Solid Phase Colloidal Organic Amendments Promote Sustained Biodegradation in Permeable Reactive Barriers

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Background/Objectives. Activated carbon-based permeable reactive barriers are effective at intercepting groundwater plumes and retarding downgradient contaminant migration. However, activated carbon does not directly promote degradation and in higher contaminant flux environments the carbon particle surfaces can become saturated with diminished barrier performance. Barrier longevity can be extended by adding complementary remediation amendments that promote contaminant destruction. Commonly used soluble fermentable remediation amendments have limited persistence (sodium lactate), and longer acting products (emulsified vegetable oil) competitively sorb to the carbon particles and this precludes their use with activated carbon. This work describes the development, modeling, and field demonstration of a novel plant-based, sub-micron fermentable remediation amendment. This is the first solid-phase colloidal material that can be co-injected with activated carbon at low pressures to promote sustained in situ bioremediation in permeable reactive barriers.

Approach/Activities. Several plant-based products were investigated to identify a material that could be reduced in size to about one micrometer and slowly degrade to support bioremediation. To inhibit the agglomeration that naturally occurs in small particle size suspensions, several food-grade dispersants were investigated. This work was followed by experiments to optimize the particle size with the goal of producing a material that could be co-applied with similarly sized colloidal activated carbon. Particle transport through sand was verified using column studies. The ability to promote biodegradation was studied using closed bottle treatability studies with chlorinated ethenes. A pilot study was then performed by DPT injection at low pressures with and without activated carbon. Monitoring well data were used to measure degradation rates and degradation pathways of chlorinated ethenes, geochemical parameters, and the generation of gaseous reaction products such as ethane and methane.

Results/Lessons Learned. After numerous iterations, a stable colloidal suspension of a biodegradable plant-based material was produced. The median particle size was about 1 micrometer with 99% of the particles less than 5 micrometers. This particle size and product appearance compares favorably to commercially available emulsified vegetable oil products. Treatability studies verified the ability to degrade TCE to ethene via reductive dechlorination. The pilot studies successfully demonstrated the ability to co-apply the product at low injection pressures with and without colloidal activated carbon. Monitoring data verified the occurrence of reductive dechlorination with ethene production continuing more than two years after product application.