AQUAREHAB

Development of rehabilitation technologies and approaches for multipressured degraded waters and the integration of their impact in river basin management

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vito vision on technology

Topics

Conferences and Announcements:

- 8th International Symposium on Subsurface Microbiology (ISMM), 11 – 16 September, 2011, Garmisch-Partenkirchen, Germany.

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Introduction

The AQUAREHAB project has now passed its two-year anniversary. Since the Third General Meeting at the Geological Survey of Denmark and Greenland (GEUS) in Copenhagen, Denmark (January 2011), we have been working to finalise the technology and modelling developments and preparing for the extension of the project results to other regions in Europe. The Fourth General meeting will be held in the Helmholtz Zentrum in Munich (23-24 November 2011) and the External Workshop will be held in Barcelona during September 2012.

In this Newsletter we provide news on the technology and modelling developments from Work Package 2 - Tailored carrier/bacteria technology for rehabilitation of areas with pesticide-containing pollution and Work Package 3 - Development of rehabilitation technologies to decrease pollutant influx between groundwater and surface water near river banks. In addition we provide information concerning the outcome of the Second Open End User Workshop in January 2011 at GEUS.

Technology and modelling developments

Tailored carrier/bacteria technology for rehabilitation of areas with pesticide-containing pollution (AQUAREHAB WP2)

In this work package AQUAREHAB is aiming to develop carrier/bacteria material that can be implemented in an open or closed drain to remediate polluted drainage water (Figure 1). The carriers support microbial biofilms which degrade pollutants. The field site selected to develop this technology is an industrial site within the Sechor-Beser river basin in Israel. The geology of the site is fractured chalk formation and the water is brackish and heavily polluted with a wide range of pollutants (mainly herbicides and pes-

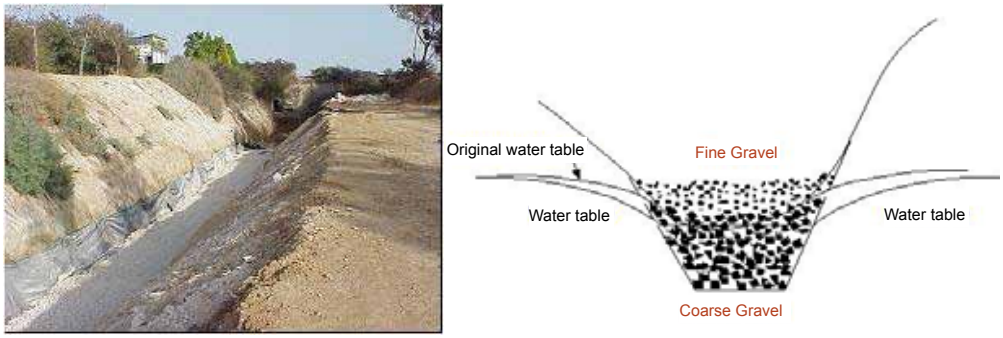

Figure1: Open trench where tailored bacteria/carrier materials will be introduced for semi-passive treatment of drained pesticide-containing water.

ticides) from the upstream industry. The research work is performed by four Institutes. The Ben Gurion University of the Negev **(BGU)** is leading the work package and is responsible for characterising and modelling the geohydrology of the industrial site, testing promising carriers in the laboratory and in the field, as well as establishing field pilot experiments. The Geological Survey of Denmark and Greenland, Denmark **(GEUS)** is carrying out laboratory work to determine the best combination of carrier and bacteria. The Catholic University of Leuven, Belgium **(KU Leuven)** is doing laboratory scale experiments to identify suitable support material (e.g. powder activated carbon, chalk powder, coconut shells, lava stone), which allows the retention of moderately-sorbing pesticides without affecting biodegradation rates. The CTM Centre Tecnologic, Spain **(CTM)** is focusing on the synergistic/antagonist effects of the co-pollutants and water chemistry on the activity and middle-term performance of immobilised bacteria.

