Snapshot
www.claire.co.uk

Copyright © CL:AIRE (Contaminated Land: Applications in Real Environments).

RP 3 - Controlling the Natural Attenuation of Fuel Hydrocarbons and MTBE in the UK Chalk Aquifer

Originally published November, 2006

Site Background

This report summarises research completed from May 2001 to November 2004 to evaluate processes controlling the natural attenuation (NA) of petroleum hydrocarbons and methyl tertiary butyl ether (MTBE) in the Upper Chalk aquifer at the site of an unleaded fuel spill in St Albans, southeast England. The unsaturated zone and saturated zone of the aquifer are contaminated with benzene, toluene, ethylbenzene and xylenes (BTEX), MTBE, tertiary amyl methyl ether (TAME) and tertiary-butyl alcohol (TBA). A mixed BTEX/MTBE/TAME/TBA plume extends 125m from the site and <10m below the water table, whereas a MTBE/TAME/TBA plume extends 220m from the site and >15m below the water table. The research was sponsored by EPSRC, Total UK and the Environment Agency and included field, laboratory and modelling studies. It was completed as a research project for CL:AIRE and hosted by the site owner.

Conclusions

The key advances arising from this research have been in process understanding and parameterisation, improved site investigation methodologies and performance assessment approaches for interpreting NA of petroleum hydrocarbons in the Chalk and other dual porosity aquifers. These science and technology advances are summarised below:

- Development of a detailed process model describing the NA of petroleum hydrocarbons and MTBE in the UK Chalk aquifer, providing data on:
  - Relationships between physico-chemical properties and reactions which determine transport and attenuation capacity, with parameter values, including degradation rates for BTEX and MTBE under different redox and environmental conditions
  - Effect of environmental factors and contaminant interactions on degradation potential and rates
  - Contribution of dual-porosity transport and biodegradation in attenuation

Apparatus used to collect groundwater samples from multilevel samplers

- Development of new improved analytical method for the simultaneous determination of ether oxygenate compound, their metabolites and BTEX in petroleum fuel-contaminated groundwater, with superior performance to existing methods (Dewesbury *et al.*, 2003)
- Development of novel method for the onsite sampling of porewater chemistry in contaminated consolidated aquifers (Spence *et al.*, 2005a)
- Development of process-based mass balance model as a decision-making tool for the performance assessment of NA in dual-porosity aquifers using typical site data and accounting for uncertainty in predictions with Monte Carlo analysis

CL:AIRE MEMBERSHIP

- Validation of conceptual model and parameters describing NA of petroleum hydrocarbons in the Chalk aquifer, allied to development of advanced numerical code, with identification of dual-porosity effects and performance prediction for NA

- Demonstration that the aquifer micro-organisms have the potential to degrade MTBE under the conditions in the aquifer.

An important finding is that natural attenuation of BTEX and MTBE in the Chalk aquifer can be significant, although by different mechanisms. For BTEX, attenuation by biological processes such as degradation is more important than physical processes and the aquifer has a large reservoir of dissolved oxidants to support degradation processes for BTEX. For MTBE, attenuation by physical processes such as diffusion is as important (or more so) than degradation, based on the evidence from this study, although this conclusion may not apply in all cases at other MTBE-contaminated sites. The evidence from this study is that natural attenuation can provide an important role in the management strategy for sites on the Chalk aquifer which are contaminated with petroleum hydrocarbons and MTBE. It should be considered within risk assessments for such sites, taking account of the various processes and controls on contaminant behaviour in the aquifer, which have been identified and quantified in this study.

Furthermore, the research has shown that a more detailed site investigation methodology, considering a wider range of techniques and measurements of aquifer properties, groundwater chemistry and other parameters, is required to provide the information necessary to consider natural attenuation with a management strategy for such sites. This objective can only be achieved by the development of more sophisticated groundwater monitoring networks than is currently practised, with the installation of multilevel samplers at sites, to provide the necessary increased spatial and temporal resolution of the plume geometry and distribution of dissolved contaminants and degradation processes in the aquifer.

Originally published November, 2006

To view the full report (CL:AIRE Member accounts only), log in to www.claire.co.uk and visit the Publications Library.