

## Consequences of Excessive Methane Production Following ERD and Conventional ISCR Treatment: Case Studies and Remedial Alternatives

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Excessive production of methane has been observed following the addition of organic hydrogen donors such as (emulsified) oils, lecithin, sugars and conventional ISCR reagents. This is because methanogens are commonly the most ubiquitous indigenous microbes in anoxic aquifer settings. And given that they can replicate in 1 to 2 hours (whereas *Dehalococcoides* spp. for example double in 24 to 48 hours), they often bloom and dominate following the addition of the organic hydrogen donors, thereby liberating large amounts of methane gas. There are at least three important consequences of this response:

- i) By utilizing hydrogen, the methanogens compete with dechlorinating microbes thus making inefficient use of the remedial amendment (20 ppm methane in groundwater represents about 35% "waste")
- ii) Rapid growth of methanogens consumes alkalinity while generating acids thereby having the potential for aquifer acidification (which may liberate heavy metals causing secondary contaminant issues); and
- iii) Elevated methane concentrations can exceed current and pending regulations of < 10 to <28 ppm in groundwater and/or 0.5% v/v methane in soil gas (e.g., 10% of the LEL) and/or indoor air regulations (methane is flammable between 5 and 15% v/v).

Five cases studies will be reviewed where methane production was problematic:

- i) Subsurface fires next to an industrial facility at a site in the Midwest USA corresponding with the application of EHC® conventional ISCR reagent;
- ii) Generation of up to 18% methane in soil gas proximal to a church in North Carolina (with sustained methane production after 8 months) from an excavated area treated with DARAMEND® conventional ISCR reagent;
- iii) Requirement to install an air sparge/SVE contingency system at a site in northern Indiana due to methane accumulation associated with an application of EOS® emulsified oil;
- iv) Changes in aquifer flow dynamics and inactivation of an *in situ* injection system due to methane production and extensive biomass following repeat applications of molasses for ERD at a site in Rio De Janeiro, Brazil; and
- v) Delayed occupancy of a newly developed residence in Sao Paolo, Brazil due to presence of elevated methane in soil gas following the use of EHC®.

It is clearly important to prevent excessive methanogenesis during a remedial action. From a regulatory perspective, public safety issues are paramount; from a property re-use or real estate (Brownfield) developers' perspective, project delays are costly and can jeopardize an entire program. The use of Provect-IR™ antimethanogenic ISCR reagent uniquely combines multiple sources of nutrient-rich, engineered-release, hydrophilic carbon sources + ZVI + other reagents along with a source of natural statins as inhibitors of protein biosynthesis and activity of enzymes systems unique to Archaea (*i.e.*, methanogens). Modifications of the reagent can be also be used as a supplement to conventional ERD amendments to make the safer and to improve their overall efficacy. Data from laboratory and field studies will be presented to demonstrate control of antimethanogenic activity during remedial actions.