In a first part of the study, carrier/bacteria mixtures have been developed and tested at laboratory scale, using materials such as chalk, activated carbon, sand and silica (or combinations of these). Metabolically active microbial populations colonised all carriers following in-situ incubation at the Israeli site, with a large variability in total biomass observed (BGU, GEUS). Laboratory work with herbicides indicated no significant MCPA or linuron mineralisation could be determined in the biofilm colonising the carriers. However, atrazine mineralisation was detected in one bottle containing sand as a carrier. Atrazine-mineralising enrichment cultures were successfully established using atrazine as either a nitrogen source (MSC-cultures) or as both carbon and nitrogen (MSC-cultures). No atrazine mineralisation was detected in the trench gravel (exposed to pollution for a long time) or in any other samples from the site, which suggests that atrazine-degraders are rare at the site and that bio-augmentation is therefore relevant. CTM focused on the elimination of triazines (atrazine, simazine, propazine and terbuthylazine) in groundwater by studying, designing and developing a mineral carrier to promote microbial activity with a reference strain (Pseudomonas sp. strain ADP). KU Leuven extended the technology to non-brackish water situations, determining sorption/desorption features of pesticides on a set of carrier materials and pesticide mineralisation by pure pesticide degrading strains under normal salinity and high salinity.

The second part of the study is dedicated to the implementation of the technology at pilot scale on the Israeli site. A pilot system has been designed and constructed for this purpose (BGU-see Figure 2). Hydraulic tests have now been finalised and currently researchers are discussing the final experimental set-up before introducing a promising carrier/micro-organism combination into the pilot drains. We have the following end-users interested in our work: industrial companies working with highly toxic chemicals in the process chain, and environmental agencies who need to follow up dangerously polluted sites. We expect that the outcome of our work after 3 years should be clearer scientific evidence of which carriers/bacteria material are best suited for rehabilitating heavily polluted ground waters in dry fractured regions. We hope that the approach and developments can be extended to other dry fractured areas in Europe and around the Mediterranean.

Figure 2. The BCR pilot plant in Ramat Hovav, Israel.

Development of rehabilitation technologies to decrease pollutant influx between groundwater and surface water near river banks (AQUAREHAB WP3)

In this work package we are aiming to develop and test remediation technologies to stimulate the degradation of Chlorinated Aliphatic Hydrocarbons (CAH) in groundwater plumes. Our work focusses on the prevention of groundwater pollutants being discharged into surface waters. The Zenne river (Vilvoorde-Machelen, Belgium) is our case study area, which we studied extensively during the FP6-project SEDBARCAH. At the site, a large CAH-contamination plume is situated near the Zenne river (Figure 3).

