Transient Mass Discharge Reduction versus Source Mass Reduction Following an In Situ LNAPL Source Remediation

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Background/Objectives. The reduction of mass discharge of soluble contaminants to the plume from a source area with NAPL after a partial mass removal is an essential parameter for evaluating the effect of a remediation. The relation between the reduction of mass discharge and the reduction of mass in the source zone can be expressed by the "Γ-model" /1/:

$$J_t/J_0 = (M_t/M_0)^{\Gamma}$$

where J_t is the mass discharge at time t, J_0 is the initial mass discharge at time zero, M_t is the mass at time t, M_0 is the initial mass and Γ is an empirical factor that vary with different types of geology and contamination. Literature show that Γ often vary between 0,5 and 2,0 for DNAPL-sites. Estimating the Γ-factor will be useful when setting remedial goals and choosing remediation strategy. However, only very limited field derived data is available so far, and none related to LNAPL remediation. Furthermore, it is to date not determined whether the Γ-factor will change over time after remediation due to steady-state equilibration and to natural attenuation processes. The objective of this study is to determine the mass discharge and the Γ-factor immediately after completion of an LNAPL source zone remediation and subsequently periodically in the following years to evaluate the Γ-factor as a function of time. The results will be useful for future remedial planning.

/1/ Falta RW, Roa PS., Basu N,(2005a): Assessing the impacts of partial mass depletion in DNAPL source zones I. Analytical modeling of source strength functions and plume response. J. Contam Hydrol 78, 259-280.

Approach/Activities. The Danish Defence has remediated a site in western Jutland, Denmark. A shallow sandy aquifer was contaminated by residual petroleum-based jet fuel (LNAPL). By using a surfactant flushing technology 40 m^3 of LNAPL was mobilized and recovered from the 1.000 m^2 source area. Mass balance based both on operating data during the remediation and on pre and post remedial investigations using laser-induced fluorescence (LIF) and chemical soil analysis (total petroleum hydrocarbon [TPH] and BTEX), shows that more than 90 % of the mass in the source zone was removed. The mass discharge was measured before and after the remediation by the transect method, with an approx. 45 m wide transect placed downgradient the remediated source zone. The transect contains six wells with a total of 35 sampling points. Groundwater samples are analyzed for TPH and BTEXN. The gradient is estimated by hydraulic head in wells, and the hydraulic conductivity is estimated from slug tests and Geoprobe Hydraulic Profiling Tool (HPT-logs). First samples were taken in June 2017, and quarterly monitoring will be performed over the next two years.

Results/Lessons Learned. The monitoring results from June 2017 show significant reductions of both TPH and BTEXN in the transect compared to baseline monitoring before remediation. Transect monitoring in June 2017 shows a mass discharge reduction of THC by 70 % and of BTEX by 98 %. Based on TPH data and the mass removal in the source zone, the Γ-factor is estimated at 0,5. Changes in the mass discharge and the Γ-factor will be followed quarterly by transect monitoring. Results from 4 post-remediation monitoring events will be available for presentation in April 2018.