Multiple lines of evidence approach to assess chlorinated ethenes degradation during treatment with liquid activated carbon and bioamendments

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Publication date: 2019

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

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Application of activated carbon together with biological amendments is an emerging technology to remediate groundwater contamination with e.g. chlorinated ethenes. These amendments are injected into the subsurface where the activated carbon sorbs the contaminants and decrease the concentration in the aqueous phase. The sorption further concentrates contaminants and bacteria together and is thereby intended to enhance the degradation. Previous field investigations have documented fast reduction in dissolved contaminant concentrations in monitoring wells post injection. Though promising, this limits the possibility of differentiating sorption and degradation with aqueous samples.

A developing method to characterize and quantify degradation is a multiple lines of evidence approach, including novel techniques such as molecular biology tools (MBT) and compound specific isotope analysis (CSIA). Further investigations are required to assess the applicability and compatibility of these tools in the presence of activated carbon, which is complicated by the expected low aqueous concentrations.

Therefore, a research & development project was carried out at field scale applying these special techniques (MBT and CSIA) along with typical measures to assess their applicability to evaluate degradation of chlorinated ethenes after the application of activated carbon and bioremediation. The AC-based product applied was PlumeStop® that consist of suspended (1-2 µm) activated carbon. PlumeStop® was injected together with a culture of Dehalococcoides and other dechlorinating bacteria (BDI Plus) and organic electron donors (HRC), as an intended barrier (12 injection wells) perpendicular to a chlorinated ethenes plume. An extensive monitoring program was carried out prior and post injection in down-gradient (54 screens) and up-gradient (26 screens) monitoring wells.

A laboratory treatability experiment was additionally carried out with the same monitoring parameters for process understanding in a closed system to support the assessment of the field results. The experiment revealed that equilibrium between the phases and PlumeStop is necessary before CSIA results could be used to characterize and quantify the degradation of TCE.

The preliminary results from the groundwater monitoring at field scale suggested effects of and interaction between transport, sorption and dechlorination. The CSIA results demonstrated that it is of high importance to understand the transport of injectates and contaminants to assess the transformation caused by the injection, given the equilibrium challenge confirmed in the laboratory experiment. Microbial analysis indicated that bacteria known to degrade the less chlorinated intermediates were not active/thriving, clarifying why the dechlorination appears to stall at cis-DCE. The multiple lines of evidence approach was necessary to evaluate the remedial action providing information the typical measures would have been unable to. The identified challenges and possibilities related to the tools and analyses will further be of use when transferred to cases with stronger sorption.