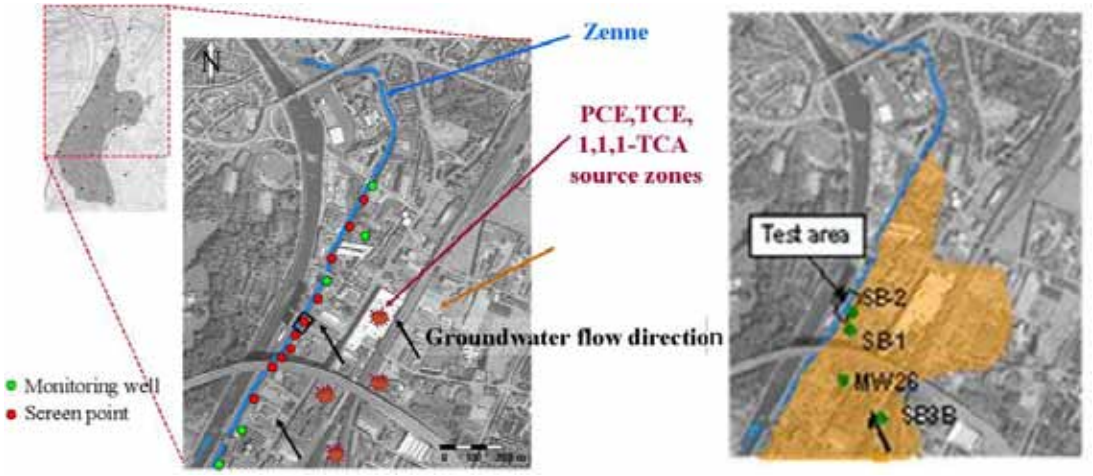

Figure 3: The Zenne test site with indication of the study area in the Zenne riverbed (rectangular,left), and the locations of the boreholes SB2, SB1, MW26 and SB3 studied in AQUAREHAB-project (right).

The research work is performed by six Institutes. The Flemish Institute for Technological Research (**VITO**) is leading the workpackage and is responsible together with the Catholic University of Leuven, Belgium (**KULeuven**) for carrying batch and column degradation tests and the field tests. The Environmental Institute, Slovakia (**EI**) is undertaking the surveying programme to monitor the overall water ecology. The University of Sheffield, UK (**US**) is developing numerical modelling techniques to provide information on the degradation process. ISODETECT, Germany, is analysing the isotopical shifts in the CAH compounds and the University of Wageningen (**WUR**), the Netherlands, is using Q-PCR analyses to quantify the number of CAH degrading bacteria and catabolic genes.

The techniques that we have considered to prevent the discharge of CAH into the Zenne river are (1) stimulation of the biodegradation just upstream of the sediment zone in the aquifer, and (2) capping of the sediment with a permeable biodegradation stimulating material.

Tests performed at batch scale indicated that VC, DCE and TCE degradation only occur in the aquifer compartment when extra carbon sources (lactate, molasses, sediment) are added. A modelling approach based on the results of these batch tests and the quantification by quantitative PCR of the CAH degraders involved in this transformation process, indicated that the degradation followed first order kinetics. Also at batch level, different capping materials could stimulate the anaerobic VC degradation in sediments. Therefore we have set up small column experiments to study the performance of the materials such as tree bark, hay and straw.

Since 2007, a wastewater treatment plant (WWTP) has been in operation in Vilvoorde Machelen, resulting in an increased oxygen concentration in the surface water. Batch tests showed that the oxygen that might infiltrate into the sediments can stimulate the degradation of VC. Currently, the bacteria involved in this aerobic degradation process are investigated using molecular techniques, and sediment samples taken in the field will provide insights into the effect of the WWTP on the overall and microbial community structure in these sediments. Samples analysed at the case study site in 2009 and 2010 indicate that the CAH-concentration flowing from the industrial site via the groundwater to the aquifer/surface water interface, has been reduced drastically in the research area. We have therefore concentrated our efforts on laboratory experiments (both at batch and column level) and field parameters obtained in the past. In addition, we are using models to simulate different scenarios to stimulate the CAH degradation and provide leads as to what the best approach is to prevent the influx of CAHs from a groundwater plume into a river.

We have the following end-users interested in our work: national and regional waste agencies (such as the Flemish Waste Agency), national and regional environmental agencies and policy makers, river basin managers, but also engineering companies involved in soil remediation and protection. We expect that the outcome of our work after 3 years should be an approach to characterise and remediate (CAH) polluted groundwater plumes before they reach the rivers and other surface water bodies . We hope that the approach and developments could be extended to other areas such as the Demer in Belgium, and similar polluted sites in Spain and Denmark.

Papers

Bosch, J., Fritzsche, A, Heister, K, Totsche, K.U., and Meckenstock, R.U. (2010). High reactivity of naturally formed iron hydroxide colloids. Geochimica and Cosmochimica Acta.

