

Optimizing EVO Formulations

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Background. Terra Systems, Inc. (TSI) manufactures a variety of emulsified vegetable oil (EVO) products called SRS[®] that incorporate soybean oil, food grade anionic or nonionic surfactants, sodium lactate, yeast extract, inorganic nutrients, and vitamin B12. SRS[®] is designed to promote the anaerobic biodegradation of chlorinated solvents like tetrachloroethene, trichloroethene, or 1,1,1-trichloroethane as well as emerging contaminants like nitrate. SRS variations include: SRS[®]-SD with a small droplet (average 0.6 microns) and nonionic surfactant formulation for maximum distribution in the subsurface; SRS[®]-FR with a large droplet (average 5 microns) formulation that can include lecithin as zwitterionic (both negative and positively charged) surfactant for maximum retention in sites with high groundwater flowrates like fractured bedrock or outwash deposits; SRS[®]-EZVI which incorporates zero valent iron (ZVI) to promote abiotic reduction of the chlorinated solvents and SRS[®] to promote biological reduction of dense non-aqueous phase chlorinated solvents; and SRS[®]-M which combines SRS[®] with an abiotic reductant to promote biological reduction of metals like hexavalent chromium to the less toxic and less mobile trivalent form and biodegradation of chlorinated solvents.

Approach. TSI has optimized SRS[®] formulations for the following applications: SRS[®]-NR for nitrate reduction in high flow rate sandy aquifers where nitrate accumulates from septic systems; SRS[®]-Basic which omits the sodium lactate and nutrients when a less expensive formulation is required; SRS[®]-STA which incorporates a shear thinning agent for injection into heterogeneous aquifers; SRS[®]-SE which includes soybean oil and the food grade surfactants and is combined with water at the injection site to reduce product and shipping costs.

Results. SRS[®]-NR uses anionic surfactants and a larger droplet to promote retention in high groundwater aquifers. It also does not include the yeast extract or nutrients. Column studies using site soils from Cape Cod, MA showed that SRS[®]-SD moved through the 3.8 foot long columns for up to three pore volumes while the SRS[®]-NR formulation was retained within three 3.8 feet long columns connected together. Both formulations supported complete nitrate reduction for over 70 pore volumes. Two applications of SRS[®]-NR have been conducted at another site on Cape Cod, MA and have promoted an average of 80.9% denitrification in zones where the SRS[®]-NR reached with DOC concentrations greater than 10 mg/L. Laboratory studies with the SRS[®]-STA materials have shown improved distribution in heterogeneous sand boxes.

Lessons Learned. EVO formulations optimized for site-specific contaminants, hydrogeology, and geology, improves product performance and increases the number of sites where EVO anaerobic biodegradation is a viable remediation alternative.