI.
11. **Full Indemnification for You and Your Client.** EHC ISCR technology is the subject of numerous patents which we enforce and protect. **Adventus will provide copies of our patents and written, full indemnification backed by insurance coverage that protects and defends you and the end-user / client from any lawsuits purporting patent infringement or other technology violations.**
12. **Health and Safety.** EHC is composed of food grade materials and does not contain Genetically Modified Organisms (GMOs). EHC is safe to handle and easy to use with no bulky or hazardous material disposal issues.
13. **Applicability.** EHC is easily and quickly injected using conventional construction technologies. It has been successfully applied to hundreds of sites around the world with varying lithology. Demonstrated effectiveness on a wide range of COI, including chlorinated solvents, Freon, pesticides, perchlorate and other energetic compounds (explosives).
14. **Longevity with no Rebound.** EHC remains active in the environmental for 12 to 60 months hence COI rebound phenomena are not observed (rebound is common when using readily biodegradable, liquid substrates);
15. **Complete Technology.** EHC provides major, minor and micronutrients that are essential to the activity of fastidious anaerobic bacteria involved in recognized dechlorination reactions.
16. **Buffering Capacity.** EHC provides substantial pH buffering capacity and **no additional buffers are required**. In contrast, the addition of conventional organic substrates (*e.g.*, emulsified oils, molasses or lactate-based materials) to promote biodegradation can often lead to aquifer acidification.
17. **Facilitates Natural Attenuation.** For all the reasons summarized above, EHC enhances the natural biological processes. Other technologies may offer short term COI reduction via displacement, sorption reactions, etc. but they can alter the environmental conditions such that natural attenuation mechanisms are adversely influenced.

* A complete copy of this Report is available via PDF at <http://www.adventusgroup.com/pdfs/EHCvsOILS.pdf>



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