

Long-term groundwater investigation on a large refinery site in Northeast Germany: Evaluating Natural Attenuation

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Background

At the PCK refinery site in the Northeast of Germany mineral oil processing has resulted in a large-scale contamination of the shallow aquifer with aliphatic petroleum hydrocarbons (TPH) and with aromatic compounds (BTEX) and the fuel oxygenate methyl tert.-butyl ether.

On a local scale the aquifer is contaminated with nitrate and ammonia stemming from a fertilizer production facility on site. To prevent contaminants from being transport off site with the groundwater a hydraulic containment system is in operation already since the early 1970ies. Systematic groundwater monitoring was implemented at the same time. After the reunion of both German states the groundwater investigation program was intensified in 1994 on the site was installed one of the Ecological Large-Scale Projects which were installed in the former GDR to appropriately handle the most heavily contaminated large industrial sites. The long-term groundwater investigation ist still carried out today.

The largest national collaborative research programme on monitored natural attenuation in Germany, KORA, included the site as a reference for the development and testing of innovative approaches to the investigation and evaluation of the contamination situation and to the quantification and the stimulation of the natural attenuation potential. Some of the methodological approaches are still used in the current groundwater monitoring. Moreover, new conceptual approaches were included with regard to the groundwater monitoring procedure and to the data evaluation. They are used for the continuous optimization of the monitoring network and programme.

The groundwater monitoring basically aims to the following targets:

1. To perform a qualified monitoring to assess the contamination situation and the effectiveness of current remediation and containment, as required by the competent authorities.

2. To prove that natural attenuation processes are taking place as a prerequisite to the economically favourable realization of an MNA-based remedial strategy, as supported by the re-financing entities.
3. To provide PCK with monitoring results that can be used to develop source remediation strategies for source reduction using enhanced natural attenuation (ENA).

Scope of investigation and methods used

To be able to cover the different targets detailed above, the requirements for the evaluation of the groundwater bodies both in space and time exceed the usual level for groundwater monitoring programmes substantially. In the scope of this presentation of the long-term investigation programme we will (1) point out the specific investigation targets, (2) detail the particular components of the investigation programme, and (3) describe the evaluation procedures developed to handle the specific requirements on site.

The scope of investigation corresponds to the integral approach to the evaluation of the relevant hydraulic, chemical, and microbial processes in terms of the above-mentioned specific targets as named before:

- To use statistical procedures (e. g. MK-Test) to assess transport processes and plume stability.
- To analyse bio-chemical environmental conditions by systematic evaluation of the redox conditions and the presence of terminal electron acceptors.
- To predict the microbial degradation processes using specific metabolites, e.g. benzoic acid, and the presence and distribution of methane, carbon dioxide, and hydrogen carbonate.
- To estimate the degradation capacity after Wiedemeyer et al. (1995, 1999) considering the usage of terminal electron acceptors, to assess the degradation activity in the course of specified ground water flow lines comparing readily degradable species as BTEX with relatively persistent species as MTBE, and to carry out mass flux by up-stream vs. down-stream balances.

Utilization of results

The results of the groundwater monitoring programme as carried out to date prove that microbial degradation processes result in a notable mass reduction of the most relevant parameter group BTEX. The mass reduction rate is relevant in comparison to the mass removal rates achieved by the hydraulic containment system.

As a result of the ongoing monitoring programme and of the research project KORA, carried out from 2004 to 2008, the implementation of a large-scale integrated groundwater management system is currently evaluated.

The proposed management system aims to quantitatively and qualitatively improve the aquifer status by the re-infiltration of groundwater. The quantitative improvement is supposed to be based on a stabilization or elevation of the groundwater table, which has been impacted by the long-lasting groundwater abstraction by the containment system. The qualitative improvement is supposed to be achieved by the addition of electron acceptors to the water before re-infiltration (ENA).

Establishing an ENA measure provides the site owner with the option of adapting the operation of the hydraulic containment system in an economically favourable way or even to put it out of operation, as the BTEX mass flow with the groundwater is further reduced by the stimulated microbial degradation. Furthermore, a large-scale ENA-project will cover contaminated areas which are not accessible for other remedial measures due to the given extensive site use. An increase of the overall remediation activity is possible, accordingly.