Presentations

The AQUAREHAB team has recently made presentations and shown posters at the following conferences:

- European Geosciences Union General Assembly 2011, 3-8 April 2011, Vienna, Austria http://meetings.copernicus.org/egu2011
- First International Symposium on Microbial Resource Management (MRM) in Biotechnology, 30 June-1 July 2011, Ghent, Belgium. www.labmet.ugent.be
- Third Symposium of the "Centre of Competence for Soil, Groundwater and Site Revitalization" (TASK), 8 June 2011, Leipzig, Germany www.ufz.de/data/Symposium_Program_EN14335.pdf

AQUAREHAB meetings

AQUAREHAB's Fourth General Meeting

The AQUAREHAB project will be having its Fourth General Meeting at the Helmholtz Zentrum in Munich (23-24 November 2011). The meeting is an opportunity to discuss the progress of the Project in its third year, present the results achieved in 2011, and finalise the preparations for the work to extend the project to other regions in Europe. Other issues such as how the work of the project is being disseminated and the involvement of end users will also be discussed, particularly in light of the External Workshop to be held in Barcelona in September 2012.

AQUAREHAB's Second Open End User Meeting

More than 30 people attended AQUAREHAB's Second Open End User Meeting at GEUS in Copenhagen (18 January 2011). After a few words of welcome from Bjørn Jensen the Deputy Director of GEUS, Leen Bastiaens the coordinator of AQUAREHAB provided an introductory presentation of the aims and goals of the projects, highlighting the set up of the project, the specific work packages and the expected outcome by the end of the project. The Work Package Leaders then provided short presentations of the achievements made so far in developing the rehabilitation technologies and the modelling techniques, and how they plan to take the project's work forward. In the afternoon presentations were given by stakeholders who are interested in the outcome of AQUAREHAB and scientists who have been leading other research projects that are relevant to AQUAREHAB. Ann Fuglsang from the Ministry of Environment, Danish Nature Agency, at Fyn, provided an overview of a LIFE+ project REGAIN that has been running in the River Odense and Odense Fjord to restore wetlands. She highlighted the role that wetlands can take in removing nitrates and also improving biodiversity in the region. Lorenzo Paolo Galbiati from the Catalan Water Agency in Spain presented an overview of the aims and objectives of the River Basin Management Plan of the River Ebro. In this region the majority of investments in the near future will be basic measures (e.g. installation of waste water treatment facilities) – while the principal problems remaining include better information concerning priority substances polluting surface and ground water bodies, diffuse pollution of ground water bodies, and salt water intrusion in coastal ground water bodies. Philip Binning from the Department of Environmental Engineering at the Technical University of Denmark gave a presentation of the RiskPoint project (www.risk-point.dk), which carried out an integrated ecological risk assessment of contaminated sites in Denmark, using the AQUATOX model. David Lerner from the University of Sheffield, UK, presented the outcome of the SABRE project (www.sabre-eu.eu), which aimed to develop an in-situ bioremediation of a DNAPL (dense non-aqueous phase liquid) source zone. Results showed that the remediation technology was not a proven success for removing heavily contaminated sources.

The Second Open End User Meeting was a successful event in terms of disseminating early results of the AQUAREHAB project and interacting with interested stakeholders and scientists working on similar projects.

AQUAREHAB in a nutshell

AQUAREHAB is a large scale EU financed research project (FP7) that started 1st May 2009 with 19 project partners. The AQUAREHAB consortium will work together on the project for 56 months (until 2013). Within this project, different innovative rehabilitation technologies for soil, groundwater and surface water will be developed to cope with a number of priority contaminants (nitrates, pesticides, chlorinated compounds, aromatic compounds, mixed pollutions…) within heavily degraded water systems. The expected outcome of the project is new or improved remediation technologies; guidelines to describe feasibility tests, applications and monitoring; technology specific numerical tools to improve designs and predict the long term effects of technologies; and, a generic river basin management tool that predicts the impacts of measures on surface and ground water bodies. AQUAREHAB therefore aims to be the basis for improving future river basin management tasks and site specific remediation management.