ENHANCED IN-SITU DECONTAMINATION OF LNAPL SOURCE ZONES BY SOIL WASHING AND BIOSTIMULATION

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At a former lignite smouldering combustion site in Central Germany, an LNAPL contamination of soil (aliphatic hydrocarbons AHC) and groundwater (BTEX, phenols, PAH) has been held from spreading by applying pump-and-treat and mobile oil recovery technologies for more then 15 years. In order to reclaim the industrial site for reuse and to allow for a transition from long-lasting technical efforts to lower-invasive enhanced natural attenuation (ENA), an in-situ decontamination technology was implemented in a sub-area for two years and lead to a post-operative maintenance. The source zone of contamination was flushed by infiltration of pure n-butanol to mobilize semi-residual spill oil. The mobilisate (a mixing of spill oil, butanol, and water) with a lower viscosity ,was formed in the capillary fringe zone. Floatings of mobilisate were continuously removed by combined oil-and-water-extraction-systems. A flooding procedure by infiltration-pumping water with off-site extraction fluid management withdrew residual mobilisate, dissolved n-butanol and hydrocarbons. As a final cleaning step, immissions into groundwater below the source zone were continuously lowered by stimulating microbial sulfate reduction and aerobic degradation using direct oxygen gas injections. In the course of the remediation, it was found that bio-stimulation was activated even in the source zone of AHC residuals, and in the vadose zone.

The change in the composition of soil gas above the storage of oxygen injection showed, that a high degree aeration of the gas permeable soil zone has been achieved with stimulation of the decomposition of organic substances. This effect has been shown by partial pressures of CO2 with up to 40% (final product of the degradation) and significantly declining BTEX soil gas concentrations in the center. The composition of soil gas within the injection zone showed no relevant stripping of pollutants or wash fluid (n-butanol) into the soil gas phase by direct gas injection.

In addition and with the removal of the wash-fluid butanol the degradation of contaminants (BTEX, phenols and naphthalene) was stimulated. Organic acids as intermediates supported the solubilization and the co-metabolism of the pollutants. The emission of butanol from the mobilisat - residuals ensued only diffusely. Butanol dominated no longer as the organic carbon source in groundwater. While hydraulically and stationary operating periods pollutant concentrations of alkyl phenols, BTEX and naphthalene in upper and lower aquifer decreased. Although a direct evidence of decomposition for benzene by C13 isotope screening was not yet possible, the in-situ bio-stimulation of the biodegradation was demonstrated in a verifiable a chain of evidence.